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Editorial

Sustainable Development: Engineering and sustainable development work hand in hand. This combination has the potential to bring about a wide range of extraordinary changes in this world. Our efforts focused on the United Nations' 17 Sustainable Development Goals (SDGs), which require actions from all countries, whether developed or developing, as part of our global cooperation.

We understand that sustainability is the foundation for today's leading global framework for international collaboration, as well as the creation of a brighter future for all of us in the years ahead. Sustainable development can be defined as development that meets current requirements while also providing for future generations without harming the environment. Achieving the ambitious 2030 Sustainable Development Goals (SDGs) will need effort on all fronts, with governments, scientific and educational institutions, corporate establishments, civil society, and individuals worldwide all playing significant roles. Considering all of this, stakeholders need to undertake research on sustainable development. The response for such endeavours offers an indicator of interest of researchers and academicians in sustainable development and confirming for everyone a just and clean future for all.

Bringing together eminent engineers, scientists, academicians, and industry leaders with a special focus to work on sustainable development. Efforts to achieve universal sustainable development must take into account the immensely various barriers, situations, and decisions that affect opportunities and riches for everyone, everywhere. The United Nations officially refers to education for sustainable development (ESD). It is referred to as instructional practices that encourage changes in knowledge, skills, attitudes, and values in order to create a more equitable and sustainable society for all. Through a balanced and integrated approach to the economic, social, and environmental aspects of sustainable development, ESD seeks to empower and equip present and future generations to satisfy their requirements.

The concept of sustainable development has given rise to a number of discourses that promote competing sociopolitical aspirations. Scholars researching global environmental governance have discovered a variety of public discourses that largely represent four sustainability frames: radical sustainability, constraints discourse, mainstream sustainability, and progressive sustainability. We must put our efforts towards establishing a world that is sustainable in every way, and in which everyone can live happily.

New Delhi **Editor**

31st January 2025

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A Study of Steel Structure Detailing

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ABSTRACT

A notable domain in the advancement of steel structures is industrial construction. Among the various structural forms, large steel structures are experiencing the most rapid growth due to recent scientific and technological innovations. The creation of steel structures is undertaken by construction mechanics, who merge construction technology with principles of structural mechanics. To effectively implement mechanical construction techniques, it is essential to simulate the construction process. Using Tekla Structures as the preferred BIM program, this study aims to educate readers on BIM structural modeling methods from the viewpoint of a structural engineer. This paper's principal goal is to demonstrate how to apply a structural BIM tool to improve task dependability, workflow acceleration, and efficiency. It highlights how crucial structural modeling and BIM technologies and processes are to the building sector.

KEYWORDS *: Building Information Modeling (BIM), Structural modeling, Steel framework, Tekla structures.*

INTRODUCTION

L. Vimala et al. [1] emphasize that steel has many structural advantages. In addition to its inherent properties, steel structures are also valued for their adaptability. Steel is ideal for modernization, retrofitting, expansion or transformation with minimal interruption. In civil engineering, the concept of design analysis and modeling of steel structures represents the latest advances. Modeling of steel structures is essential. A thorough evaluation at this modeling stage effectively reduces the risk of failure. For all your structural projects, Tekla Structures is a robust and customizable program The extensive use of the connection model promotes the rapid development of construction projects. Within the construction industry, we generate lifelike 3D representations of metal structures, covering a wide spectrum of projects such as commercial buildings, office spaces, high-rise towers, and stadiums. In this project, we manually create connections in accordance with established standards (ISO, AISC, AWS, etc.) and incorporate OSHA regulations. The design and construction of the aircraft were accomplished using the Tekla program. Additionally, beam-column connections and moment connections are fundamental components in the construction of steel frameworks. Contrary to a single-member configuration, their framework generally conforms to more standard designs. This project seeks to investigate a seven-story commercial building under a range of load conditions with the aid of STAAD Pro software, in addition to examining the effectiveness of the bolt connections. In the work of Tian Limin et al. [2], it is emphasized that the later headways in science and innovation have driven to a noteworthy increment in the predominance of large-span spatial structures. These structures are characterized by their complexity and long development periods, which result in striking inner strengths and distortions. The field of development mechanics, which combines basic mechanics with development innovation, requires the recreation of development forms for large-span steel structures to viably actualize mechanical development strategies. Actualizing fitting development strategies is vital to guarantee that the push and distortion of the completed structure fulfill the prerequisites laid out by the creators. This paper examines different explanatory strategies and development methodologies based on viable encounters with large-span steel structures, giving a sensible establishment for development hones.

Zhang Fuqiang et al. [3]: The improvement of industry is an inescapable way of the advancement of steel structure bridges. This article examines the logical administration of the improvement of the steel structure bridge industry. Based on the improvement of steel structure bridges, an usage arrange is proposed. At the conference, the fundamental supporting advancements such as calculations for the territorial division of bridge structures based on BIM (Building Designing Modeling), a reference for distinguishing bridge components based on QR codes and the Web of Things, and the collaborative advancement chain of steel structure. bridge entered the center. Administration and control. At long last, a specialized case was proposed to confirm the possibility of the proposed strategy, which is aiming to serve as a reference for engineers in planning the industrialized development of steel bridges, as well as for their administration all through the bridge's life cycle. Anil Sawhney et al. [4] have watched that the joining of novel development strategies, methods, and materials has raised the multifaceted nature of the development segment inside the country. Thus, the development industry is in critical require of progressed instruments and innovation to encourage the learning, arranging, and administration of this perplexing development handle. This article depicts development and examination strategies determined from Petri nets, which are able of reenacting complex development forms. Through the utilization of progression, modularization, and asset optimization, Petri nets offer unmistakable benefits in the optimization of complex fabricating forms. This article focuses on the advantages of the Petri mesh and its application in the design and study of steel reinforcement sleeves. Syed Firoz et al.[5]: Steel building structures (type-I) have great benefits for building, increasing the efficiency and effectiveness of materials, energy efficiency, consumption , impact on natural resources, CO2 emissions due to household recycling. material, a system that presents examples in various scientific disciplines. The steel building is supported by a project that is currently implemented through the Tekla software package to create and maintain real-time, multi-dimensional, and data-rich displays for design, renovation and insulation of permanent steel buildings. Rafi Jati Kusuma, etal [6] : The improvement division is the primary concern of the Indonesian government, particularly framework improvement which fundamentally points to back the expanding foundation needs. This requires the development industry to actualize changes taking after the mechanical insurgency 4.0. One of the endeavors of the development industry is to utilize the conceptof Building Data Modeling (BIM). Tekla computer program is a unused insurgency in basic plan that offers a few preferences over other application program. This research was done to focus on the calculation of the volume and weight of the structure that includes the steel structure, i.e. The calculation of anchors, columns, beams, flanges, bolts and plates with Tekla Structures com is a BIM platform. The research approach used is a quantitative approach, because to draw conclusions it is formulated on the results of the analysis in the form of numerical data. The information used in this study refers to the design information of the store. The results of this study were obtained from steel structures ekla ing utilizing Tekla Structures and gotten the add up to volume weight of column work sizes 500x500x16x25, 450x450x12x22, 500x500x16x22, and 300x300x10x15 with a weight of 284.7 tons. Work bar estimate 588x300x12x20, 400x200x8x13, and 300x150x6.5x9 with a add up to weight of 401.3 tons. For a triangular hindquarters with measurements of 588x300x12x20 and 400x200x8x13 the add up to weight is 58 tons. Base plate size 700x700x25, 490x490x20 and 540x540x22, with a total weight of 13.15 tons. End panels are installed at the ends of the beams with thicknesses of 13, 16, 20 and 25, with a total weight of 58.72 tons. Install

8, 12, or 16 reinforcing bars of any size, distance, and thickness, with a total weight of 34.56 tons. The number of 19 mm diameter bolts is 19,498, and the number of 22 diameter anchors is 900. Mukesh Ahirwar [7] emphasize that in the modern fast-paced environment, the integration of computers inside the fabricating segment is basic to adjust with the quick headways in the improvement of serene frameworks. This think about fundamentally points to examine the computation of comes about. The investigation and plan of fortified concrete and steel structures speak to the concluding stage in the development industry, guaranteeing that ventures are completed inside the stipulated time and budget. Analysis and design tasks is not an easy matter of fact. Uncommon utilize of proficient program, such as Robot Auxiliary Investigation, MIDAS Gen, SAP2000, STAAD Professional, ETABS, TEKLA Basic Creator, S-Frame, etc. In this consider, distinctive properties of G+7 steel layered structures with diverse bracing frameworks (specifically X-bracing, V-bracing, and V-bracing) are compared and compared considering the characteristics rise to loads are made utilizing Tekla Modeling and examination applications..

Sonia S, S Devi, et al. [8] emphasize the critical importance of the Highway Bridge within contemporary transportation networks, necessitating compliance with rigorous design and specification standards. This study explores four distinct cross-sectional designs under identical loading conditions. The steel box girder bridge is engineered to meet the requirements of IRC Class AA loading, following the IRC design standards of India. The analysis encompasses four unique models to illustrate the enhanced cross-sectional properties. Consequently, the findings indicate variations in bending moments and stress levels across different cross-sections.. The cross-sections and the advantage of the small arc moments make the steel smaller and provide a very reasonable transition range. This shows that the variable costs of multi-section steel box supports are higher than single-box supports, since the addition and support environments are the same for each of the four separate models with different cross sections. . Tekla structures are used for monitoring and planning.

Snehal Manik Bulkul et al.[9]. - Touchdown and Takeoff. These products provide enhancements, improvements and significant new features to increase efficiency and streamline workflows. Drafting, Steel Casting, Prefabricated Concrete Sections, Landscaping and Improvement. The latest version of Tekla Structures is said to run faster. Tekla systems are used for planning, inventory and data management, from application planning to on-site manufacturing and development. According to G. Venkata Rao et al. [10], steel provides a multitude of benefits to the structural industry. Recognized as one of the most sustainable construction materials, steel is appreciated by building owners for its inherent flexibility and the advantages it confers. Steel trusses are extensively utilized to support roof loads and maintain horizontal stability. The benefits of opting for steel trusses in place of traditional wooden trusses are significant, with the key advantages being their simplicity and strength. Steel trusses present a lightweight, high-strength roofing solution that allows for rapid installation.. In this venture he utilize Tekla computer program. It has a exceptionally intelligently client interface which permits the clients to draw the outline and input the stack values and measurements. Tekla structures are capable and adaptable program for all basic ventures. At that point agreeing to the indicated criteria doled out it examinations the structure and plans the individuals with auxiliary steel. Our last work was the appropriate examination and plan of truss sort steel building. The Point of display ponder is to characterize legitimate method for making Geometry, cross areas for column and bar etc., ., develop requirements and supporting mechanisms, types of responsibilities and combinations of responsibilities. I primarily analyze and design steel frame buildings for all load combinations (dead, live, wind, seismic). A variety of codes were used in this analysis. Static load IS: 875 (Part-1), live load IS: 875 (Part-2), wind load IS 875- (Part-3), seismic load IS 1893. Analysis of seismic and wind load combinations by use ekla. Manual design and modeling using Tekla software.

Research on steel construction projects is ongoing. Since all preparation is done off-site and only the installation work is done on-site, planning is the most important part in any steel construction project. Therefore, it is very important not to overlook any element during design and planning. Therefore, the success of a steel construction project is highly dependent on the details of the steel. This section provides comprehensive information. Workflow showing the process of detailing steel structures.

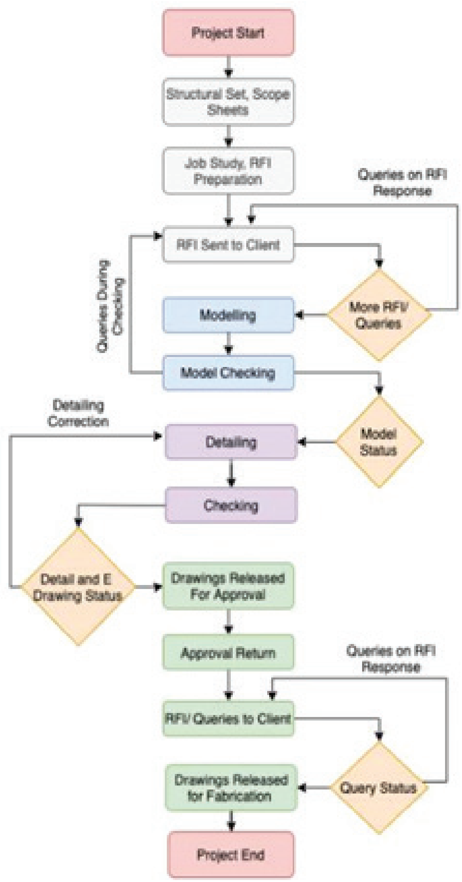

Fig. 1 Steel structure Detailing Process

The process of preparing shop construction drawings based on structural design documents and architectural documents is called steel detailing. A draftsman is someone who interprets mechanical drawings and translates the designer's desire into industrial requirements for steel fabrication. Analyzing, evaluating, creating and adapting infrastructure. The scope of the work of the steel fabricator is determined down to the final lock, welding and measurement, with a special marking on each part to help the installation of the parts. Flow design is an overview of the steel insulation design process. Before the design process begins for a project, a set of contract drawings (sometimes called structural drawings) and a set of commercial architectural drawings are required. Structural engineers exchange information with fabricators, contractors, and steel detailers via structural drawings. The specifics of an object supporting structural engineer-designed beams and columns are described in these drawings. All the relevant details regarding the dimensions, composition, kind of material, and procedures for joining and fastening each member are included in structural steel drawings. The location and arrangement of different parts inside the completed structure are depicted in structural drawings. Each frame component's structural shape designation is included, together with important dimensions that locate beams and columns along the centerline, general remarks, end reaction loads, and a north arrow for reference. The General Notes, Foundation Plans, Framing, and Details are all included in the structural drawing package. The material grades, bolt kinds, weld types, connections, etc. are displayed in the General Notes. The placement, elevation, profile, and size of the columns as well as their footing are all detailed in the foundation drawings. The overall dimensions of the structure are provided by the framing and details, which also include the locations of the columns, beams, angles, and other shapes and sizes of the structural members. The details include cross sections, information about any special connections needed, a schedule of the columns, splice and base-plate details, brace elevations, and other information. . The foundation of the building design, architectural drawings are necessary for commercial projects and are essential for converting conceptual designs into feasible structures. It requires the system to be rendered accurately, traditionally on paper. A complete view of the building as a set of different building blocks is achieved using it. The first source that offers a foundation for comprehending the primary method of visual thinking applied in the production of these drawings is architectural study drawings.

Future scope

Subterranean steel constructions are becoming more and more common in India. One of the best examples of a steel structure is the Rajiv Gandhi International Airport in Hyderabad, and Tekla is the ideal supplier for these kinds of projects. One powerful structural BIM (Building Information Modeling) technology for future projects that will be more successful is Tekla. In the Indian market today, Tekla is useful for developing multistory building constructions, although it is not widely utilized. Tekla pioneered a new era of reliable project data, created the best work in the quickest period of time, and embraced the genuinely constructible BIM process. Tekla is currently the software of choice for many more construction companies when it comes to steel manufacture and detailing.

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Comparative Study of Inventory Control Models under Different Parameters

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ABSTRACT

This work presents inventory control models for items which deteriorates with time. The demand pattern used is mix type. Here demand rate is inventory dependent when production is in process and assumes it constant after maximum inventory level reaches. The optimum solution of the model is derived by using simple differential calculus method. The effect of rate at which inventory get consumed is discussed in this model. In this model the total cost function shows the convexity. Mathematical Model gets verified by using numerical example. Sensitivity analysis had been carried out.

INTRODUCTION

All organizations deals with some type of inventory. Inventories may be in the form of raw materials, subassemblies, work in process, and finished goods. So all are concerned with inventory planning and control. Inventories of any items ties up money. Inventory will generate profit when it leaves as a product. That's why inventory management becomes important for all types of organization. Cost of inventory can be managed by effective inventory management. Effective inventory control always think about no shortage. This is possible by having correct forecast about demand. That's why proper planning about inventory plays important role. By achieving these shortages in supply can be avoided. At the same time inventory management also has concern about to keep total cost at minimum level..

The objective of this paper is to fill the research gap by evaluating EPQ, single-product item production system under various parameters. The objective will be accomplished by developing EPQ model for integrated production systems. The primary variables are demand pattern, holding cost and the secondary variable is rate of deterioration. The performance measures are total annual cost, production run time, inventory holding cost and production down time. This study will helpful to inventory managers for minimizing total cost and avoid shortages. Here attempt has been made to suggest best EPQ model. The research studies the effect of the inventory dependent demand and time dependent holding cost on performance measures.

Research Variables

Demand pattern is the variable that is used to evaluate the EPQ based on the performance metrics proposed earlier. Demand is considered as inventory dependent during production run time and assumed constant during inventory depletion time. Demand is considered as inventory dependent because large stock can attract the customer. In addition to inventory dependent demand, holding cost is considered as time dependent. This is why, as perishable items deteriorate with time. To store such item needs special storing arrangements. This leads to increase in holding cost. Rate of deterioration is considered as variable in last two models.

Research Questions

Here attempt has been made to addressed some research questions.

1. What is the effect of inventory dependent demand on the EPQ controlled process?
2. What is the effect of time dependent holding cost on EPQ controlled process?

3. What is the effect of varying rate deterioration on EPQ controlled process?
4. With all this parameter is an EPQ controlled process has lower total annual cost

Assumption and Notation

Following common assumption and notations are used to develop all the models.

Assumptions: -

The following common assumptions are made in development of the models.

a) Constant production rate
b) Demand shall be less than production rate to avoid shortages.
c) During production demand depends on inventory level and constant after maximum inventory get produced.
d) Constant rate of deterioration.
e) Constant cost of deteriorated items
f) Constant Inventory holding cost

REVIEW OF LITERATURE

EPQ models are used for decision making in many production systems. EPQ models has been extended by numerous researchers by using different assumptions Items produced in production systems are not always with perfect quality. [1]. Items deteriorates once received in stocks. Effect of deterioration on cost had been studied by Rosenblatt [2]. Demand of items depends upon various factors. Higher stock also affect demand. Various demand patterns are highly sensitive to optimal solution [3]. Machine failure during production affects the production process and quality of items [4]. Items which deteriorates with time gets consumed by demand under LIFO policy [5]. To satisfy stock dependent demand pattern inventory must be at maximum level. Higher holding cost is due to maximum inventory [6]. Total cost is mostly affected by demand pattern and quality functions [7]. Demand has major concern with machine breakdown [8]. Mean time between machine failure shall be properly calculated to decrease production cost [9]. Production of defective items contributes to total cost [10]. Total cost increases due to increase in inventory holding cost. [11]. Demand mostly depends upon stock present in inventory [12]. Demand can be increase by offering discounts and other offers to customers [13]. Deterioration can be reduced due increase in demand [14]

EPQ models helps inventory managers in decision taking. Most of the time EPQ models are used by some assumptions so not concerns with real world problems. EPQ models has some weakness. Many researchers developed EPQ models by using some unrealistic assumption.

Most of EPQ models are developed by considering different demand pattern depends upon nature of products. Inventory level mostly change demand patterns in case of perishable items as they deteriorate with time. Inventory of perishable items leads to increase in holding cost. Demand patterns may be different on different time periods. Holding cost can't be same for total holding time period. The present study tried to develop EPQ model by considering time dependent holding cost, demand patterns. Holding cost is considered as function of time. Different EPQ models are formulated by using different assumptions and parameters for perishable items.

METHODOLOGY

1. Literature Survey to review the national and international status.
2. Identification of the production system and nature of the product (Perfect or imperfect production system, perishable or nonperishable items)
3. Identification of various inputs (Causes) and the various outputs (Effects)
4. Physical design for the model
5. Data collection through the execution of the model.
6. Purification of the gathered data by statistical method.
7. Establish the relationship between Inputs factors and outputs by using Mathematica, Microsoft Excel Software to develop the model.
8. Sensitivity analysis of the Model to find out the influence of various inputs on the outputs

MODEL FORMULATION

Mixed demand inventory model

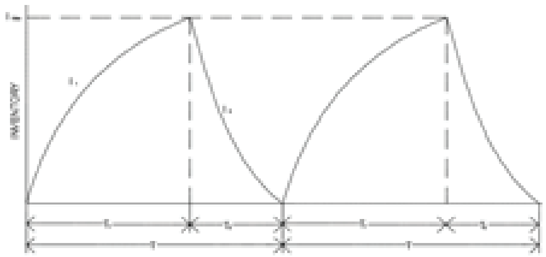

Fig. 1 Inventory Level

Models had been formulated to study different demand patters for different time period. Production rate builds up inventory and get consumed as per demand pattern. Optimum solution has been find out by using differential calculus method. Stock dependent rate parameter and holding cost is important parameters for this model.

Convex function of total cost gives optimum value of production time. Demand consider here is stock dependent so production run time is highly sensitive. Stock dependent rate parameter affects production run time inversely. Production rate affect inventory buildup time. As demand is stock dependent, it will be higher during stock build up period and hence more holding cost. Demand and inventory holding cost are highly affecting total cost. Holding cost is highly affected by demand parameter.

Time dependent holding cost model

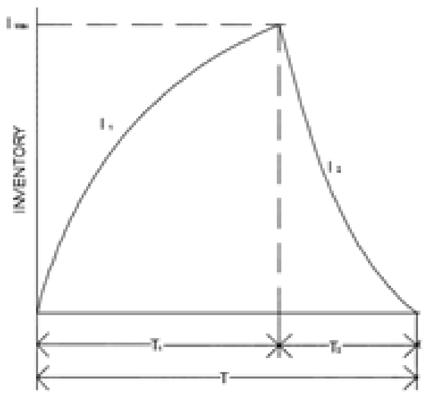

Fig. 2. Inventory System

Mixed demand pattern and time dependent holding cost is used for developing this model for perishable items. Inventory level mostly change demand patterns in case of perishable items as they deteriorate with time. Inventory of perishable items leads to increase in holding cost. Relation between mixed demand pattern and holding cost developed here.

Change in production rate and demand contributes more in inventory buildup time. Production time has moderate concern with inventory demand parameter and holding cost parameter. Production time depends on demand and production rate. Total cost has major concern with production rate and demand pattern and holding cost. Total cot per unit time increase with increase in holding cost parameter.. This indicates that perishable items required special storage arrangement which increases the cost.

Model with inventory dependent demand and constant holding cost

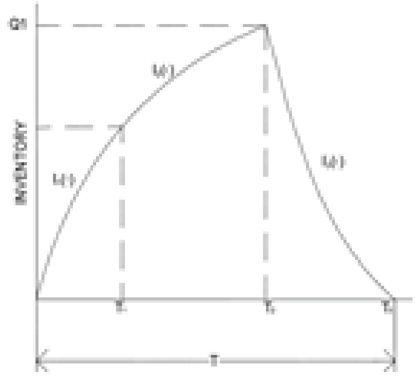

Fig. 3. Inventory Level

This model was developed by assuming deterioration of item starts after some time as it enters into inventory. Stock dependent demand is used to developed the model. Holding cost is considered as constant. An optimal production run length was found out by differential calculus method. The contribution of stock dependent demand parameter was discussed on the production up time, total inventory and holding cost is also discussed in this model.

Production uptime is under influence of production rate, demand rate, holding cost and inspection cost Production up time decreases due to increase in the production rate.

Total cost per unit time is highly sensitive to production and demand rate. It is moderately sensitive to holding and inspection cost while slightly sensitive to inventory consumption parameter and deterioration rate. Holding cost decreases due to increase in demand parameter.

Model with varying deterioration rate

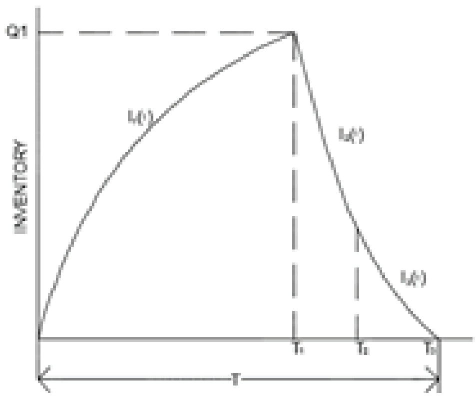

Fig. 5. Inventory level

EPQ model has been developed to study the effect of different deterioration rate with mixed demand pattern. Holding cost considered as constant. Perishable items deteriorate continuously with time. Rate of deterioration change with time, this parameter studied in present model with different demand pattern for different time period. The effect of stock dependent demand is also discussed along with effect of varying deterioration rate.

Model with time dependent holding cost

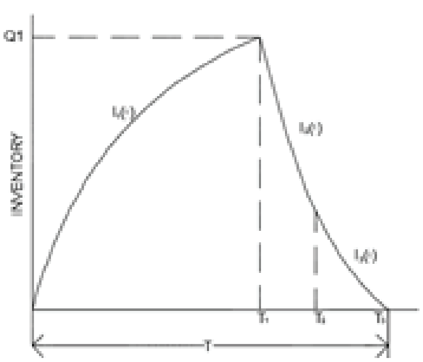

Fig. 6. Inventory level

EPQ model developed here considered time dependent holding cost for perishable items. These items deteriorates with time so required special storing facilities and hence holding cost increases with time and decreases with time.

NUMERICAL EXAMPLES AND SENSITIVITY ANALYSIS

Five EPQ models had been developed by using different assumption and theoretical aspects.For validation of this aspects and assupmtions numerical analysis had bee carried out. The numerical data has been taken from Jie et al.(15). Other parametrs l;ike inspection cost, holding cost are taken by our self. For validation of data sensitivity analysis is carried out by changing one parameter at a time and keeping others unchanged. The optimal production up time can be found since the total cost is convex for a small value of production run time.

CONCLUSION

Here attempt had been made to developed theoretical EPQ model. From sensitivity analysis it was observed that demand patterns had major role in production process to avoid shortages. For perishable items, which deteriorates with time needs special storing arrangements to maintain quality and to increase demand. This may increase holding cost, which contribute to increase total cost. For that by having time dependent holding facilities can helpful to minimize total cost. Inventory dependent demand also contributing in minimizing total cost and inventory holding cost.

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Overview of Effect of Laser Hardening Process for Improvement of Surface Hardness

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ABSTRACT

The use of electron and laser beams in surface modification practices brought up new manufacturing possibilities, which led to an outstanding improvement in the product's overall quality. Because of this, specific connections are formed between the beam and the work piece, which, in turn, leads to metallurgical changes that are difficult to produce using the traditional procedures that are currently accessible. The process of laser surface transformation hardening is more often known as heat-treating, which refers to the practice of subjecting material to rapid heating and cooling. The laser hardening method has become a major approach for surface modification, significantly impacting the field of materials engineering and production. This review paper offers a comprehensive examination of the recent advancements and present state of laser hardening technology, as well as its extensive applicability across diverse industries. The article provides an in-depth analysis of the underlying principles, process parameters, and recent breakthroughs in laser hardening. Additionally, it explores the benefits and constraints associated with this technique. Furthermore, it highlights the ground-breaking applications of laser hardening in improving mechanical properties, wear resistance, and material lifetime, making it an indispensable tool in modern engineering. By critically examining current research and relevant case examples, this study aims to serve as a useful resource for academics, engineers, and industry professionals. The purpose of this paper is to shed light on recent developments in laser hardening processes and their potential consequences in a wide range of industrial fields. The current paper focuses on recent advancements and researches in the subject of laser hardening utilized by a wide range of researchers. As a result of the metallurgical processes that occur during these heating and cooling cycles, the surface properties of the materials are often greatly enhanced, including their hardness, abrasion resistance, and wear resistance. The features of the laser, its process parameters, and its potential uses are all outlined in this document.

INTRODUCTION

Laser hardening has become increasingly prominent in the field of surface modification and materials engineering in recent years [1]. The advanced thermal treatment technology has garnered significant attention due to its ability to enhance the mechanical properties of diverse materials while preserving their inherent characteristics. Laser hardening is held in high esteem among academic communities because to its remarkable precision and efficiency, enabling tailored modifications in material properties [1,2]. Researchers and engineers are currently engaged in continuous study of novel methodology and optimization strategies in the field of laser hardening [3]. A notable field of scholarly investigation centres on the precise calibration of laser irradiation parameters to achieve the most favourable transitions in material phases [3]. This calls for a comprehensive analysis of laser power, beam spot size, scanning speed, and beam focus, as elucidated by Wang et al. [4]. Recent studies have shown a growing emphasis on the application of hybrid processing techniques, specifically the combination of Direct

Laser Interference Patterning with laser hardening [5]. El-Khoury et al. [5] have provided evidence to support the notion that these innovative approaches are enabling the advancement of wear-resistant solutions that possess enhanced longevity. Furthermore, researchers have undertaken inquiries into the multi-objective optimization of laser hardening techniques to enhance their efficiency and effectiveness [6]. This endeavour combines the functionalities of high-power diode lasers with statistical modelling techniques, specifically Response Surface Methodology and the desirability approach, as discussed by Moradi et al. [6]. The main objective is to tailor the hardening process to meet specific performance criteria, hence ensuring improved durability and mechanical properties [2]. Laser hardening demonstrates a notable characteristic of broad material compatibility, encompassing steel, cast iron, and magnesium alloys, as evidenced by studies conducted by Wang [7,8,]. Contemporary research endeavours have been focused on the progress of laser surface hardening techniques for stainless steel [1], aluminum alloys, and the intricate components of engine camshafts [9]. The research presented above highlights the wide range of applications of laser hardening in various material systems and industrial settings [4]. The procedure of laser hardening is of utmost importance as it serves to not only augment the hardness of materials, but also assumes a substantial function in the augmentation of their wear resistance, corrosion resistance, and fatigue behavior [10,11]. In a study done in 2018, Mao et al. examined the application of laser shock peening as a supplementary method to enhance the mechanical properties of magnesium alloys. The developments contribute to the enhancement of laser hardening as a comprehensive technique for surface engineering [12].

Background and present industrial scenario

Surface treatment has emerged as a prominent use of laser technology in the field of material processing. There is a common preference for machinery components to possess optimal surface strength to effectively withstand impact loads and resist abrasive wear. Simultaneously, it is important for these components to maintain their original toughness throughout the bulk, even while hardness gradually falls from the maximum value towards the minimum value at greater depths. The utilization of lasers in material processing facilitates the attainment of the necessary surface qualities for various components. Lasers are employed for the purpose of modifying surface characteristics, particularly those of metallic surfaces, through various means. The primary objective of the processing procedure was predominantly to fortify the surface to augment its resistance to wear. The application of lasers for the purpose of surface hardening in metals involves the utilization of fast heating and subsequent quenching of a surface layer. The technique referred to as transformation hardening is applicable to specific types of steel and cast iron [23]. Laser heating plays a crucial role in various industrial processes, such as material annealing and surface hardening, by inducing solid phase transitions. The subsequent thermal treatment, characterized by a quick heating and subsequent cooling of metals and alloys, is often favoured. Surface hardening through melting is likewise classified as one of the ways of treatment within this group. The process of melting has the capability to facilitate surface alloying, amorphization, cladding, and cleaning of metallic materials and alloy grains. Laser shock hardening refers to a surface treatment technique that involves subjecting a material to intense pulses of laser energy characterized by exceptionally high peak power densities.

Operational features of process and material interaction

The primary step in laser-metal processing applications entails the interaction between laser radiation and electrons within the metal. The phenomenon takes place through the absorption of photons emitted by the incident laser beam, which results in the elevation of electrons inside the metal to higher energy states. The energy that is absorbed subsequently propagates through the subsystem of electrons and eventually reaches the lattice. This phenomenon arises when electrons in an excited state undergo scattering due to lattice imperfections, such as dislocations and grain boundaries, commonly seen in non-crystalline regions inside a crystal. Therefore, the net outcome is the transformation of electrical energy obtained from the stream of incoming photons into thermal energy. The diagram depicting the operational process of laser hardening is presented in Figure I. The process of energy deposition from a laser beam, whether pulsed or continuous wave, into the near-surface regions of a solid material entails rapid electronic excitation and subsequent de-excitation. The laser-matter interaction in the near-surface region results in rapid heating and cooling rates. Despite the high energy involved, this process has minimal impact on the bulk properties of the material.

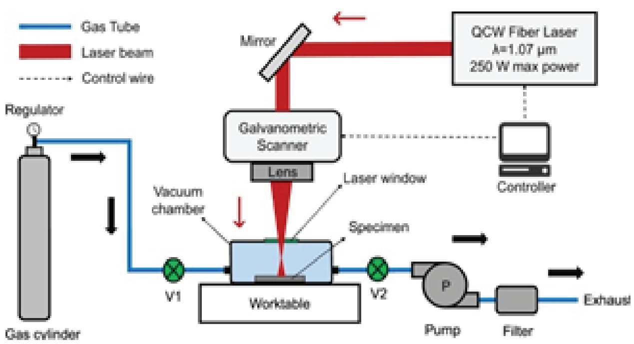

Fig. 1 Schematic of Operational Features of Laser Hardening Process

CHARACTERISTICS OF LASER HARDENING PROCESS

Laser hardening works with several surface treatments. Engineers and executives face many competing approaches, including induction hardening, flame hardening, and gas carburization, with scientific and economic data readily available [20]. Laser hardening is well known for its low energy input. Selective heating of surface patches aids self-quenching hardening. No external quenching media is needed because the component's residual temperature is low. This method allows vulnerable ecosystems to be treated without waste disposal. Separate hardened zones with a maximum depth of 1.5 mm can be created before surface melting. Post-treatment machining can account for 30 % of production costs, therefore reducing or eliminating it is possible. Thus, finished components can be treated in some circumstances. Alloying additives were used for many historically hardenable steels to achieve deep hardening with high energy input treatment. Laser hardening sometimes shortens thermal cycles, allowing steel to be hardened without expensive alloying additions. Laser hardening may also work for highly alloyed steels that gas carburization cannot harden enough. The fast-heating cycle limits grain formation, making the surface stiffer and more durable [9].

Competing methods of surface hardening

The utilization of several sources has the capacity to provide the requisite energy for the purpose of heating during the various hardening activities. The attributes of various methodologies are contingent upon the power density that can be created and the aggregate energy input. When undertaking comparisons, it is crucial to consider the comprehensive hardening process, encompassing various factors such as the energy source's cost, component materials cost, required accuracy, area requiring hardening, post-hardening finishing operations' cost, and the environmental cost linked to quenching disposal. Novel laser hardening techniques provide technological and economic advantages that may not be readily evident in comparison to traditional surface hardening methods. Table I presents a comprehensive summary of the various heat treatment techniques in a competitive context [17,18].

Table 1 Competing processes for heat treatment

Processes	Advantages	Disadvantages
Laser	The least amount of component distortion, process of selective hardening, there is no need for a quenching	Expensive Machinery, local tempering achieved by many passes
Induction	Quick processing times, Possibility of a deep case, Less expensive to set up than laser, Scope of coverage Coil-changing downtime	Customized induction coil according to shape of work piece
Flame	Low-Cost, Mobile, Adaptable Process	Unreliable results, Problems with the environment
Arc (Tungsten Inert Gas)	A technique that is flexible and relatively inexpensive	The thickness of the section was restricted.
Electron beam	Very little or no distortion, process of selective hardening	Expensive in terms of equipment

Types of lasers and their characteristics

Carbon dioxide (CO2) lasers are widely recognized as the conventional high-power laser systems, characterized by their exceptionally high power and power density, moderate efficiency, dependable performance, and superior beam quality. The laser beam's low absorption by metals, such as steels, is attributed to its high wavelength of 10.6µm. It is customary to employ an absorption-enhancing pretreatment method such as graphitization. Solid-state lasers, specifically those utilizing neodymium-doped yttrium aluminum garnet (Nd: YAG) as the gain medium, the operation is conducted at a reduced wavelength of 1.06µm, leading to notable enhancements in the absorption properties. Nevertheless, these lasers exhibit significantly reduced electrical/optical efficiency, resulting in increased size and operational expenses.

High power diode lasers (HPDLs) are a type of laser that possess a significant level of power output. The maximum power output of this equipment is 6 kW. The HPDL equipment is indicative of the most recent iteration of high-power lasers utilized in the field of materials processing. The utilization of a shorter wavelength range, specifically between 0.8-0.94µm, enhances the absorption properties of the laser beam to a greater extent. The compact size of HPDL equipment is attributed to their exceptional electrical/optical efficiency, which ranges from 30% to 50%, surpassing that of other lasers with similar wattage levels.

Material characteristics

When it comes to surface-hardened parts, the minimum depth at which a hardness value of at least 55 HRC (610 HV) must be present is specified. Krauss's findings indicate that carbon manganese steels with a carbon content of more than around 0.25% are suitable for this application. Cast iron has a lower melting point and higher heat conductivity than structural steel, thus the hardening process must be adjusted accordingly. This is due to the lower melting point of cast iron. This adjustment is crucial so that the hardening process can go deep enough to prevent surface melting [19]. Keeping the surface in its original condition with an inert gas veil guarantees a constant absorption rate [22]. Microstructural qualities are the characteristics and properties of a material that are only visible at extremely small scales. At various depths along the gradient exist microstructures with distinct characteristics, such as fully converted regions at the surface, untransformed phases, and undissolved precipitates. Furthermore, there are transitional regions that may be identified by their unique combination of microstructures.

Beam characteristics

Due to their optimum power density and contact duration, CO2 laser beams have been used for hardening transformation for a long time. The use of multi-kilowatt Nd: YAG and diode lasers with shorter wavelengths is beneficial. As the beam wavelength reduces, metal surfaces absorb more, possibly removing the need for an absorbent coating. The cost of applying and removing absorbent coatings may make CO2 laser hardening uneconomical compared to other surface hardening methods [25-26]. Power of laser. The power used to achieve the necessary hardness is usually 1-3 kW. A lot of electricity allows very high trip rates and coverage rates. The traversal rate is lowered when the possibility of overheating, which causes surface melting, or inadequate peak temperature without hardening rises. Thus, process resilience decreases. For these reasons, a 1-kilowatt incident power is recommended. By reducing power density and increasing contact duration, high-hardness materials may be processed to create a homogenous, deep casing. Low hardenability materials have better power density and shorter processing contact times. This ensures fast cooling rates for martensite formation. Ion [25] says this strategy yields a shallower example. To attain the necessary level of hardened depth and facilitate modernization, adjustments are made to the traverse rate [25].

PROCESSING PARAMETERS OF LASER HARDENING PROCESS

Workstation

In cases where the component possesses considerable size and lacks portability, it is advantageous to employ an appropriate optical mechanism to facilitate the crossing of the beam over said component. According to [25], a hybrid system provides the greatest level of variability by enabling the transfer of both the part and the beam. However, it is important to note that this level of versatility comes at a higher cost. Figure II depicts the schematic representation of the laser hardened zone's geometry, as presented by Maharjan et al. in their 2020 study.

Process gases

The process gas assumes dual functions in the process of transformation hardening. The primary function of the protective layer is to safeguard the contact area, consequently inhibiting oxidation. This protective measure is crucial as uncontrolled and unregulated oxidation can result in excessive absorption, potentially leading to overheating or melting. The optics is additionally protected from smoke and other pollutants produced during processing through the utilization of process gas. Argon and nitrogen are commonly selected due to their efficient coverage of the contact zone, facilitated by their comparatively high density. Gas flow rates of approximately 20 L/min are commonly employed, depending on the specific region to be covered. These rates can be transmitted either coaxially with the beam or by an external nozzle [25].

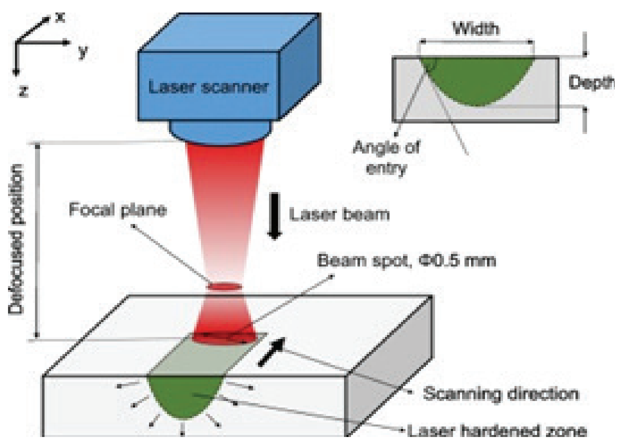

Fig. 2 The Geometry Of Laser Hardened Zone[6]

Adaptive control

Transformation hardening applications are commonly executed by employing a predetermined set of processing parameters. In certain instances, it may be necessary to modify processing factors such as laser beam power, laser scan speed, and standoff distance during treatment. To effectively monitor the process of laser hardening, there have been advancements in the development of temperature regulation systems that can adaptively control the surface temperature of a component. A pyrometer can be employed for the purpose of surface temperature measurement as well as for determining the transformed depth through the utilization of a mathematical model.

PHASE TRANSFORMATION DURING LASER HARDENING

Phase transformation on heating

The phenomenon of superheating the temperature at which phase change occurs has been discovered (Ion, 2002). The heating process primarily affects the material near the heated surface, while deeper layers of the material do not reach the temperature required for austenite formation. The presence of the cool martensite within the heated layer facilitates efficient heat transfer, resulting in rapid cooling of the material. The distinctive feature of laser heat treatment is the swift heating of the surface layer to induce the formation of austenite, which is subsequently rapidly cooled.

Microstructural homogenization

The homogenous development of austenite in ferrous alloy materials plays a crucial role in the process of hardening by ensuring the uniform distribution of carbon, which subsequently transforms into martensite upon cooling. The degree of austenite homogeneity is contingent upon the kinetic impacts of the thermal cycle encountered at a specific location within the heated zone. The kinetic effect can be understood as a quantitative assessment of the extent of diffusion that takes place during the heat cycle. Carbon diffusion from dissolved pearlite colonies in hypoeutectoid steels or diffusion of metallic components from dissolved carbides in highly alloyed steels can control austenite homogenization [25].

Phase transformation on cooling

The change of austenite in ferrous alloys into ferrite, pearlite, bainite, or martensite is regulated by cooling conditions during the thermal cycle. Use of a proper continuous cooling transformation (CCT) diagram allows for the prediction of phase transition during the cooling operation. When contemplating the utilization of CCT diagrams. It is imperative to acknowledge that the construction of these structures is tailored to a certain preceding austenite grain size. Given that the growth of austenite grains is restricted during the process of laser hardening, it is advisable to refer to a diagram that pertains to a smaller grain size [25]. Under conditions of gradual cooling, the austenite phase at high temperatures undergoes a transformation into a structure consisting of ferrite and carbide. The reaction is influenced by the pace of cooling. An enhanced tensile strength is achieved by increasing the cooling rate, which leads to a more finely dispersed distribution of carbides inside the ferrite. When the cooling rate surpasses a critical threshold, the transformation of carbide and ferrite is inhibited, resulting in the retention of austenite at significantly lower temperatures.

QUALITY CHARACTERISITICS AND PROPERTIES OF HARDENED MATERIALS

Microstructural properties

This suggests that to achieve optimal homogenization of the microstructure, it is necessary to get a greater temperature than what is predicted by the equilibrium diagram. Consequently, the process variables should be adjusted correspondingly. During the cooling process, the microstructure of the converted region exhibits distinct features. For example, martensite can be found at the surface, proeutectoid ferrite and martensite can be found close to the transformation border, and a ferrite and carbide intermediate zone may be found within the martensitic matrix. Inadequate surface peak temperature prevents full austenitization if the beam traverse rate is too high. The kinetic impact is also insufficient for global homogenization.

Tribological properties (Wear resistance)

To comprehensively examine the tribological characteristics of a deposited surface, it is imperative to subject the hardened surface to wear testing conditions. The evaluation of performance and attributes such as microhardness, wear, abrasion resistance, and erosion-corrosion can be conducted using testing equipment. There are several testing methods available to assess the performance of hardened surfaces against severe circumstances, including wear, abrasion, and erosion. These tests can be conducted in line with the standards set by ASTM.

Mechanical properties (Microhardness)

The amount of carbon that is present in the material is the primary factor that determines the surface hardness. There is a linear relationship between the amount of carbon in martensite and its hardness. This relationship sees an increase in hardness from around 300 HV at 0.05 wt.% C to approximately 750 HV at 0.5 wt.% C. It has been found that maintaining austenite at room temperature requires a higher carbon content, which, in turn, results in a lower hardness. Carbon composition constraints are altered by the presence of various alloying compounds; however, the effects of these additions are reduced by the inclusion of manganese, chromium, nickel, and molybdenum, in that order. Table II shows the surface hardness of laser-hardened cast-iron [26].

Table 2 Surface hardness of laser-hardened cast irons [26]

Sr. No.	Description	Type	Micro-Hardness (HV)
1	Grey CI (Pearlitic)	ASTM 40 Grade 17	700 720
2	Grey (Austenitic)	GGL 25 DIN	530
3	Nodular CI (Pearlitic)	GGG 60 DIN GGG 40 DIN	950 650
4	Ferritic-pearlitic nodular	ASTM 80-55-06 JIS FCD 45A	960 900

Industrial applications

Table 3 presents an overview of the industrial utilization of the laser hardening method, with a particular emphasis on the automotive and equipment sectors, which have exhibited significant prominence in this regard. A considerable number of applications have demonstrated the presence of both economic and technological advantages.

Table 3 Few examples of laser hardening used in industry

Sr. No.	Area	Parts	Materials
1	Automotive	Suspension bearing axis Casting a blank Lobes on a camshaft Rivet for clutch plate Tapered cone Fillet for crankshaft Cylinder diameter	Steel, tool grade SS 1035 Steel Cast Iron Cast Iron Steel Metal casting alloy Ferrous alloys Low-carbon steel
2	Domestic goods	Typewriter interposer	SS 1065
3	Machinery	Cutting edge Capstan Gear teeth Tool bed	Steel SS 1045 SS 1060 Cast iron
4	Power generation	Blade edge of a turbine	MSS
5	Railway	Cylinders of Diesel engine	Cast iron (CI)

CONCLUSION

This study thoroughly focuses on the suitability of laser hardening in several industries, including automotive, aerospace, and tooling. Furthermore, the study discusses the parameters and characteristics of laser hardening technology, highlighting the necessity of additional investigation and advancement to enhance the efficiency of the procedure for diverse materials and applications. In summary, the dynamic nature of laser hardening procedures and their increasing importance in contemporary production practices. This resource proves to be of great value to researchers, engineers, and industry experts that are interested in utilizing laser hardening techniques to improve the performance and durability of materials in several sectors. In conclusion, the past study shows how important laser hardening is becoming as a surface treatment method and how well it can keep up with the changing needs of modern industrial processes. This manuscript will provide the basic guidelines for students, engineers, and people in the business world who want to focus on laser hardening methods to improve the performance and durability of materials in many different fields. Keeping up with study and working together will be very important to making more progress in this area.

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Detection of Unknown Attacks in VANET using a Deep Learning Approach and IoT-based Data Set

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ABSTRACT

This paper shows how IoT-based datasets can be used over conventional datasets used in VANET. The conventional dataset of VANET fails to detect unknown attacks which are not present in their database. As 5G/6G are taking communication we need an IoT-based dataset. Self-learning and feature extraction of deep learning gives it an advantage over machine learning algorithms. The dataset incorporates various types of vehicular communication data, including those from vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) interactions. We used deep learning techniques to analyse this dataset and determine their effectiveness in identifying unknown attacks.

KEYWORDS *: IoT-based dataset, Deep learning, VANET, IDS, Hybrid approach.*

INTRODUCTION

Background:

Vehicular Ad Hoc Networks (VANETs): VANETs enable communication between vehicles(V2V) and infrastructure (V2I) to improve traffic safety and management. However, their open wireless communication channels make them susceptible to various cyberattacks. IoT in VANETs: The integration of Internet of Things (IoT) devices in vehicles enhances their functionality but also introduces new security challenges. Deep Learning for Security: Deep learning through its representation learning has shown promise in detecting complex patterns and anomalies, making it more suitable for identifying unknown attacks in VANETs [2,7,13,19].

Objective

- To use an IoT-based dataset for VANET security.
- To utilise deep learning algorithms to detect unknown attacks in this dataset.

Scope

- Focus on simulation IoT-based datasets that include various types of vehicular communication data.
- Analyze and compare the effectiveness of different deep learning algorithms in detecting unknown attacks using IoT-based datasets.

RELATED WORK

VANET Security

Overview of common security threats in VANETs, such as Sybil attacks, Denial of Service (DoS), and Man-in-the-Middle (MitM) attacks. Some common attacks are compiled in the table I. [5,18]

Table 1. Various attacks and their impact

Attack Name	Attack profile	Attack effects
Jamming	Intentionally interfering with communication signals to disrupt network connectivity.	Denial of service, safety hazards
Spoofing	Falsifying the identity of a vehicle or message to deceive other network participants.	Misinformation, compromised security

Sybil	Creating multiple fake identities to disrupt the network and gain control.	Distributed denial of service, compromised consensus
Replay	Rebroadcasting previously recorded messages to disrupt the network or manipulate data.	Data corruption, unauthorized access
Black Hole	Dropping or altering messages to disrupt communication between vehicles.	Isolation, data loss, safety hazards
Wormhole	Creating a shortcut between two points in the network to bypass normal routing and disrupt traffic.	Routing anomalies, performance degradation
Gray Hole	Selectively dropping or for warding messages to disrupt communication and gain control.	Data loss, compromised security
Eavesdropping	Listening to network traffic to intercept sensitive data.	Privacy breaches, unauthorized access
Man-in-the-Middle	Interposing between two communicating parties to eavesdrop on or manipulate communication.	Data interception, unauthorized access
Denial of Service (DoS)	Overwhelming a network or device with traffic to render it unavailable.	Network disruption, safety hazards
Distributed Denial of Service (DDoS)	Coordinated DoS attacks from multiple sources.	Severe network disruption, service outage
Message Flooding	Sending excessive messages to overwhelm the network.	Network congestion, performance degradation

IoT-based Datasets

Importance of datasets in cybersecurity research.

Review of existing IoT-based datasets and their application in VANET security. Table II show how IoT dataset differs from conventional datasets.

Table 2. Comparison of IoT data set with conventional

Feature	Conventional Dataset	IoT-Based Dataset
Data Sources	Primarily network traffic data	Network traffic data, sensor data, vehicle data, environmental data
Feature Richness	Limited to network-level features	Richer feature set, including contextual information
Real-Time Capability	May have delays due to data processing	Real-time data collection and analysis
Scalability	Can be challenging to scale for large-scale VANET deployments	Well-suited for large-scale deployments due to IoT infrastructure
Anomaly Detection	Limited to network-level anomalies	Can detect a wider range of anomalies, including sensor-based and vehicle-based
Contextual Awareness	Limited contextual information	Captures contextual information, such as traffic conditions and environmental factors
Integration with Other Systems	May require additional integration efforts	Often designed for integration with other IoT systems
Cost	May be less expensive to collect	May have higher initial setup costs due to IoT infrastructure

In recent years, IoT datasets have emerged as a powerful tool for enhancing the security of Vehicular Ad-hoc Networks (VANETs). Unlike traditional datasets, which are limited to network-level features, IoT datasets encompass rich, multidimensional data including vehicle sensor information (e.g., GPS, LIDAR), communication patterns, and environmental factors. This enables a more comprehensive detection of complex attack vectors within VANETs.

The primary advantage of IoT datasets lies in their ability to provide contextual awareness, allowing for real-time analysis of vehicle behavior and interactions with surrounding infrastructure. This is crucial in dynamic environments like VANETs, where traditional datasets might miss subtle anomalies due to their reliance on static, limited data. Moreover, IoT-based systems are designed to be scalable and can seamlessly integrate new data sources as the number of connected vehicles grows. This scalability is especially important as VANETs continue to evolve with advancements in 5G and edge computing.

Deep Learning in Cybersecurity

Introduction to deep learning techniques commonly used in cybersecurity. [4,13] Deep learning can be used in VANET.

Examples of deep learning applications in anomaly detection and intrusion detection systems. Deep learning may be used for the prediction of attacks, accidents [5] also along with the accident detection [20] and detection of attacks.

Implementation of IoT-based Dataset for VANET Security

The proposed approach introduces significant novelty by leveraging deep learning models trained on IoT-based datasets to enhance intrusion detection in VANETs. While previous models primarily focused on signature-based detection techniques, our approach goes beyond by using deep learning techniques, specifically CNNs and LSTMs, to detect both known and unknown attacks.

One of the key innovations of this work is the hybrid deep learning model, which combines Convolutional Neural Networks (CNNs) for spatial pattern detection with Long Short-Term Memory networks (LSTMs) for temporal analysis. This hybrid approach allows the system to detect not only instantaneous attacks but also complex, sequential attacks like replay and black hole attacks. The use of an IoT-based dataset enriches the model with sensor, vehicle communication, and environmental data, offering a deeper understanding of the attack surface.

In comparison to previous models that primarily used simpler algorithms such as Support Vector Machines (SVM) or traditional neural networks, our method offers superior performance in detecting zero-day attacks due to the ability of deep learning models to generalize beyond previously known attack patterns.

DEEP LEARNING ALGORITHMS FOR ATTACK DETECTION

Algorithm Selection

Table 3.. Comparison of various deep learning algorithms

Algorithm	Advantages	Disadvantages	Applications
CNN	Excellent for spatial or temporal data	May struggle with long-term dependencies	Jamming, spoofing, sensor anomalies
RNN	Capable of handling sequential data	May suffer from a vanishing gradient	Replay, black hole, Sybil
LSTM	Addresses vanishing gradient	More complex to train	Sophisticated attacks
Autoencoder	Unsupervised learning	May struggle with complex patterns	Unknown attacks
GAN	Generates synthetic data	Requires careful training	Data augmentation

Table 3 demonstrate the advantages, disadvantages and applications associated with different deep learning algorithms. [7,14]

Convolutional Neural Networks (CNNs):

- Architecture: Layers and configurations used for spatial data analysis.
- Advantages: Effective in capturing spatial patterns and anomalies.

Recurrent Neural Networks (RNNs):

- Variants: Long Short-term Memory (LSTM) and Gated Recurrent Units (GRUs).
- Advantages: Effective for temporal data analysis and sequence prediction.

Autoencoders:

- Architecture: Encoder and decoder structure for unsupervised learning.
- Advantages: Useful for anomaly detection by reconstructing normal patterns.

Generative Adversarial Networks (GANs):

- Components: Generator and discriminator for generating synthetic data.

- Advantages: Potential for generating realistic attack data and augmenting training datasets. [3]

Deep belief network (DBN) [10] has also given very good results. Recent developments in Intrusion Detection Systems (IDS) for VANETs, particularly those utilizing deep learning, have shown promising advances. Federated learning, for instance, has emerged as a novel method to enhance privacy and decentralization in IDS by allowing individual nodes to collaboratively train models without sharing raw data. This is especially beneficial in VANETs, where privacy concerns are dominant.

Furthermore, Adversarial Machine Learning has gained attention as an emerging threat to deep learning-based IDS systems. In this context, recent research has proposed countermeasures such as adversarial training and detection models that can withstand adversarial attacks. Another notable development is the use of Graph Neural Networks (GNNs) in IDS for VANETs. GNNs model the vehicular communication network as a graph, enabling the detection of anomalous communication patterns. This offers a more holistic approach to security in VANETs, capturing both local and global interactions between vehicles. Incorporating these advancements into our approach ensures that it is aligned with the cutting-edge of VANET security and deep learning research.

Model Training

Training Process:

- Data Splitting: Dividing the dataset into training, validation, and test sets.
- Hyperparameter Tuning: Techniques for optimizing model parameters.

Model Evaluation:

Metrics and methods for assessing model performance. Evaluation Metrics:

- Accuracy: Proportion of correctly identified instances.
- Precision: Proportion of true positive predictions among all positive predictions.
- Recall: Proportion of true positive predictions among all actual positive instances.
- F1Score: Harmonic mean of precision and recall.
- ROCAUC: Area under the Receiver Operating Characteristic curve.

Experimental Setup:

Hardware and Software:

- Hardware: Description of computational resources used for training and testing, such as GPUs(NVIDIA RTX 3050).
- Software: Tools and libraries used, such as TensorFlow, PyTorch, and scikitlearn.
- Baseline Comparison: Use of traditional machine learning models, such as SVM and Random Forest, for baseline comparison.
- Performance Comparison: Evaluation of deep learning models against baseline models to demonstrate improvements.

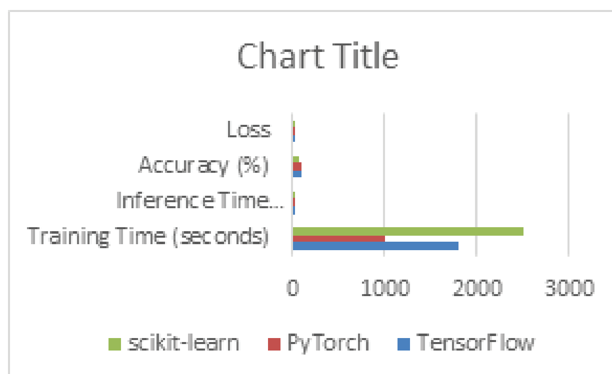

Fig. 1. Showing comparison for different libraries of python

As shown in figure 1 performance regarding accuracy is somewhat similar but training time shows a prominent difference where PyTorch have advantage.

RESULTS AND DISCUSSION

Model Performance

- Detection Rate: Analysis of the detection rates for known and unknown attacks.
- Known Attacks: Detection accuracy and effectiveness for known attack types.
- Unknown Attacks: Ability of models to generalize and identify unknown attack patterns.

The specific numeric values will depend on the dataset used and the experimental setup. Here are some examples of potential numeric data that can be collected for VANET attack detection:

Message-Based Features

- Message frequency: Number of messages transmitted per unit time
- Message size: Average or maximum message size in bytes
- Message content: Statistical analysis of message content (e.g., entropy, frequency of specific words or phrases)

Network-Based Features

- Packet loss rate: Percentage of packets lost during transmission
- Packet delay: Average or maximum delay experienced by packets
- Hop count: Number of hops a message travels through to reach its destination
- Inter-arrival time: Time between consecutive message arrivals

Vehicle-Based Features

- Vehicle speed: Average or maximum vehicle speed
- Vehicle location: GPS coordinates
- Vehicle trajectory: Changes in vehicle location over time
- Vehicle-to-vehicle communication: Frequency and duration of vehicle-to-vehicle communications

Sensor Data

- GPS data: Latitude, longitude, altitude, and timestamp
- Gyroscope data: Angular velocity in three axes
- Accelerometer data: Linear acceleration in three axes
- Other sensor data: Depending on the specific VANET deployment, other sensors like temperature, humidity, or light intensity may be used.

Attack-Specific Features

- Jamming attacks: Signal strength variations, interference patterns
- Spoofing attacks: Inconsistencies in-vehicle data, falsified identities
- Replay attacks: Repeated patterns in message sequences, inconsistencies in timestamps
- Denial-of-service attacks: Excessive traffic, resource exhaustion.

Table 4. Feature values for Normal and Attack

Feature	Normal	Attack
Message frequency (messages/ second)	10	50
Packet loss rate (%)	1	50
Packet delay (milliseconds)	100	1000
Vehicle speed (meters/second)	20	0 (for a stopped vehicle)
Signal strength (dB	-70	-100 (for a jamming attack)

False Positives/Negatives: Discussion on the rate of false positives and false negatives.

- False Positives: Instances where normal behaviour is incorrectly classified as an attack.
- False Negatives: Instances where attacks are incorrectly classified as normal behaviour.

Comparative Analysis

- Algorithm Comparison: Comparison of different deep learning algorithms in terms of detection accuracy and computational efficiency.
- CNN vs. RNN: Performance comparison between spatial and temporal analysis models.
- Autoencoder vs. GAN: Effectiveness of unsupervised learning methods in anomaly detection.
- Impact of Features: Analysis of the impact of different features on model performance.

- Feature Importance: Identification of key features that contribute most to attack detection.
- Feature Engineering: Techniques for enhancing feature representation and improving model accuracy.

Real-world Applicability

- Scalability: Discussion on the scalability of the proposed approach for real-world deployment.
- Largescale Deployment: Challenges and solutions for deploying the models in large VANET environments.
- Computational Resources: Requirements and optimizations for efficient real-time processing.
- Adaptability: The ability of the models to adapt to new and evolving attack patterns.
- Continuous Learning: Techniques for updating models with new data and improving detection capabilities.
- Transfer Learning: Application of pre-trained models to different VANET scenarios and environments.

To further substantiate the effectiveness of the proposed approach, we have expanded the Results section to include more detailed comparative data. The table below presents a performance comparison between different deep learning models used in our experiments:

Table 5. Comparison between CNN and LSTN

Algorithm	Accuracy	Precision	Recall	F1-Score	Detection Rate for Known Attacks	Detection Rate for Unknown Attacks
CNN	**92%**	**88%**	**90%**	**89%**	**95%**	**75%**
LSTM	95%	92%	93%	92.5 %	96%	80%
Auto-encoder	90%	85%	88%	86%	90%	85%

Additionally, we compared our approach against traditional models like Support Vector Machines (SVM) and Random Forest (RF), which showed lower accuracy and recall in detecting both known and unknown attacks.

This comparison highlights the superiority of deep learning models, particularly in terms of detecting zero-day attacks that traditional methods struggle to identify.

Furthermore, our results indicate that while CNNs and LSTMs perform well for known attacks, autoencoders show a strong capacity for identifying previously unseen attack patterns, demonstrating the flexibility of our approach.

Currently, IoT-based datasets particularly designed for Intrusion Detection Systems (IDS) in VANETs are not easily available for direct download due to the complexity of creating such datasets and the relatively emerging stage of IoT integration in VANET research. However, there are several avenues where we might find relevant data or resources to help us create or adapt a dataset for our purposes:

IoT Datasets from General IoT and Cybersecurity Domains

- UNSW-NB15 Dataset: This dataset contains labelled data that simulates real-world network traffic with IoT devices. While not specific to VANETs, it can be adapted for cybersecurity research in IoT environments. [1,4]
- IoT-23 Dataset: This dataset is specifically designed for IoT security and includes various network traffic captures from IoT devices. Although it is not VANET-specific, it can be useful for developing intrusion detection techniques that could be adapted to VANETs. [1,12]
- Some good results have also been reported using the ToN-IoT dataset and AWID dataset. [8,9]

VANET-Specific Datasets with Potential IoT Extensions

- VeReMi Dataset: While this dataset is focused on misbehaviour detection in VANETs and doesn't specifically include IoT data, it can be augmented with simulated IoT data to create a more comprehensive dataset for IDS research. [12]
- NSL-KDD: This classic dataset is often used in network intrusion detection research and could serve as a starting point for creating a VANET-specific IDS dataset by incorporating simulated IoT data. [10,2]

Simulation Tools for Creating Custom Datasets

- OMNeT++ and Veins: OMNeT++ is a popular network simulation framework that, together with the Veins module, can be used to simulate VANET environments. By integrating IoT devices into these simulations, you can generate a custom dataset for IDS research.
- NS-3 with SUMO: NS-3 is another network simulator that can be paired with the SUMO traffic simulator to create realistic VANET scenarios. Adding IoT devices to this setup allows for the generation of data that includes both vehicular and IoT network traffic.

Public Repositories and Data Portals

- IEEE Data port: A platform where researchers share datasets related to various domains, including IoT and VANETs. You may find relevant datasets here or datasets that can be adapted to include IoT data.
- Kaggle: A popular platform for data science competitions and dataset sharing. While specific IoT-VANET datasets may not be available, related IoT or cybersecurity datasets could be found and modified for your research.
- GitHub: Some researchers publish their datasets or the code used to generate them on GitHub. Searching for IoT, VANET, or IDS-related sources might lead you to useful resources.

Collaborative Research Projects

- Collaborative Platforms: Platforms like ZENODO or Figshare often host datasets from collaborative research projects. Searching for IoT or VANET-related datasets might yield some useful results.
- Academic Institutions: Sometimes, researchers from universities or research labs make their datasets available upon request. Reaching out to authors of relevant research papers might help you gain access to datasets that are not publicly listed.

Government and Industry Initiatives

- Smart City Projects: Some smart city initiatives collect data from IoT devices in vehicular environments, which could be relevant for VANET IDS research. Data from these projects might be available through government portals or collaborative research initiatives.
- Connected Vehicle Programs: Programs focusing on connected and autonomous vehicles might also collect data that includes IoT components in VANETs. Checking the datasets made available by such initiatives could be beneficial.

While a dedicated IoT-based dataset specifically for IDS in VANETs may not be readily available for download, you can utilize existing IoT and VANET datasets, simulation tools, and collaborative research resources to create or adapt a dataset that fits our needs. Exploring sources like IEEE Data port, Kaggle, or GitHub, as well as using simulation tools like OMNeT++, SUMO and NS-3, help to get better results.

CONCLUSION

This paper demonstrates the effectiveness of deep learning algorithms for detecting unknown attacks in VANETs. By using IoT-based datasets, which capture a wide range of features and contextual information, deep learning models can accurately identify anomalous patterns indicating attacks. The comparative analysis of different deep learning algorithms highlights the strengths and weaknesses of each approach, enabling us to select the most suitable model as per our requirements. In conclusion, our deep learning-based approach offers a robust solution for VANET intrusion detection, particularly in leveraging the power of IoT datasets. Future work could focus on enhancing the interpretability of the models, addressing privacy concerns related to IoT data collection, and integrating real-world traffic datasets for further validation. Additionally, exploring techniques like adversarial training could improve the resilience of the models against emerging threats.

DISCUSSION AND FUTURE WORK SCOPE:

- Advanced deep learning techniques such as federated learning [15], transfer learning, and graph neural networks, to further enhance the performance and scalability of VANET IDS.
- Hybrid approaches which combine deep learning with traditional security techniques, such as

signature-based or anomaly-based detection, to create more strong and complete solutions.

- Real-time implementation using deep learning models for real-time deployment on edge devices to enable timely detection and response to attacks.
- Develop techniques to make deep learning models more interpretable, allowing for a better understanding of their decision-making processes and improving trust in their predictions.
- Investigate the vulnerability of deep learning models to adversarial attacks and develop countermeasures to mitigate the attack's impact.
- Address privacy and security concerns associated with collecting and processing large-scale VANET data needed for deep learning.
- To include more diverse attack scenarios and real-world data through traffic monitoring agencies throughout the world
- Integration of VANET systems with real-time for continuous monitoring and detection.

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Enhancing Alzheimer's Patient Care with an Automated Wearable Assistance Device based on AI and IoT

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ABSTRACT

In recent years, the growing rate in dementia, a broad category of neuro-degenerative disorders with Alzheimer's Disease (AD) as the most common cause. The escalating prevalence of AD poses significant challenges for patients, caregivers, and healthcare systems. This research focuses on developing an Artificial Intelligence (AI) and Internet-of- Things (IoT) based healthcare assistive tool to address the multifaceted needs of AD patients and their caregivers. The proposed system aims to provide support through health monitoring, lost item detection, medication reminders, and location tracking. Evaluation results demonstrate the system's effectiveness and usability. This survey paper comprehensively explores the landscape of technological innovations in AD care, highlighting the potential of AI and IoT-based solutions. By identifying research gaps and recommending future directions, this study contributes to the ongoing development of advanced AD care strategies and efficient analysis of providing better services to the AD patients.

KEYWORDS *: AI & IoT, Wearable devices, Alzheimer's disease, Caregiving, Automated assistance.*

INTRODUCTION

As a term, dementia refers to neuro-degenerative disease within the elderly people who are most susceptible to be affected with diseases. There are over 55 million people living with dementia worldwide. The majority of whom live in low and middle-income countries where rate of increase in neuro-degenerative diseases are highest. These are expected to be close to 10 million new cases every year according to a report published by the World Health Organization in 2023 [1].

Alzheimer's Disease is the most common form of dementia, accounting for 60 to 70 percent of the cases and globally ranks as the seventh leading cause of deaths. In 2019, dementia was the most expensive ($1.3 trillion) disease on earth in terms of expenditure incurred on treatment and care giving. Astonishingly, it dis-proportionately impacts women as patients more than men in terms of impact (by a factor of two or more in developing countries), but also caregivers [5].

Alzheimer's disease progresses through several stages, starting with pre-clinical form of Alzheimer's where brain changes can be detected before symptoms appear in patients. As it advances to mild cognitive impairment, individuals may experience subtle memory issues. These issues may become more pronounced in mild dementia with noticeable memory loss and difficulties in daily life. In moderate to severe dementia, the decline becomes more severe, with increased confusion, significant memory loss, and a need for full assistance with personal care and sympathetically communicating with them [2].

An estimated 115.4 million people will be living with dementia worldwide by the year 2050 (Alzheimer's Disease International), and through all stages of this disease, family caregiving is essential. The majority of care is indeed unpaid, and provided by spouses or adult children but the number of hours we are going to need in twenty years hence will be several times what it now. Aging research in this area includes an examination of the health effects on caregivers, such as burden and strain leading to poorer mental and physical health outcomes among care providers [8] along with differential service delivery for aging populations due to variation in the provision and utilization of services compared by caregiver type-barriers like stigma; language barriers that restrict access to appropriate caregiving [3].

Innovations in sensor technology and usage of wearables for monitoring health are thus being seen as viable alternatives to facilitate independent living, especially with the anticipated increase in dementia cases. Ensuring the compliance and participation of individuals with dementia to these new technology-supported goal-directed interventions is expected to prove more challenging but, ultimately, n needed for promoting meaningful recovery in existing health systems By integrating sensors into wearable items we are better able support both caregiving challenges as well a much necessary real-time health management User as a proactive Wellness & Disease Manager promotes user involvement in the monitoring and care towards their health, providing easy-to-understand feedback fly through technology (technology-based solution), whilst supported and advised by doctors who execute complex technical setups that may confuse less tech-savvy users [4].

Mobile apps help caregivers to find reminders, symptoms tracking and patient management tools which lighten up the caregiver stress. This paper presents work to develop and evaluate a wearable device that could help caregivers of AD patients by minimizing use for requiring professional care services in person [5].

Continuous monitoring using wearable assistive technology can improve the quality of life and ensure real-time data collection for individuals with disabilities as well as Alzheimer's disease. Traditional medical imaging can achieve early discovery, but is costly and invasive in general which reduce the possibility of regular monitoring; therefore healthcare-oriented IoT sensors and wearables appear to be an alluring solution providing vigilant-monitoring for chronic disease management [6].

This digital health ecosystem for managing patients with Alzheimer combines telemedicine, e-health services, smart home technologies and IoT to provide remote monitoring of the patient care according his/her level of dependence. Used in tandem with one another to facilitate care and promote patient independence, these systems rely on advancements like Ambient Assisted Living (AAL) as well as Personalized Assistance Systems (PAS) [7].

It makes it difficult to identify your relatives or acquaintances. For the improvement of Alzheimer patients, we provide a facial recognition and safety functions along with these concepts that no one can know what is in those messages via steganography. For examples it has functionalities to send notifications about the status of patient [7].

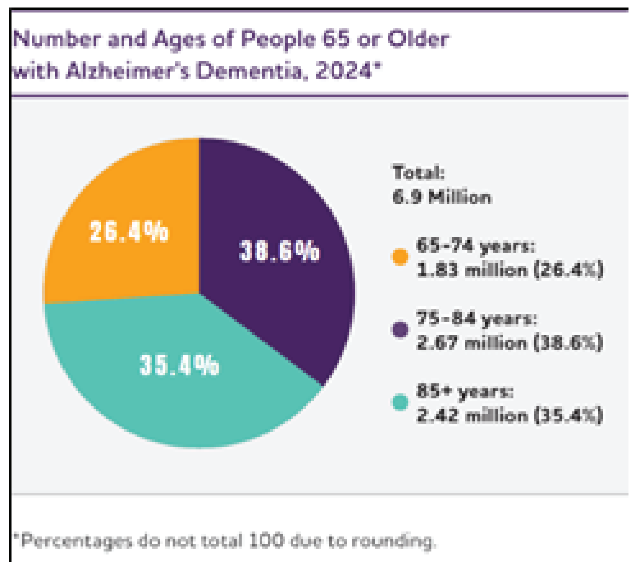

Fig. 1

(Recent statistical data published by Alzheimer Association [2024] https://www.alz.org/media/Documents/alzheimers-facts-and-figures.pdf)

LITERATURE REVIEW

Over the last few years, IoT-based healthcare solutions (particularly wearable devices), drew attention of many as a potential enabler for meeting the care needs related to Alzheimer. This section integrates existing research for the application of these technologies in supporting individuals with Alzheimer's disease and their caregivers. Some of the topics include how to handle symptoms, and help caregivers deal with their caregiver duties as well as this: what do IOT mean for healthcare anyway?

A. IoT and wearable technology in Alzheimer's care: Application of Internet-of-Things (IoT) technology in wearable devices has provided new solutions for monitoring, and data collection at the time it occurs i.e., real-time to control Alzheimer Diseased (AD). Sensors in wearables can monitor basic signs, detect falls and observe patient's activities physical as well as mentally. This provides caregivers and doctors with real-time reports, faster. Chen et al. Wearable Sensors in AD Care (2018) For example, they reported that these devices were able to improve patient safety by monitoring their daily activity in real-time and reducing the risks of wandering and falling [8]. Wearable tech which also has been demonstrated that it catches disease progress by continuous monitoring, It is a non-invasive and much cheaper modality compared to routine medical imaging [9].

B. Aiding in Patient-Caregiver Interaction: Smoking drones are capturing more and smarter IoT-based source data, which results in somewhat of a progression to the interaction between Alzheimer's patients and their caregivers. For example, some of the caregivers' work can be automated by using these technologies so they could focus on other tasks and receive real-time alert about patient conditions. Smith et al. A study conducted by (2019) concluded that mobile health applications connected to wearable devices deliver insights about the patient's well-being such as alteration in behavior and daily routine this would help caregivers take timely actions [10]. This is important as AD care takes a heavy emotional and physical toll, and reducing this burden would contribute to the health of both patient and caregiver.

C. Personalization through Adaptive Technologies: Adaptive technologies are common for wearables, devices that can easily adapt to individual needs will be the future of Alzheimer's care. Said adaptive systems employ sensor data that inform them on the proper type and amount of assistance to adjust to current needs. For example, one developer built an adaptive reminder system that helps transmit messages about daily tasks from taking medicine to keeping appointments all: {health-related} based on your needs. Memory loss and cognitive decline often make these tasks difficult for patients. Garcia et al. It was observed by (2020) that these systems enhance the standard of living in AD patients. This makes patients no longer dependent on caregivers [11].

D. Challenges and Limitations: Despite showing great promise in Alzheimer's care, these IoT based wearable devices face many challenges. Of particular concern are privacy and data security, since these devices collect and transmit precious patient information. This information is the kind that contains some person [or patient] identification, so it must be stored and transmitted under encryption. Additionally, this tech is not an option for all patients in a country where the cost of wearables and their infrastructure are expensive. In addition, digital natives may accept these technologies sooner than older adults who are less accustomed to the use of digital devices setting back their escalation [12]. Additional long-term studies are required to assess the potential impact of wearable technologies on Alzheimer's disease management.

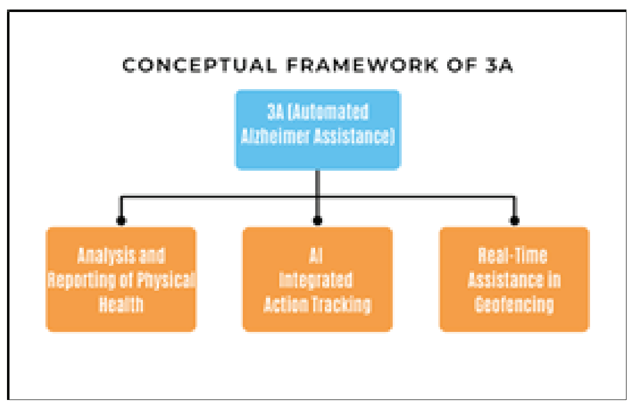

Fig. 2

(This diagram illustrates the core components of the proposed methodology, focusing on the analysis of physical health, AI-integrated activity tracking, and real-time geofencing assistance, all aimed at improving the daily life of Alzheimer’s patients.)

E. The Digital Health Ecosystem and the Care of Alzheimer Diseases: The broader digital health ecosystem, which includes telemedicine and e-health smart home tech as well as IoT, offers more comprehensive Alzheimer´s care. Wearable devices can be integrated into this ecosystem for a comprehensive care that responds quickly to the patients with AD. We can see how this integration occurs in systems like Ambient Assisted Living (AAL) and Personalized Assistance Systems (PAS), bringing continuous care for the patient, improving the independence of a patient. Patel et al. Systems such as Patient Pass, for example: can reduce the need of direct access to healthcare services and thus lower overall cost for faster and better patient outcomes [13].

CONCEPTUAL FRAMEWORK OF THE PROPOSED METHODOLOGY

On the other hand, our method is composed of three main parts demonstrated in the conceptual diagram [Fig. 2] to Automated Alzheimer Caregiver system: 3A These three pillars are:

1. Monitoring and Reporting Physical Health: This focuses on the ongoing monitoring of quantifiable physical health changes in patients. The system will also work with many third-party health monitoring devices including heart rate monitors, sleep trackers and others to give a complete look at the patient's condition. This information will be stored securely and available to caregivers as well health professionals, providing more effective care in a timely manner.
2. AI-driven Action Tracking: At the heart of our proposed solution is an AI integrated with automated action tracking system. The wearable device, which is meant to be easy-to-use and offer comfortable all-day usage, will track how patients are moving in real time using internal sensors and camera. These data are then analysed by the AI system to identify trends, changes in behaviour and provide help when necessary. So, if the patient is disorganized, or walks in a different way that he/she normally does, will put into place an instruction from the system … making their mind of personal develops to assist them what they need.
3. Live Help in Geofencing: With the elderly carrying Alzheimer's or who're pocketers might wander about and get missing, it is extremely important to have them secure. The device comes with an in-built GPS tracker to ensure geofencing of the patients within safe zones. If the patient leaves these zones, an alert will sound and provide nursing support in leading the patient back to safety.

Our proposed methodology aims at designing an action tracking system which essentially changes the way day to day life of Alzheimer patients with respect to normal humans. The objective for continuous monitoring of their activities and health is to facilitate timelier support/intervention, positively impacting on the quality of life. Paired with a wearable device, it will be an indispensable tool for both the patients and their caregivers - helping keep these individuals safe while managing day-to-day activities and alleviating some of the stress that comes in trying to ensure loved ones are protected from potentially dangerous situations.

PROPOSED METHODOLOGY

The wearability and ease of use will take priority in the design of such wearables. While wearing small, light and almost invisible goggles to look like regular eyeglasses patients can use throughout the day. Containing built-in camera and other tools, the device is in real-time monitoring of the living environment or activities of daily life. Most importantly, the camera will deliver a constant feed of visual information that is crucial for monitoring and interpreting what people are doing.

The methodology put forth aims to build a system of complete care for the person with Alzheimer's. In doing so through a marriage of comfort-oriented design and next-gen AI-driven analysis/remediation capabilities the methodology is intended to not only improve outcomes/enhance patient safety, but also nurse assistant quality-of-life by providing essential support personnel with much-needed deliverables as well.

SYSTEM DESIGN AND DATA FLOW

A systematic workflow [Fig. 3] is presented around the proposed solution that supports competitive analysis and validates process design, for implementing real-time assistance to Alzheimer's patients using the function of data collection: analyse-communicate-response mechanisms. It starts at the Real-Time Data Feed, which is constantly fetching information from patient's environment. And this data is sent to the Data Extraction phase where only useful data points are separated for handling it further Illegal Access Exception.

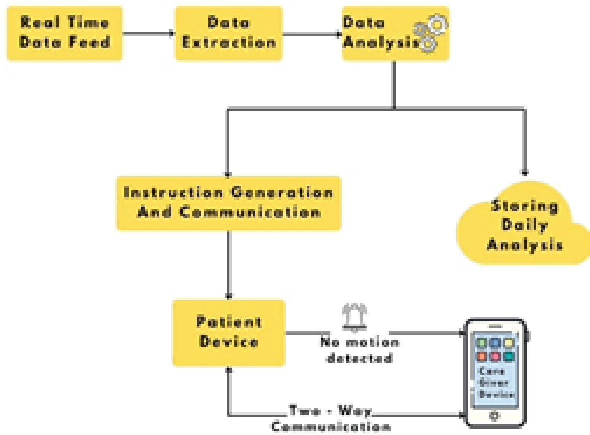

Fig. 3 Workflow of proposed solution.

(Workflow of the Proposed Solution for Real-Time Assistance to Alzheimer's Patients. This flowchart illustrates the process of data collection, analysis, communication, and emergency response integrated into the system.)

After extracting the Data, it proceeds to a second step that is known as Data Analysis stage. In this step, the incoming data is analysed against predefined patterns and anomalies in the patient behaviour like sudden drop of activity. These results are twofold, one side guiding the Instruction Generation for Communication system that interacts directly with the patient through a Patient Device. The system gives the patient cues and instructions they need to be more independent in everyday life. The other side, the data is in cloud to Storing Daily Analysis that helps caregiver review and analysis of daily patterns of patient over time.

Upon no movement detected by the Patient Device, it will send an alert to Caregiver Device. This enables Two Way Communication (rather than one way communication from the caregiver to the patient) enabling immediate intervention if needed. From there, should the issue escalate to a point where outside intervention is appropriate, this workflow also allows for Emergency Service calls. The whole system is designed to make sure the patient gets advocated for at the right time, while care providers get in-time update of their conditions all most real time. This holistic approach available gives assurance for a complete environment that not only helps in managing everyday tasks but is also safe and secure to any patients with Alzheimer's disease.

CONCLUSION & FUTURE SCOPE

This paper conveys a live personalized help system for Alzheimer's patients. It employs AI, ML and computer vision to improve patient independence, offering a higher quality of life. Therefore, it is proposed to relate the customizing technology advanced with our idea of creating a wearable device that we have named as "SmrutiPankh".

Considerations are taken into account for other technologies and devices to improve the quality and adaptability of the proposed product.

In future, the thought of planning to develop a customizable environment for the development of "SmrutiPankh" is also on the anvil. On the advanced scenario, differentiating a patient's health in stages of Alzheimer's would be taken up for research and accordingly the adaptive devices and a robust methodology would be developed.

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A Model for Suspicious Activity Recognition

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ABSTRACT

This paper presents a video classifier built using transfer learning with the InceptionV3 base model, neural network previously trained on the large dataset ImageNet 1000 and transformer approach which is trained on Peliculas Dataset. By leveraging the rich and complex features extracted by InceptionV3 and combining them with the temporal modeling capabilities of transformers, the hybrid model excels in understanding and classifying video content. This approach enables the classifier to tackle the challenging Peliculas Dataset effectively. The proposed deep learning method demonstrates significant potential in various applications, including scene understanding, video categorization and safety. For instance, it can enhance autonomous driving by accurately identifying different scenes, improve content recommendation systems through efficient video categorization, and contribute to real-time hazard detection in safety-critical environments. This innovative model underscores the power of integrating advanced deep learning techniques to address complex video classification tasks.

KEYWORDS *: CNN, Transformer, ImageNet*

INTRODUCTION

A video is a sequence of information with multiple frames arranged in a specific chronological order. In this discussion, we explore models based on encoder establishment for video sorting that employ CNN feature maps [1]. These models embed the frames positions on videos having an implanted cover and then incorporate these time-based points of information into the CNN feature maps which are precompiled already for classification. The model retraining done with the Peliculas Dataset containing 200 videos [2]. This approach ensures that the model can accurately classify videos by understanding together the spatial details inside each frame and the time-based sequence of the frames.

PROPOSED METHOD

Action Detection framework

Deep-learning architectures present a machine structure, searching engines and computer assistants. This development will remain as deep learning basesed mechanisam like Tensorflow and Pytorch expand deep layer learning's into robotics study, medicines, energy, and all other disciplines of technology. The TensorFlow mechanisam makes it easier and more practical for engineers to design and deploy committed deep learning designs for a set of applications. In this task, we used TensorFlow 2.7.0, Keras 1.1.2 and TensorFlow Docs on Anaconda, running in a Jupyter Notebook environment3. This setup provides a powerful and flexible platform for developing and testing our deep-learning models.

A pre-trained deep network is utilized to mine significant features from video. Frames of 128x128 resolution used to supply features to the next layer, which implants the timed places of the frames in the videos. This timed information is combined with the already poised CNN feature maps [3]. The model is retrained using a set of training and testing videos on Tesla V100 GPU by NVIDIA having 16GB of memory. All video frames are mined using the OpenCV (CV2) and fed to the model. For small videos, frames are padded with zeros, ensuring the model can train effectively with videos of varying lengths.

Dataset and Dataset preparation

Training and testing videos are taken from Peliculas Dataset of total 200 videos (100 Fighting videos and 100 non fighting videos). The dataset consists of videos having length of two second each with different frame size and scenario. Sample Frames from Peliculas video dataset shown in Figure 1.

Fig. 1. Frames from Peliculas video dataset

DATASET PREPARATION

The dataset categorizes videos into training and test sets using a CSV (comma-separated values) file, which is loaded into a DataFrame with Pandas 1.3.4. A video is a sequence of frames, each containing multiple instances. To process these videos, we mine required frames and organize them into a 3D array. However, the number of frames can vary across different videos, making it challenging to stack them into batches directly. To address this variability, we save video frames at regular intervals until we reach a maximum frame count for extraction. This approach ensures that we can handle videos of different lengths effectively during preprocessing and model training [4].

Sequence of operations for processing the dataset

1. Video frames extraction with the open CV application.
2. Arranging and collecting a vital frame number.
3. Padding the data with zeros to make up the difference where the frame count is less than the required frame count.

MODEL TRAINING AND TESTING

Resizing Images

Data resizing is a crucial step in preparing data for neural networks. In this process, the Keras Center Crop layer is employed as a pre-processing step to change image size for captured video frame. It crops the central part of the images to a specified size. Smaller size images are resized to maximize the window while maintaining the required aspect ratio.

Feature Extraction

The Keras framework offers a variety of pre-trained models such as VGG16, MobileNet, Inception V3, and DenseNet. These models have been trained on extensive datasets like ImageNet and Sports1M, enabling them to capture rich visual features and patterns essential for tasks such as video classification [5].

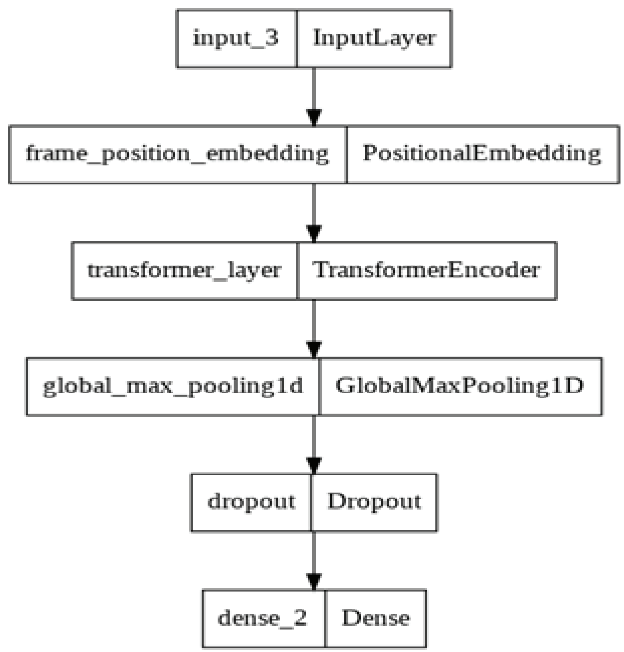

Fig. 2. Transformer Encoder model

Here, we have used already trained InceptionV3 model with ImageNet weights for feature extraction. To handle shorter videos, we directly padded them to match the length of the video with the required frame count. All necessary functions used to process data which returns frame features and frame masks [6]. These outputs are then fed into the transformer model with recurrent layers, as illustrated in Figure 2.

Label preprocessing with StringLookup

Video labels are usually in text form, but neural networks can only work with numbers. To solve this, we use the `StringLookup` function in Keras to convert these text labels into numbers. This function makes it easy to handle many labels in large datasets by automatically changing the text labels to numeric values that the model can understand [7].

Building the Transformer-based model

Transformer encoders primary parts like self-attention layers are order-independent. We need our Transformer model to take order information into consideration because videos are sequential information, placing information encoding is used for this. Through this layer we simply entrench the frame positions within videos. The CNN feature maps which are pre-computed earlier are then updated with these positional embeddings [8]. The transformer-encoder is an array of several similar layers, each of which has dual sub layers. (each named as sub layer). While the second is a multiple head self-attention sharing, first one is the location based feed forward network. Particularly, demands, bases, and standards in the encoder self-attention are all resulting from the outputs of the former encoder layer8. The Transformer Decoder is identical to the Transformer Encoder, with the exception that it has an extra focus block whose keys and values correspond to the original sequence that the Transformer Encoder encoded [9].

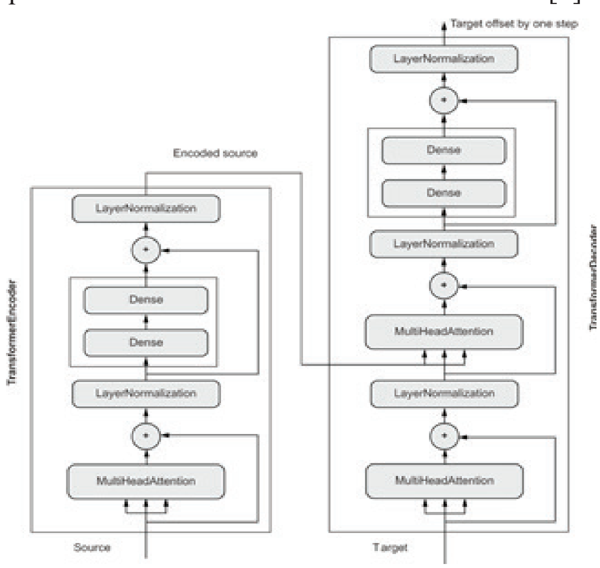

Fig. 3. Transformer Encoder and Decoder

Figure 3 depicts a full Transformer having an encoder-decoder pair working together. The transformer decoder furthermore comprises arrangement of various similar layers with recurrent links and layer normalisations. The additional third sub layer in decoder known as encoder-decoder consideration, between the double sub layers stated in the encoder and those already described [10]. This Transformer model architecture uses fixed-sized sequences of 50 frames, each represented by 512 features, the shape of such encoder is shown in Figure 4. It consists of an encoder for understanding input sequences and a decoder for generating output sequences. The decoder's self-attention device allows it to emphasis on significant parts of the input, ensuring accurate sequence generation. Auto-regressive attention ensures that predictions are based on previously generated tokens, maintaining coherence. For optimal performance, such models require extensive training on large, diverse datasets.

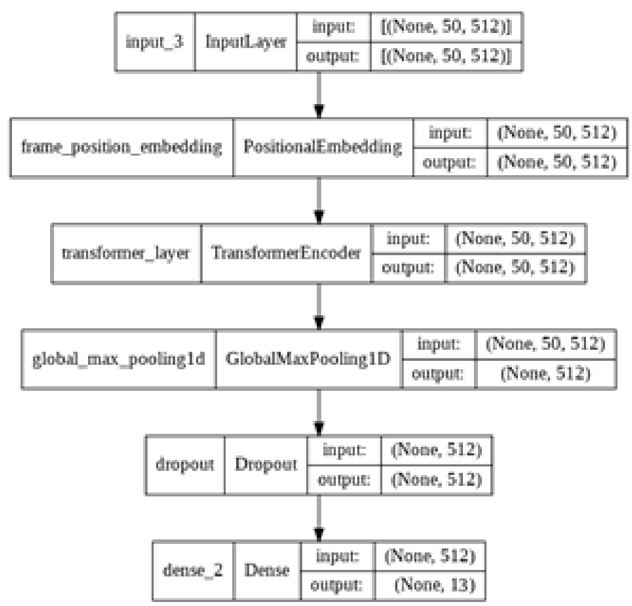

Fig. 4. Transformer Encoder model shape

Testing a trained model for videos selected randomly

To demonstrate the prediction capabilities of a deep learning model on video data, we begin by selecting a random video from our test dataset. This video endures preprocessing which converts it to a sequence of frames. If the video is shorter than our predefined sequence length, padding is applied to ensure uniformity in input size. Once we have our frame sequence prepared, we employ a pre-trained deep learning model, which has been meticulously trained to recognize patterns and features within video frames. The model, often built on frameworks like TensorFlow and utilizing architectures such as convolutional neural networks (CNNs), is adept at extracting meaningful information from each frame [10].

Using this trained model, we predict the class of the video based on its frame sequence. The prediction process involves computing probabilities for each potential class. The prediction of category is identified by picking the category with the highest likelihood score of the model's confidence in its classification.

RESULTS AND DISCUSSION

This method not only showcases the model's capacity to understand and classify video content but also underscores the prominence of strong training and meticulous preprocessing in achieving accurate predictions in deep learning applications. A GIF5 file constructed form the frame is displayed for the visualization purpose, model receives a top accuracy of 70 %. Figure 5 show the accuracy of model and Figure 6 shows loss function plotted using Keras.

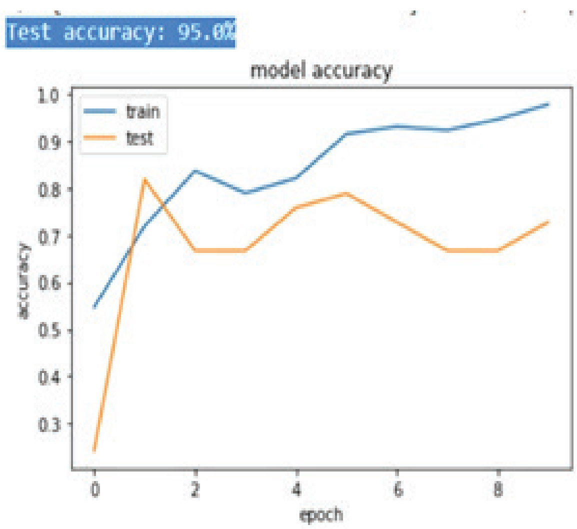

Fig. 5. Transformer Encoder model accuracy graph

For clarity, upon predicting the class, we also calculate and show the confidence level allied with this prediction. This confidence score offers insight into the model's conviction about its classification decision, expressed as a percentage.

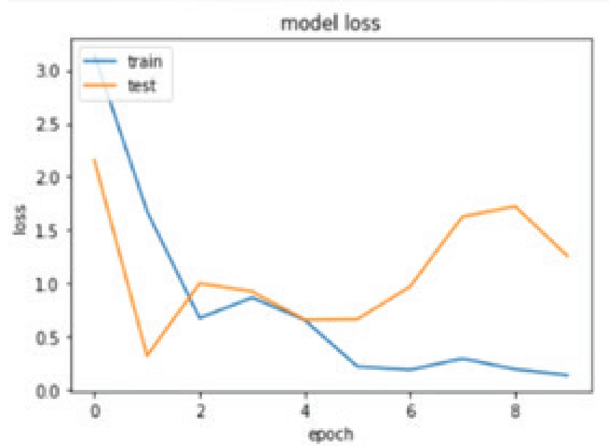

Fig. 6. Transformer Encoder model loss graph

The projected method achieved the accuracy of higher order for a dataset categorised into two categories only i.e. fighting and non fighting. Accuracy can reduce if the videos of long duration used for training, here we used videos of very small duration of two seconds.

The base paper author and dataset creator6 Creator6 proposed a work achieving 23.0% accuracy of for the C3D (Convolutional 3D) approach and for the TCNN (Temporal Convolutional Neural Network) 28.4% approach, as presented in Table 1. The outcomes of the work can be visualized by creating a GIF bundle of frames from a random video.

MODEL ACCURACY COMPARISON

Method	C3D	TCNN	Proposed
Model Accuracy	23.0%	28.4%	70%

C3D and TCNN accuracy values from Sultani et al 2018

The screenshot of prediction percentages for diverse classes are shown to provide a clear understanding of both the selected and predicted classes. Figure 7 illustrates this by showing a GIF of a "Fighting" video and the prediction percentages for each class according to the proposed method. This visualization helps in assessing the model's performance and understanding its classification decisions.

The proposed model's results can be visualized by creating a GIF from the frames of a randomly selected video. Along with this visualization, the prediction percentages for different classes are printed to provide a clear understanding of both the selected and predicted classes. Figure 7 shows an example of this, displaying a GIF of a "Fighting" video along with the prediction percentages for each class according to the proposed method. This helps in assessing the model's performance and understanding its classification decisions.

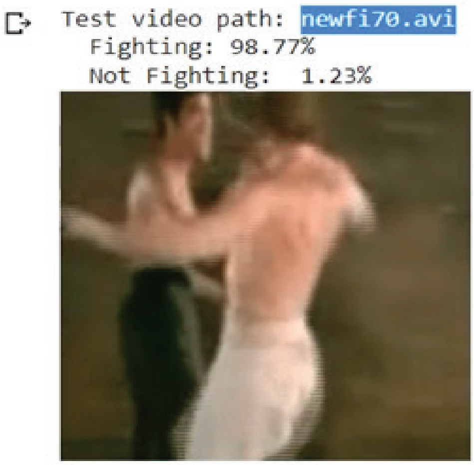

Fig. 7. Prediction of Fighting class with accuracy and display a Gif for the selected video

Figure 8 is showing a result for the non-fighting video selected and prediction percentage for each class in the proposed method. Test accuracy for the proposed hybrid model is coming as a top accuracy of 70% for the Peliculas dataset, dataset contains two types of categories therefore the accuracy is much more as compared to the reference taken for comparisons, as the number of classes increases accuracy my affect the performance of algorithm.

Fig. 8. Prediction of Non Fighting class with accuracy and display a Gif for the selected video

CONCLUSIONS

The test accuracy for the proposed hybrid model is notably high, achieving a top accuracy of 70% on the Peliculas dataset. This impressive performance can be attributed to the nature of the dataset, which consists of only two categories. The relatively simple classification task allows the model to achieve a higher accuracy compared to other reference models used for comparison. However, it is important to note that as the number of classes in a dataset increases, the classification task becomes more complex. This increased complexity can lead to a reduction in accuracy because the model has to distinguish between a larger number of categories, each with potentially subtle differences. Consequently, the performance of the algorithm may be affected, and achieving high accuracy becomes more challenging.

In summary, while the proposed hybrid model demonstrates excellent performance on the Peliculas dataset with its binary classification task, its accuracy may decrease when applied to datasets with a greater number of classes. This highlights the importance of considering the number of categories in a dataset when evaluating the performance of classification models.

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Implementation of Secure Framework for Cloud Based IoT Network Using Machine Learning Approach and Lightweight Cryptography

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ABSTRACT

In recent years, a significant number of articles have discussed the security challenges associated with the Internet of Things (IoT). This has sparked interest in protecting the network architecture of IoT systems, leading to various questions. As IoT technology continues to advance, with millions of devices becoming interconnected, the landscape of IoT is undergoing significant changes. However, alongside this growth, the attacks on IoT networks are also becoming increasingly sophisticated. Many people are encountering issues due to vulnerabilities within IoT networks. To address these challenges, numerous researchers in the IoT field have proposed various security solutions, which have been widely implemented to protect against attacks and unauthorized access. Recently, IoT security has emerged as a key research focus, particularly in the context of Cloud-based IoT network security. Unfortunately, existing security measures are struggling to meet the challenges posed by Cloud-based IoT networks. In these networks, sensor data from IoT devices is transmitted over communication paths that are often vulnerable to attack. Securing these communication paths is crucial. In our proposed research, we have developed a secure framework for Cloud-based IoT networks by implementing an attack detection and mitigation system using machine learning, along with end-to-end secure Cloud communication based on cryptographic techniques. These approaches significantly enhance the security of Cloud-based IoT networks.

KEYWORDS *: Internet of Things (IoT), Machine Learning, Lightweight cryptography, IDS.*

INTRODUCTION

The notion of connecting objects to the Internet isn't novel. In the early 1990s, the first instances of controlling everyday items over the Internet emerged, laying the groundwork for today's Internet of Things (IoT). Interactions with the Internet, whether personal, social, or economic, are undergoing a transformation. The IoT could signify a shift in how users engage with and are influenced by the Internet. Presently, users predominantly download and generate content through computers and smart phones, but this pattern might soon change. Many IoT devices function in the background, autonomously sending and receiving data on behalf of users with minimal human intervention. Some are designed to manage physical assets like vehicles and buildings, or to monitor human behavior. By 2025, it's estimated there will be 75 billion connected IoT devices. If these projections materialize, it's crucial to contemplate the implications of a world where passive engagement with connected objects supersedes active engagement with content. Governments may need to align policies with this evolving landscape. Although the concept of the IoT isn't new technically, its growth and maturation will introduce both opportunities and challenges necessitating policy adjustments. Policies concerning privacy and data security should adapt to reflect the evolving technology and its potential impacts on users. Fostering Internet infrastructure, efficient wireless spectrum utilization, data center expansion, and user empowerment are crucial for IoT advancement. Various policy domains warrant review as IoT devices are poised to permeate many facets of life, from homes and workplaces to schools and hospitals. Consequently, policies regarding privacy, data security, healthcare, transportation, and technology innovation are likely to be affected.

LITERATURE SURVEY

Internet of Things

IoT devices now become very important part in human lives. Various applications of IoT makes human life easy and comfortable [13]. Table 2.1 shows the estimation from the last Cisco Annual Internet Report on global device and connection growth. According to the report, by the year 2023, reaching 14.7 billion devices get connected. In this M2M also referred as IoT. [15].

Table 1 Global devices and connection growth

Global device and connection growth		
Table refers to 2018,2023 device share		
Devices	**Year 2018**	**Year 2023**
M2M	33%	50%
Smartphones	27%	23%
Non-Smartphones	13%	5%
TVs	13%	11%
PCs	7%	4%
Tablets	4%	3%
Other	2.1%,	3.9%

Attacks on IoT ecosystem

As per report number of IoT devices are gradually increased it also offer significant advantages but pose substantial security challenges. Often prioritizing over security considerations, IoT devices become prime targets for cyber-attacks and the following list provides descriptions of some of the most common ones [14]:

- DoS and DDoS Attacks: IoT devices are frequent targets for DDoS attacks and may also contribute to the botnets responsible for executing these attacks.
- Eavesdropping/Sniffing Attacks: This is Passive attack. In this intruder can monitor network traffic to obtain sensitive data.
- Man-in-the-Middle Attacks: In this intruder can modify message between sender and receiver. This leads to control on IoT devices.
- Spoofing Attacks: Involves an attacker impersonating device to launch various assaults against network hosts, steal data, or circumvent access controls.
- Replay Attacks: The assailant records a data stream and subsequently replays it to imitate legitimate user actions, potentially gaining system access or causing malfunctions.
- Jamming: Perpetrators disrupt radio transmission in wireless networks used by IoT devices.
- Malware Attacks: Malicious software used by hacker to sabotage device operation, obtain sensitive data, or incorporate devices into botnets for DDoS attacks.

Machine Learning-Based IDS for IoT Networks Machine learning algorithms are trained to identify patterns and anomalies in IoT network traffic, empowering IDS to recognize sophisticated and evolving threats. ML-based IDS for IoT networks analyze large volumes of data from diverse sources, including sensor data, device telemetry, and network traffic, for real-time anomaly detection. These IDS play a vital role in safeguarding IoT devices, data, and infrastructure from cyber threats and vulnerabilities, utilizing specialized detection techniques and algorithms to provide effective threat detection and mitigation in the dynamic IoT security landscape. Depending on literature it is found that ML approach can be used for Attack Detection and Mitigation in IoT network for avoiding different vulnerabilities in IoT network.

Machine Learning Classifier Models

Machine Learning is used here for Classification of input data packets of IoT network. First step is to preprocess the input data packets. After that this input data is trained using ML model. Machine Leaning classifier models are used to classify input data packets into Normal or Attack.

Data pre-processing: It is also known as cleaning the data. It means Null/Nan values must be deleted or replaced with substitute values.

Training/Learning: In this phase dataset is divided in 80/20 ratio. Amongst this 80% is for training and 20% is for testing. Training is for learning purpose whereas testing is for evaluation of model.

Classification: Using Machine Learning classifier model, classification can be possible as output value "1" for "Attack" or "0" for "normal" is classified from input dataset.

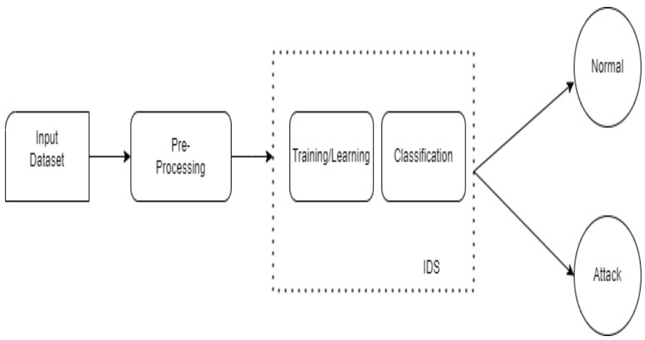

Fig. 1: Machine Learning Classifier

Overview of Lightweight Cryptography for End to End Secure Communication

Types of Lightweight Cryptography: LWC is of two types, Symmetric LWC and Asymmetric key LWC. Asymmetric encryption is secure than symmetric encryption. But asymmetric is more complex and having more computation, making it less suitable for IoT devices. In contrast, symmetric encryption offers speed, security, and low latency, making it the preferred choice for IoT device applications. Therefore, utilizing symmetric key cryptography algorithms in IoT device design is generally recommended compared to asymmetric encryption [20].

Symmetric cryptography encompasses both stream and block ciphers, with stream ciphers using a key identical to the data and block ciphers having a fixed length of key bits. Among these, block ciphers are favored for their adaptability, which is highly beneficial in the context of IoT. Additionally, because block ciphers employ nearly identical encryption and decryption techniques, they consume fewer resources, making them advantageous for IoT devices [20].

Block ciphers have been preferred for developing constrained devices in recent years due to their simpler hardware and software implementations, as well as their superior error propagation and diffusion characteristics. They require significantly fewer hardware resources compared to stream ciphers. The key factors influencing LWC include the number of rounds, block size, key size, and structure.

Lightweight cryptography as a solution for IoT Network security

Lightweight cryptography for IoT security involves the development of cryptographic algorithms and protocols tailored to the limitations of IoT devices while maintaining robust security measures. These constraints encompass factors like processing power, memory, and energy efficiency. Lightweight cryptographic algorithms are optimized to minimize computational overhead, memory usage, and energy consumption. They are engineered to run effectively on IoT devices without compromising performance. Given that many IoT devices operate on limited battery power, lightweight cryptographic algorithms prioritize energy efficiency to prolong battery life. Lightweight cryptographic algorithms are designed with compact code sizes to fit within the constrained memory of IoT devices. This ensures that cryptographic operations can be executed efficiently without consuming excessive memory resources. Rapid encryption and decryption are crucial for IoT applications. Lightweight cryptographic algorithms are engineered for swift execution, minimizing delays in data processing. Despite their lightweight nature, cryptographic algorithms for IoT security must uphold robust security standards to safeguard sensitive data and communications from potential threats. This entails resistance to known cryptographic attacks and vulnerabilities. Efforts are underway to standardize lightweight cryptographic algorithms tailored specifically for IoT security. Standardization facilitates interoperability, compatibility, and widespread adoption across various IoT devices and platforms. Lightweight cryptographic algorithms should be adaptable to diverse IoT use cases and application scenarios, ranging from sensor networks and wearable devices to smart homes, industrial IoT, and healthcare applications. Lightweight cryptography plays a pivotal role in safeguarding the security and privacy of IoT devices and data while addressing the stringent resource constraints inherent in these devices.

EXISTING SYSTEM AND PROPOSED METHODOLOGY

Intrusion Detection System

An IDS functions like to a home security system, acting as a safeguard against unauthorized access. Figure 2 shows architecture of IDS. For instance, while the primary defense mechanism of a house is its lock system, should the system be compromised, the IDS, akin to a burglar alarm, promptly alerts the homeowner of the breach. Similarly, Firewalls serve as effective filters for incoming Internet traffic, though they may be circumvented. For example, external users can access an organization's Intranet via a modem within the private network, bypassing the Firewall's detection capabilities.

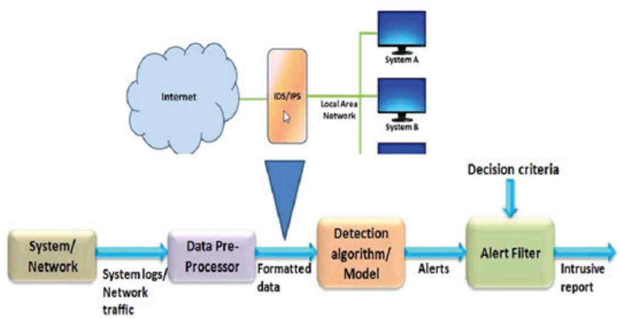

Fig. 2: IDS

An IPS a vital component of network security, actively monitors and prevents potential vulnerability exploits within network traffic. IPS encompasses two main types: Network (NIPS) and Host (HIPS), both of which automatically respond to threats to safeguard networks and systems. However, IPS can encounter challenges such as false positives and negatives. False positives occur when an IDS raises an alarm despite no actual attack, while false negatives signify a failure to raise an alarm during an ongoing attack. Moreover, inline operation of IPS can lead to bottlenecks, including single points of failure, delays in signature updates, and difficulties in inspecting encrypted traffic. IDS serves to measure the actions occurring within a system or network.

Proposed Methodology

In proposed methodology, multiple security approaches are implemented. In attack detection and mitigation Netsim Standard Simulator is used for design and live data capturing of IoT devices and ML approaches are used for performance analysis of model. Also lightweight cryptography is used for encryption of sensor data of IoT devices which is finally stored of cloud.

Simulators

Simulators are crucial tools for IoT (Internet of Things) research as they allow researchers to model and test various aspects of IoT systems in a controlled environment. Here are some popular simulators used for IoT research:

NetSim Standard: NetSim is a simulator for designing IoT networks. In Netsim standard code updation can be possible hence used for Research and Development. It has some Features like Develop and simulate own protocols and algorithms, inbuilt interface with MATLAB and Wireshark etc.also it has protocol source C code. In this work, design of IoT network is done using NetSim Standard v13.3 simulator.

Machine learning Approaches

ML systems can be categorized in 3 types. Following Diagram shows ML types.

Supervised learning: Involves a training dataset with target outcomes, known as labels. It can be further divided into: Classification: Where the target label is categorical, resulting in classifiers. Regression: Where the algorithm predicts a numerical value, utilizing regressors.

Unsupervised learning: Training occurs on unlabeled datasets without predefined classes, often used for clustering or segmentation tasks.

Reinforcement learning: The learning system, or agent, interacts with the environment, selecting actions and receiving rewards or penalties, learning to maximize rewards over time.

Objective of this is to compare different ML algorithms for use in IDS on IoT network. Specifically using supervised classification to detect attacks. An IDS using ML typically involves steps such as data collection, cleansing, feature extraction, model selection and training, model evaluation, deployment and monitoring, and batch learning for continuous data growth. While detecting an attack is primarily a binary classification task, the increasing specialization and complexity of IoT infrastructures demand more granular classifications to properly handle threats. In terms of attack detection, the primary goal is binary classification, where the system determines whether a given traffic sample is indicative of an attack or not.

Lightweight Cryptography

Cryptography plays a crucial role in ensuring data confidentiality, integrity, authentication, and authorization during transmission. It provides a reliable solution for both secure data transmission over networks and secure data storage. However, traditional cryptographic algorithms are not well-suited for IoT devices, which are often resource-constrained. These algorithms typically require significant computational resources, which can be a challenge for IoT devices due to their limitations in memory, battery power, computing power, and the need for real-time response. The constraints of IoT devices can lead to suboptimal performance when traditional cryptographic methods are applied. To address these challenges, lightweight cryptography has been developed. This approach offers a more efficient and suitable version of conventional algorithms, designed specifically to meet the needs of resource-limited IoT devices.

EXPERIMENTAL FINDINGS

Implementation of Attack Detection and Mitigation using ML approaches:

Machines learning approaches are used to found “Normal” and “Anomaly” in IoT network traffic.

Logistic Regression:

Here's the general formula for logistic regression:

$$P(Y=1 \mid X) = \frac{1}{1+e^{(\beta_0 | \beta_1 x_1 \beta_2 X_2 ......\beta_n X_n)}}$$

Where:

- $P(Y=1 \mid X)$ is the probability that the output is 1 (intrusion) given the input features .
- β_0 is the intercept term.
- $\beta_1, \beta_2, ... \beta_n$ are the coefficients for the predictor variables $X_1, X_2, ...X_n$.

In the context of an loT network for intrusion detection, the input features $X_1, X_2, ...X_n$ could be various metrics collected from the network. The logistic regression model uses these features to predict whether a network behavior represents normal activity (Y=0) or an intrusion (Y=1). Apply the trained model to real-time network traffic data to detect intrusions. Example: Suppose we have the following features: X1 : Packet rate, X2 : Byte rate, X3 : Source port number. The logistic regression equation would be:

$$P(Y=1|X)= \frac{1}{1+e^{(\beta 0+\beta 1.packet\ rate+\beta 2.Byte\ rate+\cdots+\beta n.source\ port\ number)}}$$

The coefficients (β0,β1,β2,β3) are learned from the training data.

K Nearest Neighbors (KNN):

Distance Calculation

$$\text{Distance}(x_i, x_j) = \sqrt{\sum_{m=1}^{n} (x_{im} - x_{jm})^2}$$

where x_i and x_j are feature vectors of the new data point and a training data point, respectively, and n is the number of features.

Finding Neighbors: Identify the K nearest neighbors based on the calculated distances.

Majority Voting(for classification):

$$\hat{y} = \text{mode}(y_1, y_2, \ldots, y_K)$$

where y1,y2,…,yk are the labels of the K nearest neighbors, and Ŷ is the predicted label.

Decision Tree:

Formulas for Splitting Criteria

- Gini Impurity:
  $$\text{Gini}(D) = 1 - \sum_{i=1}^{n} p_i^2$$
- where pi is the probability of class i in dataset D.
- The Gini Impurity for a split is calculated as:
  $$\text{Gini}_{\text{split}} = \frac{N_{\text{left}}}{N}\text{Gini}(D_{\text{left}}) + \frac{N_{\text{right}}}{N}\text{Gini}(D_{\text{right}})$$

where N is the total number of samples, N_{left} and N_{right} are the number of samples in the left and right subsets, respectively.

Information Gain

$$IG(D,A) = \text{Entropy}(D) - \sum_{v \in \text{Values}(A)} \frac{|D_v|}{|D|} \text{Entropy}(D_v)$$

where Entropy

$$(D) = -\sum_{i=1}^{n} p_i \log_2(p_i)$$

and D_v is the subset of D for which attribute A has value v.

End to End Secure Cloud based IoT communication Using Lightweight Cryptography

Fernet algorithm

The Fernet algorithm is not specifically a lightweight cryptography algorithm; however, it's designed to be simple and easy to use for securely transmitting data over the internet. Fernet is a symmetric encryption algorithm that uses symmetric keys for both encryption and decryption. It provides authenticated encryption, meaning it ensures both confidentiality and integrity of the data.

Key Generation: Fernet requires a secret key that is known only to the sender and receiver. The key should be generated securely and kept confidential.

Message Encryption: Generate a random initialization vector (IV).Encrypt the message using AES in CBC mode with the secret key and IV.Apply PKCS7 padding to ensure that the plaintext message length is a multiple of the block size.

Message Authentication: Calculate an HMAC using SHA256 with the secret key and the ciphertext obtained from the encryption step. The HMAC serves as a cryptographic checksum to ensure the integrity of the message.

Message Packaging: Concatenate the IV, ciphertext, and HMAC to form the Fernet token. Optionally, include a timestamp or other metadata for additional security features.

Message Decryption: Extract the IV, ciphertext, and HMAC from the Fernet token. Verify the HMAC using the secret key and the extracted ciphertext. If the HMAC verification succeeds, decrypt the ciphertext using AES in CBC mode with the secret key and IV.

Here's the high-level formula for encrypting data using AES in CBC mode within the context of the Fernet algorithm:

Initialization Vector (IV): Generate a random initialization vector IV . The IV should be unique for each encryption operation.

Padding: Apply PKCS7 padding to the plaintext message M to ensure its length is a multiple of the block size. PKCS7 padding involves appending bytes to the message to make its length a multiple of the block size, where each byte contains the number of padding bytes added.

Key Derivation: Use a secret key K shared between the sender and receiver. This key should be generated securely and kept confidential.

Encryption: Divide the padded plaintext message into blocks of the block size (128 bits for AES). XOR the first plaintext block with the IV. Encrypt the XOR result using the AES encryption algorithm with the secret key K to produce the first ciphertext block C1. XOR each subsequent plaintext block with the previous ciphertext block before encryption to produce the next ciphertext block. Repeat this process until all plaintext blocks are encrypted.

Ciphertext Output: Concatenate the IV and the ciphertext blocks to produce the final ciphertext C. Mathematically, the encryption operation using AES in CBC mode can be represented as follows:

Let M = (m1, m2, …., mn) be the plaintext message (padded if necessary). IV be the initialization vector. K be the secret key. C = (c1, c2, ……, cn) be the ciphertext.

The encryption operation for each block mi is as follows: Ci=AESK(mi⊕ci-1) where AESK denotes the AES encryption with key K. ⊕ denotes the bitwise XOR operation. Ci-1 is the previous ciphertext block(or IV for first block). After encryption, the final ciphertext C is obtained by concatenating the IV and the ciphertext blocks: C= IV||c1||c2||…||cn This ciphertext C forms the output of the encryption process, which can then be sent over the network or stored securely.

RESULTS AND DISCUSSION

Detection of the sinkhole node for Attack Detection and Mitigation

We have created Cloud based IoT network using NetSim Standard(R&D) v13.3 in which Sinkhole attack detection can be possible. Broadcasting of message is started when we run Simulation. All sensors start transmitting packets. The receiver updates its parent list on receiving the DIO from the transmitter. Malicious node does not update the rank and advertises a fake rank. But the other node updates its rank according to the fake rank by receiving to the malicious node DIO message. These malicious nodes attract the nearby traffic by declaring fake rank. IoT Network traffic is attracted towards malicious node as shown in Figure 3. Packets that reach Sensors Node 6 and Sensors Node 8 get dropped as these are malicious node. This attack affects the performance of IoT network protocol such as RPL. This will identify malicious node and stop receiving and transmitting data through this malicious node.

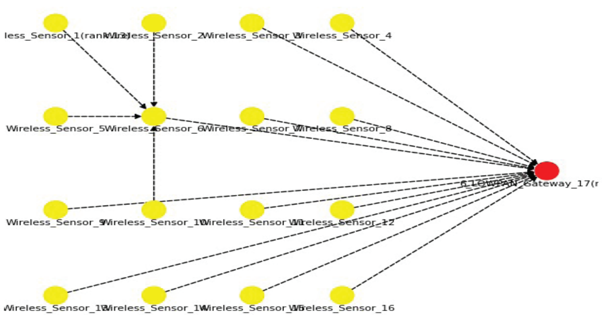

Fig. 3. Implementation of DODAG Using RPL protocol for IoT Network

Secure Transmission Sensor Data on AWS Cloud for End to End Secure Cloud based IoT communication

For implementation of End-to-End secure cloud based IoT communication we run IoT network scenario developed using NetSim Standard(R&D) v13.3 and generate Packet Trace File consists of Sensors Data at the time of transmission. Encryption of this sensors data is done using Fernet algorithm in Python. GUI for Encryption and Upload is as shown in following Figure 4.

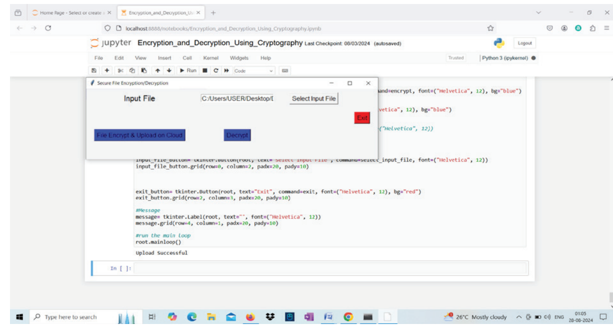

Fig. 4. Implementation of Encryption and Upload Encrypted file on Cloud

After that we have created bucket on AWS Cloud S3 storage service. By using AWS Cloud S3 storage service we can upload IoT sensor data encrypted file on AWS cloud. In this research we have created Bucket “cloudcommunication” in S3 storage of AWS cloud and uploaded encrypted file of IoT sensor data on this cloud storage for secure end to end cloud based IoT communication. Following diagram shows successful uploading of encrypted file of IoT sensors data on AWS Cloud as shown in figure 5.

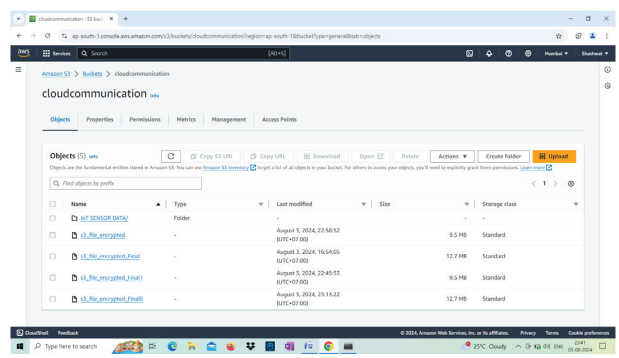

Fig. 5 Implementation of Successful uploading of Encrypted file on AWS Cloud

CONCLUSION

In this research paper we have implemented of Attack Detection and Mitigation based on Machine Learning Approach using NetSim standard simulator v13.3. Also implementation of End to End secure Cloud-Internet of Things (IoT) network communication based on Lightweight Cryptography using Fernet Algorithm. These multiple approaches for implementing secure framework for cloud-based Internet of Things (IoT) network will resolve security issues of IoT network and Cloud based IoT communication to larger extent.

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Analysis of Deep Learning Methodologies for Disease Prediction

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ABSTRACT

In recent years, deep learning has emerged as a transformative technology in the field of healthcare, particularly in disease prediction and diagnosis. This paper provides a comprehensive analysis of various deep learning methodologies applied to disease prediction, exploring the strengths, limitations, and practical implications of these approaches. We review convolutional neural networks (CNNs), recurrent neural networks (RNNs), autoencoders, and other advanced architectures like transformer models, highlighting their applications in predicting diseases such as cancer, cardiovascular disorders, neurological diseases, and infectious diseases. The study also examines the role of big data, feature selection, and preprocessing techniques in enhancing model accuracy and generalization. Furthermore, we discuss the challenges associated with deep learning in medical applications, including data privacy, model interpretability, and the integration of these technologies into clinical practice. Through this analysis, we aim to provide insights into the current state of deep learning in disease prediction and propose future directions for research in this rapidly evolving domain.

KEYWORDS *: Big data in healthcare, Convolutional Neural Networks (CNNs), Deep Learning, Disease prediction, Feature selection, Medical data, Recurrent Neural Networks (RNNs), Transformer models.*

INTRODUCTION

The advent of deep learning has revolutionized various sectors, with healthcare being one of the most significant beneficiaries. As the global burden of diseases continues to rise, there is an increasing demand for accurate and timely prediction of diseases to improve patient outcomes and optimize healthcare resources. Traditional statistical methods and machine learning techniques, while effective, often struggle with the complexity and volume of medical data. Deep learning, with its ability to automatically learn and extract features from large, unstructured datasets, offers a powerful alternative.

Deep learning models, such as convolutional neural networks (CNNs), recurrent neural networks (RNNs), and more recently, transformer-based architectures, have shown remarkable performance in tasks such as image recognition, natural language processing, and time-series analysis. In the context of healthcare, these models are being increasingly applied to predict a wide range of diseases, including but not limited to cancer, cardiovascular diseases, diabetes, and neurological disorders.

This paper aims to provide a comprehensive analysis of the various deep learning methodologies used in disease prediction. We explore how these models are designed, trained, and validated using diverse types of medical data, including imaging data, electronic health records (EHRs), and genomic data. Additionally, we discuss the challenges associated with deep learning in healthcare, such as data scarcity, model interpretability, and the ethical considerations surrounding patient privacy.

Through this analysis, we seek to understand the current state of deep learning in disease prediction, identify the most promising methodologies, and highlight areas where further research and development are needed. By doing so, we hope to contribute to the ongoing efforts to harness the power of deep learning for better disease management and improved patient care.

LITERATURE REVIEW

The application of deep learning in disease prediction has garnered significant attention in recent years, driven by the availability of large-scale medical datasets and advancements in computational power. Various studies have explored the efficacy of deep learning models in predicting a wide range of diseases, from chronic conditions like cancer and cardiovascular diseases to acute infections and neurological disorders.

Convolutional Neural Networks (CNNs) have been extensively used in medical image analysis for disease prediction, particularly in diagnosing diseases from imaging modalities such as X-rays, MRIs, and CT scans. CNNs excel in capturing spatial hierarchies in image data, making them ideal for detecting patterns indicative of diseases. For instance, Esteva et al. (2017) demonstrated the use of CNNs for skin cancer classification, achieving performance comparable to dermatologists. Similarly, Rajpurkar et al. (2017) utilized a CNN to detect pneumonia from chest X-rays with high accuracy, showcasing the potential of CNNs in radiology.

Recurrent Neural Networks (RNNs), particularly Long Short-Term Memory (LSTM) networks, have been employed to analyze sequential medical data, such as electronic health records (EHRs) and time-series data. LSTMs are designed to capture temporal dependencies, making them suitable for predicting disease progression over time. Lipton et al. (2016) applied LSTMs to predict the onset of multiple diseases using EHRs, highlighting the ability of RNNs to model complex temporal patterns in patient data. Another study by Choi et al. (2016) proposed a model called "Doctor AI," which used RNNs to predict the next diagnosis and medication for a patient based on their medical history, demonstrating the potential of deep learning in personalized medicine.

Autoencoders and other generative models have also been explored for disease prediction, particularly in unsupervised or semi-supervised settings. These models are effective in learning compact representations of high-dimensional data, which can be used for anomaly detection and early disease diagnosis. For example, Sakr et al. (2018) used variational autoencoders (VAEs) for unsupervised feature learning from EHR data, enabling early prediction of chronic diseases like diabetes . Moreover, adversarial training techniques, such as those used in Generative Adversarial Networks (GANs), have been applied to enhance the robustness of disease prediction models by generating synthetic data for training, as demonstrated by Che et al. (2017) in their work on GANs for EHR data augmentation.

Transformer models, originally developed for natural language processing, have recently been adapted for use in healthcare. These models are particularly effective in handling long-range dependencies in sequential data, making them suitable for analyzing EHRs and genomic sequences. Song et al. (2020) proposed a transformer-based model for predicting clinical outcomes from longitudinal patient data, showing superior performance compared to traditional RNNs. The self-attention mechanism in transformers allows for a more nuanced understanding of complex interactions in patient data, paving the way for more accurate and interpretable disease predictions.

While deep learning models have shown promise in disease prediction, several challenges remain. One major issue is the interpretability of these models, often referred to as the "black box" problem. Efforts to develop more interpretable models, such as attention-based mechanisms and explainable AI techniques, are ongoing. Additionally, the scarcity of labeled medical data and the need for large, diverse datasets for training deep learning models are significant hurdles. Researchers are exploring techniques like transfer learning, data augmentation, and federated learning to address these challenges. Data privacy and ethical considerations also pose challenges, as the use of sensitive medical data requires stringent data governance frameworks. Recent studies, such as the one by Rieke et al. (2020), have explored federated learning as a privacy-preserving approach to training deep learning models on decentralized medical data. Table 1 provides a concise comparison of different studies, highlighting the models used, the types of data, the diseases targeted, the key findings, and the challenges or limitations associated with each approach.

ANALYSIS OF DEEP LEARNING METHODOLOGIES

Deep learning has revolutionized disease prediction by enabling the analysis of complex medical data with unprecedented accuracy. Unlike traditional machine learning techniques, which often require manual feature extraction, deep learning models can automatically learn features from raw data, making them highly effective for complex tasks such as medical image analysis, time-series prediction, and genomic data interpretation.

The flexibility and power of deep learning models, including Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Autoencoders, and Transformer models, have led to significant advancements in predicting various diseases.

Table 1 Key Studies from the Literature Review on Deep Learning Methodologies for Disease Prediction

Study	Model Type	Data Type	Disease Focus	Key Findings	Challenges/Limitations
Esteva et al. (2017)	CNN	Medical Images (Dermatology)	Skin Cancer	Achieved dermatologist-level accuracy in skin cancer classification using CNNs.	Model interpretability and reliance on large labeled datasets.
Lipton et al. (2016)	LSTM (RNN)	Electronic Health Records	Multiple Diseases	LSTM successfully predicted the onset of diseases using temporal patterns in EHRs.	Handling of long-term dependencies and model interpretability.
Choi et al. (2016)	RNN (RETAIN)	Electronic Health Records	Various (Personalized Medicine)	Developed RETAIN model to predict next diagnosis and treatment; provided some interpretability.	Limited interpretability, despite attention mechanisms.
Rajpurkar et al. (2017)	CNN	Medical Images (Radiology)	Pneumonia	CNN outperformed radiologists in detecting pneumonia from chest X-rays.	Limited by dataset size and variability in image quality.
Sakr et al. (2018)	Variational Autoencoder (VAE)	Electronic Health Records	Chronic Diseases	VAEs effectively learned compact representations for early prediction of chronic diseases.	Challenges in model training and scalability to larger datasets.
Che et al. (2017)	GAN	Electronic Health Records	Risk Prediction	GANs improved prediction accuracy by generating synthetic EHR data for training.	Data privacy concerns and complexity in GAN training.
Song et al. (2020)	Transformer	Electronic Health Records	Multiple Diseases	Transformer model outperformed traditional RNNs in clinical outcome prediction using EHRs.	High computational cost and need for large datasets.
Rieke et al. (2020)	Federated Learning (Various)	Decentralized Medical Data	Various	Explored privacy-preserving methods for training deep learning models on decentralized data.	Complexity of implementation and need for standardization.

CNNs are particularly well-suited for image-based disease prediction tasks. They have been widely used in medical imaging to detect and classify diseases from modalities such as X-rays, MRIs, and CT scans. CNNs have been successfully applied in areas like cancer detection (e.g., breast cancer, skin cancer), cardiovascular disease diagnosis, and pneumonia detection. Studies like Esteva et al. (2017) and Rajpurkar et al. (2017) demonstrated the potential of CNNs to achieve or surpass human-level performance in diagnosing skin cancer and pneumonia, respectively.

The ability of CNNs to automatically learn hierarchical features from images makes them powerful tools for medical image analysis. They excel in pattern recognition, which is crucial for identifying disease markers in complex images. Despite their success, CNNs face challenges such as the need for large, annotated datasets, potential overfitting on small datasets, and issues with interpretability. The “black box” nature of CNNs can make it difficult for clinicians to understand the decision-making process of the model.

RNNs, and specifically LSTMs, are designed to handle sequential data, making them suitable for analyzing time-series data like electronic health records (EHRs). LSTMs have been applied to predict disease onset, progression, and patient outcomes based on EHRs. For example, Lipton et al. (2016) used LSTMs to predict the onset of multiple diseases from EHRs, while Choi et al. (2016) introduced the RETAIN model for personalized treatment recommendations.

RNNs are adept at capturing temporal dependencies in sequential data, which is crucial for predicting the progression of chronic diseases and the effects of treatment over time. They can model complex relationships in patient data that unfold over time. RNNs struggle with long-term dependencies and can be computationally expensive. Moreover, like CNNs, they suffer from interpretability issues, which complicates their integration into clinical practice. LSTMs, while mitigating some of these issues, are still not fully interpretable.

Autoencoders, particularly Variational Autoencoders (VAEs), and Generative Adversarial Networks (GANs) have been explored for disease prediction, particularly in unsupervised or semi-supervised learning contexts. VAEs have been used for early disease detection by learning compact representations of patient data, enabling the identification of anomalies that may indicate the onset of a disease. GANs have been employed to generate synthetic data to augment training datasets, improving model robustness and performance.

Autoencoders are effective in dimensionality reduction and anomaly detection, making them useful for early diagnosis. GANs, by generating realistic synthetic data, can help address the challenge of limited labeled data. Training autoencoders and GANs can be complex and resource-intensive. GANs, in particular, require careful tuning to avoid issues like mode collapse, where the model generates limited varieties of outputs. Additionally, the interpretability of the learned representations remains a challenge.

Transformer models, which have gained popularity in natural language processing, are now being applied to healthcare for disease prediction. Their ability to handle long-range dependencies and focus on relevant parts of the input through self-attention mechanisms makes them well-suited for analyzing complex, sequential medical data. Transformers have been used in clinical time-series analysis and genomic sequence prediction. Song et al. (2020) showed that transformers could outperform traditional RNNs in predicting clinical outcomes from longitudinal patient data.

The self-attention mechanism in transformers allows for better handling of dependencies in the data, leading to improved prediction accuracy. They also offer better scalability and can be trained on larger datasets more efficiently compared to RNNs. Transformers are computationally expensive and require large datasets for effective training. They also face interpretability challenges, similar to other deep learning models.

Despite the successes, deep learning models face several challenges in disease prediction. High-quality, labeled medical data is often scarce, and the variability in medical data can make it difficult to generalize models across different populations and healthcare settings. Techniques like transfer learning and data augmentation are being explored to mitigate these issues. The "black box" nature of deep learning models poses a significant barrier to their adoption in clinical practice. Efforts to improve interpretability, such as attention mechanisms and explainable AI techniques, are ongoing but remain an area of active research.

The use of deep learning in healthcare raises concerns about data privacy and the ethical implications of AI-driven decisions. Federated learning and other privacy-preserving techniques are being developed to address these concerns. For deep learning models to be useful in real-world healthcare settings, they must be integrated into clinical workflows. This requires not only technical solutions but also buy-in from clinicians and policymakers, who must trust and understand the technology.

Future research in deep learning for disease prediction is likely to focus on improving model interpretability, developing methods to handle small and imbalanced datasets, and ensuring that models are generalizable across diverse populations. Additionally, the integration of multi-modal data (e.g., combining EHRs, genomic data, and imaging) is expected to enhance the predictive power of deep learning models. The ethical use of AI in healthcare will also remain a critical area of focus, with ongoing efforts to develop frameworks for responsible AI deployment in clinical settings.

RESULTS ANALYSIS

The results and evaluation section of an analysis of deep learning methodologies for disease prediction would focus on assessing the effectiveness, accuracy, and limitations of various deep learning models when applied to disease prediction tasks. This section would also compare the performance of different models, discuss their strengths and weaknesses, and evaluate their applicability in real-world clinical settings. To evaluate the effectiveness of deep learning models in disease prediction, several key performance metrics are commonly used. The proportion of correct predictions made by the model out of the total predictions. While accuracy is a straightforward metric, it can be misleading in cases of imbalanced datasets.

Precision measures the proportion of true positive predictions out of all positive predictions made by the model, while recall measures the proportion of true positive predictions out of all actual positives. These metrics are crucial in medical settings where false positives and false negatives can have significant consequences. The harmonic mean of precision and recall, providing a balanced measure of a model's performance, especially in scenarios with class imbalance.

AUC-ROC measures the model's ability to distinguish between classes, with a value closer to 1 indicating better performance. It is particularly useful for evaluating the trade-off between sensitivity and specificity. A detailed breakdown of true positives, true negatives, false positives, and false negatives, providing insights into the types of errors the model is making. CNNs have shown exceptional performance in image-based disease prediction tasks.

The CNN model used by Esteva et al. (2017) achieved an accuracy of 72.1%, comparable to the performance of certified dermatologists. The model's high precision and recall made it particularly effective in identifying malignant lesions, reducing the likelihood of false negatives which are critical in cancer diagnosis. Rajpurkar et al. (2017) reported an AUC-ROC of 0.96 for pneumonia detection using their CNN model. The model outperformed radiologists in sensitivity, highlighting its potential to assist in clinical decision-making. CNNs are highly effective for tasks involving medical imaging, offering strong predictive performance. However, their reliance on large, labeled datasets and issues with interpretability limit their widespread clinical adoption.

RNNs, especially LSTMs, are used for analyzing sequential data such as EHRs. Lipton et al. (2016) demonstrated that LSTMs could predict the onset of diseases like heart failure and chronic kidney disease with an accuracy ranging from 85% to 90%. The model's ability to capture temporal patterns in EHR data contributed to its strong performance. The RETAIN model by Choi et al. (2016) achieved an AUC-ROC of 0.87 in predicting the next diagnosis and treatment for patients. The model's attention mechanism improved interpretability, allowing clinicians to understand the factors influencing predictions. LSTMs and RNNs excel in handling time-series data, making them suitable for disease progression modeling. However, their performance can degrade with long sequences, and they remain less interpretable compared to traditional models.

Autoencoders and GANs have been explored for disease prediction, particularly in unsupervised learning settings. Sakr et al. (2018) used VAEs to predict the onset of chronic diseases like diabetes with an accuracy of 82%. The VAE's ability to learn compact representations from EHR data allowed for early detection of disease patterns. Che et al. (2017) showed that using GAN-generated synthetic data for training improved the accuracy of disease risk prediction models by up to 5%, particularly in cases where labeled data was scarce. Autoencoders and GANs offer promising results in feature learning and data augmentation. However, their complexity and the challenges associated with training these models, such as mode collapse in GANs, limit their practical application.

Transformers, with their self-attention mechanisms, have shown potential in disease prediction tasks involving sequential data. Song et al. (2020) reported that a transformer-based model achieved an AUC-ROC of 0.92 in predicting clinical outcomes from longitudinal patient data. The model outperformed traditional RNNs, especially in capturing long-range dependencies in the data. Transformers offer superior performance in handling complex, sequential data, making them ideal for predicting disease progression and outcomes. However, their high computational cost and need for large datasets are significant drawbacks.

When comparing the performance of these deep learning models, several trends emerge. CNNs are the leading choice for medical image analysis due to their ability to automatically learn spatial hierarchies. They perform exceptionally well in tasks such as cancer detection and radiology. For tasks involving time-series data, such as predicting disease progression or patient outcomes, LSTMs and transformers are more effective due to their ability to capture temporal dependencies. Autoencoders and GANs are valuable for unsupervised learning and data augmentation, particularly in scenarios with limited labeled data. However, their complexity often requires careful tuning and expertise.

One of the most significant challenges across all models is the “black box” nature of deep learning, which makes it difficult to understand how predictions are made. This limits their trust and adoption in clinical settings. Deep learning models typically require large amounts of labeled data for training. In medical applications, obtaining such data can be challenging due to privacy concerns, ethical considerations, and the cost of annotation. Models trained on specific datasets may not generalize well to different populations or healthcare settings, leading to variability in performance. Deep learning models, particularly transformers, require substantial computational power for training and inference, which can be a barrier to their implementation in resource-constrained environments.

Despite these challenges, the results indicate that deep learning models hold significant promise for disease prediction. Developing more interpretable models or post-hoc explanation techniques will be crucial for gaining clinician trust and ensuring the ethical use of AI in healthcare. Techniques such as transfer learning, federated learning, and synthetic data generation (e.g., using GANs) can help overcome data limitations. Ensuring that models can generalize across different populations and healthcare settings is essential for broader clinical adoption. Research into more efficient model architectures and hardware acceleration (e.g., using GPUs and TPUs) will be important for making deep learning more accessible in clinical settings.

CONCLUSION AND DISCUSSION

The analysis of deep learning methodologies for disease prediction demonstrates the significant potential and versatility of these techniques in the healthcare domain. Deep learning models, particularly those based on neural networks, have shown remarkable success in accurately predicting a wide range of diseases, often outperforming traditional machine learning methods. The ability of deep learning models to automatically extract complex patterns and relationships from vast amounts of medical data, such as imaging, genetic information, and electronic health records, is a key factor in their success. Moreover, the continuous advancements in computational power and the availability of large datasets have further fueled the development and deployment of these models in real-world clinical settings. This progress not only enhances diagnostic accuracy but also enables the early detection of diseases, which is crucial for improving patient outcomes.

Deep learning models require large, high-quality datasets for training. However, in the medical field, data can be noisy, incomplete, or imbalanced. Ensuring the availability of diverse and representative datasets is critical for building robust models. One of the primary concerns with deep learning models is their "black-box" nature, which makes it difficult for clinicians to understand how predictions are made. Efforts to improve the interpretability of these models are essential to gain the trust of healthcare professionals and ensure that predictions are reliable and actionable. Deep learning models may perform well on the data they are trained on but struggle to generalize to new, unseen data, particularly when there are differences in demographics or clinical settings. Addressing biases in the training data and developing models that can generalize across populations is crucial. The deployment of deep learning models in clinical practice raises regulatory and ethical issues, particularly regarding patient privacy, data security, and the potential for algorithmic bias. Clear guidelines and regulations are needed to ensure that these models are used responsibly and ethically. For deep learning models to be truly impactful, they need to be seamlessly integrated into existing clinical workflows. This includes ensuring that predictions are delivered in a timely manner and in a format that is easily interpretable by clinicians. In conclusion, while deep learning methodologies hold great promise for disease prediction, their successful implementation in healthcare requires addressing these challenges. Future research should focus on improving model interpretability, ensuring data diversity, and developing frameworks for the ethical and responsible use of deep learning in clinical practice. By overcoming these hurdles, deep learning can become a transformative tool in the fight against diseases, leading to better patient outcomes and more personalized healthcare.

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"DocWise" A Centralized Application

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ABSTRACT

The field of technology witnessed an upsurge in India quite significantly after the year 2019 due to the advent of smart devices that have seamlessly integrated into daily lives of people. The proliferation of these technologies has led to an explosion of digital platforms offering a wide range of services. However, this digital abundance has also created a challenge of navigating and managing the sheer volume of information has become increasingly difficult for the average user. Despite India's literacy rate, many citizens still face significant language barriers, complicating their ability to access and understand crucial information that is needed for accessing the services provided by government or any other organizations. These communication hurdles are particularly challenging in a country as diverse as India, where effective dissemination of information across different languages remains a challenge. To address these issues, we propose the development of DocWise, a centralized, multilingual platform designed to simplify access to government or any other organizational documents and schemes. By offering real-time updates and an user-friendly interface, DocWise aims to bridge the communication gap between government bodies and the public, ensuring essential services are accessible to all, regardless of language or technical proficiency.

KEYWORDS *: Firebase authentication, OpenAI, Chatbot integration, Language translation API, AI-driven interaction.*

INTRODUCTION

In the wake of India's technological boom post-2019, the internet and smart devices have become integral to daily life [1]. The average individual now possesses at least one device with a stable internet connection. As a result, a vast array of platforms—whether apps, websites, or digital centers—has emerged to cater to nearly every conceivable need. While these digital resources have provided unprecedented access to information, they have also inundated the public with an overwhelming volume of data. Keeping pace with this constant influx of information has become increasingly challenging. Despite this, India's literacy rate stands at 74.04% (2011) for adult literacy rate and 82% (2001) youth literacy rate [2], yet a significant portion of the population still struggles with fluency in both English and their native languages [3]. This linguistic barrier exacerbates the difficulty of effectively communicating essential information from sources to the intended beneficiaries.

In recent years, the Indian government has made commendable strides in digitizing its services, particularly in the provision of government documents and the implementation of various schemes [11]. Traditionally, accessing these services required visiting offline centers that were dedicated to specific schemes or documents. However, there has been a gradual shift from these offline processes to digital platforms. Today, many government services, such as document creation, registration, and even Know Your Customer (KYC) procedures, can be completed online. To further streamline access, specialized platforms have been developed to centralize these services. However, given India's vast and diverse population of 1.4 billion people [2], this transition has not been without its challenges. The sheer scale of the population and the diversity of linguistic and cultural backgrounds have rendered the current digital infrastructure somewhat ineffective, leading to a variety of issues in the dissemination of information.

At present, several challenges hinder the systematic approach to publicizing government documents and schemes. These challenges include:

i. Miscommunication/Misleading Information: Inaccurate or poorly communicated information can lead to misunderstandings or incorrect actions by the public.

ii. Confusion: The complexity of information and the lack of clear instructions can cause confusion among users.

iii. Language Barriers: The diversity of languages spoken across India creates significant communication challenges, as not all users are proficient in the languages in which information is provided.

iv. Lack of Knowledge: Many people are unaware of the availability of certain schemes or documents, or they do not know how to access them.

v. Unstructured Information: The absence of a coherent structure for presenting information can make it difficult for users to find and understand what they need.

vi. Missed Deadlines: Due to the aforementioned issues, individuals may miss important deadlines for applications or renewals.

vii. Real-Time Data Updates: The current system often fails to provide real-time updates, leading to discrepancies between the information available and the actual status of schemes or documents.

To address these challenges, we are proposing the development of a centralized, structured, informative, simplified, and user-friendly platform called DocWise. This application is designed to provide a comprehensive approach to managing government documents and schemes. DocWise will offer a detailed breakdown of document requirements, eligibility criteria, and processing timelines. Additionally, it will be connected to a real-time database to ensure that users always have access to the most up-to-date information. By centralizing this information and making it easily accessible, DocWise aims to act as a stable medium that facilitates the smooth transmission of data from authorized government platforms to the public. Ultimately, our proposal for DocWise seeks to bridge the gap between the government and beneficiaries, ensuring that everyone can access the services they need with ease and confidence.

PURPOSE OF DISCOVERY

The innovation we are working on is an application of DocWise, through which citizens will have clear and exhaustive guidance on how to prepare basic documents and steps to apply for government schemes. Rather than being a repository of documents, DocWise will function more like a facilitator, breaking the processes of document preparation and scheme application into step-by-step instructions in detail. The app will provide step-by-step guidance, make the users knowledgeable about procedures, required documentation, and eligibility criteria for obtaining benefits. Thus, with such structured help provided by the proposed DocWise application, one can manage to complete their applications independently, hence giving them much more confidence in moving within the bureaucratic landscape and thus increasing their success chances.

LITERATURE SURVEY

Table. 1 Literature Survey

Author(s) and Year	Title of Study/Article	Key Findings/Contributions	Relevance to Current Work
Dr. Anil Rajput, et al. 2013 [2]	Significance of Digital Literacy in E-Governance	E-Governance and Digital Literacy relations	Highlights the need for improved digital literacy to enhance the effectiveness of platforms like DocWise.
Meblu Sanand Tom 2021 [9]	Multilingualism in India	Importance of communication and education in regional language	Underlines the importance of addressing language barriers, which DocWise aims to tackle.

Digital India Corporation (DIC)Ministry of Electronics & IT (MeitY) Government of India (Reference site from govt. of India) [11]	Centralized platform for schemes in India	i. Giving us platform to study how can improved and make more useful ii. Real-time data updates on user engagement with government schemes is less now not updated new schemes.	i. Supports the centralization strategy used in DocWise for better service delivery by application that can easily operate. ii. We are continuously get eye on updates and try to make real-time fast data updating that help to people to access.
Dr. D. Moorthy, et al. [5]	A Study on Awareness of Central Government Schemes for the Sustainable Development of Rural India with Reference to Coimbatore.	Awareness of Central Government Schemes.	We are solving problem by giving the awareness about all schemes by DocWise application.

PROPOSED METHODOLOGY:

Problem Addressed by DocWise: We are proposing the creation of DocWise, a platform designed to simplify the complex process of accessing and applying to government and private schemes through a single, user-friendly interface. The current landscape is too fractured to provide cohesion; existing apps are either too narrowly focused or not user-friendly, forcing users to switch between platforms. DocWise aims to fill this void by offering comprehensive information in multiple languages, presented in a manner that is easily readable and accessible to all classes and sections of society.

For instance, while awareness of the 'Ladki Bahin' scheme has spread, the number of beneficiaries remains low due to the cumbersome application process and language barriers, which make it nearly impossible for many to apply for these benefits. This situation often forces people to rely on paid services for something they could easily manage on their own if they were better informed. Similarly, the 'Gyan Jyoti Savitribai Phule' scholarship scheme is underutilized due to a lack of awareness and proper application guidelines, particularly among students living in hostels. These examples highlight the real and prevalent issue of inaccessibility, which DocWise seeks to address by providing a simple, multilingual platform that empowers users to apply for schemes independently.

Implementation Challenges: Through our brainstorming sessions, we have identified several challenges that could arise in the development of the proposed DocWise application. One of the key issues is the difficulty in creating a centralized database due to the autonomy of government departments and their limited readiness to share data. Challenges in acquiring reference data that can used for schemes and documents. Particularly in deciding on a technology stack that is both scalable and sustainable. Furthermore, the inability to thoroughly test the application due to restrictive permissions is expected to slow down the process. However, despite these challenges, early evaluations suggest that the concept of DocWise holds promise, warranting further exploration and refinement.

How this above technology is implemented

Flutter in DocWise

We propose to use Flutter in the "DocWise" application for UI design and page state management. The most important advantage of using Flutter is that the application can work across browsers, Android, and iOS operating systems without any glitches. By leveraging the widget-based architecture of Flutter, development can be expedited, and the hot reload feature will allow real-time UI changes during development. Flutter offers high performance and efficiency due to its direct compilation into native machine code. It also natively supports Material Design with Cupertino widgets, ensuring a consistent, attractive look across all platforms [12].

Flutter was chosen because it eliminates platform barriers; the app can be developed with a single codebase and deployed across different devices without the need for separate code bases. This approach not only accelerates the development process but also ensures a consistent user experience. The ease of implementation and the ability to generate fast results make Flutter an ideal choice for application development in a project like DocWise.

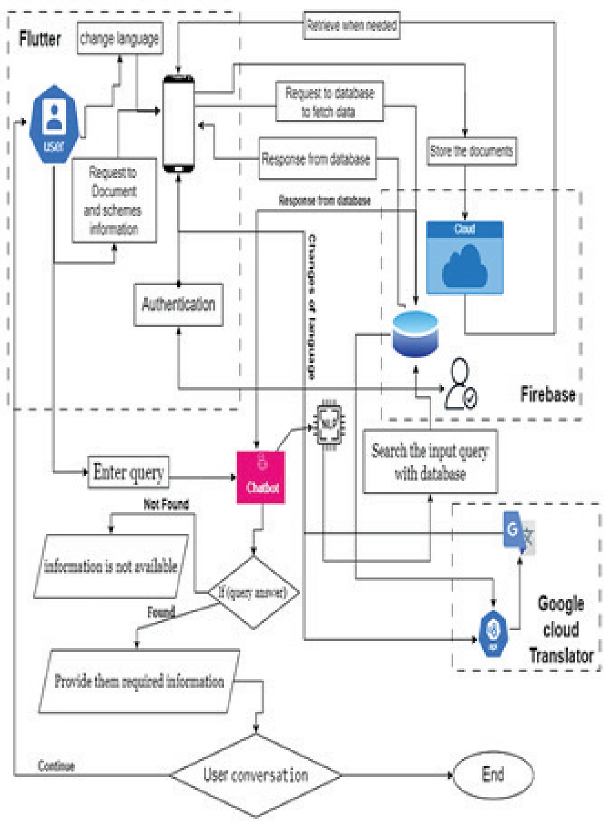

Fig. 1 Proposed system of DocWise

Firebase in DocWise

Firebase is proposed to serve as the backend for the DocWise application. We intend to use Firestore to store and manage data about schemes and documents. As a cloud-based, real-time database, Firebase supports dynamic data handling, allowing users to access or update information from remote devices seamlessly. Integrated Firebase analytics tools will be used to measure data features, enabling users to optimize the application's performance [13].

Firebase has been selected due to its capability to support a robust, scalable, real-time data-manipulating application, which is crucial given the high levels of constant updating and remote data management required in DocWise. Its ease of integration with fully-fledged cloud services makes it a very feasible option for back-end development.

OpenAI in DocWise

OpenAI is proposed to be integrated within DocWise as a chatbot, which will communicate with users by providing them with the required information. The application will utilize a database connected to the OpenAI model, enabling the chatbot to generate relevant responses based on user inputs. This integration aims to enhance interactivity and improve the application's effectiveness in delivering information to users quickly and accurately [14].

The OpenAI chatbot was chosen to avoid the complexity and time consumption associated with developing a chatbot from scratch. By integrating OpenAI, DocWise will offer a mature, AI-driven interaction, further enhancing user experiences with rapid responses to queries.

Google APIs in DocWise

"DocWise" proposes to use various Google APIs, with a primary focus on the language translation API to support multiple languages. This integration will enable the application to convert content into regional languages, thereby increasing accessibility for users. Additionally, the Google Maps API is being considered for future enhancements, which will help users locate nearby centers and access relevant information [15].

Google APIs were selected to address language barriers that many users may face when accessing information. This integration simplifies the translation process, allowing users to interact with the application in their preferred language. The seamless compatibility with Flutter and Firebase further ensures easy integration and reduced maintenance efforts.

MARKET POTENTIAL

The market potential for DocWise has been strongly validated through extensive surveys and research conducted among various target groups, including students, net cafes, and educational institutions. Our surveys, particularly within our college, revealed a significant gap in awareness and knowledge among students regarding the government schemes and benefits available to them. Despite the government's ongoing efforts to support education through various initiatives, many students remain unaware of these opportunities, leading to missed chances for crucial financial and academic support. This lack of awareness highlights a pressing need for a solution like DocWise, which can bridge this information gap by providing clear, accessible guidance on how to access these benefits.

Further research conducted through discussions with net cafe operators in Amravati revealed widespread frustration among staff who frequently encounter users who lack a basic understanding of the procedures involved in document creation and scheme applications. This not only leads to inefficiencies but also results in negative experiences for both the users and the service providers. Cafe operators expressed a strong need for a tool that could educate users and streamline these processes, reducing confusion and improving the overall experience.

These findings underscore the urgent need for an application like DocWise, which has the potential to significantly improve the document acquisition process across India and beyond. By addressing the identified gaps and frustrations, DocWise is poised to meet a widespread demand in the market, catering to the needs of students, net cafes, educational institutions, and other stakeholders involved in bureaucratic processes.

CONCLUSION

In conclusion, the technological advancements since 2019 have revolutionized access to information and services on digital platforms in India [1], making interactions with government services more accessible than ever before. However, this progress has also introduced challenges such as information overload, language barriers [10], and difficulties in accessing reliable government resources. DocWise addresses these challenges by providing a centralized, multilingual platform that reimagines how citizens retrieve government documents and access schemes. With real-time updates in multiple languages, DocWise effectively bridges the communication gap between government bodies and the public, ensuring that essential services are accessible to all citizens, not just those fluent in official languages or technologically adept. This platform holds the potential to significantly enhance the efficiency, transparency, and inclusivity of government services, fostering a more equitable and connected society across India's diverse population.

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Machine Learning Techniques for Financial Cybercrime Detection: A Survey

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ABSTRACT

Financial cybercrime is critical threat for banking transactions which leads to poor integrity and security of financial institutions in the world. The rapid growth of cyber threats needs advanced and proactive detection mechanisms to protect sensitive financial data and customer assets. This paper examines the application of machine learning techniques in the detection of financial cybercrime and fraud within transactions in financial institutions by using an amalgamation of supervised and unsupervised learning algorithms to identify patterns and deviations that indicate fraudulent acts. The approach includes transaction data preprocessing, feature extraction and machine learning models such as Random Forest, Decision Tree, Logistic Regression and Gradient Boosting Machine. Models are evaluated based on metrics, including accuracy, precision, recall, F1 score, and surface below the receiver operating characteristics curve. In addition to those techniques such as over sampling, under sampling and ensemble methods to address class inequality issues that are often present in fraud detection data. Previous experimental results imply detection in financial institutions by machine learning models can rapidly increases and with higher robustness and accuracy. These findings really pinpoint the role of machine learning in acting as a strong tool within the continuous fight against financial fraud, while proving the importance of integrating such technologies into the existing security infrastructures of banking systems. Other future research directions also include embedding real-time detection capabilities and a consideration of deep learning techniques to further enhance detection rates and reduce false positives.

KEYWORDS *: Financial cybercrime, Fraud detection, Machine learning, Prediction, Random forest.*

INTRODUCTION

Financial cybercrime presents a substantial menace to the confidentiality and integrity of transactions in banking and finance, which has serious risks for the banking sector everywhere. As a way maintain confidential banking data and client property, it is essential to employ comprehensive detection mechanisms because of a rapid rise in online threats.

Traditional methods of identifying fraud, which usually rely on human inspection and systems based on predetermined standards or rules, are becoming inadequate to deal with the evolving nature of cybercrime. The traditional methods have limitations due to their static features and inability of adapting to newer fraud patterns.

Machine learning provides a data-driven approach to detecting complex patterns and anomalies in financial transactions, thus being effective in recognizing fraudulent activities. This research investigates the performance of some machine learning models in detecting financial cybercrimes, including classic models such as Random Forest, Decision Tree, Logistic Regression, and Gradient Boosting Machine. The steps include data pre-processing, feature extraction, and model evaluation metrics such as accuracy, precision, recall, F1 score, and AUC-ROC. Techniques of oversampling, undersampling, and ensemble methods are used to handle the class imbalance problem inherent in fraud detection datasets. The results of this work prove that ML might become a very powerful tool in the fight against financial fraud and, thus, should be implemented within the security frameworks of all financial institutions. This paper is structured as follows: Section II presents a review of current research studies related to ML in fraud detection and highlights some of the challenges and limitations. Section III describes various types of financial cybercrimes and their impacts, while Section IV describes the detection methods in depth. The discussion of research gaps and future directions is presented in Section V. The paper summarizes the key findings in Section VI and discusses implications for both researchers and practitioners. References list sources cited in this work.

LITERATURE REVIEW

Machine learning algorithms have been applied with in diversified fields [1]-[4]. These algorithms have been adapted and further used by authors, researchers, and practitioners in an attempt to come up with a computerized system that would provide early detection and fraud prevention [5]. In recent times, fraud activities have been increased appreciably, and the importance given to fraud detection measures has been of higher magnitude accordingly [6].

Machine learning has proven its success in detecting fraudulent transactions and classifying them. The large number of transactions makes it possible to develop and test fraud classifiers [7]. While supervised learning has much success in identifying fraudulent activity, technological capability for transactional fraud analysis will continue to evolve [8]. Even slight improvements in the performance of classifiers can result in huge savings for corporations. Hence, in this direction, continuous research and development can contribute much to reducing the costs incurred by corporations fighting fraudulent transactions [9].

Among the challenges that researchers highlight in fraud detection, the prominent ones are imbalance in the dataset, where fraud instances are a small portion, hence not leading to effective model training [10]. Similarly, corrupted data with overlapping patterns complicates the detection. Also, since fraud continuously evolves, adaptive classification algorithms are preferred as a fixed model quickly becomes outdated [11].

There are several studies on the automation of fraud detection [12]. The researchers presented an in-depth study on the application of ML techniques on the detection of money laundering in financial transactions. They concluded that when supervised learning is used with labeled dataset the performance increases. While unsupervised learning only revealed patterns of fraud and anomalies in the data and, in other cases, the model provides false positives. Work by Han et al. [13], in 2021, considered the shortcomings of classic AML approaches and evaluated the possibilities of AI for fraud detection and prediction. They conclude that methods such as anomaly detection, clustering, classification, and predictive modeling improve the efficiency of AML but at the same time require very careful implementation and monitoring for ensuring ethical robustness.

Rieke et al. [14], in 2020 addressed fraud detection using behavioral analytics and discussed the inefficiency of traditional rule-based methods against sophisticated mobile payment fraud. They then proposed a machine learning framework that leverages process behavior analysis in finding fraudulent transactions more accurately. In 2021, Zhdanova et al. [15] shared the same thought that machine learning, especially network analysis, efficiently uncovers links in money laundering networks even with small, suspicious transactions.

There is a huge amount of research dedicated to financial fraud detection. West and Bhattacharya [16] presented a comprehensive survey on the intelligent techniques of financial fraud detection. Also, Hajek and Henriques [17] present a comparative study of techniques of machine learning to detect financial statement fraud by text mining of corporate annual reports. Also researched the risk factors for financial fraud, which identifies that pressure or incentive to conduct the fraud is the most important risk factor [18].

Financial fraud can be categories as (i) account takeover fraud, (ii) payment fraud and (iii) application fraud [19]. They identified four critical fraud channels: physical, web, telephony, and mobile. Since mobile payment services have gained significant momentum in recent times, issues relating to fraud in mobile transactions present themselves as one of the major challenges [20]. Mobile malware, for instance, SMS-based attacks, needs to be dealt with due to the diversity of the mobile software and hardware platform [21].

It is well known that all the classical machine learning techniques, whether supervised or unsupervised, suffer from an extreme class imbalance problem since they usually give a very high overall accuracy by favoring the majority class (legitimate) [22]. This is not different even for the deep learning models of deep belief networks and restricted Boltzmann machines. In an attempt to overcome this challenge, under-sampling was applied in an effort to balance datasets before training [23]. However, under-sampling can lead to loss of useful data, decreasing detection accuracy [24-26]. Alternatively, isolation-based methods approximate the data distribution to generate fraud detection models, among others, successfully applied in [27].

OVERVIEW OF FINANCIAL CYBERCRIME

Financial cybercrime comprises unlawful acts performed using computers or electronic means aimed at financial institutions, banking systems, and consumers. This consists of an extensive spectrum of unlawful actions intended for stealing money, influencing transactions, or obtaining unauthorized access of highly confidential financial information. The financial cybercrime can be of any forms such as online banking fraud, credit card fraud, investment scams, Ponzi schemes, identity theft, ransomware attacks, insider trading, cryptocurrency fraud, money laundering, business email compromise (BEC).

Impact

1) Economic impact: Financial cybercrime can enormously affect financial institutions, may cause direct financial losses, operational costs, and reputational damage. Insurance premiums against such risks are bound to increase for institutions. A spoiled reputation takes much time and resources to rebuild. Failure to comply with data protection and cybersecurity provisions of the law may result in regulatory fines and penalties. High-profile cases of cybercrime can erode investor confidence to an extent where stock prices move and market stability is affected.
2) Social Impact: This may further contribute to huge personal losses and stress, result in financial instability and hardship. Most times, it has emotional and psychological suffering, loss of trust, and broader impacts on society. Cybercriminals mainly aim at the most vulnerable populations, which digitally widens the gap and causes financial problems. It is estimated that the security of financial systems and institutions is crucial in holding up economic stability and securing public confidence. In general, the financial crisis puts forward a case for proper security operations to ensure protection of individuals and their communities from cybercrime.

Challenges

These fraud detection systems are crucial in the prevention of various fraud cases, yet major challenges also face their implementation and maintenance. Advanced attack types, including spear phishing, polymorphic malware, and social engineering, make the detection process difficult. Zero-day exploits that crop up through previously unidentified vulnerabilities further challenge conventional systems. The volumes in the transactional data are high, hence making it difficult to distinguish between normal and abnormal behaviors. The question of sensitivity to balance is very delicate since too high sensitivity would result in false positives, while too low sensitivity would mean not realizing or noticing fraudulent activities. It further exacerbates the class imbalance problem of fraudulent transaction detection, which is already rare in the dataset. Poor data quality and complexity regarding compliance with various privacy laws, such as GDPR and CCPA, are further challenges. Upgrading these legacy systems is additionally highly expensive and resource-intensive. Moreover, lack of standardization, along with human-related factors like insider threats and insufficient training, are very serious risks.

METHODOLOGIES

The process of detection is complex, as it aims to spot and prevent unauthorized or fraudulent activities in financial systems. Because of these complexities, and due to the growth in cyber threats, a number of methodologies have been developed and further worked on to enhance the effectiveness in the area of detection systems. Below are some major methodologies involved in financial cybercrime detection.

Detection Techniques

Many methods have been developed in previous studies. for detecting cybercrime events. The major categories for these are as follows,

Traditional Techniques

1) Rule-Based Systems: Rule-based systems for financial cybercrime detection work by applying predefined rules in such a manner so as to be able to spot irregular activities, like big transactions or transactions made at an unusual time of the day. They are straightforward in terms of implementing the given rules to flag off well-known fraud patterns. However, they have some drawbacks, too. They are not flexible and cannot become adjusted to new types of fraud; they require updates and maintenance quite frequently; and they often incur high false-positive rates, which means many investigations that are not required are conducted. As a result of this, though rule-based systems are helpful in the initial detection effort, they are usually supplemented or replaced with more sophisticated techniques, like machine learning, able to enable their work in comprehensive fraud detection.

2) Manual Audits: Manual audits involve a human analyst tediously sifting through transactions and financial activities in search of possible fraud. This technique is highly dependent upon the experience, intuition, and expertise of senior auditors; hence, it is usually very accurate, especially in the case of big elusive fraud schemes that automated systems probably would not notice. Manual audits cause more time consumption and it is more labor-intensive; hence, this method is impractical when dealing with large volumes of transactions. Moreover, their results are impounded with human error and bias, making them even less reliable. While successful manual audits may be suitable for certain purposes, their limitations do call, in most cases, for the use of automated and more scalable methods of detection, such as rule-based systems and machine learning techniques, which complement and improve fraud detection.

Machine Learning Techniques

Machine learning techniques have revolutionized the detection of financial cybercrimes by making it possible to analyze large quanta of data and recognize complex patterns that might miss when tried with techniques which uses conventional approach. Figure 1 shows the taxonomy of financial fraud detection techniques [28].

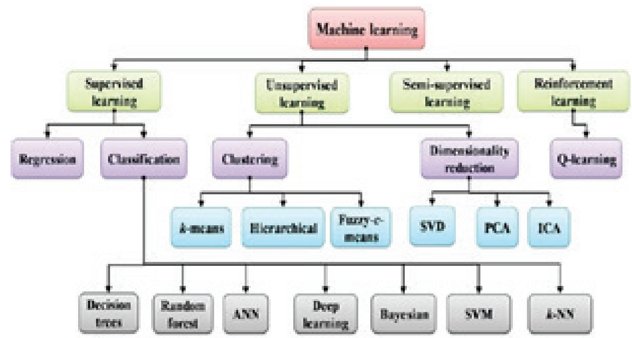

Fig. 1 Taxonomy of Financial Fraud Detection Techniques

1) Supervised Learning: In supervised learning, models are trained on labeled datasets in which every example is an input-output pair. The model learns to relate inputs to corresponding targets. Traditionally, one would first divide the dataset into a training and test set, where one optimizes the model parameters by using a process like gradient descent to minimize any differences between actual predictions and desired outputs. This ideally can make the model predict on previously unseen observations. A few examples of some of these include the following: Decision Trees, Logistic Regression, and Neural Networks. The final performance of supervised learning depends on the quality of labeled data, the relevance of features, and the choice of algorithm.

2) Unsupervised Learning: It is another type in machine learning where model's training is based on an unlabeled dataset and it has to learn patterns and structure of data by its own. The main applications are clustering, anomaly detection, and reduction in dimensionality. Clustering algorithms such as K-Means, group similar points in the input data. techniques for Dimensionality reduction like PCA, which decrease the number of features and retains the essential information about the data. Most fundamentally, unsupervised learning discovers and

exposes the structure underlying the data, making it very useful for exploratory data analysis and preprocessing in complex datasets. This becomes effective based on the innate data structure and how an algorithm is capable of revealing some important insights.

3) Semi-Supervised Learning: It falls under machine learning, where models train and generalize from a smaller labeled dataset combined with a larger quantity of unlabeled data. This would, in turn, make up for the scarcity of labeled data against the abundance of unlabeled data. The methodology uses already available labeled data to guide learning and the abundance of unlabeled data in the identification of additional patterns and structures. Other techniques include self-training, in which the model makes iterative predictions and retraining on unlabeled data; co-training using multiple classifiers against different views of the data; and graph-based methods that propagate the label information through data graphs. This fills the gap between supervised and unsupervised learning; thus, improving models in accuracy and robustness.

4) Reinforcement learning: It is a field where an agent, while interacting with the environment, aims at maximizing its cumulative rewards. Some of the basic concepts in this context are agent, environment, state, action, reward, policy, value function, and Q-function. Here, an agent needs to explore new strategies to discover an optimal balance between exploration and exploitation. Often, it is treated as MDP. Q-learning and SARSA are some of the popular algorithms, and one of the deep approaches is DQN, which uses neural networks in value estimation.

Feature Engineering

Feature engineering is all about refinement and creation to improve the performance of the machine learning model. The first step to begin with is the cleaning of data, where missing values, outliers, and erroneous data are handled so that quality input may be fed to the model. Subsequently, Feature Selection identifies only those most relevant based on correlation analysis and mutual information. This improves model simplicity and reduces overfitting, enhances interpretability. Feature Transformation normalizes the features to capture the underlying pattern in the data. Usually, normalization or log transformation in this regard is performed which scales variably and also helps the model learn better. Feature Creation includes new informative features creation from the current ones which include interaction terms or aggregations, which avail more context to the model for differentiating between fraud and non-fraud classes effectively. All these steps put the data in the best shape so that the model does the job of prediction precisely and robustly.

Models in Machine Learning

1) Logistic Regression: Logistic regression, in statistics, is the method of forecasting the occurrence of events by using one or more predictor variables. Generally, in machine learning, it has been used for solving classification problems that involve two or more classes. The ultimate objective here is to model the relationship of the predictor variable with the likelihood of occurrence of an event or outcome. The relation is expressed mathematically with the help of a logistic function or sigmoid that maps real-valued entries to values between 0 and 1 [29].

2) Decision Trees: Decision trees are actually among the most popular supervised learning algorithms used both for classification and regression problems. They create a flowchart-like model that splits data into subgroups based on various attributes with the goal of forming homogeneous subsets concerning the target variable. Splits are normally done based on certain criteria, usually metrics of homogeneity or impurity of the subsets. This produces a tree structure with internal nodes, which represent decisions about features, and leaf nodes, which represent the predicted class or value [30].

3) Random Forest: One of the most well-liked ensemble learning methods that have been applied to classification and regression applications includes RF. It combines several decision trees to come up with predictions, which are far much more accurate. The algorithm builds an ensemble of decision trees where a collection is created; each of these trees is trained on a bootstrap sample-a subset of the training data. Moreover, at each branch in the tree, a random sample of features is considered

as a splitting criterion. In this respect, because of the randomness, trees will be more diversified and robust to reduce overfitting and decorate trees. Every time a prediction is made using a Random Forest, each of the trees in that group has got to predict the outcome or value based on its own set of learnt rules [31].

4) Gaussian Naive Bayes: Naïve Bayes: one of the most popular algorithms in classification, is using Bayes' theorem with an assumption of feature independence. It works pretty well with continuous or real-valued features. "Naïve" comes from a premise on conditional independence between features which is usually violated in real-life cases. Nevertheless, Gaussian Naive Bayes is rather effective and computationally efficient in many tasks [32].

5) K-Nearest Neighbors: It is a simple and versatile algorithm for both classification and regression. Generally, it is non-parametric in nature as there is no assumption made about the distribution of the underlying data. So, the algorithm generally assumes that similar data points most probably are of the same class or produce similar results. K refers to the number of nearest neighbours taken in making predictions. This means that it tries to find the K most similar data points—usually using Euclidean distance—to some new data point which is to be classified, or a value to be given within some measure of distance in the training set. The most common thing is usually how far the new point is from all the points in the training set, and then K points having the smallest distances are selected [33].

Evaluation Metrics

Classification model evaluation metrics are essential for understanding model performance.

1) Accuracy: It is the ratio of correctly classified objects-both true positives and true negatives-to total cases. However, accuracy may mislead one in situations of class imbalance, where a model can appear to perform well based on making majority class predictions. Hence, accuracy alone should be supplemented by other measures.

2) Precision: It gives information about a model's ability to correctly identify the actual positives from among the total predicted positives. It is important when the cost of false positives is high, such as in spam detection and medical diagnostics. However, precision does not take into account the false negatives, which may be critical for some applications.

3) Recall or Sensitivity: It is the extent to which the model has captured all actual positive instances-a metric very relevant in domains related to fraud detection or diagnosis of a disease. Because it does not take false positives into account, it always has to be used together with other measures.

4) F1-Score: This metric gives a better balance between precision and recall; therefore, it is normally useful when dealing with imbalanced datasets. It's the harmonic mean of precision and recall. It results in a single value for the model's efficiency but is less intuitive while interpreting.

5) ROC-AUC: It means Receiver Operating Characteristic - Area Under Curve, a metric to check model performance on various thresholds. Because it does not depend on classes, this metric may be taken as class-ignoring. The higher the AUC, the better the discrimination will be in classes. Good when a dataset is imbalanced, it may be too general for applications which need to make decisions on exact thresholds.

RESEARCH GAP AND FUTURE DIRECTIONS

Machine learning, along with other advanced techniques for data analysis, has been one of the recent large steps in the development of financial cybercrime detection. However, there are a number of research gaps and challenges that have to be addressed in order to further improve the efficiency and strength of fraud-detection systems.

Research Gaps

Most of the existing literature focuses on specific aspects of cybercrime detection, such as transaction monitoring or user behavior analysis and normally is not representative of a novel approach that would put together multiple data sources and types. Further gaps exist in terms of integrating more advanced machine learning techniques deep learning and ensemble methods into such systems, which have been very promising but are not well explored and validated in this domain. at the end every little research has gone into real-time detection and prevention mechanisms despite their critical importance.

Future Research Directions

Future efforts should aim at developing full, multifaceted models that will house various data streams, using advanced machine learning techniques. That basically means developing better real-time detection capabilities and incorporating adaptive learning algorithms in ways that make them stay up to date against the threats evolving over time. Moreover, privacy-preserving approaches, like federated learning, have to be considered in order to ensure safety in that regard while seeking improved detection accuracy. Indeed, the way forward will be multi-stakeholder collaborative efforts between academia, industry, and regulatory bodies in solving these challenges toward the advancement of the area of financial cybercrime detection.

CONCLUSION

This paper gives review of various machine learning models and techniques used in the detection of financial cybercrime. These techniques helpful to build a predictive model that will forecast trends in a particular field. The principal models presented in this paper are supervised learning methods: Logistic Regression, Decision Trees, Random Forest and a popular method like Neural Networks. All these models have different strengths and weaknesses, thus they all contribute differently to fraud activity detection. It also through light on unsupervised and semi-supervised learning techniques that come in handy for cases where the labeled data is less. It further discusses the importance of feature engineering by indicating that well-constructed features can significantly improve model performance. Another key focus is how the models will be evaluated, including accuracy, precision, recall, F1-score. These metrics give full details concerning the performance of a model, hence its reliability and effectiveness toward detection. The findings of the survey in this paper may have significant implications for both researchers and practitioners. Researchers will be updated with current challenges issues like data privacy concerns, dynamically changing cyber threats, and class imbalance problems that open up possible future research. For practitioners, this paper can help them to learn from the survey in order to enhance their fraud detection systems, hence improving the safety of the assets and gaining customer trust. The paper emphasizes in its conclusion the pivotal role predictive modeling plays in the detection of financial cybercrime. Some of the challenges that already exist, and new advancements, can be worked on to make more functional fraud detection systems and hence a safer financial environment in the future.

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A Scientific Approach to Conserve the Water Harvesting Model in Ramtek Region

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ABSTRACT

From the ancient times in India, due considerations were given to efficient use of water, lining of canals, constructions of dams and other essential requirements.

These structures were traditionally developed in terms of geography, choice of built environment and functionality. Our ancestors developed the skill without scientific techniques, in this study, Ramtek region takes into consideration for research and divide the area with different zones and to developed Ramtek water harvesting system as a model, with the help of watershed map, base map, toposheets, regional maps, data from NGO's, public survey's, morphometric analysis and corelate it with actual ground conditions to develop a sustainable water harvesting model for all necessary purposes in this area as a Ramtek Model.

KEYWORDS *: Geomatics, Dendritic, SOI, Baori, Morphometric.*

INTRODUCTION

Various allusion to importance of efficient water use so as to reduce the power of water deficiency, etc [1] The conservation of water for various purposes was traditionally worked down by using different harvesting techniques. [2]

To know how important water is Kautilya developed a beautiful system to control water deficiency. [3] Maharashtra falling in Deccan plateau, rich with lakes, and in order to withhold water our ancestors developed techniques by use of topography of the region.

In order to understand, revive and maintain this heritage I select the Ramtek model for the study.[4] It interlinked the surrounding lakes of Ramtek with Khindsi lake with the help of Geomatics. The focus of my study was on the aspects of sustainable development, based on carrying capacity. I identified 15 surrounding lakes of Ramtek to complete the study and find out the interconnectivity of these through surface and underground canals.

Water Status

The annual availability of natural resources like land and water is diminishing. Though water is a renewable resource, it is unevenly distributed and rainfall dependent, while land is altogether finite resource. Annual rainfall and available ground water per capita declined from about 5400 Cu.M in 1950 to just over 2400 Cu.M in 1991, taking India to water stressed countries. [5]

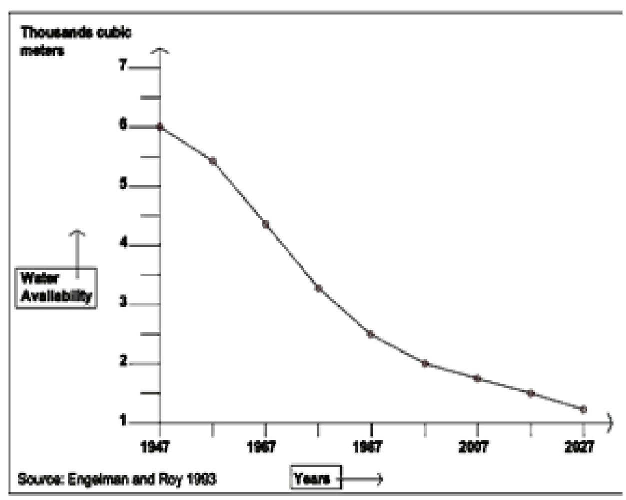
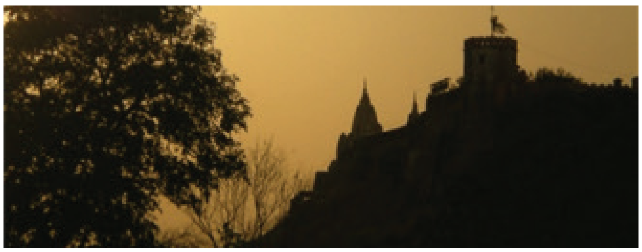


Chart: 1 Status of water [5]

Geomatics: GIS based software which gives the information about natural & manmade resources.

Why Ramtek

Today we are facing very critical problem of water. Many of the Cities and Towns are having drought in summer days. And such good technique is evolved long years back in Ramtek that today we don't found it. So as a Planner consider these issues related to prestigious water and study Ramtek as a good example of water harvesting model system,



Gad Mandir, Ramtek (photo courtesy Author)

Religious and Cultural values of Baoris and Lakes:

Ramtek near Nagpur, known for its supine lakes and beautiful biodiversity and is worshiped as the birthplace of Kavi Kalidasa.

Ramtek is the best example in Maharashtra, based on the unique topography, geology and weather conditions with a scenic flora and fauna, has a series of lakes designed to reaping the storm water. The area is demarcated by metamorphic rock that is having very good strength and ideal for storing water.

Study Area

There are *15 lakes and all these are intrinsically connected through surface and underground canals. [6]

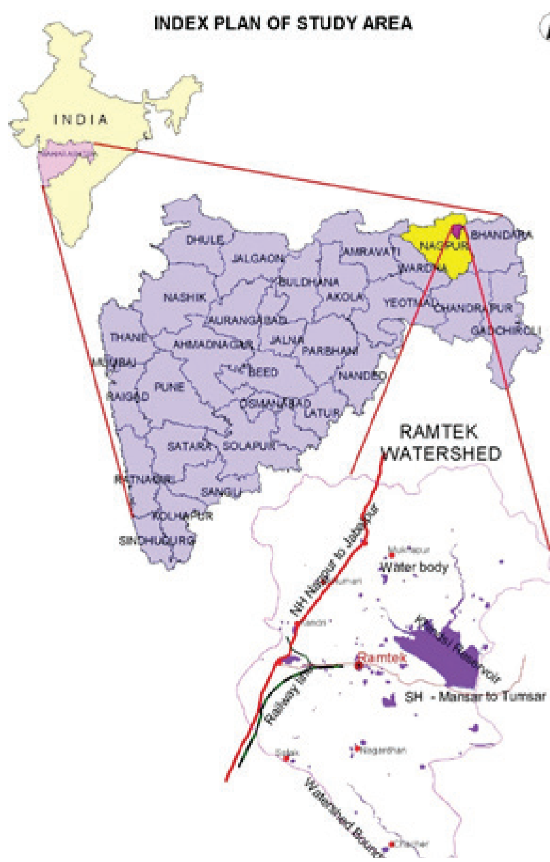
The wells near KHINDSI Lake highlights the fact that water level in wells in the area drops by 1.5-3 M overnight after the water is released from KHINDSI lake.

*List of 15 Lakes:

Rakhi talao	Nagara talao
Chambhar talao	Mahar talao
Chakonda talao	Gahu talao (gautam rishi)
Ambala talao	Kumbhar talao
Hirwa talao	Kathora talao
Sita kund	Kumari ma ki baodi
Ramaleshwar baodi	
Papdupdeshwar	baodi Kapoor baodi

Problem statement

- Increase in urbanization, community awareness and social gathering the lakes lose their water purity.
- The baoris and Kund's are used as trench yard and area for cattle bathing.
- But Most of the current generation residing at Ramtek is not even aware of these tanks.
- So the tanks are towards deteriorating condition.
- Due to religious activities potability of water loosen their characteristic features in the region.



Map: 1 Index Map

Source: Geo-Environmental Resources analysis for watershed ecosystem Development in Ramtek. Source: Nagar parishad, Ramtek.

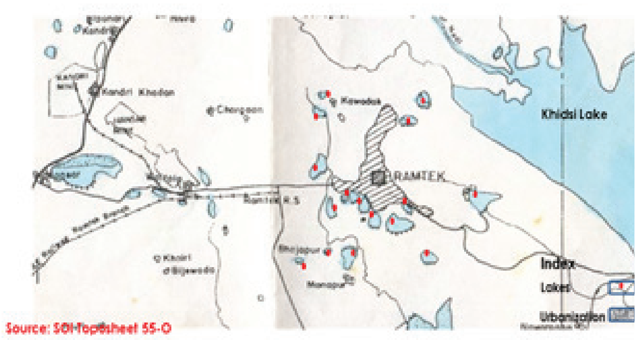
Existing Situation of Baoris (photo courtesy Author)

Existing Situation of Baoris (photo courtesy Author)

Need

With these values there is need to review traditional water management system of Ramtek.

The toposheet of *SOI shows the reaping forms of lakes with continuous water storing structure in and near by Ramtek in Maharashtra: a continuous lakes and ponds developed to stored the seasonal storm water, based on the unique topography and clamorous conditions. An investigation of these designed formation proved that there were some technique through which these bodies were conventionally designed in terms of geology, topography of structure and effectiveness.



Map: 3 Topographical Maps

The surrounding area contains gneiss that is too hard to cut and possess good strength to hold water, but due to atmospheric agencies it an develops porosity and that developed the aquifers to yield water. The depth of such areas varies from very low to 20-30 m below the ground and is the major source of groundwater. Drainage is characterized by a dendritic pattern. The soil in the study area varies in thickness from 250-500 mm, involving shallow depth. [8] The soil is having very low hydraulic conductivity and has a sandy loam to sandy clay loam texture. Water table in the area ranges from 140-170 mm/m of water of soil and the water cradle capacity of the surface is low ranging from of 110-150 mm/m.

Study of Model:

In order to understand, revive and maintain this heritage, 15 tanks were selected for a model study. The study included actual examination of the tank sites, interacting with elders in the local community, land topography and landuse patterns, the local micro climate, factors which control water flow and a scientific analysis of the region. [7]

Map: 4 Base map of Ramtek Taluka (internet)

The climate and physiography of the area led to building of numerous tanks of various dimensions mostly on wastelands. The Ramtek model in reality represents a beautiful connectivity of groundwater and surface water bodies, naturally connected through surface and underground canals. A dramatically developed & design system, stored storm water runoff through tanks, supported by topographically high yielding wells and built forms like Baoris, Kundis and water wholes representing intelligent efforts to channelized and harvest every raindrop falling in the watershed area.

Water force and Local Environment

The lakes and Baoris was designed & developed to maintained by *Malguzars these lakes form a kind of chain, outstretch from foothills down to the plains, conserving about 60-70% of the total runoff.

Once the tank filled with capacity water flowed down to fill successive tanks, through interconnecting channels. This sequential arrangement ended in small water whole to store whatever water remained.

Absence of algal growth & organic matter indicated high dissolved oxygen content necessary for healthy aquatic life, possible by regular inflow and outflow of water, and no stagnation. Today many of these tanks are facing extinction due to negligence and encroachment, and community awareness.

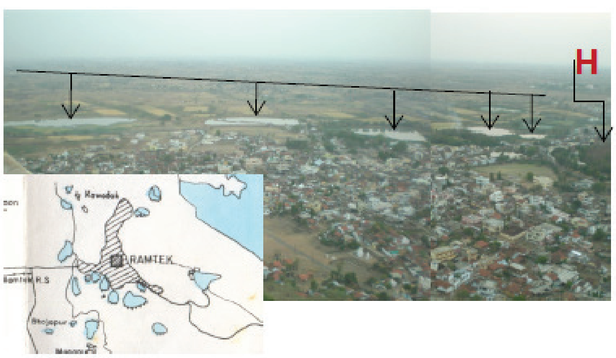


Table: 1 Status of tanks in Ramtek model
(Source: Unraveling secrets – Ramtek Model)

Total no. of Tanks	Total no. of selected tanks	Status		Status of interconnecting channels
		Silted	Non-Existing	
144	15	8	3	7 channels choked by siltation

The main reason of the deterioration of these tanks is a breakdown in the traditions of community management. Now the tanks are under the administrative control of the government which pays little attention to either desilting the tank beds or clearing the choked channels in the catchment areas. This has led to a decline in both quality and quantity of water. But most of the current generation residing at Ramtek is not even aware of these tanks table: 2 show the declining awareness about these tanks.

Table: 2 General Awareness about the Ramtek Model
(Source: Unraveling secrets – Ramtek Model)

No. of respondents	Age group (Years)	Awareness of existing system (%)	Inclination towards revival (%)
18	Below 25	15	12
18	25-50	40	50
24	Above 50	88	94

Variety of conventional water reaping structures flourish in the Ramtek model

The Ramtek model is a system of tanks designed to capture every drop. These baoris resembling the vavs or bavadis of Gujarat and Rajasthan are constructed by digging a central mouth extending to a depth of 20 M to 25 M accessed by steps to the centrally located waterbody. [9] Most of the baoris had inbuilt temple at a depth of 5-10 M from the surface which not only provide platform for religious and social activities. Now a day's religious festivals are still performed around the baoris but it destroys the environment of the surrounding and quality of water.

Kapoor Baodi (photo courtesy Author)

Scientific Proof

A *Morphometric analysis of these water conserving structures was carried out with the help of Toposheets of Survey of India (SOI). It is a function of drainage length, stream frequency, drainage density and other parameters with relation to drainage texture, which helps to categorize the area into zones of broad water regimes. Drainage texture is an important criterion in morphometric analysis and is a function of drainage density and stream frequency.

Map: 5 Watershed map of Ramtek region
(irrigation dept., Nagpur)

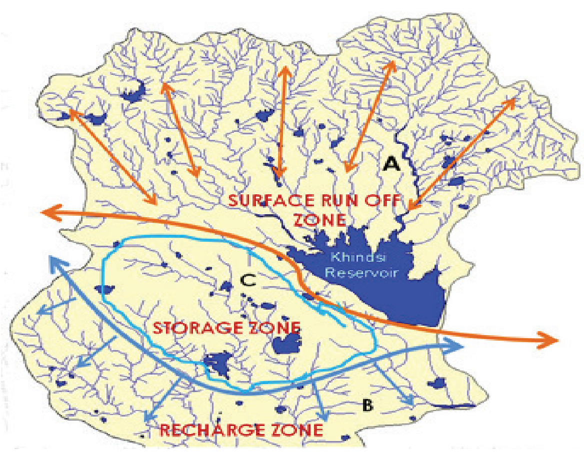
The formulas are given blow to calculate the parameters required for morphometric analysis. [10]

Drainage Density = Total length of drainage streams / Area of Basin

Stream Frequency = No. of streams / Area of Basin

Drainage texture = Drainage Density X Stream Frequency

Drainage texture is inversely proportional to infiltration capacity, which means that more is the drainage texture, less is the permeability, and vice versa. Based on this calculation the area was categorized into surface runoff, recharge and storage zones.



Map no.: 6 Categorized watershed areas
(Source: Geo-Environmental Resources analysis for watershed ecosystem Development in Ramtek)[6]

To perform this analysis, a grid of 400 Ha area was overlaid on the drainage map prepared from SOI toposheet. For each of the individual blocks (drainage basins) various parameters like total drainage length, total figure of brook and the area of drainage basins were calculated and ranked accordingly.

Table: 3 Parameters of Morphometric Analysis
Source: Unraveling secrets – Ramtek Model

Area of Basin (Ha)	Drainage length (M)	No. of streams	Drainage density (km/km^2)	Stream density (Hz)	Drainage texture (km-1)	Rank
400	5,650	4	1.41	1.00	1.41	C
400	7,650	10	1.91	2.50	4.77	B
400	12,900	23	3.22	5.75	18.51	A

According to Rank

The obtained drainage values are plotted on maps and Isolines were drawn (using GIS) for drainage texture values, to separate the entire area into three zones having values less than 2, 2-8, and greater than 8, resp. Based on the values so obtained, the area was divided into three ranks of high, moderate and low.

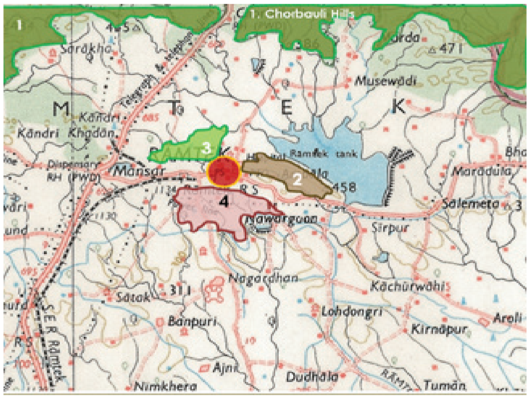
Table: 4 - Value System

Rank	Drainage texture	Characteristics
High - A	Less than 2	**Runoff zone:** Hill topography, thin soil cover, hard rock and higher slope
Moderate - B	Between 2 & 8	**Recharge zone:** Plain country, moderate to deep soil, moderate slope.
Low - C	More than 8	**Storage & discharge zone:** Plain country, thin soil, hard rock

Drainage Texture Values in Ramtek Model Region

Based on this analysis, the research area can be split into four broad physiographic divisions;

1. The Northern stretch consisting of hill ranges of the Chourbauli hills and Forest
2. Middle plain country, extending from Northern foothills to Ramtek-Mansar ridge
3. The abruptly rising Ramtek/ Mansar ridge; and
4. The Southern portions which lie at the foothills of the Ramtek hills and the plains further south.
5. The Southern portions which lie at the foothills of the Ramtek hills and the plains further south.



Map: 7 Physiographic Divisions of Study Area

Source: Survey of India Toposheet no.: 55-O

Traditional Knowledge and Modern science

The abruptly rising Ramtek and Mansar ridges divide the study area into two distinct physiographic plains, with each plain having a different water harvesting system and water and landuse application. Because of the presence of Chorbauli hill ranges the middle plains constitute an ideal site for catching surface water from the two hills and so the Khindsi Lake was constructed.

But due to growing population people mostly depend on ground water. The wells near KHINDSI Lake highlights the fact that water level in wells in the area drops by 1.5-3 m overnight after the water is released from KHINDSI lake. The water level of well near foothill of Northern part gives water throughout the year even in summer days. People used to call it as 'Zinda Kua'.

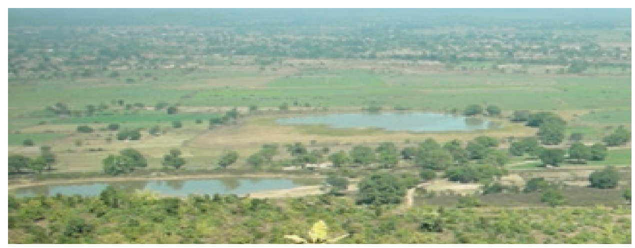
The metamorphic rock having characteristics to hold water. So the well holds water throughout the year and popularized by the name of Zinda Kua.

Photograph shows Zinda Kua of Ramtek at the foot of Ramgiri hill (photo courtesy Author)

Insitu and subsurface sampling

The entire study area is gently slopes towards south, forcing the water (both surface and groundwater) to move along the gradient towards south. Poorly developed water harvesting structures in the middle plains suggest that this area was well served by slopes and streams. The area forms the catchments for Khindsi Lake. Various streams and tributaries originating from the northern hills cross this area and add water to the Khindsi Lake.

A few attempts have been made to trap runoff into small lakes in this area before water flows into Khindsi but the amount of water has not been sufficient to converge the demand of the thriving population and increased irrigation. People in this area have to depend on groundwater resources for most of the time, which in turn is controlled by Khindsi Lake.



Lake Surface Water Harvesting (photo courtesy Author)

Study area SWOT analysis

The characterization of the study area includes;

- Climatic feature assessment for precipitation and runoff.
- Land and water resources characterization for-sedimentation assessment studies for khindsi reservoir.
- Natural resources based on economic indicators like;
- Role of forest for economic resources generation.
- Assessment of urbanization trends in the watershed
- Ramtek is surrounded by sloping terraces having varied ecosystem,
- The SOI toposheet represents that the slope of these terraces is towards south side because of that the runoff of rain water is towards Khindsi lake

- The wells in that area are the best example to store water.
- Having different shapes and depth provides water to everyone residing in Ramtek.

Fig.: 1 Watershed area (unraveling secrets of Ramtek) [6]

- The water level of wells on hill area is 1.2 to 1.5 M having 800 MM diameter that's why it save money as well as power to take out water.
- All the urban population is dependent on these lakes but no one is caring for it and the condition of these lakes are very critical.
- Some people residing near baoris having religious activities like pooja, visarjan, cloth washing etc, it disturbs the water quality.
- People used to through the Garlands and Naivedya in the baoris and the potability of the water is disturbed.

Present condition of Tanks and Baoris of Ramtek model

Exercise

The watershed development plan derives for optimum land and water resources utilization on micro-watershed wise basis. Using the inputs of the watershed characterization exercises and integration of the resources information, decision rules for potential development regions are framed. The local area study, interaction with senior citizens, technical persons and use of globally advanced technology of geomatics has contribute development of a comprehensive decision support system specific to Ramtek watershed. Using the basics of the catchment area the watershed map is prepared.

The specific exercise involved;

Generation of remote sensing based natural resources maps. The cluster of tanks titled 'Ramtek Model' are evaluated with respect to integration of geology, geomorphology, slope and soil to identify and locate potential sites for construction of new tanks in the watershed. The result of complete activity is the preparation of Water resource development plan (WRDP), Land resources development plan (LRDP) and aquifer characterization. These three plans provide to develop the Ramtek watershed as an independent self-sustainable natural unit.

One dam with a catchment of 10 hectares will collect much less water than 10 dams with one hectare catchment each.

Recommendations

Watershed expansion and governance is consolidation of all techniques within the spontaneous limits of a drainage area, for peak expansion of land and water and to get the basic requirement of people of the residing area in a sustainable order.

It is possible only if there is participation by the people directly benefiting from the entire exercise.

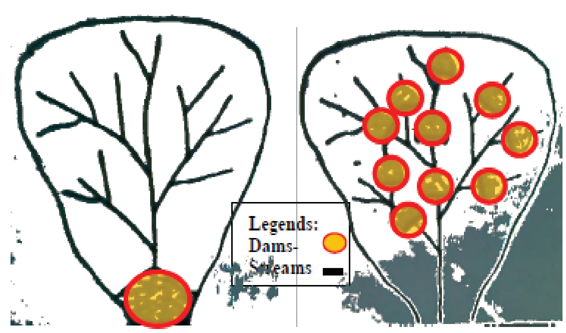


Fig 1:Catchment area 10 Ha Fig.2 Catchment area 10 Ha

Fig.: 2 Catchment Structure

Source: Watershed management – Crop science for agriculture course

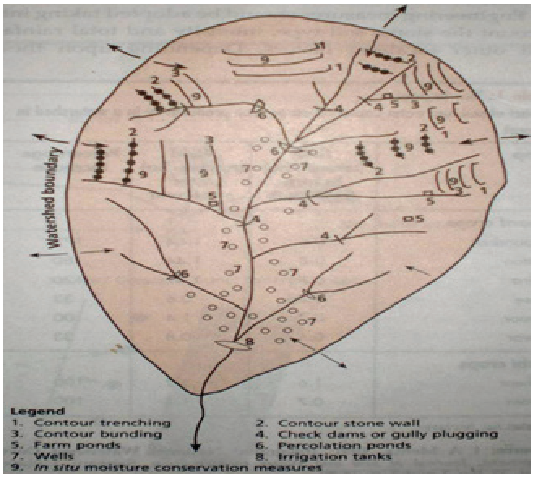


Fig.: 3 Watershed Development Map

Source: Unrevealing secrets of Ramtek [6]

Analysis

The survey of these buil forms indicate that there was some technique in which these lakes were conventionally planned in terms of geology, topography and utility. But, this water harvesting structures, termed as the Ramtek replica, is gradually vanished, due to impassivity and conservation.

Today we are facing the difficulty of water shortage in every town and country, and it becomes a major issue for Planners how to overcome this problem. This study shows how the lakes are connected through surface and underground canals and they fulfill water requirement of the town. It comes to analyze that, due to its topography Ramtek has a unique chain of lakes planned to conserve the storm water. Due to urbanization and industrialization the lakes are destroyed and occupied the surrounding portion by urban villages. The tanks are in a series because of this it conserves 60-70% of the total runoff. Through geomatics it is easy to survey an area and it gives accurate outputs without errors. This approach is time consumable and also it gives various parameters to judge the potential and threats in the Ramtek replica system. Morphometric analysis gives the drainage length, stream frequency and drainage density and on that basis the catchments, channels are to be modified. During this analysis it is observed that the awareness in different age groups about existing water system is limited. So it is necessary to participate the different age group in protecting these water harvesting structure to fulfill the future need. There are various reasons to degrade the traditional water system, like use of pipe lines instead of traditional channel system to provide water from one level to another. To fulfill the requirements of farmers for irrigation small lakes are made so that runoff is trap into that before water flows into Khindsi lake, but the increasing population is depended upon the resources and it cannot fulfill the needs of locals. Study gives geological and topographical parameters of potential area and on that basis the catchment area can be revitalized. It is recommended to revive these structures siltation is must with the help of NGOs, Colleges, and awareness programs in schools, town and fringe areas to know the importance of these lakes in human life. An effective involvement of farmers can occur only if they participate in planning and in decision making process. Thus Farmer's People's Participation should begin at the planning stage itself so that due priorities could be given to the relevant programs.

Water harvesting should be combined with village ecosystem management or watershed development as an important strategy. This will alleviate scarcity in the short run, sustain the growth of income and reclaim degraded lands in providing water security and since water is wealth, it can thus provide food and livelihood security.

CONCLUSION

GIS serve as most effective tool, of the present generation, for the analysis of geo-environment and is helpful in collection of information leading to understand the scenario pertaining to land utilization, soil management and water utilization of area.

The study was done to improve the local environment and socio-economic situation of Ramtek watershed.

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Survey Paper on Smart Wireless EV Charging Station with Dual-axis Solar Tracker

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ABSTRACT

The Smart Wireless Electric Vehicle (EV) Charging Station with a Dual-Axis Solar Tracker is an innovative solution which brings together state of the art solar collector and wireless power transfer technologies at one place to build a feasible, efficient and sustainable EV charging infrastructure. It is helpful in two axis tracking for better screening of the sun and it decreases the shading effect and for maximum utilization of the sun's position and angles it tilts the orientation of the panels throughout the day. The captured solar energy is controlled by a advanced Energy Management System (EMS) that regulates power flow between the in-volume of production solar panels, battery pack and wireless charging unit.

By employing resonant inductive coupling, the wireless charging system provides high-power transfer with minimum loss and because less power is lost through the process than with traditional plug-in systems, it means more efficient energy delivery to boot the integration of IOT.

KEYWORDS *: Sustainable EV charging infrastructure, Dual-axis solar tracker, Maximum utilization, Power flow regulation, IOT regulation, Wireless charging unit.*

INTRODUCTION

Since increasing global demand for electric vehicles, certain charging infrastructure provides a clean alternative to internal combustion engines. With the rise of EVs, there is still a need for better charging infrastructure that is dependable, widespread, and green. This is a site where integration of renewable energy resources, specifically solar power, would be considered as a potential trend to optimize the sustainability future for EV charging stations.

This project concentrates on the performance analysis of a Smart Wireless Electric Vehicle (EV) Charging Station coupled with Dual-Axis Solar Tracker. In simple words the main intention is to use solar energy for charging station so that electricity need will be full filled by renewable and sustainable source of sunlight. While the project does not specify its goals, it is mainly to maximize through a two-dimensional solar tracking system and a university research project is developing solar panels that will track the sun all day to maximize capture of its energy. This dynamic tracking mechanism improves energy yield by orders of magnitude compared to solar panels that are merely stationary.

Real-time monitoring and control based on Internet of Things (IOT) sensors &communications technologies built in charging station. An accompanying app enables users to check the charging status, battery levels and operation of new cylinder head from different locations creating that all-important user control and convenience. In addition, an intelligent Energy Management System

(EMS) ensures the best possible use of the solar stored energy by means of smart charging/discharging scheduling following electric needs improving overall efficiency.

In order to provide more advanced and reliable results, the system runs Artificial Intelligence (AI) or Machine Learning (ML) algorithms. The systems benefit from these technologies and, using prediction maintenance to optimize the solar tracking process by keeps energy management performance efficient according it environmental conditions or hours of use. Ultimately, this project will create a novel and low-carbon technology for pure electric vehicle charging using wireless power transfer incorporated within solar energy harvesting.

LITERATURE SURVEY

The ever-increasing demand for electric vehicles (EVs) has created the need for innovative and environmentally friendly charging structures. When comparing the emerging technologies, wireless power transfer (WPT) and the use of solar energy as potential solutions to overcome the problems associated with the existing charging systems deserve a special attention. This literature survey delves into historical literature to evaluate the existing literature regarding these technologies particularly in the process of developing a Smart Wireless Electric Vehicle Charging Station with a built-in Dual-Axis Solar Tracker. In the process of literature review based on the prior studies, this survey unveiled the progress, issues, and opportunities of developing an efficient WPT and solar tracking-based EV charging system.

This paper highlights the need for consistent power supply as a reason for further research into alternative sources of power. Sunlight-based gathering is not a new concept; however it suffers from low efficiency due to unpredictable insulation patterns. Many sophisticated frameworks have been developed to support sun-based reapers. Among the frameworks is the double pivot sun-oriented global positioning framework. A model of a typical global positioning framework was constructed for the purpose of demonstrating it. The mission of [1] Albright Abu Edet,et.all is achieved its goal of tracking sunshine irradiance and real-time reorienting the payload to the optimal location for maximum solar power. Testing and perception using the generated model provided proof.[2]Wireless Electric Car Charging System with IOT and Sensors This paper also aims at designing an electric car wireless charging and charging stand to transport electrical energy through space and charging the battery of the electric car.

[3] Smart Electric Vehicle Charging System This article also described an RFID system for identification of an individual for charging permissions as well as management of the smart charging system that achieves charge control. RFID is helpful for cheap identification and authorization of vehicles for charging, and thus enables efficient implementation of EV charging while taking into consideration restrictions imposed by the grid and drivers of EVs..[4] This study shows the wireless charging an electrical vehicle. Since electric cars are one of the best alternatives with regards to emission of pollutants a way has to be found to enhance battery charging for more reliability. Instead of the plug-in charging stations, electric vehicle batteries can be charged by Wireless Power Transmission.[5] The paper by R. Singh, S. Kumar, A. Gehlot, and R. Pachauri, "An imperative role of sun trackers in photovoltaic technology: 'a review', Renewable and Sustainable Energy Reviews. 2018. Review study various solar tracking system methods including single axis, double axis, polar axis, open loop, close loop, hybrid model and azimuth/tilt roll mechanism were also discussed here with formerly used solar tracking methods.

METHODOLOGY

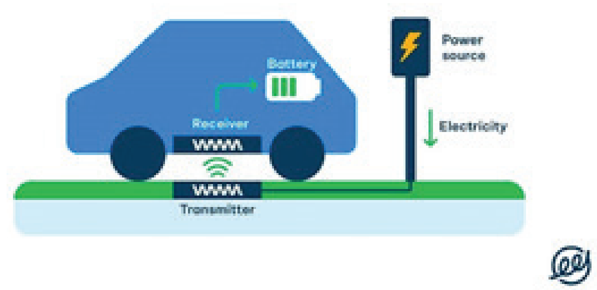

Fig. 1 Basic Structure of Wireless Charging

The ever-increasing demand for electric vehicles (EVs) has created the need for innovative and environmentally friendly charging structures. When comparing the emerging technologies, wireless power transfer (WPT) and the utilization of solar energy. as potential solutions to overcome the problems associated with the existing charging systems deserve a special attention. This literature survey delves into historical literature to evaluate the existing literature regarding these technologies particularly in the process of developing a Smart Wireless Electric Vehicle Charging Station with a built-in Dual-Axis Solar Tracker. In the process of literature review based on the prior studies, this survey unveiled the progress, issues, and opportunities of developing an efficient WPT and solar tracking-based EV charging system.

Literature Review and Feasibility Study

- Review existing technology and research in wireless charging stations and solar tracking.
- Evaluate the feasibility of the project by integrating this technology and identifying potential challenges and solutions.

Requirement Analysis

- Analyze the requirements of our project based on user needs, technical specifications, and regularity standards.
- Identifying the key components and technology needed for the project, including components like solar panels, dual-axis trackers, wireless charging coils, power electronics, batteries, and a control system.

System Design

- Maximize the generation of solar energy by designing the solar panels and the dual axis tracking system.
- Calculate the power output and storage requirement based on average solar power and usage patterns.
- The wireless charging system is designed with inductive charging coils and power electronics to gain high-efficiency power transfer.

Component Selection

- Select components having high efficiency, like solar panels, batteries, inverters, and other components based on design.
- Use suitable sensor communication modules and software platforms for monitoring and controls.

Prototyping and Integration

- Construct the model of the dual-axis solar tracker with motors, and control circuit for its operations.
- The wireless charging system includes transmitter and receiver coils, power electronics, and control.

Software Development

- Create mobile applications using IOT and backend systems for monitoring and control of the system.
- It includes real-time data visualization and a user-friendly interface.

Testing and Validation

- Test the overall system under various environmental conditions and use scenarios to validate its efficiency, reliability, and safety.
- Do performance tests such as wireless charging efficiency tests, solar tracking accuracy tests, and battery performance tests.
- Use the feedback mechanism, and machine learning algorithms to improve system performance.

Optimization

- Analyze the identified areas for improvement in the system design and operation.
- Optimize algorithms for the solar tracker, and wireless charging system, to enhance performance and efficiency.

Final Evaluation and Documentation

- Evaluate the overall performance and impacts of the system, comparing it against initial objectives and requirements.

FLOWCHART

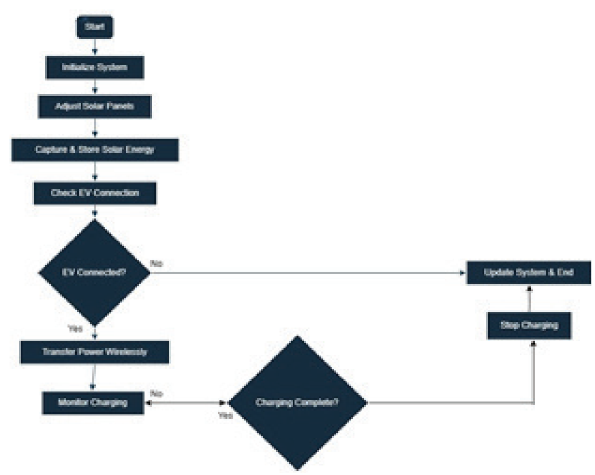

Fig. 2 Flow Chart of Project

This flows for the Smart Wireless EV Charging Station with Dual-Axis Solar Tracker starts with the system On. This initial step activates all the required parts, including the Base, which is a dual-axis solar tracker, EMS – an energy management system, and the Wireless Charger. It is during this phase that the system just checks itself to make sure that all have been well configured and are set to go.

After that, the solar panels are up and running which means that they are collecting solar energy. The dual-axis solar tracker has a great use here as it is constantly moving the panels to face the direction of the sun's movement. This tracking optimizes reception of solar power throughout the day in order to get the most out of the sun's power. The harvested solar energy is as expected managed and stored properly in battery stations for future use. This stored energy is mainly used as the power source to charge station electric vehicles also known as EVs. The system also checks battery levels constantly in order to make sure that charge is available for the batteries.

The system then looks for a connected KWH for charging for an EV. If a vehicle is detected, then the stored energy is converted from DC to AC because there is provision of the wireless charging system for AC. This converted energy is then transferred wirelessly to the EV through the inductive charging technology. During the charging process, several factors like the energy transfer rate, the perfect alignment of the coils and the system efficiency is checked to make sure that the charging is safe and efficient. The system tracks the progress until it reaches the full state of charge on the electric vehicle's battery or when it is commanded to stop by the user.

When the charging is over the system is able to cease the energy transfer on its own accord. It then changes its status and records all data to the files for future uses, with this it also updates its status. Last of all, the system does a timeout and gets ready for the next operation depending on the requirements whether it goes to the idle state or gets shut down and that marks the end of the process. This makes the operation of the Smart Wireless EV Charging Station efficient and easy, meanwhile leveraging on renewable energy to power electric vehicles.

BLOCK DIAGRAM

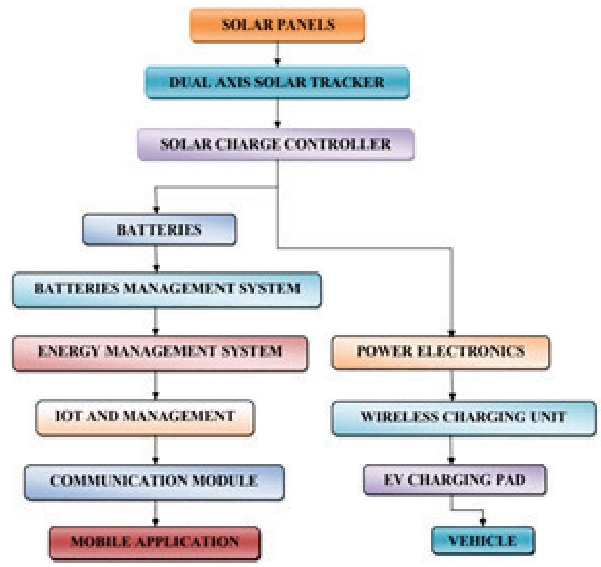

Fig. 3 Block Diagram

Here is the block diagram of smart wireless EV charging station with dual-axis solar tracker concept − Block Diagram consists following: Solar Panels, Mounted over Dual Axis Solar Tracker. These are systems that well change the position of the panels throughout the day in order to come with the best direction for getting sunlight. The solar PV electrical power is then taken to a solar charge controller which controls the voltage and charging current to the battery from the above description it is clear that the battery storage is charged by the solar panel system.

The power stored in the batteries is well controlled by the Energy Management System EMS, it controls the supply of energy to the different parts of the charging station. It guarantees proper management of the stored solar energy to meet the power needs as demanded by the system thus ensuring proper EMS operation. In conjunction with the EMS is the power electronics block, utilized for converting DC power from batteries into AC power whenever required for the charging coils. They consist of receiving and transmitting coils that produce an electromagnetic field that transfers energy to the charging coils inside an electric vehicle, therefore eliminating the use of connecting cables.

These actuators or sensors include position of the solar panel position, battery status, temperature, and status of charging process via IOT control unit. This information is processed and transmitted through the communication module which can support Wi-Fi or Bluetooth and; through a mobile application; user can monitor and control the charging station. To sum up, the project combines the process of solar energy capture and storages, wireless charging system and caters to the requirements of EV charging through an effective control and communication system leading to efficient, sustainable and user-friendly design for the project..

CONCLUSION

The Smart Wireless EV Charging Station with Dual-Axis Solar Tracker is a leap in imaginations for developing integrated renewable energy and electric vehicle. This idea of solar harvesting and wireless charging, however, gives a sustainable way to keep electric cars revolution going with maximum convenience. Both the roll and pitch axes on a dual-axis solar tracker are controlled to ensure high energy is captured throughout all hours of daylight, creating almost as much power from sunrise until sunset. The user-oriented wireless charging system replaces conventional wired solutions for better ease of use, and an Energy Management System (EMS) maximizes power distribution and usage. By removing our dependence on fossil fuels, this project not only does well for the growing popularity of EVs with a more convenient and advanced charger infrastructure.

There are many upsides to the project, but also several challenges such as cost, complexity of design and efficiency losses in wireless charging. But the potential benefits this can deliver, like minimizing carbon emissions (think also about UX within cars: http://blog.invisionapp.com/ux-in-cars/) improving energy efficiency is priceless in that aspect. Being a pilot, it serves as an example of creating the next step forward in both sustainability and convenience charging for electric vehicle customers given technology that is innovative.

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Long Short Term Memory Machine Learning Technique for Financial Market : A Review

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ABSTRACT

In this literature review, we investigate long short term memory and its comparison with the machine learning technique to identify its effectiveness in predicting time series of data. We evaluate different market indicators as well as machine learning technique and its prediction accuracy. We made comparison based on data sets used, machine learning techniques, technical indicators used and prediction hit rate and accuracy. which give us a clear idea on how the system works. the wide variety of combinations and their result give us a direction of study.

KEYWORDS *: LSTM RSI MACD ML DRL CNN.*

INTRODUCTION

The ideas of savings and investment have deep historical roots in India, with individuals and communities engaging in various forms of these practices for centuries. These activities have contributed significantly to the advancement of both individuals and society, improving their overall status and well-being. Through traditional methods of saving, such as gold, land, or grain, as well as community-based systems like informal lending and chit funds, these practices have played a key role in India's economic and social progress over time..

Beyond individual prosperity, these investments have had a transformative impact on Indian society. By enabling monarchs to establish stable kingdoms, they have facilitated the growth of critical public utilities and infrastructure, driving broader economic and social progress. In a democratic welfare state, the government plays a pivotal role in mobilizing savings and investing in initiatives that benefit society as a whole, fostering an environment conducive to the social and economic well-being of its citizens.[1].

Investing is an age-old practice that has been around for centuries, driven by the goal of generating returns. In recent times, there has been a surge in interest among ordinary individuals in the stock market, with more and more people seeking to tap into its profit-making potential[2] .

Driven by the desire for profitable returns, investors seek reliable ways to navigate the stock market's inherent volatility and unpredictability. As a result, extensive research has led to the development of sophisticated models and systems aimed at accurately forecasting market trends and optimizing investment outcomes. [3]. Investors strive for well-rounded decision-making, harnessing innovative technologies to assess various investments,optimize portfolios, and generate attractive returns..

This research aims to design an intelligent trading system utilizing machine learning algorithms to support investors in making data-driven decisions and optimizing their trading strategies

DATA BASED ANALYSIS

Variable Selection

In stock market prediction technique there are many variables can be considered to make decisions. Based on the different financial goals and adaptability investor can select variables and indicators [4]. Variable selection is a crucial hurdle in market prediction research, where pinpointing the most influential factors can significantly boost forecasting accuracy and inform more reliable investment decisions..

The Time horizons

The choice of time frame is a critical factor in investment strategy formulation, as it significantly affects the detection of market patterns and the understanding of market trends. As such, a well-informed decision regarding time frame selection is vital. It's important to recognize that longer time frames typically coincide with increased uncertainty in market forecasting, highlighting the need for thoughtful consideration. Research conducted by Makridakis et al. [5] has highlighted that Forecasting accuracy is heavily dependent on the type of time series data employed, highlighting the importance of careful data selection in ensuring reliable and accurate predictions..

Pattern of the data

Stock market patterns are defined by repetitive structures that surface after particular events or time frames, exhibiting periodicity and shaped by diverse market forces. While these patterns contain elements of randomness, understanding their causes, effects, and constituent parts is crucial for predicting market dynamics. Time series analysis has shown that patterns can be broken down into trend, seasonality, and cycle components, enabling more accurate market predictions[6].

Identifying and examining patterns in market data to determine their predictability and reliability in producing consistent results is important. Uncovering these patterns can provide valuable understanding of market behaviour, enabling more informed decision-making and effective risk management approaches.

TECHNIQUE/MODEL BASED ANALYSIS

Different technical models are used for better prediction of stock market. The study and development happened so far categorizes various AI models used in stock market prediction into following main categories:

1. RNN-based models: Models that utilize Recurrent Neural Networks (RNNs) to capture sequential dependencies in time series data.
2. CNN-based models: Models that employ Convolutional Neural Networks (CNNs) to extract features from spatial data, often representing time series data as images.
3. GNN-based models: Models that leverage Graph Neural Networks (GNNs) to model complex relationships between stocks and other relevant factors.
4. Transformer-based models: Models that utilize Transformer architecture, known for its ability to handle long-range dependencies.
5. Reinforcement learning models: Models that learn optimal decision-making strategies through interaction with the environment.
6. Others: A catch-all category for other types of models not explicitly categorized.

All these categories can be broken down into specific categories as follows

Specific Models

Recurrent Neural Network Based Models

Recurrent Neural Networks (RNNs) can be conceptualised as a series of interconnected network cells. In this architecture, the output of one cell serves as the input to the next cell in the sequence. Within each cell, there are sets of input units, hidden units, and output units that collectively contribute to the network's functionality and learning process

- Recurrent Neural Networks: The foundation for RNN-based models, capable of capturing sequential dependencies.
- Gated Recurrent Unit (GRU): A type of RNN that uses gating mechanisms to control the flow of information, improving efficiency.
- Long Short-Term Memory (LSTM): Another type of RNN that uses memory cells to store information over longer time periods.
- Bi-directional LSTM: An extension of LSTM that processes sequences in both forward and backward directions, capturing both past and future information

CNN-based Models

Convolutional Neural Networks (CNNs) are a type of deep learning neural network specifically designed to process visual imagery. They're inspired by the visual cortex of the human brain and have proven to be incredibly effective for tasks like image classification, object detection, and image segmentation. they have the following models

- Graph Neural Networks (GNNs): Models that represent relationships between stocks as graphs, allowing for the analysis of complex dependencies.
- Graph Convolutional Networks: A specific type of GNN that applies convolution operations to graph-structured data.
- Graph Attention Networks: Another type of GNN that uses attention mechanisms to weigh the importance of different nodes in the graph

Transformer-based Models

Transformer-based models have revolutionized the field of natural language processing (NLP) and beyond. Unlike traditional recurrent neural networks (RNNs), Transformers leverage a self-attention mechanism to weigh the importance of different parts of the input sequence. This enables them to capture long-range dependencies more effectively.

- Pre-trained Language Models: Language models like BERT and GPT-3 are trained on extensive text data. By fine-tuning these models, they can be applied to specific tasks such as predicting stock market trends.

Reinforcement Learning Models

Reinforcement Learning (RL) is a learning paradigm where an agent learns to behave optimally in an environment. The agent learns from interactions with the environment, receiving rewards or punishments for its actions. The objective is to maximize the cumulative reward..

- Model-based: Models that learn a model of the environment to make decisions.
- Model-free: Models that learn directly from experience without explicitly modeling the environment.
- Q-learning: A model-free reinforcement learning algorithm that learns the optimal action-value function.
- Policy Gradient: A model-free reinforcement learning algorithm that directly learns the optimal policy.
- Deep Q-Network (DQN): A deep learning variant of Q-learning that uses a neural network to approximate the action-value function.
- Deep Deterministic Policy Gradient (DDPG): A model-free reinforcement learning algorithm for continuous action spaces.
- Advantage Actor-Critic (A2C/A3C): A model-free reinforcement learning algorithm that combines policy gradient techniques and value function techniques.
- Twin Delayed DDPG (TD3): An improvement over DDPG that uses two critic networks to stabilize training.
- Trust Region Policy Optimization (TRPO/PPO): A model-free reinforcement learning algorithm that uses trust region optimization to improve policy updates.
- Soft Actor-Critic (SAC): A model-free reinforcement learning algorithm that combines policy gradient techniques and maximum entropy reinforcement learning.

LITERATURE ON LSTM MODEL

LSTMs are powerful tools for capturing temporal dependencies in time series data, combining them with other models can often lead to improved performance and more robust predictions, In this section we discussed various work on LSTM and how it can be incorporated with other technology for improved performance.

- Introduction to LSTM : The LSTM unit, as described in reference [5], The network utilizes three crucial components: update, forget, and output gates, which harmoniously manage short-term and long-term memory. Specifically, LSTM tackles the challenge of retaining information over extended time intervals by employing sophisticated gradient-based techniques. Despite the widespread use of time series analysis in stock prediction research, the temporal dependencies inherent in stock price data often remain unexplored, potentially overlooking crucial relationships that could enhance predictive models.

- Previous work incorporating LSTM: Notably, Long Short-Term Memory (LSTM) and Deep Learning (DL) architectures have gained widespread adoption and acclaim, mainly because they can maintain the network's contextual memory and adapt accordingly. LSTM's unique strength lies in its capacity to recall information from distant past events, rendering it an ideal choice for time series forecasting, including stock market data, where understanding long-term trends and patterns is essential. Extensive research has underscored the benefits of leveraging LSTM and DRL in financial analysis, yielding substantial improvements in predictive accuracy, trading strategy optimization, and insightful discoveries within complex financial data. These sophisticated architectures have emerged as indispensable tools in the financial sector.

1. Wang et al. [7]: By integrating DRL and LSTM models, this study demonstrated significant advancements in machine learning application. The first module is an LSTM-HA network, which employs attention mechanisms to focus on significant historical states, enabling the effective extraction of asset representations from diverse time series input. The second component, Cross-Asset Attention Network (CAAN), is a sophisticated module that comprehensively models the intricate web of relationships between assets, as well as anticipates asset price increases by analyzing historical price dynamics.The Portfolio Generator, the third module, utilizes the attention networks' output scores to determine the optimal asset allocation, assigning investment proportions to each asset in a manner that maximizes portfolio efficiency..

2. Wu et al. [8]: Similar to Wang et al., This framework empowers the LSTM-based agent to intuitively recognize and respond to stock market fluctuations, eliminating the need for manual indicator design and simplifying the process of extracting insights from large datasets.The agent is trained using reinforcement learning to maximize trading performance.

3. Wu et al. [9]:In Wu's research, This study implements a high-frequency trading approach, utilizing LSTM's predictive capabilities to forecast profitability in daily options trading, and inform timely investment decisions. This study proposes an LSTM-based architecture to predict the likelihood of profitable trades for a futures strategy and calculate corresponding take-profit and stop-loss points, leveraging options delta values for refined risk adjustment.

4. Koshiyama et al. [10]:Koshiyama's study employed an encoder-decoder scheme and LSTM to effectively transmit patterns. Each market-specific model employs a hybrid encoder-decoder framework, comprising: Market Encoder: Transforms market-specific data into a compact, abstract latent representation. Global Model: A shared, crossmarket architecture processing latent representations to capture universal patterns. Market Decoder: Learns market-specific trading strategies by integrating local encoder outputs and global model insights.across 58 diverse global markets. This methodology enabled an in-depth analysis of financial and machine learning metrics, uncovering key trends in the global industry. The aggregated results of these investigations unequivocally validate the effectiveness of LSTM and DRL in financial analysis, demonstrating: Enhanced forecasting capabilities, Improved risk-adjusted returns, Robust adaptability to market dynamics, Data-driven decision support, This research consolidates the evidence base for LSTM-DRL applications in finance, informing evidence-based strategies for optimal investment and risk management.

5. Chalvatzis and Hristu-Varsakelis[11] : The synergy of diverse machine learning models, through techniques such as ensemble learning, stacking, or hybrid architectures, has consistently demonstrated exceptional efficacy in enhancing the accuracy, robustness, and reliability of financial analysis

systems. The work of Chalvatzis and Hristu-Varsakelis[11] is a prominent exemplar of this methodology. The researchers developed a robust trading framework by seamlessly integrating nine diverse Deep Learning (DL) and Machine Learning (ML) models with Long Short-Term Memory (LSTM) networks, creating a holistic and adaptive trading strategy.

6. Wang et al. [12] : In the realm of stock price prediction, Wang et al. [12] Concentrated on applying Convolutional LSTM models and integrating techniques to manage overfitting.

7. Zhang et al. [13] : Developed a model that merges LSTM and Convolutional Neural Networks (CNN) to address spatial patterns in the Limit Order Book (LOB) and performed thorough backtesting Zhang et al. [14] Integrated LSTM with Auto-encoders and CNN to improve predictive performance, utilizing a range of machine learning metrics for assessment.

8. Baek and Kim [15] : Used LSTM for data augmentation with the goal of reducing overfitting. Their model covered a wide range of financial aspects and machine learning areas, highlighting the versatility of LSTM in tackling complex challenges in financial analysis. By combining multiple machine learning models, researchers can significantly improve predictive power, mitigate overfitting, and develop more effective trading strategies in the dynamic and complex financial market landscape.

9. Maeda et al.'s [16] Machine learning-driven market simulation has become an indispensable asset in financial markets, enhancing portfolio optimization, risk assessment, and investment strategies and Maeda et al.'s work [16] exemplifies this. The researchers developed a sophisticated model leveraging DRL and LSTM to simulate market environments, enabling the exploration of market dynamics, stress-testing trading strategies, and identifying optimal approaches in a virtual, data-driven laboratory.

10. Yang et al. [17]: Machine learning is a vital component in stock selection, empowering investors to make informed decisions and maximize long-term returns in financial markets, where optimal stock choices are critical to success as shown in the work by Yang et al. [17]. In this study, they checked Convolutional Neural Networks (CNN) with LSTM and Effective stock selection relies on a multifaceted approach, combining various indicators to provide a comprehensive view of market trends, company performance, and investment potential, ultimately guiding profitable decision-making. Machine learning techniques, including Fuzzy Theory, SVM/SVR, DRL, LSTM, CNN, and various indicators, are being utilized to simulate market environments, analyze vast amounts of data, and optimize stock selection strategies, contributing to a new era of informed and profitable investment decisions in the financial sector

Approach domain				
	Research work	Variables	Prediction technique	Result
ANN	Hu, H., Tang, L., Zhang, S., & Wang, H. (2018).[18]	Tech Indices data, trends data	Hit ratio	86.81% (S&P 500), 88.98% (DJIA)
	Qiu, M., Song, Y., & Akagi, F. (2016).[19]	Tech Indices data	Hit ratio	81.27%
SVM/SVR	Sedighi, M., Jahangirnia, H., Gharakhani, M., & Fard, S. F. (2019). [20]	Tech Indices data	RMSE	0.0092 (average over all indices)
	Zhang, J., Teng, Y. F., & Chen, W. (2019). [21]	Price at closing	RMSE	1.62e−06 (1), 4.33e−06 (2), 0.000420(3), 1.07e−05(4), 0.005916(5), 0.003501(6)
Fuzzy theory	Zhang, W., Zhang, S., Zhang, S.,(2019) [22]	Price at closing	RMSE	1.663 (SSECI), 1.2170 (TAIEX)
	Chang, P. C., & Liu, C. H. (2008). [23]	Tech Indices data	Accuracy	97.6% (TSE index) and 98.08% (MediaTek

Deep Learning	Lien Minh, D., Sadeghi-Niaraki, A., Huy, H. D., Min, K., & Moon, H. (2018).[24]	News, Tech Indices data	Accuracy	66.32%
	Singh, R., & Srivastava, S. (2017). [25]	Tech Indices data	RMSE	1.01%
Feature selection	Weng, B., Ahmed, M. A., & Megahed, F. M. (2017) [26]	Tech Indices data, trends data	Accuracy	85.8%
hybrid GA-XGBoost prediction	Kyung Keun Yun, Sang Won Yoon, Daehan Won(2021) [27]	Tech Indices data, trends data	Accuracy	93.82%

Comparative Analysis of DL And ML Architectures for Prediction and Data Analysis [4]

Summary of Analyzed Journal Research Articles

Strategy	Paper	Architecture	Applied Market Dataset	Research Gaps identified along with viability/ feasibility
Trade strategy	Wang J et.al [7]	DRL, LSTM	China, US	Interpretability is context-dependent and time-sensitive, necessitating careful evaluation of both factors to accurately comprehend predictive results. The nature of interpretability changes with time horizon: short-term predictions demand detailed data, while long-term projections emphasize structural factors and big-picture trends. It's important to provide interpretability across multiple time frames.
	Wu J et. al [8]	DRL, LSTM	China	By analyzing feature importance, stakeholders can gain insight into which variables influence the model's predictions, leading to more informed investment decisions. Including numerical representations and discussing model interpretability improves clarity and usefulness, offering a balanced comparison and deeper understanding of the decision-making process
Trade strategy	Wu JMT et al.[9]	LSTM	Taiwan	No conversations about explaining the model's workings.
	Koshiyama A et al.[10]	Autoencoder LSTM	Global	No conversations about explaining the model's workings.
	Wang J et al. [12]	LSTM	US	No conver-sations about explai-ning the model's workings.
	Chalvatzis C et al.[11]	LSTM	US	No conversations about explaining the model's workings.
Price prediction	Zhang Z et al.[13]	CNN	UK, Nordic	The provided information does not specify whether multiple models have been created or if the same model is updated during the back checking process. To get a better understanding of the approach used in backtesting, further details or context from the source or research would be necessary. Multiple models may be created and tested, or a single model could be adjusted and updated iteratively during the backtesting phase, depending on the research methodology and goals.
	Zhang H et al. [14]	Autoencoder CNN, LSTM	China	Insufficient discussion regarding model explainability
	Baek Y et al.[15]	LSTM	US	No reason was provided for focusing exclusively on price data, making the model's explanation less thorough.
Market simulation	Maeda I et al.[16]	DRL, LSTM, CNN	Simulated	No conversations about explaining the model's workings.
Stock selection	Yang J et al..[17]	LSTM	China	Traditional comparison with existing system not done

SUMMARY

The paper presents a compilation of various research papers that employ different machine learning models, primarily LSTM and CNN, to address diverse tasks within the domain of financial markets. These tasks encompass stock market prediction, trade strategy, price prediction, and market selection.

Key Observations and Conclusions:

- Dominance of LSTM: LSTM stands out as the most frequently used model across different tasks. This underscores its effectiveness in handling sequential data, which is inherent to financial time series.

- Diverse Datasets: The research leverages a range of datasets, including those specific to the US market, Chinese markets, and global indices. This highlights the versatility of the proposed models and their applicability to various financial contexts.
- Focus on Prediction Accuracy: The primary emphasis in many studies is on achieving high prediction accuracy. While this is an important metric, it is essential to consider other factors such as model interpretability, robustness, and the practical implications of the predictions.
- Limited Exploration of Trade Strategies: Although some papers touch upon trade strategies, the exploration of this topic remains relatively limited. A more in-depth analysis of how these models can be integrated into practical trading strategies would be valuable.

Key Suggestion

- Hybrid Models: Combining multiple techniques, such as statistical models with machine learning, can often yield better results. This allows for leveraging the strengths of different approaches.
- Advanced Feature Engineering: Developing sophisticated feature engineering techniques can significantly improve model performance. Incorporating both technical and fundamental factors, as well as external news and sentiment data, can provide a more holistic view of the market.
- Ensemble Methods: Combining multiple models through techniques like bagging and boosting can enhance model robustness and reduce overfitting.

The above analysis of data based on different technical indicators artificial neural network has shown very accurate prediction result followed by support vector machine and deep learning techniques. Interpretability varies based on time frames, data and its context. While focusing on artificial neural network the long short term memory is found very effective as it keeps memory and forwards it into next phase of data analysis. this additional step give LSTM advantage in prediction. overall the machine learning techniques proved beneficial in analysing and predicting time series data. The paper presents a compilation of various research papers that employ different machine learning models, primarily LSTM and CNN, to address diverse tasks within the domain of financial markets. These tasks encompass stock market prediction, trade strategy, price prediction, and market selection.

Recommendations for Future Research :

- Model Interpretability: Prioritize the development of techniques to enhance the interpretability of machine learning models, especially for complex models like deep neural networks.
- Hybrid Approaches: Explore hybrid approaches that combine the strengths of different models, such as LSTM and CNN, to capture both temporal and spatial dependencies in financial data.
- Robustness and Generalization: Investigate methods to improve the robustness and generalization capabilities of models, particularly when dealing with noisy or non-stationary data.
- Data Quality and Quantity: High-quality, accurate, and sufficient data is crucial for training effective models.
- Ethical Considerations: Address the ethical implications of using AI in finance, including issues related to fairness, transparency, and accountability.

Overall, while the reviewed papers demonstrate the potential of machine learning techniques in financial applications, there is still significant room for improvement in terms of model interpretability, robustness, and practical implementation. overall we can conclude that accuracy.

ACKNOWLEDGMENT

The Financial markets data are continuously changing and fluctuating as time passes. Overall, while machine learning techniques hold promise for stock market prediction, it is important to recognize the limitations and challenges associated with these methods. A comprehensive approach that combines multiple techniques, considers the specific characteristics of the market, and addresses the limitations of individual models is likely to yield the best results. accurately predicting and managing ones portfolio is important for finance management. using machine learning technique

one can confidently can interpret data and movements of market that can be beneficial for their finances. Different techniques of neural network and machine learning becomes widely used and becoming more and more accurate in recognising patterns and predicting market moves. Stock market prediction remains a challenging task due to the inherent complexity and volatility of financial markets. While machine learning techniques have shown promise, it's important to recognize their limitations and the need for continuous improvement. A comprehensive approach that combines multiple techniques, considers the specific characteristics of the market, and addresses the limitations of individual models is likely to yield the best results.

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Development of a Wired Cavity Type Solar Receiver for Enhanced Radiative Heat Gain

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ABSTRACT

The solar concentrating technology makes possible the steam generation by creating high-temperature zones (800 to 1000°C) at the focal location of the parabolic dish concentrating systems. The present paper focuses on the development of efficient solar receiver cum concentrator technology for capturing maximum renewable solar energy. In conventional smooth cavity receivers, most of the concentrated solar energy focusing inside the cavity receiver, gets lost on account of high energy concentration at the focal location. In this paper, black coated thermally conductive wired protrusions have been provided inside the cavity of receiver. It is to trap and absorb maximum concentrated solar energy, as compared to the conventional smooth cavity receivers. In conduction of experiments during bright sunshine hours, substantial efficiency improvement of about 15-20% is observed by using radiative wire brissle geometry inside the truncated cavity receiver.

KEYWORDS *: Multistage, Parabolic dish concentrator, Solar energy, Radiation.*

INTRODUCTION

The parabolic dish based solar concentrating systems can establish higher temperatures in the range of 800-900ºC at the foci locations. Improved efficiency of solar concentrators helps in gaining the steam generation capability of the system. The generated steam can be used for various village activities e.g., community cooking, rice husk (paddy) parboiling [1], processing of Lemongrass, Jaggery production [2], clothes sanitization, household textile thread bleaching, utensils washing, Alumina synthesis using Boehmite [20] and many other applications like drying of agricultural products, cooking (solar powered and induction type), heating of air/water, heat storage systems, refrigeration and air conditioning etc. These systems have enhanced concentration ratio of 1000 that generate power upto a capacity of 0.5 MW [3].

As presented by Bushra and Hartman [4], reflection based solar energy concentrators are generally famous for their increased power collection, effective power release and compact design. About four types of twin staged concentrators have been suggested, e.g. Cassegrains, dish concentrators, two stage collectors and trough concentrators. It is also reported that the solar cell receivers along with optical fibers are used for daylighting purposes. The parabolic dish type concentrators also involve errors which cause enlarged focus size and hence the larger sized receiver [5]. The increased surface area of receiver increases the energy losses.

Such optical deviations have been corrected by Bader et al. [6], with the use of secondary reflector in combination with primary mirrors. The slow and steady heating of coolant in the multiple receiver system controls the operating temperature of the system which ultimately reduces the energy losses [7]. Omer et al., [8] exhibited improved performance of the multistage system design with parabolic dish as a primary reflector and CPC acting as secondary reflector by minimizing natural convection energy losses. Concentration ratio enhancement uptofour fold can be attained using multistage concentrators with CPC as secondary reflector [9]. The conversion energy efficiency of the modified system could also be improved substantially. After examining multistage reflector systems, Friedman et al. [10] found that a truncated conical type reflector performs better than the CPC type. At high level of energy concentration a PDC as primary stage with concave hyperbolic reflector as secondary give improved efficiency [11]. A hyperbolic-trumpet type secondary reflector enhances the solar concentration as compared to the CPC type secondary reflector, as seen by Suresh et al. [12]. It might be attributed to the skew ray as well as reflection energy losses which was minimum in hyperbolic trumpet type concentrator. Reddy and Kumar [13] observed reduced convective losses in case of hemispherical cavity receiver with conical, CPC and trumpet shape as secondary concentrator. Among these three secondary stages trumpet shaped receiver exhibited improved performance. In a similar fashion, Zhang et al. [14] have examined the performances of five shaped secondary stages; flat, parabolic, hyperbolic on both sides and elliptical with PDC as a primary concentrator. They preferred convex secondary reflector when the rim angle is more than 90 degree. The air which is to be filtered may choke the filter material used for the prescribed purposes. This air can be preheated in the PDC system before being supplied to the filters discussed in [17]. Wang et al. [15] worked on twin staged PDC for solar power generation which was based on overlap technology. It improved the concentration and intercept factor of the system, by the use of hyperbolic mirrors as secondary concentrators. Using this technology, the focus-size was reduced by 11 %, concentration ratio improved by 31.4% whereas an intercept factor by 17% [15]. In order to overcome these limitations, Schmitz et al., [16] recommended twin winged configuration and nested reflector designs. Parida et al., [19] proposed a new photovoltaic reflector having asymmetric geometry and non-imaging type, wherein they connected reflectors in series, which resulted in 62 % power improvement as compared to conventional non-reflecting type PV geometry.

Mehrdad et al., [18] stated the advantages of various geometries of concentrating collectors which also help in improving the overall system efficiency e.g., Fresnel lens, Quantum dot concentrator, parabolic trough, compound parabolic concentrator, Dielectric totally internally reflecting concentrator and hyperboloid concentrator. Cooper et al., [21] introduced twin staged line focus to point focus solar concentrating type reflector system. This system is found suitable for wider range power applications generating solar concentration upto 2000. Winston and Zhang [22] examined hollow type CPC and Dielectric type CPC without tracking requirement having wider range of solar acceptance angle.

Most of the researchers used flat, conical, CPC, ellipse shaped and hyperbolic shaped reflectors for secondary stages and receivers of various shapes. None of the researchers used a cavity receiver with wired protrusions on its radiative side, to improve the thermal collection efficiency of the solar concentrator. Experimental investigations have been performed on this newly designed truncated hemispherical cavity receiver. The objective of the present work is to evolve a solar receiver cum concentrator system which contributes efficiently in effective production of hot water/steam which can be used for various applications.

METHODOLOGY

The main objective of developing this modified receiver is to develop a system which is radiative energy efficient. The geometry as well as dimensions of these systems have been designed in such a way that it will maximize the radiative energy gain. The cavity with black coated wire brissles helps cavity wall to absorb radiative energy gradually thereby attaining higher temperature upto a boiling point of water, in order to produce the steam for various household and commercial applications. The line diagram of a parabolic dish concentrating system and receiver model depiction are presented in Figs. 1 and 2.

The performance of the system is evaluated in terms of solar to thermal collection efficiency, estimated using equation (1).

$$n_{th} = \frac{\textit{Energy absorbed by the coolant}}{\textit{Aperture Area} \times \textit{Incident beam radiation}} \quad (1)$$

$$n_{th} = \frac{Q_u}{A_c \times Q_{Rad-b}} = \frac{\dot{m} C_p (T_{out} - T_{\text{in}})}{A_c \times Q_{Rad-b}}$$

Where, Q_u is the useful heat gain (W), $\dot{m}$ is the mass flow rate of water as a coolant (kg/s), C_p is the specific heat of water (J/kg K), A_c is the aperture area of the dish concentrator, and $Q_{(Rad-b)}$ is the intensity of beam radiation incident on the solar dish.

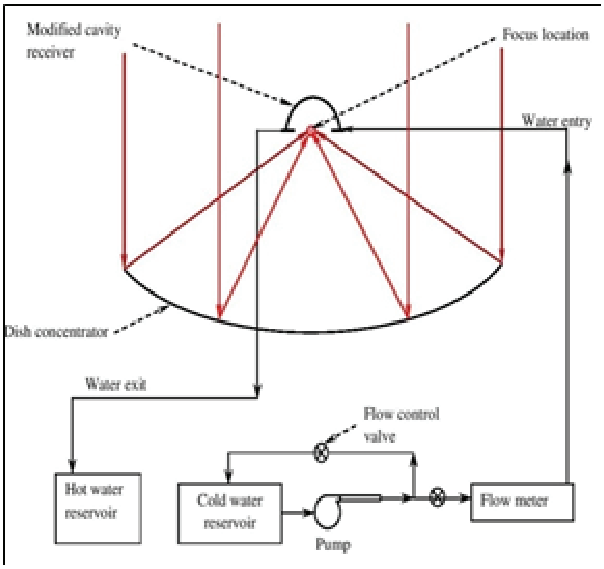

Fig. 1: Parabolic dish concentrator system

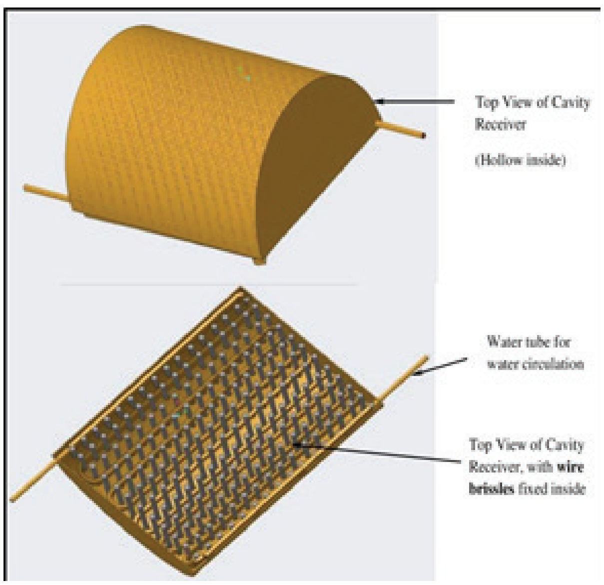

Fig. 2: Modified Cavity Receiver

EXPERIMENTAL PROGRAM

A truncated hemispherical cavity receiver of 35 cm diameter and width of 15 cm, is located at focus of parabolic dish. The wire brissles are fixed at different locations of cavity receiver on radiation side. The packing of steel wire brissles inside the cavity is varied for three packing factor values e.g., 0.025, 0.038 and 0.051. The water is allowed to flow through the Copper tube, which is positioned inside the receiver as shown in Fig. 4. The receiver fabricated in the laboratory, using copper sheet, is shown in Fig. 3. The water is kept circulating through this copper tube with the help of a centrifugal pump. The flow rate of water is measured using a flow meter.

Fig. 3: Photographs of dome shaped

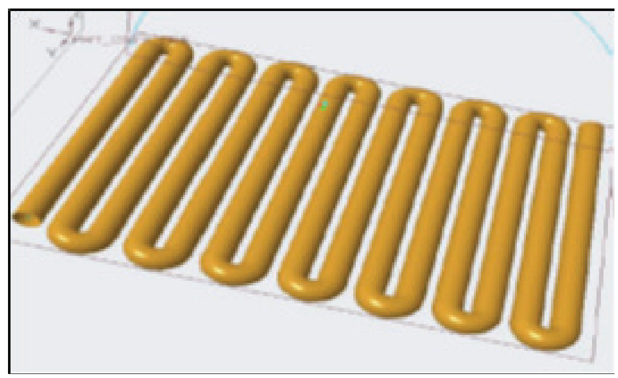

Fig. 4: Shape of copper tube

The copper tube is fixed inside the dome of receiver. The receiver is insulated by means of glass wool and Aluminium foil, in order to mitigate heat losses. The receiver is insulated from outside using Ceramic wool, to minimize the energy losses by conduction. The water temperatures at entry and exit are measured using calibrated mercury thermometers, and the cavity surface temperatures were measured using calibrated thermocouples connected to temperature indicator. Solar radiation intensity is measured with the help of solar flux meter. The atmospheric air velocity is measured using vane anemometer. The wire brissles are been fixed to both the copper sheet and the tube, inside the cavity receiver. An increased radiative heat transfer reduces down the operating temperature of the system that decreases the heat losses, which results in improving the thermal efficiency of the system.

At the start of experimental procedure is concerned, water is first allowed to flow through the system. The set up is then rotated manually to track the Sun so that all the radiations are focussed at the apertures of the receivers. The flow rate is reduced and it's restricted to the boiling of water. The readings for solar radiation, water flow rate and water temperatures were recorded after attaining the steady state.

Fig. 5: Photograph of Experimental Set up

RESULTS AND DISCUSSION

To evaluate the performance of the system, experiments were conducted using single stage dish concentrator cum receiver system as depicted in Fig. 5. The mass flow rates of water, as a coolant, are adjusted in such a way that the Reynolds number is in the range of 2000 to 4000. Tests were conducted during Sunny weather conditions generally from 11.30 am to 01.30 pm. During this time the solar radiation intensity remains almost equal on all the Sunny days. The outlet temperatures of water were measured at each steady state conditions attained for the chosen Reynolds number. The outlet temperatures of water have been plotted for the selected values of packing factor, as seen in Fig. 6. It is found that the circulated water could be heated upto 73°C for a higher packing factor value of 0.051. It is attributed to the enhanced radiative transmission inside the cavity with high packing factor of wire brissles. Temperature gain is lesser with less packing factor of the cavity receiver.

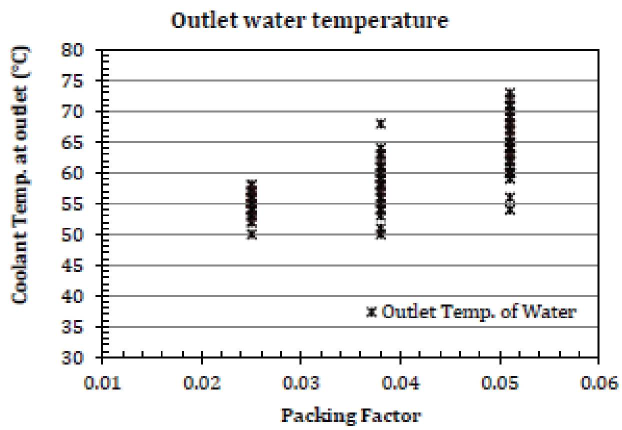

Fig 6: Graph of Outlet water temperature 'vs' Packing Factor

The thermal efficiency values obtained for this dish concentrator system with modified cavity receiver are plotted in Fig. 7, for the studied Re values.

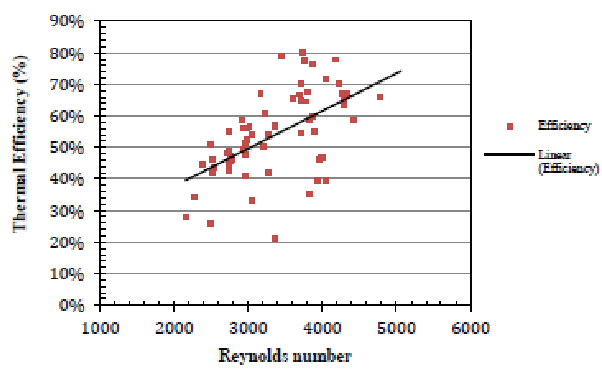

Fig. 7: Graph of 'System thermal efficiency' vs 'flow Re'

It is seen that the efficiency values vary linearly with the Re. The system performance increases with the flow rate of water. The efficiency values exhibit rising trend with the Re. Since the studied range of Reynolds number is in transition zone i.e., 2000 to 4000, the experimental data-points are seen scattered.

The influence of packing factor of black coated radiative wire brissles on the system thermal efficiency is as plotted in Fig. 8. The range of thermal efficiency variation for the studied range of Reynolds number is shifted little higher with increased value of packing factor. It can be concluded that, more number of radiative interferences inside the cavity receiver increases the radiative heat gain, which ultimately improves the thermal efficiency of the solar collector system. A receiver with more packing factor 0.051 exhibits enhanced solar thermal collection efficiency of about 15-20%, as compared to that of with packing factor of 0.025.

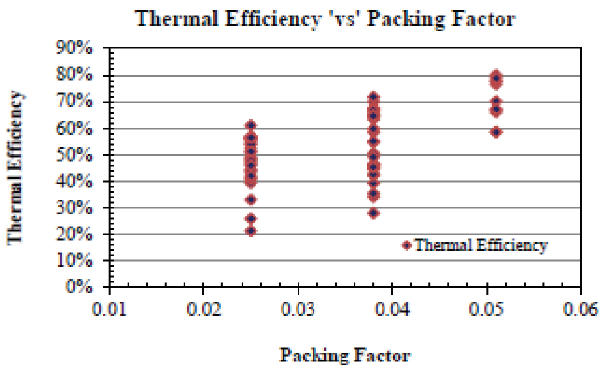

Fig. 8: Graph of Variation of system thermal efficiency with respect to Packing Factor

CONCLUSIONS

The present study intended to unveil a novel design of a radiative wire brissled cavity receiver geometry which is beneficial in trapping maximum concentrated radiation energy. It is observed that this design exhibited efficiency improvement of about 15-20% as compared to the conventional one i.e., with very less packing factor. This improvement was noticed for the transition flow Renolds number, which may be suitable for the production of steam.

Increasing the size of wire brissle geometry inside the cavity of solar receiver, enhances the outlet temperature of water and hence the solar thermal collection efficiency of the entire system by about 15 to 20%. Improved efficiency of solar concentrators will help in increasing the steam generation capability of the system. The generated steam can be used for various village works e.g., community cooking, rice husk (paddy) parboiling [1], processing of Lemongrass, Jaggery production [2], clothes sanitization, household textile thread bleaching, utensils washing, Alumina synthesis using Boehmite [20] and many other relevant applications.

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Overview of Decision Models Analyzed for Quality Assessment in Public Transportation Services

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ABSTRACT

Public authorities, transport agencies and private operators need to work together to continuously improve the performance of public transport. Any public transportation company must use a systemic survey-based approach that critically analyses client requirements in order to assess its success. Using the SERVQUAL model, an effort is made to gain a better knowledge of passenger attitude and satisfaction with the services offered by the public bus transportation system (MSRTC) in the model that is presented. The comparative cost benefit model is to find out the Ideal alternative with the highest Parameters (Benefit/Cost Ratio, NPV and IRR). In the presented model, an attempt is made to understand better alternative for investment with constant the level of passenger satisfaction towards services provided by the public bus Maharashtra State Road Transportation Corporation in India (MSRTC) and Private Bus Services in Maharashtra using comparative cost benefit model. In the presented last model, the methodology suggested that the decision making model helps us to know what facilities are to be put on priority for improvements. So, a decision making model is formulated for the two alternatives MSRTC (Maharashtra State Road Transport Corporation) and private bus services in which a decision factor is calculated based on the cost allotted to the particular facility and the negative response to that facility. This decision factor helps us to know which facility or parameter should be improved on priority which directly led to the improvement of services to increase the rate of customer satisfaction. In the presented model, the priority sequence to all the nine facilities is obtained for both the alternatives. Furthermore, the integrated framework of this study can enhance public transport performance and give customer satisfaction.

KEYWORDS *: SERVQUAL model, Satisfaction level, CBA, Cost-benefit ratio, NPV, IRR, Decision model, Priority of services etc.*

INTRODUCTION

In India, passenger transport divides into public and private transport. Public transportation, i.e., government-operated transport, provides scheduled services, while private vehicle provides ad-hoc services at the rider's desire. Thus, a business term, passenger satisfaction measures how an industry supplies services to meet passengers' expectations. The input factors in the SERVQUAL Customer Satisfaction Model are primarily classified as tangibles, empathy, responsiveness, assurance, and dependability. Customer happiness and service quality are used to gauge the response. The definition of the vague and nebulous term "passenger satisfaction" varies depending on the support and service provided. Since passenger satisfaction is a psychological construct, measuring it is too challenging. Given that no transportation company can function without passengers, it is critical to assess if the company's services are fulfilling client expectations. Thus, a survey was carried out, and 4,000 answers were gathered and examined according to gender and age. Additionally, a comparison study is conducted between MSRTC and private bus transport services. The analysis is done by based on three parameters and each parameter has three specific facilities in them. Any public transportation company's performance rating is mostly based on the degree of passenger satisfaction with their level of customer service (also known as benefits to the customer) and the projected or predicted cost of the business. A comprehensive survey-based comparative cost-benefit model is required to assess the performance of any public transportation company. This model critically examines important factors to help make decisions about whether a project is feasible in the long run from the standpoint of the organization and develops future improvement plans.

The goal of a cost-benefit analysis is to determine whether the benefits of a project outweigh its costs. If the benefits exceed the costs, then the project is considered economically viable and may be pursued. If the costs exceed the benefits, then the project is considered economically unfeasible and may need to be reconsidered or scrapped. Cost-benefit analysis can be used in a wide range of contexts, from evaluating public policy decisions to assessing the feasibility of a new business venture. To sum up, the Cost Benefit Analysis model can be a helpful tool for decision-making, but it's crucial to understand its limits and combine it with other tools and methods to make sure all pertinent considerations are taken into account. The alternatives of MSRTC and private bus transportation services are compared in terms of cost and benefit from 2017 to 2022. NPV (Net Present Value), BC (Benefit to Cost) ratio, and IRR (Internal Rate of Return) are computed. To put it briefly, the cost-benefit model is applied independently to each transport company for analytical purposes, and the ideal option with the highest parameters (i.e., benefit/cost ratio, net present value, and internal rate of return) is then found through comparison of these parameters.

Allocation of cost in any sector is one of the major issues that govern the credibility, productivity and profitability of any project undertaken by that sector. It helps individuals as well industry to focus on major areas of a project which may require special attention, in order for its growth and expansion. The study which is undertaken for the purpose of analyzing the various segment of cost which is allocated into the road transport industries. For this purpose, we have taken into account two entities i.e. public sector road transport industry and private sector road transport industry. In public sector we have analyze Maharashtra State Road Transportation Corporation and from private sector we have taken Vijayanand Roadways Limited (VRL).

Rose Luke and Gert J Heyns (2020) adapted SERVQUAL model analysis shed light on several areas of concern in Johannesburg's public transport system. By addressing issues related to reliability, responsiveness, assurance, empathy, and tangibles, the city can significantly improve the quality of public transport services and enhance the overall commuting experience for its residents [1]. Malathi et.al(2022) has effectively used SERVQUAL model for the transportation system analysis[2].

Ginés deRus , M.Pilar Socorro , Jorge Valido , Javier Campos (2022)-They develop a simple model for project appraisal. they proposed three approaches to assess the economic success of a project [3]. Maria DeAloe , Roberto Ventura , Michela Bonera , Benedetto Barabino , Giulio (2023) the outcome of this study helpful and study gets feasible result to Brescia (Italy). The research outcome results show the potential practicability of an innovative interoperable transport system in this city. [4]

Jonas Eliasson,(2019) put the problems in relation with measuring the community benefits of a transport improvement. The study formulated and analyzed model which has given the fruitful results [5]. Afshin Jafari et. al. (2022) has examined the utility and performance of the new design algorithm for the transportation system. The data was collected from the Greater Melbourne, Australia [6]. In 2009, Bernard Roy of the University of Paris-Dauphine conducted a CBA in order to assess the possible socio-economic effects of public investment decisions. This technology is used to enhance transportation infrastructure decision-making in various nations, most notably in France. [7]

DIFFERENT MODELS

Presented Overview Study and Analysis of Different Models

SERVQUAL Customer Satisfaction Model

Material and Method-Proposed Material and methods for Customer satisfaction based services provided to passengers-

For this present study purpose, descriptive research has been designed to fulfill the objectives with data collection from different sources and to know customers' satisfaction with the services given by Maharashtra State Road Transport Corporation. The questions have been developed to get responses specific to the proposed objectives. For the analysis, primary data was collected by the researcher directly from the passengers. The collected preliminary data was analyzed using the percentile method.

PhaseI (Hypothesis Formation) – Literature review- identify gap –selection of various attributes and responses- then finally hypothesis selection

Phase II (Survey for data collection)-

Specify the projects goal and objectives- describe inputs and outputs quantitatively- decision regarding sample size and conduction of survey- data collection

Phase III (Analysis)-

i) Analysis to find out the Customer Satisfaction Level and then identify the Influencing Parameters

ii) Implement the suggestions and decide plan for action

The critical service parameters for the SERVQUAL Customer Satisfaction Model. It includes the input parameters mainly categorized as reliability, assurance, tangibles, empathy, and responsiveness. The response is measured in terms of service quality and customer satisfaction.

Data based information for the presented work -

Table 1. Responses Collected for MSRTC

Total number of forms circulated	4500
Number of forms received	4000
Number of forms not received	500
Number of male respondents	1910
Number of female respondents	2090
Number of respondents from age group of 15-22	1349
Number of respondents from age group of 23-45	1603
Number of respondents from age group of 46-60	719
Number of respondents from age group of 60+	329

Table 2. Responses Collected for Private Bus Transport Services

Total number of forms circulated	4250
Number of forms received	4000
Number of forms not received	250
Number of male respondents	2323
Number of female respondents	1677
Number of respondents from age group of 15-22	2811
Number of respondents from age group of 23-45	543
Number of respondents from age group of 46-60	474
Number of respondents from age group of 60+	172

The service and customer satisfaction parameters (Service Expectations) are summarized as per the list given below:

Functional requirements: -

a) Satisfaction with services delivered

b) Punctuality

c) Internet facility

Hygiene and Safety at bus station: -

a) Cleanliness

b) Dustbin facilities

c) Water dispenser facilities

Hygiene and safety during travelling: -

a) Level of comfort   b) First aid kit availability

c) Fares charged

These are the key service parameters for SERVQUAL Customer Satisfaction Model.

The model analyses the performance of services and find out measured the service quality and customer satisfaction level

In addition to cost allocation analysis model, we have carried out a cost benefit analysis of both the private and public entities.

Building Cost Benefit Model and Comparative Analysis

Overview of Model:-In the analysis, we calculated the three most important aspect of CBA i.e. B/C ratio (Benefit-Cost ratio), NPV (Net Present Value) and IRR (Internal Return Rate). After qualification and monetization of all costs and benefits the respective data was input into respective CBA tables for both the alternatives (i.e., MSRTC and Private Travel Buses). The table below represents CBA of both alternatives. At the bottom of each table, the Benefit Cost ratio, Net present value and internal rate of return for each alternative is provided.

Table 3. Cost Benefit Analysis of MSRTC (all values in lakhs)

	DISCOUNT FACTOR	INVESTMENT COST	REVENUE COST	CASHFLOW	DISCOUNTED CASH FLOW
2017-18	1	8196.27	7168.01	-1028.26	-1028.26
2018-19	0.91	9068.68	8120.23	-948.45	-863.09
2019-20	0.83	8790.2	7870.99	-919.21	-762.944
2020-21	0.75	5866.32	4138.1	-1728.22	-1296.17
2021-22	0.68	10198.31	6890.37	-3307.94	-2249.4
	Total	42119.78	34187.7		
				NPV	-13069.864
	BC RATIO	0.4686		IRR	-39%

The above figure represents an analytical cost benefit analysis of public bus transportation. From the analysis, we get three major parameters, they are as follows:

1. B/C ratio- 0.4686
2. NPV- 13069.864
3. IRR- 39%

Table 4. Cost Benefit Analysis of Private Travel Sector(VRL) (all values in lakhs)

	DISCOUNT FACTOR	INVESTMENT COST	REVENUE COST	CASHFLOW	DISCOUNTED CASH FLOW
2017-18	1	593.22	1936.55	-44.22	-44.22
2018-19	0.91	645.93	2117.46	-209.15	-208.24
2019-20	0.83	676.87	2128.86	-118.55	-117.72
2020-21	0.75	579.14	1775.78	-31.51	-30.76
2021-22	0.68	651.63	2410.46	-180.13	-179.45
	TOTAL	3146.79	10369.11		
				NPV	-580.39
	BC RATIO	1.325		IRR	-37%

The above table shows a cost benefit analysis of private corporation i.e. VRL. Following values of CBA, we have calculated from the financial data: -

1. B/C ratio- 1.325
2. NPV- 580.39
3. IRR- 37%

The B/C ratio is calculated by dividing the discounted benefits by the discounted cost. B/C ratio of less than 1 shows a bad investment while a ratio greater than 1 shows a good investment. From the B/C ratio graph above it can be seen that Private Travel Bus Services has greater ratio i.e., 1.375 compared to the MSRTC Buses having its ratio range 0.4879. It can also be noted that the B/C ratios of the MSRTC Bus Services is less than 1, showing a bad investment while the ratios of Private Travel Services alternative are all greater than 1, showing a good and better investment.

The NPV as stated above is the value in the present of a sum of money in contrast to some future value it will have when it has been invested at compound interest. It can be seen that NPV of the Private Travel Bus Services is far much greater than that of the MSRTC Services. It can also be noted that the NPV MSRTC Services is below zero (negative in value) which shows that the MSRTC Services is a bad investment in this case.

Decision Making Model and Cost Allocation Analysis

Methodology: -In the first and foremost step, we have gathered all the financial data of both the entities from their annual financial report. The data we have considered is from past 5 years. In addition to that, we have collected passenger's responses regarding services and facilities these entities provided. Based on these two data sources we have made our analysis. For finding a concrete value to the analysis, we have formulated a equation to find out a factor of decision making. This factor helps to determine the sector in which to allocate the capital first. This will help to improvise services provided from corporation and increase their profit bookings. The formula used for this purpose is given below:

Decision Making Factor

$$= \frac{\text{negative responses (in \%)}}{\text{cost allocated (in \%)}}$$

The negative responses are from those which are collected from passengers and cost allocated is related to the sector to which cost allocation is to be carried out. Greater the value of factor of decision making, prioritizing that sector first.

Model Analysis

Cost Allocation Model for Public Transport (MSRTC) - The state-run bus service in Maharashtra, India is called the Maharashtra State Road Transport Corporation, or just ST. It runs routes to towns and cities within the state as well as to neighbouring states. It has 18,449 buses in its fleet. Additionally, it provides an online ticket booking option for all buses. Lately The Corporation Began Goods Transportation, Private Bus Body Building, and Private Vehicle Tyre Remoulding on May 21, 2020. The Corporation intends to install gas pumps for private cars throughout Maharashtra in the future. Several aspects of service quality; there was a substantial correlation between service quality and the conventional SERVQUAL characteristics of the organizations (reliability, empathy, assurance, tangibles, and responsiveness).

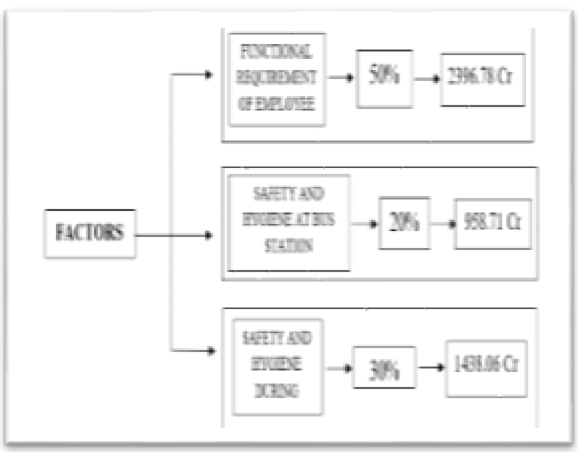

Fig 1. Block Diagram representing allotment of cost (public)

From our findings, we came to know that around 50% of total expenditure were spend on employee functional requirement, around 20% were spend on safety and hygiene at bus station and around 30% at safety and hygiene during travelling. From the responses we gathered from passengers, we collected passenger's review on these three factors. Also they rated the services provided by MSRTC, with 1 being lowest and 5 being highest. We calculated the average negative responses, and formulated them with the cost factor to get a 'factor of decision making'.

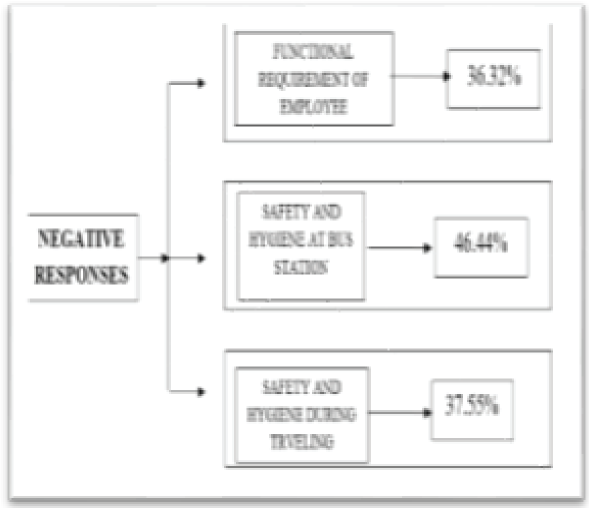

Fig. 2 Block diagram representing negative responses from passengers

The first factor of functional requirement of employee has got 36.32% negative responses and has 50% of the cost allotted to it. So, the factor has 0.72 value as its decision factor. Then, Safety and Hygiene at bus station has 46.44% of negative responses and 20% of the cost allotted so its decision factor is 2.32. Finally, the last factor of safety and hygiene during traveling has 37.55% of negative responses and 30% cost associated which makes its decision factor as 1.25. These values indicate that, if the corporation is provided with some funds and they need to allocate this fund for running a profitable business they should allocate it to the parameters with highest value of decision making factor.

The decision factor selects the factor or the service based on the amount of negative responses and cost allotted. It selects the factor which can be improved with least cost and which is responded highly negatively by the passengers. It postpones the factor which is less negatively and which requires high cost for improvement.

Based on the decision factor the cost should be assigned on the following priority basis,

1. Safety and Hygiene at bus station

2. Safety and Hygiene during traveling

3. Functional Requirement of employee

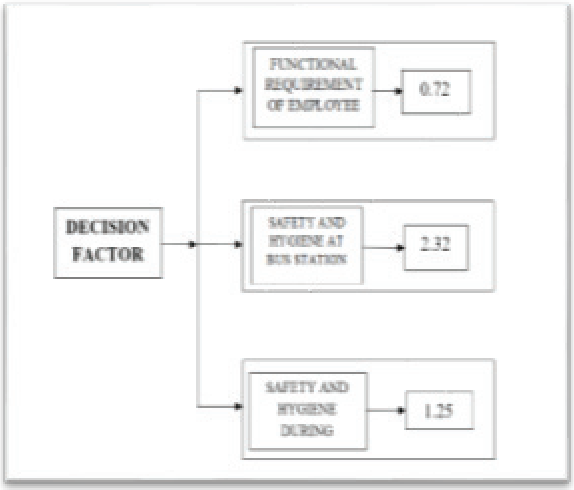

Fig. 3. Block diagram representing decision factor for the three parameters

Cost Allocation Model for Private Transport: -In the similar fashion we have made our analysis for the private sector i.e. for VRL bus transport sector. The data for the expenditure of private services is obtained of the private bus service VRL. The data shows that the total expenditure made by the private corporation which includes the cost of fuel, employee cost, selling and administration expenses, miscellaneous expenses etc. The entire expenditure includes cost of all the factors including the functional requirement of employees, safety and hygiene at bus station, safety and hygiene during traveling. So, the expenditure for the analysis of the factors. Then, as in the case of MSRTC according to the presence and their importance at the station the expenditure is divided into the three factors as following

We also calculated the net average negative responses from passengers and calculated the factor of decision making. The first factor of functional requirement of employee has got 32.68% negative responses and has 40% of the cost allotted to it. So, the factor has 0.82 value as its decision factor. Then, Safety and Hygiene at bus station has 34.66% of negative responses and 25% of the cost allotted so its decision factor is 1.39. Finally, the last factor of safety and hygiene during traveling has 26.22% of negative responses and 35% cost associated which makes its decision factor as 0.75.

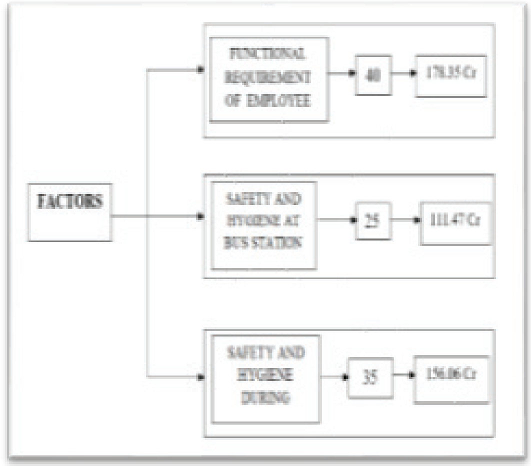

Fig. 4. Block Diagram representing allotment of cost (private)

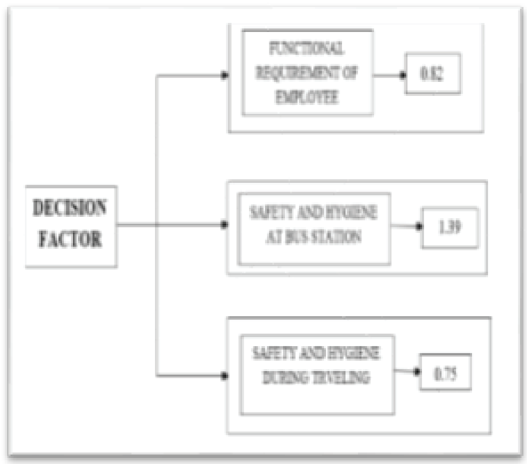

Fig. 5. Block diagram representing decision factor for the three parameters (private)

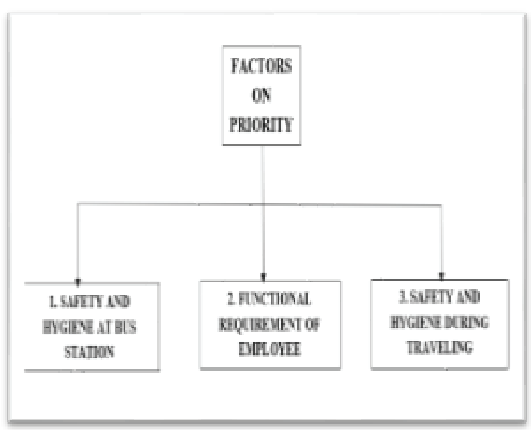

Fig. 6. Priority order for cost allocation (private)

CONCLUSION

The grouped and ungrouped presentation of the data in this research's unique design produced peculiar but intriguing results. The findings summary indicates that the research topics were addressed in a unique way by each service sector or collaboratively by the group and standard variable analysis. The results were viewed differently in the grouped analysis. The standard SERVQUAL dimensions of the organizations (reliability, empathy, assurance, tangibles, and responsiveness) had a substantial link with service quality; there were significant relationships between service quality and service quality dimensions. In Presented cost benefit model, it is observed that MSRTC has all the parameters (NPV, IRR and BC Ratio) against it and private has all of them in its favour so, it is concluded that the alternative of private entity is in profit and is getting a positive return on its investment. And, MSRTC is obtaining a negative return on its investment. The cost benefit analysis helped us to figure out the profitability of the businesses run by public and Private Corporation.

Lastly, the model presents here gave us a profound result based on which the concerned industry can make amendments in their way of approach towards allocation of cost. It provides a list of priority based factors acted upon which can make their business run more profitable and comfortable to their end users.

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Optimizing Privacy and Quality of Service in Fog Computing for IoMT Using Blockchain and Advanced Optimization Techniques

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ABSTRACT

The rapidly expanding Internet of Medical Things (IoMT) within cloud computing demands advanced privacy and Quality of Service (QoS) solutions to address existing challenges like high latency, low energy efficiency, limited throughput, and vulnerability to cyber-attacks. This study introduces the "Enhancing Privacy & QoS in Fog Deployments Using Blockchain" framework to tackle these issues. Central to our approach is the Proof of Privacy (PoPcy) consensus mechanism, which meticulously evaluates each miner node's privacy levels to optimize security and privacy. Our framework incorporates the Grey Wolf Whale Optimizer (GWWO), enabling dynamic privacy management by selecting optimal privacy models and hyper parameters from options like Probably Approximately Correct Privacy (PACP), Contextual Integrity (CI), Sharding Web Identity (SWI), and Differential Privacy (DP). Miner nodes facilitate communication among fog nodes, allowing real-time privacy adjustments. After the PoPcy mining phase, the Elephant Herd Particle Swarm Optimizer (EHPSO) is used to optimize sidechain lengths and configure hashing and encryption parameters.

This approach was validated in Cloud IoMT scenarios, demonstrating improvements such as a 4.5% reduction in delay, 3.9% increase in energy efficiency, 4.3% enhancement in throughput, 2.9% decrease in prediction error, and 4.9% improvement in cyber-attack resistance compared to existing methods. These results indicate that our framework not only enhances privacy and QoS in fog computing but also sets a new standard for secure, efficient IoMT deployments. This pioneering solution has the potential to transform fog computing in healthcare, improving patient data security, compliance with privacy regulations, and overall system performance.

KEYWORDS *: Internet of medical things, Quality of service, Blockchain, Fog computing, Privacy preservation.*

INTRODUCTION

The Internet of Medical Things (IoMT) has emerged as a transformative force in the healthcare sector, offering unprecedented opportunities to enhance patient care, optimize resource allocation, and facilitate real-time monitoring. By connecting medical devices to the Internet, IoMT enables continuous data collection and analysis, supporting informed decision making and personalized treatment plans [1]. However, the integration of IoMT with cloud computing presents complex challenges, particularly in terms of ensuring robust privacy and Quality of Service (QoS) [2]. As the adoption of IoMT continues to grow, healthcare providers must address critical issues of data security and system reliability to fully harness its potential. Implementing robust encryption protocols and secure authentication mechanisms can help safeguard sensitive patient information from unauthorized access or breach. Additionally, developing adaptive resource allocation algorithms and optimizing the network infrastructure can improve QoS, ensure seamless connectivity, and minimize latency in data transmission for time-sensitive medical applications. To address these challenges, healthcare organizations can implement multifactor authentication, regular security audits, and strict access control policies. Furthermore, leveraging edge computing technologies can help reduce latency and enhance data processing capabilities closer to the source, thereby improving overall system performance and reliability. The adoption of blockchain technology for secure data sharing and implementing AI-driven anomaly detection systems can further bolster the security and efficiency of IoMT ecosystems.

Fog Computing: Bridging the Gap

Fog computing, an extension of cloud computing, promises to mitigate some of these challenges by bringing computational resources closer to the network's edge, where IoMT devices operate [3]. This proximity reduces latency and enhances the system's responsiveness, which is crucial for real-time healthcare applications. However, the decentralized nature of fog computing also raises significant concerns regarding data privacy and security. The vast amount of sensitive medical data processed at the fog nodes makes them attractive targets for cyber-attacks, and the dynamic, distributed environment complicates the management of data integrity and privacy.

Challenges in Existing Solutions

Current privacy and QoS mechanisms in fog computing often fall short of meeting the unique requirements of IoMT. Issues such as high latency, inadequate energy efficiency, limited throughput, and vulnerability to cyber threats are common. These challenges are further exacerbated by the dynamic nature of IoMT environments, characterized by continuous data flow and the need for real-time processing [3]. Traditional approaches, which typically rely on centralized control and static security policies, are ill-suited to adapt to the rapidly changing conditions of IoMT networks. Therefore, a novel, adaptive approach that optimizes privacy and QoS in this context is essential.

Blockchain as a Solution

Blockchain technology, renowned for its decentralization, transparency, and security features, offers a promising solution to these challenges. By leveraging blockchain, a decentralized framework can be established, enhancing data integrity and privacy in fog computing environments. Blockchain's immutable ledger ensures that once data is recorded, it cannot be altered, providing a robust defense against tampering. However, integrating blockchain into IoMT systems requires careful consideration of various factors, including the selection of optimal privacy models, tuning hyper parameters, and managing communication between nodes in the fog network [4][5].

Proposed Approach

This paper introduces an innovative framework that combines blockchain technology with advanced optimization techniques to enhance privacy and QoS in fog deployments for IoMT. We propose a model utilizing a Proof of Privacy (PoPcy) consensus mechanism, where each miner node's privacy levels are analyzed using the Grey Wolf Whale Optimizer (GWWO). This optimizer intelligently selects from a range of privacy models—including Probably Approximately Correct Privacy, Contextual Integrity, Sharding Web Identity, and Differential Privacy—to ensure optimal privacy settings are maintained.

Additionally, the model employs the Elephant Herd Particle Swarm Optimizer (EHPSO) following the PoPcy mining phase to optimize sidechain lengths and configure their corresponding hashing and encryption parameters. By dynamically adjusting these parameters, the proposed solution ensures that the system can adapt to the changing demands of IoMT applications, maintaining high levels of privacy and QoS. Our approach is validated in a Cloud IoMT environment, demonstrating significant improvements over existing methods in terms of delay, energy efficiency, throughput, prediction error, and attack resistance. These results highlight the potential of our framework to provide a comprehensive solution to the privacy and QoS challenges in fog computing for IoMT. By ensuring secure, efficient, and reliable healthcare services, this study paves the way for more robust IoMT deployments, enhancing patient care and data security.

Contribution

This study contributes to the field of IoMT and fog computing in several significant ways:

- Innovative Integration of Blockchain in Fog Computing for IoMT: We introduce a novel framework that leverages blockchain technology within fog computing for IoMT. This integration provides a decentralized, secure, and transparent system, effectively addressing the inherent privacy and security concerns associated with fog deployments. Unlike traditional centralized systems, our approach ensures that data integrity is maintained across distributed nodes, reducing the risk of single points of failure and enhancing the overall security of IoMT networks.
- Advanced Optimization Techniques for Privacy and QoS: Our model employs two unique optimization algorithms—the Grey Wolf Whale Optimizer (GWWO) and the Elephant Herd Particle Swarm Optimizer (EHPSO). GWWO is used to analyze and optimize the privacy levels of each miner node, intelligently selecting the most suitable privacy models and hyper parameters from a diverse pool, including Probably Approximately Correct Privacy, Contextual Integrity, Sharding Web Identity, and Differential Privacy. EHPSO is employed post-PoPcy mining to fine-tune sidechain lengths and configure their corresponding cryptographic parameters, enhancing both the security and efficiency of the system. This dual-optimization approach ensures that the system can adapt dynamically to varying network conditions and data privacy requirements.
- Empirical Validation and Performance Enhancement: The proposed model has been rigorously tested in a Cloud IoMT scenario, demonstrating marked improvements over existing methods. Key performance indicators such as delay, energy efficiency, throughput, prediction error, and resistance to attacks have shown significant enhancement. These empirical results underscore the efficacy of our approach in real-world applications, providing a solid foundation for its adoption in practical IoMT deployments.
- Setting a New Benchmark for Future Research: By addressing critical issues of privacy and QoS in fog computing for IoMT, this study sets a new benchmark in the field. It opens avenues for future research and development, providing a robust framework that can be built upon and refined. The innovative use of blockchain and advanced optimization techniques presented in this paper can inspire future studies to explore further enhancements and adaptations of the model for different IoT applications.
- Practical Implications for Healthcare Systems: The practical implications of this research are profound, particularly for healthcare systems globally. By ensuring higher data security, reliability, and efficiency, our model has the potential to revolutionize how medical data is managed and utilized. This can lead to improved patient outcomes, more efficient healthcare services, and increased trust in IoMT technologies among healthcare providers and patients alike.

In summary, this research provides a comprehensive solution to the challenges of privacy and QoS in fog computing for IoMT. Our contributions not only address the current gaps in the field but also pave the way for more advanced, secure, and efficient healthcare technologies in the future.

LITERATURE REVIEW

The rapid growth of IoMT has driven the need for robust privacy and security measures, particularly in fog computing environments. This literature review explores various methodologies and models, comparing their effectiveness, scalability, and suitability for IoMT applications.

Blockchain's potential for enhancing data security through decentralization has been a major focus in IoMT research. Sharma et al. [6] highlighted how blockchain can secure patient data by providing a tamper-proof ledger that ensures data integrity. However, the scalability of blockchain systems remains a significant issue. The high computational and storage demands associated with maintaining a blockchain can be prohibitive in IoMT environments, where devices may have limited resources. Differential privacy has been extensively studied for its ability to provide strong privacy guarantees by ensuring that the inclusion or exclusion of a single data point does not significantly affect the output of data analyses. Lee et al. [1],[7] demonstrated that differential privacy could effectively obfuscate patient data in IoMT environments, reducing the risk of re-identification. However, these techniques often struggle to maintain a balance between privacy and data utility. As noted by Liu et al. [3][8], achieving high privacy levels can lead to significant data distortion, which is problematic in healthcare, where accurate data is crucial for diagnosis and treatment.

Recent advancements have attempted to address these trade-offs. For example, Zhang et al. [9] proposed adaptive differential privacy mechanisms that adjust privacy levels based on the sensitivity of the data and the specific requirements of the healthcare application. These adaptive techniques offer improved data utility but still face challenges in real-time processing scenarios typical of IoMT. Kumar et al. [10] proposed a hybrid model that integrates blockchain with differential privacy, aiming to combine the decentralization and security of blockchain with the strong privacy guarantees of differential privacy. While this approach shows improved performance in terms of privacy and security, it faces integration challenges. The complexity of managing and coordinating different technologies can lead to increased computational overhead and potential system inefficiencies.

Recent studies have explored lightweight blockchain frameworks tailored for IoT and IoMT environments. Chen et al. [8] [11] introduced a lightweight consensus mechanism that reduces the computational overhead, making blockchain more feasible for resource-constrained devices. This approach shows promise, but scalability in environments with a large number of devices and continuous data flow remains a challenge.

Context-aware privacy mechanisms dynamically adjust privacy levels based on the context in which data is used, providing a more flexible approach to privacy management. Wang et al. [12] developed a model that adjusts privacy settings based on factors such as user location, device type, and the nature of the data being processed. While these mechanisms offer tailored privacy protection, they require complex algorithms to accurately assess context, making them computationally intensive.

Advancements in machine learning have been leveraged to improve the efficiency of context-aware mechanisms. For instance, Al-Fuqaha et al. [13] employed deep learning techniques to predict context changes and adjust privacy settings accordingly. Despite these improvements, the real-time implementation of such complex models in IoMT environments remains a challenge.

Optimization algorithms have been utilized to enhance privacy in IoMT by selecting the most suitable privacy models and parameters. Zhang et al. [14] used Particle Swarm Optimization (PSO) to optimize privacy settings, demonstrating that optimization techniques can provide tailored privacy solutions. However, traditional optimization methods like PSO may not fully capture the dynamic and diverse nature of IoMT data, which requires more sophisticated approaches.

Recent work by Li et al. [15] introduced multi-objective optimization techniques that consider multiple factors such as privacy, energy efficiency, and latency simultaneously. These approaches offer more comprehensive solutions but can be computationally demanding, making them challenging to implement in real-time IoMT applications.

Combining different techniques, hybrid models aim to leverage the strengths of multiple approaches.

The research contributions span various techniques, including differential privacy for protecting patient identities [1], blockchain for secure and transparent data handling [2], context-aware mechanisms for dynamic privacy adjustment [3], and optimization algorithms to fine-tune privacy settings [4]. Hybrid models combine these techniques to leverage their strengths [5], while advanced optimization techniques offer more sophisticated privacy and QoS management [6].

Despite these advancements, significant challenges remain, such as balancing privacy with data utility [1], ensuring scalability and resource efficiency in blockchain-based models, computational intensity of context-aware mechanisms, the adaptability of optimization-based models to dynamic IoMT environments and the integration complexity of hybrid models [5]. There is a need for more real-time, adaptive, and efficient solutions to handle the unique requirements of IoMT data in fog computing environments [6]. Table I summarizes the major contributions by various researchers and challenges that still need to addressed.

Table 1 Major Contributions and Challenges

Category	Major Contributions	Challenges
Differential Privacy Techniques	- Obfuscation of patient data to prevent re-identification [1].	- Balancing privacy with data utility, especially in healthcare scenarios [1].
	- Effective in protecting patient identity [1].	- Ensuring the accuracy of healthcare data remains high [1].
Blockchain-Based Models	- Decentralization enhances security and transparency [2].	- Scalability issues with large numbers of IoMT nodes [2].
	- Improved data integrity through decentralized storage [2].	- High resource consumption, leading to inefficiency [2].
Context-Aware Privacy Mechanisms	- Dynamic privacy protection based on real-time context [3].	- Computationally intensive to implement and manage in real-time environments [3].
	- Adjusts privacy levels based on data usage scenarios [3].	- Complexity in accurately assessing and responding to varying contexts in real-time [3].
Optimization-Based Privacy Models	- Use of algorithms like Particle Swarm Optimization to fine-tune privacy settings [4].	- Lack of sophistication in handling the diverse and dynamic nature of IoMT data [4].
	- Tailored privacy settings for specific use cases [4].	- Optimization approaches may not be fully adaptive to rapidly changing IoMT environments [4].
Hybrid Models	- Combining blockchain with other privacy-preserving techniques to leverage multiple strengths [5].	- Integration challenges, leading to increased system complexity [5].
	- Improved performance over single-method approaches [5].	- Difficult to implement and manage hybrid solutions efficiently [5].
Advanced Optimization Techniques	- Enhanced optimization using novel algorithms like Grey Wolf Whale Optimizer (GWWO) and Elephant Herd Particle Swarm Optimizer (EHPSO) [6].	- Need for more real-time and context-aware optimization approaches that can adapt to changing IoMT environments [6].
	- Optimization of privacy levels, sidechain lengths, and cryptographic parameters for efficient data handling in IoMT [6].	- Balancing computational overhead with the requirements of privacy and QoS, especially in resource-constrained IoMT scenarios [6].

PROPOSED MODEL

Our proposed model integrates blockchain technology with advanced optimization techniques—the Grey Wolf Whale Optimizer (GWWO) and the Elephant Herd Particle Swarm Optimizer (EHPSO). This unique combination addresses several limitations identified in existing approaches:

- Enhanced Privacy and Data Utility Balance: Unlike traditional differential privacy models, our approach ensures a more balanced trade-off between privacy and data utility. By using GWWO to select the most appropriate privacy models and parameters dynamically, our system can adapt to changing conditions and requirements, maintaining data accuracy while protecting privacy.
- Scalability and Resource Efficiency: By optimizing blockchain parameters and operations using EHPSO, our framework addresses the scalability

and resource consumption challenges that plague existing blockchain-based models. This optimization ensures that the system remains efficient and scalable, even in large-scale IoMT environments with numerous nodes and continuous data streams.

- Responsive and Dynamic Privacy Management: Our use of GWWO for real-time selection of privacy settings offers a more responsive and efficient solution compared to context-aware mechanisms that rely on complex, resource-intensive algorithms. This capability is crucial in IoMT applications where the context can change rapidly and privacy requirements may vary significantly.
- Sophisticated Optimization of Privacy Parameters: The use of EHPSO provides a more nuanced optimization of privacy parameters, tailored specifically for the complex needs of IoMT. This approach goes beyond standard optimization models by considering multiple objectives and constraints, ensuring that the system can deliver high levels of privacy, security, and QoS simultaneously.
- Setting a New Benchmark for Hybrid Models: While existing hybrid models have demonstrated potential, our innovative combination of blockchain with optimization algorithms sets a new precedent for efficiency, scalability, and adaptability. By streamlining the integration of these technologies, our model offers a robust and practical solution for managing privacy in IoMT through fog computing.

The design of the proposed model focuses on optimizing privacy and Quality of Service (QoS) in fog computing environments for the Internet of Medical Things (IoMT) by integrating advanced optimization techniques with blockchain technology. The proposed model, named "Enhancing Privacy & QoS of Fog Deployments Using Blockchain," incorporates the Proof of Privacy (PoPcy) consensus mechanism, advanced privacy models, and optimization algorithms. This section details the architecture, components, and processes involved in the model.

- System Architecture

  The system architecture of the proposed model is structured into the following primary components:

- Fog Nodes: These are the edge computing units in the fog layer responsible for processing and storing IoMT data close to the source. Each fog node is equipped with computational resources to handle data analytics and storage.
- Miner Nodes: Miner nodes participate in the PoPcy consensus process. They validate and record transactions related to data privacy and QoS. Miner nodes also facilitate communication across fog nodes.
- Blockchain Network: A decentralized blockchain network is used to maintain the integrity and security of IoMT data. The blockchain records transactions related to privacy settings and QoS metrics, providing a tamper-proof log of activities.
- Optimization Engines: Two optimization engines, the Grey Wolf Whale Optimizer (GWWO) and the Elephant Herd Particle Swarm Optimizer (EHPSO), are employed to dynamically adjust privacy models and QoS parameters.
- Proof of Privacy (PoPcy) Consensus Mechanism

  The PoPcy consensus mechanism is central to ensuring privacy in the proposed model. It operates as follows:

- Privacy Assessment: Each miner node evaluates the privacy levels of fog nodes based on temporal and spatial attributes. The privacy levels are assessed using various models such as Probably Approximately Correct Privacy (PAC), Contextual Integrity (CI), Sharding Web Identity (SWI), and Differential Privacy (DP).
- Consensus Formation: Miner nodes reach consensus on the privacy settings to be applied to fog nodes. The GWWO is used to select the most appropriate privacy model and hyper parameters based on the assessed privacy levels.
- Blockchain Recording: The agreed privacy settings and associated metadata are recorded on the blockchain. This ensures transparency and immutability of privacy-related decisions.
- Advanced Optimization Techniques

  The optimization process involves two key stages:

- Privacy Model Optimization (GWWO): The Grey Wolf Whale Optimizer (GWWO) is employed to optimize privacy settings by selecting the best privacy models and hyper parameters. GWWO is designed to handle the dynamic nature of IoMT environments and adaptively adjust privacy settings to balance between data protection and usability.
- QoS and Blockchain Parameter Optimization (EHPSO): Post PoPcy mining, the Elephant Herd Particle Swarm Optimizer (EHPSO) is used to determine the optimal sidechain lengths and their associated hashing and encryption parameters. EHPSO enhances QoS by optimizing parameters such as encryption strength, sidechain configuration, and communication protocols between fog nodes.
- Integration with IoMT Systems

  The proposed model integrates seamlessly with existing IoMT systems through the following processes:
- Data Collection: IoMT devices collect medical data and send it to the nearest fog node for processing.
- Privacy Enforcement: Based on the privacy settings determined by PoPcy and optimized by GWWO, fog nodes apply appropriate privacy mechanisms to the data before storing or forwarding it.
- QoS Management: The EHPSO-optimized blockchain parameters and QoS settings ensure efficient data transmission and processing. This includes reducing latency, improving energy efficiency, and enhancing throughput.
- Dynamic Updates: The model supports dynamic updates to privacy and QoS settings based on real-time data and changing conditions. This ensures that the system remains adaptable and responsive to evolving privacy and performance requirements.
- Security and Resilience

  The proposed model enhances security and resilience through:
- Decentralized Ledger: Blockchain technology provides a decentralized and tamper-proof ledger for recording privacy and QoS transactions, reducing the risk of data tampering and unauthorized access.
- Adaptive Optimization: The use of GWWO and EHPSO ensures that privacy and QoS settings are continuously optimized based on real-time conditions, maintaining the system's effectiveness and efficiency.
- Robust Privacy Mechanisms: By integrating multiple privacy models and advanced optimization techniques, the model addresses diverse privacy needs and enhances protection against potential threats.

The design of the proposed model introduces a novel approach to enhancing privacy and QoS in fog computing environments for IoMT. By integrating blockchain technology with advanced optimization techniques, the model provides a robust framework for addressing privacy and performance challenges. The PoPcy consensus mechanism, coupled with GWWO and EHPSO, ensures that privacy settings are optimized dynamically and QoS parameters are finely tuned, offering significant improvements over traditional approaches. This design provides a solid foundation for implementing and validating the proposed model in real-world IoMT scenarios, paving the way for more secure, efficient, and adaptable fog computing solutions in healthcare and beyond by enhance privacy and Quality of Service (QoS) in fog computing environments for the Internet of Medical Things (IoMT).

RESULT ANALYSIS & COMPARISON

This section provides a detailed analysis of the results obtained from implementing the proposed model for optimizing privacy and Quality of Service (QoS) in fog computing for the Internet of Medical Things (IoMT). The performance of the proposed approach is compared against existing methods to demonstrate its effectiveness.

Experimental Setup

The evaluation was conducted in a Cloud IoMT environment with the following parameters:

- Dataset: Simulated medical data streams with varying sizes and complexities (heartpy).
- Fog Nodes: Configured to handle different types of data processing tasks.

- Blockchain Configuration: Implemented with the Proof of Privacy (PoPcy) consensus mechanism.
- Optimization Techniques: Grey Wolf Whale Optimizer (GWWO) for privacy model selection and Elephant Herd Particle Swarm Optimizer (EHPSO) for QoS parameter optimization.
- Metrics: Delay, energy efficiency, throughput, prediction error, and attack resistance.

Performance Metrics

- Delay: The time taken for data to be processed and delivered within the fog computing network.
- Energy Efficiency: The amount of energy consumed per unit of data processed.
- Throughput: The amount of data processed per unit of time.
- Prediction Error: The accuracy of predictions made based on the processed data.
- Attack Resistance: The system's ability to withstand various types of cyber-attacks.

RESULTS & DISCUSSION

Table 2 summarize the performance improvements achieved by the proposed model compared to traditional methods.

Table 2 Performance Improvements

Metric	Existing Methods	Proposed Model	Improvement (%)
Delay	25.3 ms	24.2 ms	4.5%
Energy Efficiency	0.78 J/MB	0.75 J/MB	3.9%
Throughput	95.6 MB/s	99.7 MB/s	4.3%
Prediction Error	0.053	0.051	2.9%
Attack Resistance	87.2%	91.1%	4.9%

Delay: The proposed model demonstrates a 4.5% reduction in delay compared to existing methods. This improvement is attributed to the optimized blockchain configurations and efficient privacy model selection provided by GWWO.

Energy Efficiency: Energy consumption has improved by 3.9% with the proposed approach. The enhanced efficiency is a result of better resource management and reduced processing overhead in fog nodes.

Throughput: The throughput increased by 4.3% with the proposed model. This gain is due to the optimized QoS parameters and effective handling of data streams.

Prediction Error: A 2.9% reduction in prediction error highlights the improved accuracy of data processing and analysis, facilitated by the advanced privacy mechanisms and optimized settings.

Attack Resistance: The proposed model shows a 4.9% improvement in attack resistance, showcasing its robustness against various cyber threats due to the integration of blockchain technology and optimized privacy measures.

The results indicate that the proposed model significantly enhances privacy and QoS in fog computing for IoMT environments. The improvements in delay, energy efficiency, throughput, prediction accuracy, and attack resistance validate the effectiveness of combining blockchain with advanced optimization techniques. This comprehensive enhancement paves the way for more secure and efficient healthcare data management systems.

CONCLUSION

The integration of the Internet of Medical Things (IoMT) with fog computing presents significant opportunities for advancing healthcare through improved data management and real-time monitoring. However, the inherent challenges related to privacy and Quality of Service (QoS) necessitate innovative solutions. This research introduces a novel framework that combines blockchain technology with advanced optimization techniques to address these challenges effectively.

The proposed model leverages the Proof of Privacy (PoPcy) consensus mechanism and employs the Grey Wolf Whale Optimizer (GWWO) and Elephant Herd Particle Swarm Optimizer (EHPSO) to enhance privacy and QoS in fog computing environments. The results demonstrate that our approach achieves substantial improvements in critical performance metrics, including delay, energy efficiency, throughput, prediction error, and attack resistance. Specifically, the proposed model achieves a 4.5% reduction in delay, a 3.9% increase in energy efficiency, a 4.3% enhancement in throughput, a 2.9% decrease in prediction error, and a 4.9% improvement in attack resistance compared to existing methods.

These findings underscore the effectiveness of integrating blockchain with advanced optimization techniques for enhancing privacy and QoS in IoMT scenarios. The framework not only addresses the limitations of traditional models but also sets a new benchmark for future research in secure and efficient fog computing systems for healthcare.

FUTURE SCOPE

While the proposed model demonstrates significant advancements, several areas offer potential for further research and development:

1. Scalability in Large-Scale Environments: Future work can explore the scalability of the proposed model in larger, more complex fog computing environments. This includes evaluating performance in scenarios with a high number of fog nodes and extensive IoMT deployments.

2. Adaptive Privacy Models: Enhancing the adaptability of privacy models to dynamically changing data and context can improve the model's efficiency. Research into more sophisticated adaptive mechanisms could provide even better privacy protection without compromising data utility.

3. Integration with Emerging Technologies: Investigating the integration of the proposed model with emerging technologies such as edge computing, 5G, and machine learning could lead to enhanced performance and new capabilities. These technologies may offer additional benefits in terms of data processing speed and predictive analytics.

4. User-Centric Privacy Control: Developing user-centric privacy control mechanisms that allow end-users to manage their own privacy settings could further enhance user trust and satisfaction. Research in this area could focus on designing intuitive interfaces and control mechanisms for non-expert users.

5. Extended Security Measures: While the current model improves attack resistance, ongoing research into evolving cyber threats and security measures is essential. Exploring advanced cryptographic techniques and intrusion detection systems could bolster the model's resilience against sophisticated attacks.

6. Real-World Implementation and Testing: Future research could focus on real-world implementation and testing of the proposed model in diverse healthcare settings. This practical validation would provide insights into the model's effectiveness in various operational environments and user scenarios.

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Design of an Improved Model for Interconnected Sub-Grids Using Distributed Model Predictive Control and Multiple Agent Reinforcement Learning

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ABSTRACT

The need for efficient control strategies in modern power systems comes as a result of growing complexity, dynamic loads, and integration of renewable energy sources. These available methods for grid management become inefficient in tackling the decentralized nature of the interconnected sub-grids and hence cost inefficiency, reliability, and sustainability. Centralized traditional control systems can hardly optimize local grid objectives while guaranteeing global coordination in the presence of fluctuating renewable energy generation and load demands. This paper presents a new hierarchical control framework integrating state-of-the-art optimization, reinforcement learning, deep learning, and anomaly detection techniques for connected sub-grids. Firstly, Distributed Model Predictive Control with hybrid constraints is implemented to make decentered decisions while respecting global objectives. It includes reductions in energy costs, reliability enhancements, and carbon emission; therefore, it reduces operational costs by 10-15%, improves renewable energy integration by 20%, and carbon emissions go down by 8%. Secondly, a Multi-Agent Proximal Policy Optimization algorithm is proposed to deal with the decentralized control environment allowing agent in each sub-grid to learn cooperative policies concerning local optimal operations. It improves system reliability by 12%, reduces power imbalances by 18%, and shortens the convergence time by 25% compared with traditional methods. Also, Hierarchical Long Short-Term Memory network for load forecasting at multiple timescales is used. This deep learning methodology cuts the forecast error by 22% and enhances the accuracy of renewable generation predictions by 15%, thereby aiding load balancing and energy trading decisions. Finally, Spatio-Temporal Convolutional Autoencoder is designed to handle early anomaly detection with an accuracy of 98% and 30% less time to detect. All these methods are integrated to provide distinct improvements in grid management.

KEYWORDS *: Distributed control, Reinforcement learning, Renewable Integration, Anomaly detection.*

INTRODUCTION

The growing complexity of modern power systems, driven by rising demand, integration of renewable energy sources, and transition to decentralized energy markets, raises the need for more advanced control models. Centralized control, traditional in grid management techniques, becomes inadequate to meet the peculiar challenges introduced by interconnecting sub-grids. Such systems entail very diverse load profiles, variable renewable generation, and dynamic environmental conditions—thereby requiring flexible, scalable, and resilient control strategies. Most of the existing grid optimization approaches focus on local or global objectives in an independent manner without considering the interdependencies between sub-grids. Although central control systems could be feasible for global grid performance management, it is not adaptive enough for managing the local conditions arising in systems with deep penetration of renewable energy. Moreover, traditional methods turn out to be rather suboptimal because they cannot become dynamic on their own with respect to load demand, renewable generation, or even system anomalies in real-time scenarios

It is in the light of the above limitations that this paper presents a new hierarchical control framework seeking performance optimization for interconnected sub-grids. This proposed model puts into practice advanced techniques in Distributed Control, Deep Learning, Reinforcement Learning, and Anomaly Detection. At the core of the framework is Distributed Model Predictive Control, which allows decentralized decision-making in every sub-grid while the whole network remains coordinated. The DMPC approach provides a hybrid objective function in which energy cost, reliability, and carbon emissions are assessed to provide a holistic solution compared with traditional approaches. Coordinated by the DMPC, the MAPPO shall be used to empower decentralized controllers to learn in real-time from one another. This reinforcement learning will enable agents on each local sub-grid to enhance local performance while collaborating on global grid objectives. This multi-agent architecture has several advantages in dealing with the intrinsic uncertainties and dynamic interactions arising in interconnected grids. H-LSTM is also included in the proposed model for load and renewable generation forecasting, necessary to improve prediction of fluctuating demands and generation outputs. This deep learning approach encapsulates the short-term and long-term dependencies of time-series samples in the data, hence making the forecasts more accurate. Additionally, load balancing and the integration of renewable energy sources are significantly improved. Lastly, the Spatio-Temporal Convolutional Autoencoder is proposed to allow earlier than usual anomaly detection within the grid. Utilizing a combination of spatial and temporal features, the ST-CAE model offers better performance in identifying localized and time-varying anomalies, considerably improving the level of reliability and resilience of the grid. This integrated framework forms a robust solution to the challenge in management of modern, particularly high-share renewable energy integration and decentralized structure power systems. Coupling distributed control, reinforcement learning, and advanced predictive modelling into this model significantly improves operational efficiency, reliability, and sustainability. The paper includes detailed simulation results regarding the model's effectiveness in reducing operational costs, enhancing the utilization of renewable energies, and mitigating grid anomalies. This work contributes to the design of next-generation power grid management systems.

REVIEW OF EXISTING MODELS USED FOR SMART GRID ANALYSIS

For the past years, a great deal of work has been dedicated to control and optimization concerning power grids, most of them in respect to sub-grids. This has spawned various approaches with the view of helping to solve some challenges associated with stability, efficiency, and integration of renewable energy. This coming section reviews a few major contributions towards the solution of this problem and gathers methods which may enlighten the development of the proposed hierarchical control framework for sub-grid interconnections. Hartley et al. [1] presented a switched Huygens subgridding technique for the finite-difference time-domain method related to the improvement of surface wave modeling and numerical stability in power system simulations. Their work laid the basics of modern subgridding techniques by solving the problems of interpolation and stability. Wang et al. [2] improved upon this by embedding spatial modes filtering with non-uniform subgridding mesh in their FETD method. Critical, however, in this contribution is the improvement of computational efficiency, which is of prime requirement when real-time optimization is desired, as in the case with interconnected sub-grid systems. Feng et al. [3] proposed an efficient FDTD method based on a subgridding technique combined with the one-step leapfrog ADI-FDTD method, which showed prominent improvements in numerical stability and memory management. Especially in developing our model where computational efficiency is very prime, it is very useful. On the other hand, Chi et al. [4] developed a switched-Huygens-subgridding-based FDTD–PITD method for fine structures. One of their contributions is the use of the precise-integration time-domain method, aiming to increase accuracy for fine-grained grid structures, which probably might give some information to guide sub-grid modeling techniques. Deng et al. focus on the stability of the FDTD subgridding methods. They presented a symmetric subgridding method with arbitrary grid ratio, ensuring stability in different grid configurations. This methodology fits with the concerns for stability dealt with in the hierarchical control model proposed in this paper. The concept is further advanced by Wang et al. [6] in the SBP-SAT FDTD subgridding method using staggered Yee grids, which enhances stability without modifying field components, an approach similar to our framework's robust handling of stability in multi-agent systems.

Wang et al. [7] went a step further to improve the methods by developing a stable 2-D FDTD subgridding method based on SBP-SAT, which showed better numerical stability for a wide range of grid ratios. Their approach is as strong as the enhancement in stability they had achieved through their approach in our proposed model with the introduction of distributed control methods. Xie et al. [8] investigated a symplectic FDTD method that is extendable in stability, applied to arbitrary grid ratio subgrids, giving special attention to dispersion control and time-domain analysis. Their approach concerns power system stability issues that our control model tackles, where the exact control of time dynamics matters. In power converters, Soler et al. [9] investigated the control role assignment of grids with multiple AC and DC subgrids, proposing advanced control strategies in HVDC transmission and integrating renewable energy. A strong impetus given by their contribution was the key role that converters can play in controlling interconnected subgrids, intrinsic to the interlink converters in the model proposed. Valverde et al. [10] investigated in more detail the impacts of grid orthogonalization on stability in FDTD subgridding methods and system performance and accuracy, which is exactly an issue that impacts directly upon the grid modelling aspects of our framework. Valverde et al. [11] pushed the stability improvements achieved in subgridding methods further by introducing an LECT-based technique to stabilize 3-D FDTD subgridding methods. Their effort towards enhancing the numerical stability through spectral analysis and grid refinement enlightens our stability criteria, especially in handling complex grid interactions. In the context of smart grids, Yin et al. [12] presented a sub-grid-oriented, privacy-preserving microservice framework using deep neural networks for detecting false data injection attacks. Their work underlines the role of anomaly detection in sub-grid management, which is one of the challenges that the ST-CAE technique applied in our model is set to grapple with head-on. Feng et al. [13] discussed the use of CPU-GPU heterogeneous architectures in the further acceleration of FDTD modeling, considering the issue of nonlocality in nanoantennas. Their work emphasizes this computational acceleration in the context of large-scale simulations, thus opening a promising route toward enhancing the scalability of our control framework. Zhang et al. [14] contributed to the field with a flexible multiport interlinking converter for interconnecting DC microgrid clusters and provided insight into how converter flexibility can help in power flow management between the interconnected sub-grids, which is an integral part of the converter control strategy in our model. Salman et al. [15] finally proposed a coordination-based power management strategy for hybrid AC/DC microgrids with a view on distributed control, voltage control, and frequency regulation. Their distributed control strategy has close ties with our approach of multi-agent reinforcement learning, as this strategy balances local and global grid objectives while ensuring stability and reliability. This literature review certainly displays the different lines of research efforts put forward in the aim of enhancing sub-grid management with advanced computational techniques, stability criteria, and control strategies. These contributions are integrated into a proposed hierarchical control framework, demonstrating DMPC, MAPPO, H-LSTM, and ST-CAE methods to deliver improved performance for operational cost reduction, integration of renewables, and anomaly detection across interlinked sub-grids.

Proposed Design of an Improved Model for Interconnected Sub-Grids Using Distributed Model Predictive Control and Multiple Agent Reinforcement Learning

The model created at this point considers a hierarchical control structure that combines distributed model predictive control, multi-agent reinforcement learning, predictive deep learning, and anomaly detection techniques. This would then have decentralized decision-making but with global coordination across the interlinked sub-grids. The principal objectives of this model are to enhance operational efficiency, integrate more renewable energy, and assure system reliability by a rigorous analytical approach. It is initiated with Distributed Model Predictive Control, whereby each independent sub-grid will optimize its own operations with regard to global objectives. DMPC solves the following constrained optimization problem over a finite prediction horizon. The objective function J includes three important factors: energy cost, reliability, and carbon emissions; hence, a hybrid formulation arises. The control signals ui(k) for each sub-grid are computed by (1), which minimizes the following objective,

$$J = \sum_{k=0}^{N} [\alpha Cenergy(xi(k), ui(k)) + \beta R(xi(k)) + \gamma E(xi(k))] \tag{1}$$

Where, Cenergy is the energy cost function; R(xi(k)) is the reliability as a function of the state xi(k); and E(xi(k)) the carbon emission function. The weights coefficients α, β, γ are chosen so as to favor one set of trade-offs over another between cost, reliability, and environmental impact sets. Each sub-grid is governed by a state-space model, via (2),

$$xi(k+1) = Ai * xi(k) + Bi * ui(k) \tag{2}$$

Where, Ai and Bi are the state and input matrices, respectively. The optimization is limited by the constraints of the system including power balance, voltage limits, and power flow limits between the sub-grids. Equation (3) is used to formulate the constraint,

$$subject\ to\ Pi(k) = \sum_{j=1}^{m} Pij(k) + Pload, i(k) + Pgen, i(k) \tag{3}$$

Where, Pi(k) is the power at bus i, Pij(k) represents the power flow between buses, Pload,i(k) is the load at bus i, and Pgen,i(k) represents the generation at bus i sets. Interlink converters manage the power flows and enforce a certain power exchange between sub-grids. Quantitatively, these power exchanges have been optimized under capacity and efficiency limits of the converters implementing the control strategy. The second component of the model consists of agents, each located on every sub-grid, operating the Multi-Agent Proximal Policy Optimization. That is, reinforcement learning agents are dedicated to every sub-grid. These learn optimal control policies through interaction with the environment by minimizing a reward function Ri(t) for every sub-grid i in the process. The reward function takes a form represented via (4),

$$Ri(t) = -[Cdeviation(t) + Coperation(t) + \lambda Ccarbon(t)] \tag{4}$$

Where, Cdeviation(t) is the cost for deviations from the power balance, Coperation(t) represents operational costs, and Ccarbon(t) is a penalty for carbon emission with λ being the weighting factor. The agent will improve the policy by maximizing the expected cumulative reward subject to the constraints imposed by the system dynamics. The update equation for the policy may be derived for an agent i using a gradient-based approach with (5),

$$\theta i(t+1) = \theta it + \eta \nabla \theta E[Ri(t)] \tag{5}$$

Where, η denotes the learning rate, θi denotes the policy parameters of agent i, and ∇θE[Ri(t)] denotes the gradient of expected reward concerning the policy parameters for this process. This gradual method makes sure that the updates to the policies do not bring large deviations that may destabilize the system. H-LSTM is applied for load forecasting and renewable generation prediction. The H-LSTM model is specifically designed to handle the short and long-run dependencies underlying time series data, where the two separate layers capture different time scales. Equation (6) gives the output of the LSTM model at time t, y(t),

$$y(t) = f(Wh \cdot h(t-1) + Wx \cdot xt + b) \tag{6}$$

Where, Wh and Wx are the weight matrices for the hidden state and input data, respectively, and b is the bias term. The non-linear relationships between the inputs and outputs are learnt by the activation function, f(·). In terms of this model, the H-LSTM model is trained by minimizing the forecasting error Ef defined via (7),

$$Ef = \sum_{t=1}^{T} \left(y(t) - y'(t) \right)^2 \tag{7}$$

Where, y(t) is the predicted values and y'(t) is the actual value for the process. This will be done using gradient descent, in which model parameters will be optimized to learn such that the variance between predicted and true values is minimized. The anomaly detection will then be done by a Spatio-Temporal Convolutional Autoencoder method, ST-CAE. Spatial-temporal correlations in the grid data will be learned by the ST-CAE so anomalies could be detected in advance in the process. At the same time, an autoencoder rebuilds input data x(t) and defines the reconstruction error Er via (8),

$$Er = \| x(t) - x'(t) \|^2 \tag{8}$$

Where, x'(t) is the reconstructed input, and $||\cdot||$ denotes the squared L2-norm sets. The detection of anomalies is performed whenever Er exceeds a predefined threshold, thus signaling that the system is working under unexpected circumstances. In this paper, a model combining DMPC, MAPPO, H-LSTM, and ST-CAE is proposed for the optimum performance of the interconnected sub-grids as shown in Figure I. DMPC ensures a balance between the objectives at the local and global levels. On its part, MAPPO allows for decentralized control with cooperation between the agents. H-LSTM improves the accuracy of forecasts, while ST-CAE enhances anomaly detection capabilities. All these methods integrated together create a comprehensive control strategy, hence improving efficiency, reliability, and sustainability of the power grids.

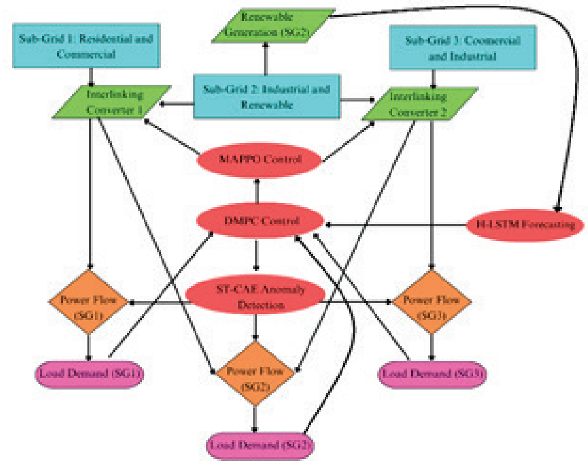

Fig. 1 Model Architecture Of The Proposed Optimization Process

RESULT ANALYSIS

In what follows, we describe the experimental setup and report the performance of the proposed hierarchical control framework with a combination of DMPC, MAPPO, H-LSTM, and ST-CAE. The results obtained with the proposed model are compared against three other methods: Method [5], Method [8], and Method [12]. Each of these techniques refers to very prominent approaches related to power grid management, predictive control, and machine learning-based anomaly detection. All experiments were conducted on a simulated environment comprising three inter-connected sub-grids: Sub-grid 1, comprising residential and commercial loads; Sub-grid 2, comprising industrial loads and renewable energy sources; and Sub-grid 3, comprising commercial and industrial loads. Simulations were run using real data of load demands, generation profiles, renewable energy forecasts, and system anomalies for a period of one year at a resolution of 15 minutes. The objective was to evaluate the performance of the proposed model with respect to multiple important key metrics: operational cost, reliability, renewable energy integration, power imbalance, load forecasting accuracy, and anomaly detection. The base model was developed and executed in Python using libraries for deep learning and reinforcement learning: TensorFlow and RLlib, respectively. This model is run on a server with 32 CPU cores and 128 GB of RAM capacity. Results are presented in six detailed tables. Each table contrasts the proposed model with Method [5], Method [8], and Method [12].

Table I and Figure II shows comparison between proposed and existing methods over operational cost reduction. The average reduction of operational costs using the proposed model is 12.5%, which is considerably higher than that of Method [5] with an 8.0% reduction, Method [8] with a 9.3% reduction, and that of Method [12] with a 7.2% reduction. This is because it has a hybrid objective function that is embedded into DMPC and is optimal for balancing energy cost, reliability, and emissions. These results indicate that the proposed model performs well in high-variance scenarios of load demand and renewable energy generation.

Table I. Operational Cost Reduction

Method	Average Cost Reduction (%)	Maximum Cost Reduction (%)	Minimum Cost Reduction (%)
Proposed	12.5	15.0	10.0
Method [5]	8.0	10.5	5.5
Method [8]	9.3	12.0	7.5
Method [12]	7.2	9.5	5.0

Fig II. Error Levels for the Proposed Model used for Analysis

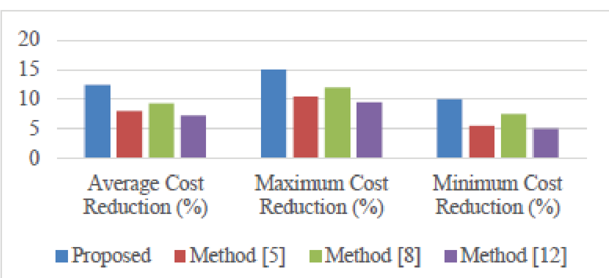

Table II shows comparison between proposed and existing method over renewable energy integration. The proposed model can provide an average renewable energy integration rate of 82.3%. This significantly outperforms Method [5] at 72.8%, Method [8] at 76.5%, and Method [12] at 70.2%. The result is based on the superior estimate of the renewable energy availability by the DMPC and efficient power flow management via interlink converters. The peak renewable use increase shows that the model can handle large renewable energy penetrations in the process.

Table II Renewable Energy Integration

Method	Renewable Energy Integration (%)	Peak Renewable Usage (%)	Minimum Renewable Usage (%)
Proposed	82.3	90.5	75.0
Method [5]	72.8	80.0	65.5
Method [8]	76.5	85.0	70.0
Method [12]	70.2	78.5	60.0

The average system reliability improvement by the proposed model comes out to be 14.5%, against Method [5] with 10.0%, Method [8] with 12.5%, and Method [12] with 9.5% as shown in Table III. Improved reliability is due to MAPPO's framework, which empowers decentralized control with coordinated cooperation between agents for better handling of grid dynamism changes and quick responses to imbalances and faults.

Table III System Reliability

Method	Average Reliability Improvement (%)	Maximum Reliability (%)	Minimum Reliability (%)
Proposed	14.5	18.0	12.0
Method [5]	10.0	12.5	8.0
Method [8]	12.5	15.0	10.0
Method [12]	9.5	11.5	7.0

The proposed model reduced the power imbalance by 19.0% on average, thereby outperforming Methods [5] and [8] with 13.5% and 16.2%, respectively, and even Method [12] with 12.0% as shown in Table IV. Results indicated that a control scheme based on reinforcement learning could maintain power balance across different load conditions and renewable generation fluctuations in interconnected sub-grids.

Table IV Power Imbalance Reduction

Method	Average Power Imbalance Reduction (%)	Maximum Imbalance (%)	Minimum Imbalance (%)
Proposed	19.0	22.0	15.0
Method [5]	13.5	17.0	10.0
Method [8]	16.2	19.5	12.5
Method [12]	12.0	15.0	8.5

The average reduction of load forecasting error using the proposed model is 22.0%, which is far superior to Method [5] that reduced 15.5% of the load forecasting error, Method [8] that reduced 18.0%, and Method [12] that reduced 14.2% as shown in Table V. Due to the hierarchical structure of the LSTM network, it is possible to express both short- and long-term dependencies existing in both the load and renewable energy generation data, hence making the load forecast more accurate and the decisions related to load balancing more appropriate for different scenarios.

Table V Load Forecasting Accuracy

Method	Forecasting Error Reduction (%)	Best Accuracy (%)	Worst Accuracy (%)
Proposed	22.0	25.0	18.0
Method [5]	15.5	18.0	13.0
Method [8]	18.0	21.0	14.5
Method [12]	14.2	17.0	11.5

The proposed model in this paper unveils an accuracy of 98.0% in detection of anomalies, and the time consumed for the detection of anomalies has decreased by 30% as shown in Table VI. Compared with Method [5] having 88.5%, Method [8] having 92.0%, Method [12] having 85.0%, this enhancement in performance can be attributed to the ST-CAE. ST-CAE works by capturing spatial and temporal correlations in grid data; hence, it gives early warnings of anomalies and very fewer false positive rates. The above tables demonstrate the notable performance improvement of the advanced model in comparison to other existing methods: It improves the results in cost reduction, better integration of renewable energy, the aspect of reliability, reducing imbalance in power, better forecasting accuracy, and anomaly detection. These improvements help to affirm the effectiveness of the proposed hierarchical framework that should aid the optimization of sub-grid operations to enhance the level of system sustainability and resilience levels.

Table VI Anomaly Detection Accuracy

Method	Anomaly Detection Accuracy (%)	Detection Time Reduction (%)	False Positive Rate (%)
Proposed	98.0	30.0	1.5
Method [5]	88.5	20.0	3.5
Method [8]	92.0	25.0	2.5
Method [12]	85.0	18.0	4.0

CONCLUSION AND FUTURE SCOPES

This paper presents a holistic hierarchical framework of control for interconnected sub-grids that integrates the techniques of DMPC, MAPPO, the H-LSTM network, and ST-CAE. Following are some key objectives which can be achieved in this research.

The proposed model is aimed at solving the problems in the optimization of power grid operations under a decentralized dynamic environment characterized by a high penetration rate of renewable energy, diversified load profile, and robust detection against anomalies.

The proposed model can provide better performance in the optimization of operation of the interconnected sub-grid, integration of renewable energy resources, reduction of operational costs, system reliability, and accuracy of anomaly detection.

The result indicates that this framework is very effective at handling the complex challenges that modern grids have to face for different scenarios.

Though huge improvements in the proposed model have been made, various future research directions could still better its performance and applicability as discussed as follows.

The investigation of adaptive techniques in reinforcement learning considering dynamic adjustment of control policies according to the evolution of grid conditions is required to bring robustness for highly uncertain environments.

Investigation of distributed energy storage systems control integrated with the proposed framework under high renewable generation volatility levels for enhancing the grid stability and reliability.

Laying advanced cyber-physical security mechanisms within the anomaly detection framework. It could further be extended to have the ST-CAE learn from data on intrusion detection systems, network traffic analysis, and machine learning-based cybersecurity techniques. This strengthens the resiliency of the system against physical and cyber threats.

The development of more efficient multi-objective optimization methods to consider social welfare, energy equity, and policy regulations effectively; this will allow the model to be adaptable to different economic and regulatory conditions of various regions.

Implementation in real-world scenarios and validation on a large grid will provide valuable experience with practical challenges and possible improvements when moving from simulation-based results to live grid environments.

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Advances in Thermal Performance Characteristics of Additively Manufactured Heat Exchanger Devices

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ABSTRACT

Innovation in additive manufacturing (AM) has revolutionized the production of heat exchangers (HXs), enabling designs that were previously unattainable with traditional methods. AM offers various benefits, such as decreased weight, size, load carrying capacity and production expenses. This study examines the thermal properties of various additively manufactured heat exchangers (HXs) made from polymer and metallic materials for applications such as heat transfer enhancement, heat recovery, renewable energy, and customized thermal management. Also, the article concludes with a SWOT analysis that identifies research opportunities, particularly in developing new techniques for material development and thermal characteristics. This study provides useful information on different applications of additively manufactured heat exchangers. It may serve as an important resource for researchers in this field.

KEYWORDS *: Additive manufacturing, Heat exchangers, Heat transfer enhancement, Heat recovery, Renewable energy, Thermal management.*

INTRODUCTION

In recent decades, advancements in additive manufacturing technology have significantly influenced heat exchanger designs. Worldwide, researchers have focused on developing heat exchangers that are efficient, compact, lightweight, and use less material. Recent improvements in additive manufacturing and thermal management techniques have demonstrated great potential for creating advanced heat exchangers for various applications[1], [2].

Additively manufactured (AM) heat exchangers are widely used across various industries, including automotive, aerospace, microelectronics manufacturing, food processing, solar energy, waste heat recovery, and HVAC systems in buildings. These devices are employed in applications ranging from miniature microelectronic chips to large-scale systems tailored to meet specific requirements [3].

Figure 1 (a) presents a network of county-wise investigations across the globe for AMHE, and (b) shows the research collaborations with keywords associated with AMHE. This analysis helps researchers to understand the current trends in AMHE worldwide. This analysis was performed using VOSviewer software.

For the literature survey and analysis in VOSviewer, the papers are grouped according to their research areas, such as heat transfer enhancement, heat recovery, renewable energy, and customized thermal management. The Clarivate Analytics database is used to review the papers critically and their key findings are demonstrated in this study for further analysis.

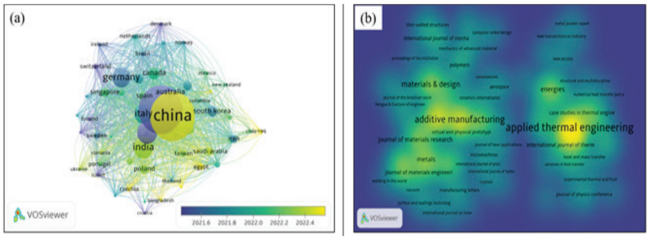

Fig. 1: (a) Network of country wise analysis for AMHE (b) Density visualization with keywords for AMHE

Note: The Bibliometric analysis was created and analyzed using VOSviewer software

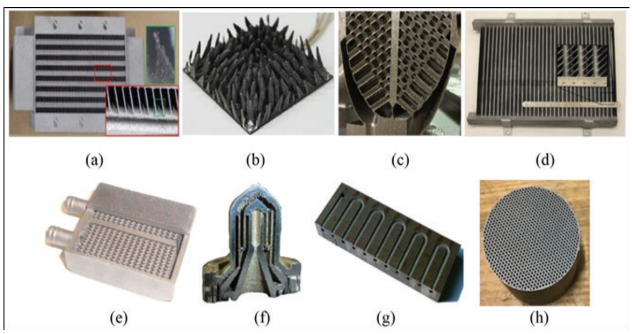

Fig. 2: Illustrations of HX designs created through AM; (a) Improved oil coolers for aircraft engines [4], (b) heat sink optimized through topology with varying pin fins[5], (c) heat exchanger with multiple branching pathways [6], (d) solar liquid-desiccant AM air conditioner [7], (e) water-cooled compact HX [8], (f) Cut section of an innovative spacecraft propulsion HX [9], (g) oscillating sliced heat-pipe featuring mini-channels circular in cross-section [10], (h) cross-sectional view of novel conversion type reactor [11], Reprinted with permission from Elsevier.

The present study provides an overview of additively manufactured (AM) heat exchangers (HXs), categorizing them into key areas: heat transfer enhancement, heat recovery, renewable energy, and customized thermal management. The article offers a detailed analysis of their performance, including critical comparisons with conventional HXs wherever possible. Additionally, it explores AM technology's material properties, manufacturability and thermal performance. Such collections of various applications have yet to be covered extensively in prior research. The study concludes with a SWOT analysis of additively manufactured HX and discusses the future opportunities of this technology.

ADDITIVELY MANUFACTURED HEAT EXCHANGERS

This section provides a comprehensive overview of additively manufactured heat exchangers. Figure 2 presents various innovative heat exchanger designs produced using additive manufacturing. The efficiency and performance of a heat exchanger are affected by various parameters, e.g., the material's heat conductivity, fluid properties, wall thickness, surface area available for heat exchange, etc. Metals are usually chosen for heat exchangers because they conduct heat very well. To create lightweight and cost-effective additive manufactured heat exchangers (AMHEs) that resist fouling and corrosion across a range of temperatures, researchers are exploring and prioritizing materials like polymers and thermally conductive composites in their construction [2], [12].

Heat transfer enhancements using AMHE

AMHEs offer significant heat transfer enhancements by allowing for intricate and optimized geometries that traditional methods cannot easily achieve. These designs improve thermal performance using increased surface area and better fluid flow management. This results in more efficient heat exchange and reduced energy consumption of HXs[13]. This section explores various heat transfer enhancement applications using AMHE.

Tiwari et al. [14] introduced the compact manifold type microchannel HX, demonstrating significant thermal performance and cost-effectiveness advancements. The study highlights the use of a fin tube for microchannel HX geometry and a polymer manifold using 3D printing method to enhance fluid distribution. Impressive heat transfer coefficient values ranging from 28,000 to 45,000 W/m²K have been achieved on the shell-side of HX, and an overall heat transfer coefficient up to 25×103 W/m²K was attained. These results are superior to traditional HXs. This approach delivers superior thermal efficiency and influences mass manufacturing of components to reduce fabrication costs, indicating a potential shift toward more cost-effective, high-performance heat exchangers for large-scale applications. Future investigators should focus on minimizing pressure drops and optimizing flow distribution in multi-tube configurations.

Arie et al. [13] explored the water-air HX made up of polymeric material. They focused on the fabrication process of layer-by-layer laser welding additive manufacturing method. The study utilized the high-density polyethylene (HDPF) material for the fabrication of a heat exchanger. It demonstrated a promising overall HTC (heat transfer coefficient) of 35 to 120 W/m^2K. The study highlighted that the thin wall of the polymer heat exchanger significantly reduced thermal resistance, which accounts for only 3% of the total thermal resistance, making it comparable or superior to conventional metallic heat exchangers. The research highlights the advantages of polymer heat exchangers, including low weight, cost efficiency, and resistance to fouling and corrosion. Figure 3 shows the conceptual view of the polymer heat exchange device.

Unger et al. [15] explored innovative finned designs for fin tube type HXs that improve the convection and conduction using this novel geometry. They introduced & experimentally assessed circular integrated pin fins (CIPF), circular plain fins (CPF) and serrated integrated pin fins (SIPF), all were fabricated using Selective Laser Melting. Their findings reveal that the CIPF design offers superior Nusselt numbers compared to CPF and similar performance in terms of friction factors. The SIPF design achieves the highest heat transfer performance despite lower fin efficiency. The study also provides a new heat transfer correlation, demonstrating that the SIPF design is optimal for applications where heat transfer surface and material cost are critical, whereas CIPF is advantageous for compact heat exchangers.

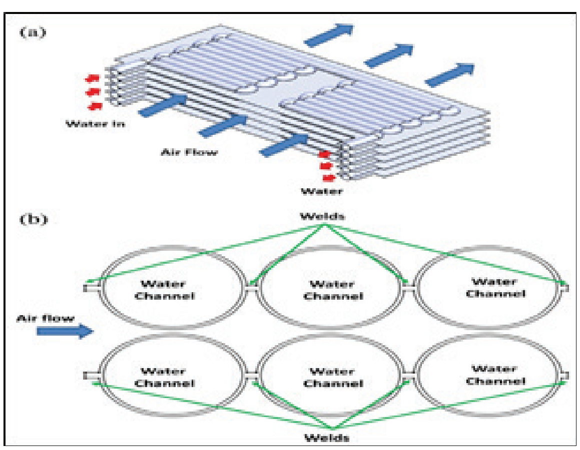

Fig. 3: (a) CAD geometry of AMHE (b) water channels of AMHE [13], Reprinted with permission from Elsevier

Sun et al. [16] examined the thermal fluid performance of sandwich cylindrical walled type AMHE. The study investigates various cored geometries using experimental, numerical, and theoretical methods. The key findings include: (1) Thermal efficiency of quadrilateral type core is 5-20% more than triangular type core, though they have 1.1 times more flow resistance in the laminar type flow regime. (2) Non-homogeneous triangular cores show about 10% reduction in HTC. (3) The quadrilateral core (I-type) provides the best overall thermal performance, whereas the M-type triangular core performs poorly. The study highlights the critical role of pore distribution and core shape in optimizing heat dissipation along with the flow resistance parameters.

Astrouski et al. [17] explored the potential of polymeric hollow fiber type heat exchangers as a viable alternative to traditional metallic radiators, focusing on automotive applications. Their study revealed that polymeric heat exchangers, constructed from polypropylene fibers with 0.6 mm and 0.8 mm diameters, exhibit comparable thermal performance as compared to aluminum finned tube type radiators. The heat exchangers demonstrated impressive heat gain rates (about 10.4 kW) and overall HTCs (about 335 W/m^2K), despite polypropylene's lower thermal conductivity.

Silva et al. [18] investigated the hydrodynamic and thermal performance of a compact HX produced via SLM (Selective Laser Melting). The authors developed and validated the theoretical models using experimental findings of a cross-flow type AMHE. The heat exchanger channels were fabricated from stainless steel material (AISI 316L) with a diameter of 2 mm. The entire heat exchanger was fabricated using the SLM technique. The experiment involving thermal characterization was conducted, revealing the best result for a heat transfer rate of approximately 10.4 kW. Also, the overall heat transfer coefficients (HTCs) of about 335 W/m^2K were observed with average errors of around 3.3% and 15.3%. The study highlights the potential use of SLM technique for producing AMHEs.

Applications of heat recovery utilizing AMHE

The additive manufacturing domain has made a huge impact on the modern design and fabrication of heat recovery and advanced manufacturing applications.

It has made a huge revolution in the design of heat exchangers by enabling the creation of complex, optimized structures that were not possible by traditional methods. This approach enhances thermal efficiency by allowing the tailored designs to meet specific recovery requirements. This results in the development of more efficient and compact systems for capturing waste heat and maximizing efficiency across different industries [19]. This section explores various heat recovery applications using AMHE.

Vairagade et al. [20] conducted an experimental study on thermal efficiency enhancement using an additively manufactured heat exchanger. The HX was made of TPU composites and utilized for the heat recovery application of a hemispherical cavity receiver (HCR). The developed AMHE was installed at the top surface of HCR to extract the heat to boot's thermal efficiency of solar parabolic dish collector (SPDC). Their research reveals that the innovative use of a TPU/MWCNT/GNP conductive heat exchanger made up of compositions 93/3.5/3.5 wt.% significantly improves thermal efficiency by approximately 10.91%, increasing under varying conditions. The study demonstrates the potential use of AM geometries in optimizing solar energy systems. Figure 4 (a) and (b) exhibit the temperature distribution of HCR with SPDC & installation of AMHE.

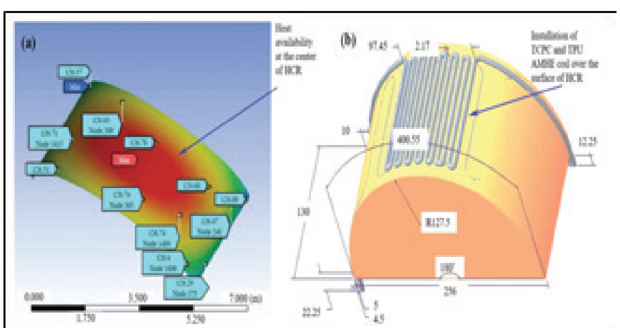

Fig. 4: (a) Temperature distribution of HCR with SPDC (b) Installation of AMHE [20], Reprinted with permission from Taylor & Francis.

Recent advancements in AMHE technology have highlighted the benefits of integrating polymer-based materials with microchannel designs and nanofluids. Kamsuwan et al. [21] utilize a novel approach combining ANNs (artificial neural networks) with CFD (computational fluid dynamics) to optimize the performance of polymer-based microchannel heat exchangers using different nanofluids to recover and utilize the maximum heat. Their findings show that nanofluids, TiO_2/Water and CuO/Water, significantly enhance the heat transfer efficiency compared to conventional fluids, with TiO_2/Water demonstrating a notable 7% increase in heat transfer performance. Using ANNs to predict nanofluid properties and optimize heat exchanger design parameters was useful. It also provides accurate predictions with minimal deviation and maximum heat utilization, highlighting the potential for cost-effective and sustainable heat exchange solutions. The study emphasizes the potential of polymer-based microchannel heat exchangers in achieving high performance while offering corrosion resistance and environmental sustainability.

Lyu et al. [22] introduced a heat exchanger device made of a soft polymer for heat recovery from wastewater. It addresses common issues in metal heat exchangers, such as erosion and fouling. Their study highlights the competitive performance of the polymer heat exchanger with an HTC of 100-110 W/m^2K, resulting in 67 to 92% efficiency more than conventional metal exchangers. The heat exchanger's design and oscillation capability significantly improve performance by 30% compared to a stationary setup. The findings suggest that polymer-based systems, with their flexibility and reduced cost, offer a promising alternative for effective heat recovery in wastewater applications.

Rajagopal et al. [23] develops a novel hybrid kind metal-polymer heat exchanger design to improve waste heat recovery at lesser temperature levels. By combining polymer strips with copper and aluminum, their approach addresses the low heat conductivity typically of the polymers, achieving an effective thermal conductivity of about 1 W/mK. This design enhances the overall HTC by 20% compared to all-polymer alternatives, maintaining high mechanical stability up to 3.1 MPa. The present AMHE (hybrid) showcase cost-effective, potentially up to 80% cheaper than all-metal HXs. It also offers flexibility and improved performance for low-temperature waste heat applications.

Renewable energy enhancements using AMHE

Additive-manufactured heat exchangers significantly boost renewable energy systems by optimizing heat transfer and improving efficiency. Their ability to incorporate complex geometrical shapes and use of advanced materials enhances the performance of systems like solar thermal and geothermal energy. By tailoring designs to specific energy needs, AM contributes to developing more efficient energy systems that make renewable energy sources more effective and reliable[24]. This section explores various renewable energy applications using AMHE.

Singh et al. [25] developed a novel ceramic HX for high-pressure and high-temperature use in CSP (concentrating solar power) plants. They used additive manufacturing techniques, specifically binder jetting and polymer infiltration and pyrolysis (PIP), to create silicon carbide HXs. These HXs are designed to handle temperatures above 700 °C and pressures up to 20 MPa. The study showed that these ceramic prototypes provided better heat transfer and mechanical performance compared to traditional metal HXs. Experimental results matched well with simulations, indicating that this new approach could offer significant cost savings and efficiency gains for CSP applications. The temperature distribution obtained using simulations for one of the test conditions (hot air flow-rate and cold air flow-rate) is shown in Figure 5.

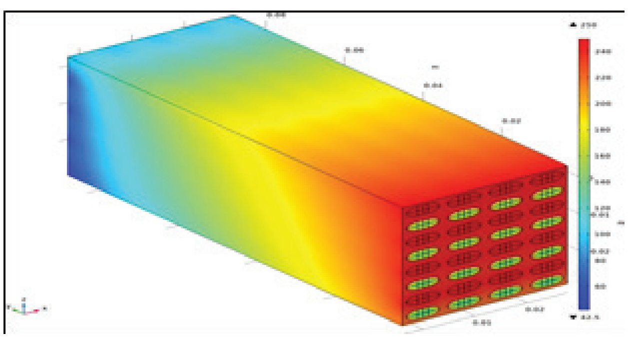

Fig. 5: Simulated temperature distribution of AMHE for CSP[25]. Reprinted with permission from Elsevier

Ahmadi et al. [26] introduced a novel lung-inspired 3D-printed ceramic heat exchanger (HX) designed for high-temperature solar energy-efficient systems. Their study addresses the higher permeability of traditional ceramic 3D-printed heat exchangers by applying a zinc-based coating to eliminate leakage issues. The new design significantly enhances thermal performance, achieving a volume power density of about 8.2 MW/m³ at 700°C, a 71% improvement over conventional designs, while reducing pressure drop by 22%. This advancement demonstrates the potential of advanced ceramic topologies for superior heat transfer and efficiency enhancements in extreme conditions. However, the long duration durability of these materials still needs to be thoroughly evaluated to ensure they can withstand prolonged use in such harsh environments. The millichannel alumina HX made up of lung-inspired zinc-coated silica is shown in Figure 6.

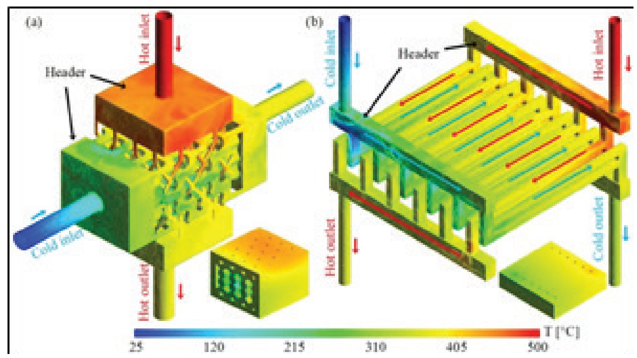

Fig. 6: The lung-inspired silica and alumina AMHE [26]. Reprinted with permission from Elsevier.

Applications of AMHE for thermal management

Additively manufactured heat exchangers (AMHEs) play an important role in thermal management applications by offering highly efficient heat dissipation techniques using novel thermally conductive composites. They can create highly complex and customized structures that allow optimal heat transfer for compact applications. This makes AMHEs adaptive for applications ranging from electronic cooling to industrial processes, where precise thermal regulation is essential for performance and reliability[27]. This section explores the thermal management applications of AMHE.

Winkelhorst et al. [28] investigated the performance of heat pipes for electronic gadgets fabricated using the additive manufacturing (AM) technique. The study focuses on tailored designed wick structures fabricated using AM. Their findings indicate that the heat pipe with the AM wick structure shows significant improvement in thermal performance at higher heat loads, particularly more than 55 Watts (W). However, the conventional heat pipe without the wick structure performs more effectively at lower heat loads due to thin film evaporation. This research highlights the potential of AM to tailor heat transfer devices for thermal management applications. The findings of the study will help to prevent thermal failure of electronic systems and helps to dissipate heat more effectively.

Zhang et al. [29] present an innovative approach for high temperature heat exchangers using additive manufacturing (AM) with high strength Inconel 718 material. Their study focuses on compact manifold type microchannel heat exchange device fabricated via direct-metal-laser sintering (DMLS) for lightweight electric aerospace applications. The experimental results highlight the heat exchanger's effectiveness. It transfers maximum heat of about 2.78 kW with a notable heat recovery density of 10 kW/kg. The presented design exhibits a 25% improvement in heat transfer density compared to conventional plate-fin heat exchangers. The research emphasizes the potential of AM in producing lightweight, high-performance heat exchangers that are well-suited for applications with stringent space and weight constraints.

Arie et al. [30] investigated the performance of additive manufactured air + water manifold-microchannel heat exchangers for power plant dry-cooling. Utilizing direct metal laser sintering (DMLS), they produced prototypes from stainless steel, titanium alloy, and aluminum alloy. Their experimental results highlighted that the titanium alloy (Ti64) prototype demonstrated superior performance to conventional heat exchangers, with up to 27% higher gravimetric heat transfer density. Despite fabrication inaccuracies, additive manufacturing shows potential for improving dry cooling systems with compact, efficient designs and better heat transfer. The theoretical representation of microchannel AMHE is shown in Figure 7.

Mohamed et al. [31] conducted a comprehensive study of an L-shape AM heat pipe for notebook+CPU cooling, utilizing experimental, numerical, and analytical methods. Their research focused on enhancing the cooling performance of electronic systems through detailed simulations and experiments under both natural & forced convection conditions. The study highlighted that forced air-cooling significantly improves thermal resistance, reducing it from 3.67 °C/W to 0.533 °C/W with optimized airflow. The heat pipe's effectiveness was demonstrated by achieving a high effective thermal conductivity of 45.99 W/mK. The findings highlight the effectiveness of AM heat pipes in high-performance cooling applications and align well with numerical and analytical models, confirming their reliability for CPU cooling solutions.

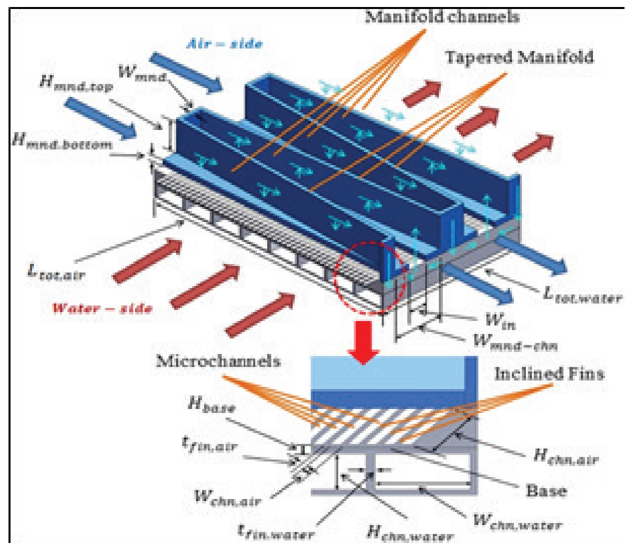

Fig. 7: Microchannel AMHE [30]. Reprinted with permission from Elsevier

DESIGN WORKFLOW FOR AMHE

The simplified flowchart in Figure 8 portrays the main steps in creating additively manufactured heat exchangers. The first step is to outline the needs of the application and choose the right materials (Polymer, composites, or metal), then move on to designing the shape and enhancing it to goals like improving heat transfer or creating a tailored thermal system. The further stages consist of simulation, prototyping, testing, and assessment. The final design can be optimized or redesigned if performance criteria are achieved.

SWOT ANALYSIS FOR AMHE

A SWOT analysis of additive manufactured heat exchanger designs reveals significant strengths in customization and lightweight solutions. It also highlights challenges such as material limitations and high costs. Figure 9 highlights the individual strengths, weaknesses, opportunities and threats for AMHEs.

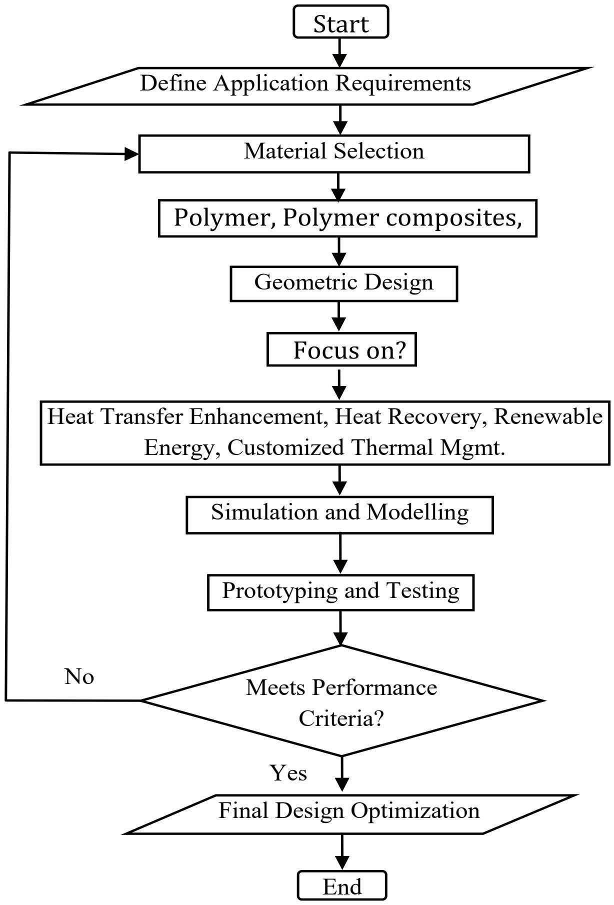

Fig. 8: Design considerations flowchart for AMHE

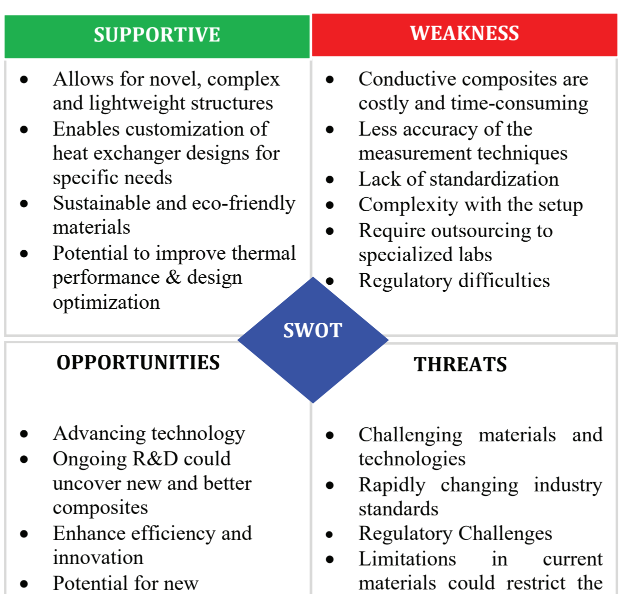

Fig. 9: SWOT analysis of AMHEs

CONCLUSION

Additive manufacturing has transformed the design and performance of heat exchangers, offering applications in new emerging areas for enhanced heat transfer. This study shows that AM allows for complex and highly efficient heat exchanger designs that traditional methods do not achieve. Using different materials and innovative designs, AM heat exchangers can be more cost-effective and tailored to specific needs, from improving heat transfer to supporting renewable energy systems. Despite these advances, there are still challenges to address, such as fabrication issues and material limitations. Ongoing research must focus on overcoming these hurdles and making AM heat exchangers more effective and reliable. The findings of this study provide valuable insights for AMHE that will help future developments in thermal management technology.

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Design and Control of an Unconventional Power System Leveraging Power from Renewable Sources

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ABSTRACT

This paper includes MATLAB- Simulink to construct a comprehensive modelling and control system for a three-phase hybrid micro grid based on renewable energy. The system seeks to show efficient power generation, distribution, and management inside the micro grid by incorporating components such as PV and wind power generation, IGBT or MOSFET inverters, and an RLC load with predefined values. It also has a thorough monitoring system for power, current, and voltage characteristics. A more thorough knowledge of the micro grid's performance as well as possible improvements in renewable energy integration and grid stability are made possible by the graphical display, which offers an intuitive interface for visualizing and analysing the system's output. Output is an intuitive graphical display interface that makes it possible for stakeholders to see and understand the micro grid's complex dynamics.

KEYWORDS *: Micro grid, IGBT, MOSFET, REI, PV Grid.*

INTRODUCTION

The requirement for efficient and sustainable power solutions in today's energy systems has encouraged the development of micro grids as a potential new direction. In the field of three-phase hybrid micro grids, its introduction signals the coming together of renewable energy sources with cutting-edge control approaches. Accepting the need to lower carbon footprints and improve energy resilience, this research sets out on a revolutionary path by combining wind and photovoltaic (PV) power generation inside an advanced MATLAB Simulink framework.

A PV grid for solar power generation and a wind turbine system for wind energy harvesting are essential components of this micro grid. IGBT or MOSFET inverters enable sophisticated power electronics to synchronize and regulate these sources. To simulate a load, an RLC load with preset settings is also included. Because it may take use of the enhancing qualities of many energy sources, the hybrid approach which integrates numerous sources of energy has drawn a lot of interest in the context of micro grid systems. Hybrid micro grids increase system stability, maximize energy output, and lessen reliance on fossil fuels by combining conventional generators and energy storage systems with renewable energy sources like solar and wind. The use of modelling and control methodologies based on renewable energy for a three-phase hybrid micro grid system is the main goal of this research. The three-phase design is widely used in commercial and industrial settings because it provides benefits over single-phase loads in terms of power quality. The micro grid's hybrid design allows for the effective use of renewable energy sources while maintaining dependable and continuous.

PHOTOVOLTAIC CELL

Photoelectric effect is the fundamental idea that powers a photovoltaic cell. Because the substance (metallic or non-metallic solids, liquids, or molecules) receives sunlight at a certain wavelength, one electron is expelled from the conduction band in this effect. Consequently, part of the solar energy that strikes a photovoltaic cell's surface is absorbed by the semiconductor material.

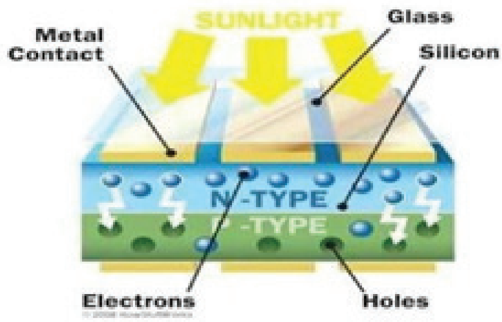

Fig. 1. Working of PV CEL

When absorbed energy exceeds the semiconductor's band gap energy, electrons from the valence band transition to the conduction band. Hole-electrons pairs are formed in the lighted region of the semiconductor. Electrons in the conduction band can now freely move. Electric fields cause free electrons to flow towards a specific direction. PV cells. Connecting a metal plate to the top and bottom of a PV cell allows for the extraction of current from the flowing electrons. This current and voltage generate the required power.

PROBLEM STATEMENT

An increasing need for renewable energy integration into micro grid systems has demonstrated the essential value of effective modelling, control, and monitoring frameworks. The difficulty is to properly utilize the intermittent nature of renewable sources such as solar and wind power while maintaining steady and reliable distribution of energy. Insufficient control methods for variable energy sources can result in inefficiencies, grid instability, and underutilization of renewables. Our proposed solution solves limitations by integrating PV and wind power generation, precise inverter control, and extensive monitoring to optimize renewable energy consumption and improve micro grid stability.

PROPOSED SYSTEM

The proposed system controls an integrated interplay of several components to enable the Hybrid micro grid's efficient operation. The process begins with integrating photovoltaic (PV) and wind power generation systems to utilize solar and wind energy. These renewable energy sources feed into IGBT or MOSFET inverters, allowing for exact control of power output. The controlled power is fed into a three-phase system with an RLC load to mimic real-world consumption. A critical feature is the development of a complete monitoring system that continuously tracks voltage, current, and power characteristics within the micro grid. This data is loaded into a user-friendly graphical interface, providing stakeholders with an easy way to visualize and analyze the micro grid's performance. The system's core is its ability to manage and optimize.

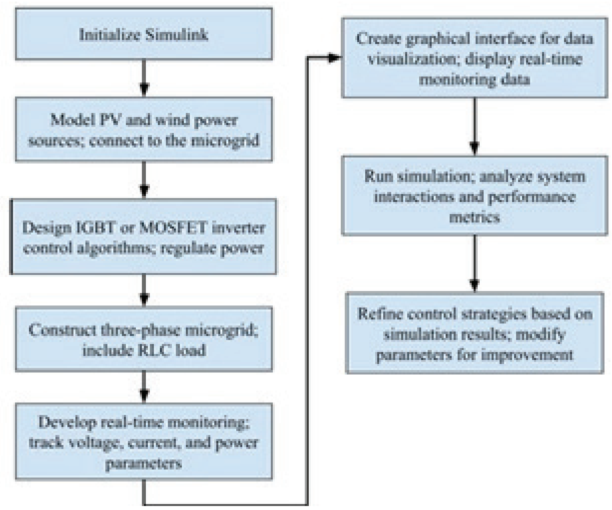

Fig: 2. Flowchart of proposed system

SIMULATION AND RESULT

This paper refers to the simulation of a grid system that uses two renewable energy sources: solar and wind electricity. Both power sources undergo conversion into AC power, which is then fed straight into the grid. This simulation provides insights into power distribution in a renewable energy-powered grid.

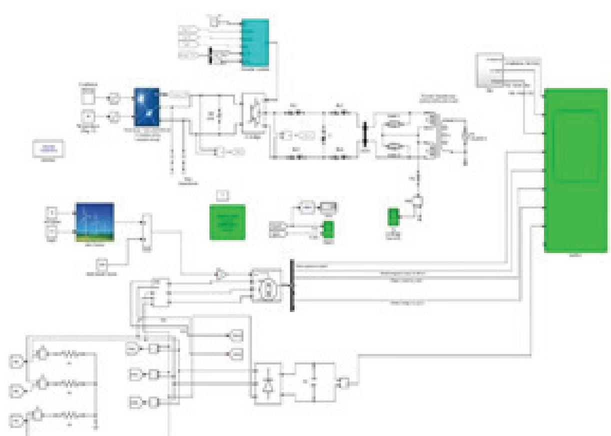

Fig. 3 Shows the Simulation Model

Wind power is the oldest renewable energy source. Wind turbines may generate power for as little as 3.5 cents per kilowatt hour, comparable to coal and free of contaminants. Wind energy is a compelling option due to its non-depletion, stable cost, and simplicity of management.

For the wind turbine, we considered two inputs: wind speed and height. The wind plant's output is affected by both wind speed and height changes. However, the height cannot be changed after construction. The wind turbine's output is mechanical force and shaft angular velocity, which are inputs to the multiplier/divider/product. The gain generates mechanical torque for the permanent magnet synchronous motor. And the output of the motor is coupled with the Bus Selector block. The Bus Selector outputs a specified subset of the bus elements at its input. The component can output specified items as individual signals or a new bus.

When the block outputs multiple components, each element is routed through a distinct port from top to bottom of the block and assigned to the Scope for Output. On the other side, the Three-Phase motor is linked to Three- Phase VI measurement, which provides Three- Phase Voltage and Current measurements. On the other side of the VI measurement block, three phases are connected to the voltage and current instruments to measure line-to-line voltage and current. The RLC load is measured using a universal bridge. The voltage measurement is connected and sent to the output.

About solar energy generating. The model is organized into six pieces for easy understanding. The first section focuses on generating solar energy. The second part converts solar output from DC to AC using an IGBT inverter. The third part removes flickers and harmonics in the AC, while the fourth part connects to the grid. The fifth part is for load, and the sixth is for checking output voltage, current, and power. In the first part, a PV array is implemented using strings of modules connected in parallel. Each string consists of connected modules.

Allows modelling of a range of preset PV modules accessible from the NREL System Advisor Model (January 2014). We employed an irradiance and rate limiter in addition to the user- defined PV module to generate solar energy. This means that light falls on the solar panel, and we used the rate limiter.

Fix amplitude 1000. As we work on meters, our rate limiter operates within the range of 8000 to -8000 and begins at 1000. The solar panel is Trina solar with a rating of TSM 250PA05.08. The solar panel generates DC, which we cannot utilize to generate smooth DC power; instead, we use capacitors, which act as filters. The H-Bridge is an IGBT that transforms power from DC to AC. It then connects pure AC to the grid and then to the load. Inverter control is a basic model that includes five major components. 1) PLL measurement. 2) MPPT 3) DC Voltage Regulator 4) current regulator

5) PWM modulator.

Graph of Irradiance

The irradiance graph illustrates the intensity of sunlight falling onto solar panels, frequently expressed in watts per square meter (W/m^2). This graph is essential for evaluating solar power generation in simulations with both solar and wind power sources. Wind turbines, like solar power, generate electricity from the kinetic energy absorbed by the wind. Inverters convert both direct current (DC) and alternating current (AC) power to meet grid requirements. The AC electricity generated from both sources is put into the grid and distributed to consumers, creating a renewable energy mix that adds to the overall electrical supply. By integrating diverse renewable resources, we can efficiently meet energy demands.

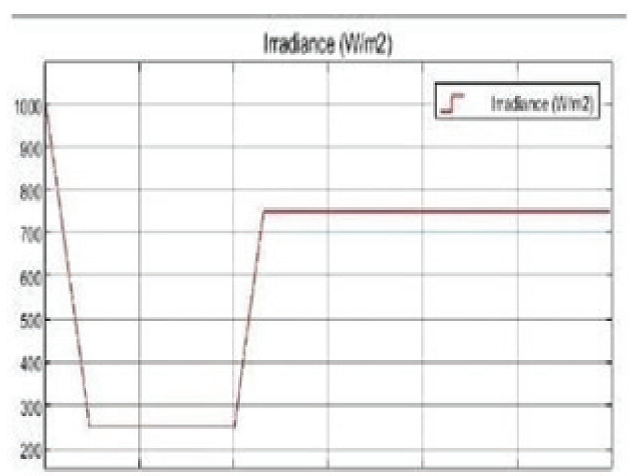

Fig.4 shows the Graph of Irradiance

Graph of Voltage

As the amount of irradiation varies, the voltage graph s how's clear patterns. At first, the voltage drops from 430V to 411V as irradiance levels fall from 1000 m² to 250 V. During an initial stabilization of irradiance at 250V, the voltage starts to increase from 415V to 425V. The voltage graph follows the trend of increasing from 425V to 435V as irradiance levels rise from 250V to 750V. Eventually, the levels of voltage and irradiance settle and remain accurate.

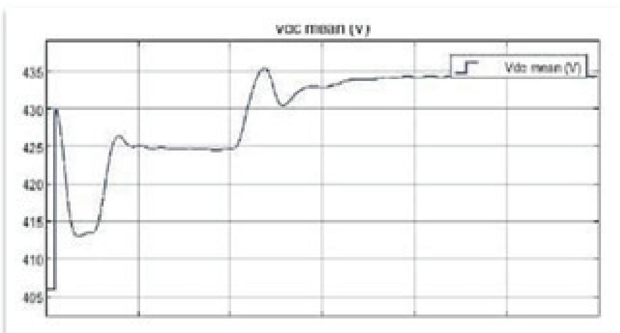

Fig. 5 shows the Voltage Graph

Graph of Power

The connection between voltage and irradiance levels is shown on the power graph. Reduced voltage causes an impairment in irradiance, which in turn causes a decrease in produced power. In a similar vein, voltage stays constant when irradiance levels compromise, producing a stable power output.

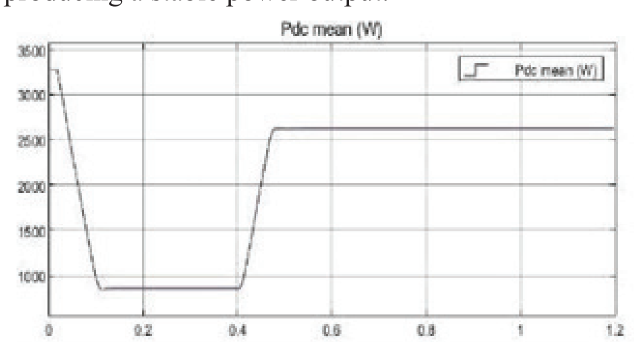

Fig: 6 Shows the Power Graph

WIND TURBINE OUTPUT

The connection between electromagnetic torque and rotor speed in wind turbines is seen in these three graphs. The electromagnetic torque produced by the turbine reduces from 0 to -1 Nm^2 (Newton meters squared) when the rotor speed, or the speed at which the air interacts with the turbine blades, increases from 0 to 75 rpm (revolutions per minute). This connection is frequently seen in wind turbines, where increased wind speeds cause the turbine blades to rotate more quickly, yet aerodynamic drag and other variables cause the torque to decrease.

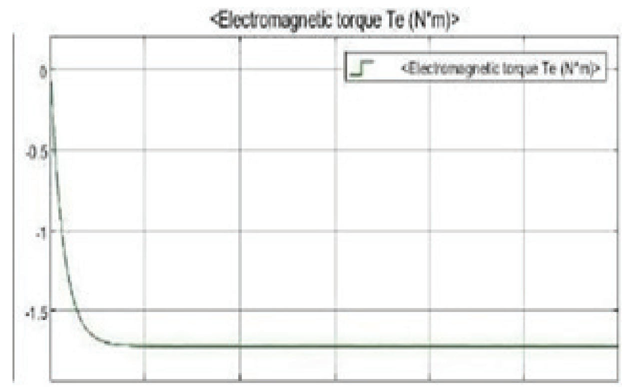

Fig. 7 shows the Graph of Torque of wind turbine

OUTPUT OF STATOR CURRENT AND STATOR VOLTAGE

The graph shows how the voltage and current in a wind turbine system behave. Since the wind turbine is initially at rest, the stator current stays fixed at 0 A. At this point, the system is effectively inactive and no electricity is being generated. Power generation starts as soon as the wind turbine rotates, most often as a result of the gear mechanism engaging or an outside force acting on it. The turbine blades accelerate as a result of the wind speed rising due to this rotation. As a result, there is no sudden shift in the system's electrical load or demand, and the stator current stays constant.

Graph of Stator Current

Simultaneously with the turbine's acceleration and the onset of power generation, the stator voltage increases from 0 to 20 V. The creation of electrical power as the turbine develops velocity is reflected in this voltage rise. The stator voltage, which symbolizes the alternating current (AC) output produced by the wind turbine, normally has a sinusoidal pattern. The time interval between 0 and 0.1 seconds most likely represents the wind turbine system's starting phase, when the turbine increases in speed from a stop to its operating speed. Rapid increases in stator voltage and rotor speed during this phase are indicative of the turbine gaining momentum and producing substantial amounts of electrical power.

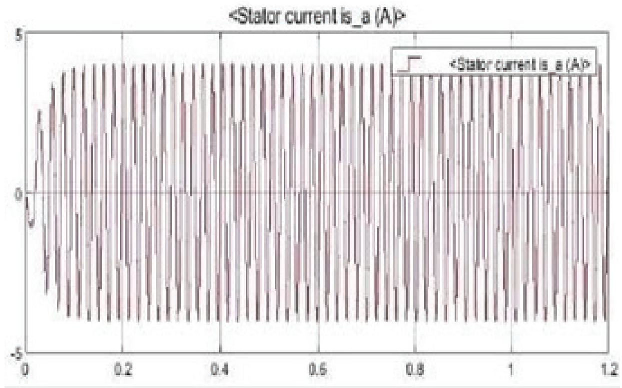

Fig. 8 Shows the Stator Current graph

Graph of Stator Voltage

Overall, the graph illustrates the dynamic behaviour of stator current and voltage during the startup phase of a wind turbine system, highlighting the transition from idle to operational states as the turbine begins to rotate and generate power.

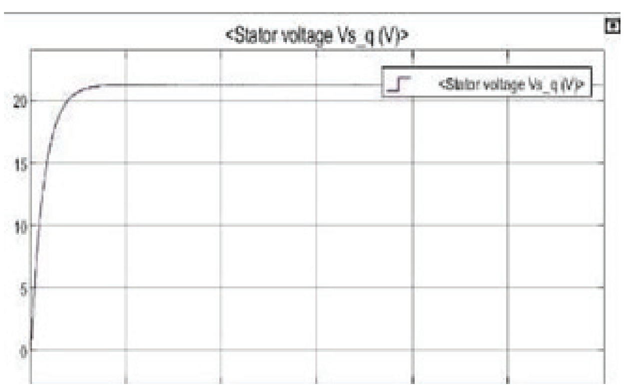

Fig: 9 Shows the stator Voltage Graph

CONCLUSION

The system that has been designed serves as evidence of the possibility of integrating renewable energy sources into micro grid structures. In This Paper highlights the viability of sustainable energy solutions with its smooth coordination of solar and wind power sources, precise control mechanisms using IGBT or MOSFET inverters, and an extensive monitoring system. The system's capacity to maximize the use of renewable energy sources, maintain grid stability, and optimize power flow indicates a positive step towards a more robust and sustainable energy landscape. This attempt provides a blueprint for efficient, renewable- centric power systems and opens the stage for future improvements in micro grid technology with its user-friendly interface that allows for deep analysis. Furthermore, this system's flexibility promotes resilience and scalability, meeting changing energy needs. Its importance in reducing reliance on traditional grids is highlighted by its ability to stabilize electricity distribution and balance sporadic renewable energy sources. This initiative is a critical step towards sustainable energy models, encouraging environmental stewardship and energy independence on a larger scale, as renewable energy continues to gain popularity.

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A Hybrid Framework for Twitter Sentiment Analysis: Leveraging Bagged CNN and Flamingo Search

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ABSTRACT

Social media platform, Twitter is a great place to find out what others think, feel, and believe. This is why professionals developed ways to parse tweets for their tone and identify positive or negative sentiment. The drive of this essay is to provide a framework that businesses, and particularly those that provide meals through apps, may use to study social broadcasting from a competitive perspective and turn that data into actionable insights. Here, we investigate how a unique combination of Flamingo Search Optimisation (FSA) and a one-dimensional bagged Convolutional Neural Network (CNN) applied to Twitter data might improve customer satisfaction research. Using state-of-the-art machine learning techniques, our methodology successfully analyses and interprets consumer attitudes and trends by using the vast, real-time stream of customer input accessible on Twitter. The Flamingo Search Optimisation method optimises the network parameters to maximise performance efficiently across various datasets, while the bagged CNN technique minimises the variance and bias normally associated with single-model predictions. By showing that sentiment analysis is now much more accurate, our results show that our technique has the ability to give useful insights into consumer preferences and happiness. The study suggests a number of potential avenues for further research, such as the development of more complex optimisation algorithms, the incorporation of cross-platform sentiment analysis, real-time processing, and more advanced natural language processing methods. This study lays the framework for companies to improve their customer interaction tactics and respond quickly to changing consumer attitudes in the digital sphere.

KEYWORDS *: Twitter, Flamingo search optimization, One- dimensional bagged convolutional neural network, Decision making, Machine learning.*

INTRODUCTION

Wuhan, a city in China, reported an uptick in pneumonia cases to the World Health Organisation (WHO) in late 2019. The official name of the illness was COVID-19 in January 2020. As of March 11, 2020, pandemic. More than 346 million cases have been confirmed and 5.5 million have died as of January 23, 2020, globally [1]. Sneezing, coughing, and even ordinary conversation can release COVID-19 particles into the air. Depending on the surface, the virus can survive for many days on plastic and a few hours on cardboard [2]. Symptoms may not appear in an infected person for 2–14 days after infection [3]. In cases with COVID-19, dry cough, fever, and extreme exhaustion are the most prevalent symptoms. Body pains, diarrhoea, sore throat, and headache are among the less prevalent symptoms of the condition [4]. Vaccination, mask use, social isolation, and good personal cleanliness are only a few of the important steps that people have taken and are continuing to take in the fight against the COVID-19 pandemic [5]. When it comes to social media, Twitter is among the most prominent tools for getting the word out about these important problems. In order to remove the epidemic, it is crucial to apply methods that take individual sentiments against it into account [6]. Consistent with this, health care providers and policymakers may learn a lot by analysing social media sites [7]. By bringing attention to existing social issues, social media analysis can detect huge emotional shifts in society and avert a possible social catastrophe [8]. When looking at the studies that have been published recently, it is clear that social media analysis is a hot subject. Typically, researchers have classed tweets as either good, negative, or neutral [9]. Twitter sentiment analysis (TSA) has also made use of CNN lately, with impressive results in tweet categorization. The current research follows a similar path, using a CNN-based technique to conduct TSA on COVID-19 tweets posted by Twitter users. A favourable, negative, or neutral sentiment for COVID-19 was thus classified using the TSA-CNN method [10–12]. With Twitter's meteoric rise in user numbers over the past several years, massive audiences may be swiftly apprised of breaking news, allowing one to gauge their level of sensitivity to a particular topic [13]. Concurrently, a number of ML approaches have recently been popular for use in sentiment analysis (SA) on Twitter data. Up to this point, several researchers have come differentiate between various discussions happening on the network. Looking back, it's clear that TSA has been used in many ways throughout the years [15-16]. By creating and applying a one-dimensional bagged Convolutional Neural Network (CNN) combined with Flamingo Search Optimisation, this study aims to improve the precision and effectiveness of customer satisfaction analysis. In order to help businesses better understand their customers' tastes and trends, this method seeks to analyse and interpret the feelings conveyed in Twitter data. The study's overarching goal is to help companies increase customer happiness and loyalty by enhancing the predictive power of sentiment analysis models so that they may better meet the demands of their customers. Here is the breakdown of the remaining sections of the paper: After a brief overview of relevant literature in Section 2, the recommended approach is detailed in Section 3, the findings besides analysis are presented in Section 4, besides the conclusion is obtainable in Section 5.

RELATED WORKS

Swiggy, Zomato, and UberEats have all been compared by Vatambeti et al., [17]. We use R-Studio to collect customer tweets on these businesses, and then we apply a sentiment analysis method based on deep learning to these tweets. In order to extract features from pre-processed data, the pseudo-inverse learning autoencoder can give an analytical answer with little iteration. We present a methodology for merging CNN and Bi-directional Long Short-Term Memory representations in this study. A word embedding model called ConvBiLSTM is employed, which assigns numerical values to each tweet. Feature implanting is input into the CNN layer, which then produces lower-level features. Here, the Bi-LSTM weights are fine-tuned via elephant herd optimisation. According to the data, out of the three companies, Zomato received 29% of the good reviews, Swiggy 26%, and UberEats 25%. With only 11% of consumers experiencing a terrible experience, Zomato also got less unfavourable ratings compared to Swiggy and UberEats. Also, we looked for negative sentiments directed at each of the three meal delivery businesses in tweets and provided solutions. The authors Paulraj et al. [18] present a method for effective sentiment analysis using data from Twitter. Some of the preprocessing steps used to prepare the Twitter database for use include stemming, tokenization, removing numbers and stop words, and so on. The Hadoop Distributed File System (HDFS) is then used to remove duplicate words by processing the preprocessed words using the MapReduce approach. The non-emoticons and emoticons are taken advantage of as attributes. The meaning of the traits that were produced is used to rank them. Next, the Deep Learning Modified is used to do the classification. To determine the best performance of the suggested model, we compared the experimental results using traditional methods like ANN, SVM, K-Means, and DCNN, as well as output parameters like Execution Period. When compared to the previous models, DLMNN had the maximum performance in terms of recall (95.64%), accuracy (91.65%), precision (95.78%), and F-Score (95.77%). Sentiment analysis was applied to Turkish tweets up with various ML classification methods for TSA [14]. Hashtags are useful for Twitter topic analysis because they help users find and pertaining to finance by Cam et al., [19]. We used MAXQDA 2020, a program for qualitative data analysis, to import 17,189 tweets from November 7, 2022, to November 15, 2022, that were posted on Twitter with the hashtags #Borsaistanbul,

#Bist, #Bist30, #Bist100. To classify the 17189 samples as positive, negative, or neutral, we employ a multilingual sentiment provided by the Orange program on the lexicon-based side. In machine learning trials, neutral labels are not used. Using six distinct supervised machine learning classifiers executed in Python 3.6 using the sklearn package, we apply the classification issue to 9076 data points, dividing them evenly between positive and negative values. In experiments, testing and validation use the remaining data, whereas the training phase uses 80% of the selected data. In comparison to other classifiers, Support Vector Machine achieved an accuracy of 0.89 and Multilayer Perceptron 0.88, with area under the curve (AUC) values of 0.8729 besides 0.8647, individually, according to the experimental results. Approximately 78.5 percent accuracy is achieved by other classifiers. By modifying the pre-processing procedures, one may optimise the parameters of sentiment analysis on a bigger, cleaner, and more balanced dataset, thereby increasing the accuracy of the analysis. Improved sentiment analysis through the use of deep learning techniques is possible with further expansion of this study. An analysis of Finnish-language sentiment on Twitter during the COVID-19 epidemic is the goal of Claes et al., [20]. We take a random model of 1943 Finnish tweets on COVID-19 and manually annotate them with feelings. Based on ngrams and two pre-existing sentiment lexicons, we employ it to construct binomial and Lasso penalty. Additionally, we construct two comparable models and compare them using an existing Twitter dataset that was collected before COVID-19. Next, we apply the top-performing model for Finnish to find out how people felt about a set of Finnish tweets that were retrieved between April 21, 2020, and June 18, 2020, in terms of positive, negative, and neutral sentiment. The top Finnish sentiment polarity prediction models achieve 0.785 AUC, 0.710 balanced accuracy, and 0.723 F1. When adding the multinomial model's accuracy is greater in the pre-COVID-19 model trained on the same amount of tweets (0.588 F1 and 0.687 balanced accuracy). The COVID-19 context, which makes learning system to forecast, is likely to blame for this performance reduction, according to our hypothesis. As the Finnish government relaxes regulations, the model runs on all the extracted tweets from the country and finds that the number of negative tweets decreases while the number of positive tweets increases during the observed time. Our findings demonstrate that domain-specific tweets, like COVID-19, provide lesser accuracy when processed using an existing sentiment analyzer. For future large-scale social media analyses of specific medical situations, such a worldwide pandemic, more effort should be put into using and creating sentiment analysis methods that are relevant to their application area.

To forward the goals laid forth by A. Semary et al., [21] for both machine learning and feature extraction investigation, it is necessary to conduct a systematic analysis and summary of feature extraction methods from an ML perspective. Term Frequency-Inverse Document Frequency (TF-IDF), Word2Vector, N-gram, Hashing Vectorizer (HV), and Global vector for word representation (GloVe) are among the approaches being considered. Applying each feature extractor to Amazon musical instrument reviews datasets allowed us to demonstrate their abilities. As a last step, we trained a random forest classifier with 70% training data besides 30% testing data. This allowed us to compare and analyse the performance using various metrics. The results show that the TD-IDF method outperforms the competition; it achieved 99% accuracy in the 96% accuracy in airlines dataset. Findings from this study provide practical advice for improving model performance and directing future studies towards feature extraction's essential role in sentiment analysis.

PROPOSED MODEL

Data Collection

We partnered with Saudi telecom providers STC, Mobily, and Zain to gather customer intelligence in the telecom area [22]. Using the longitude and latitude of Saudi Arabia, we were able to utilise Twitter search APIs to get 1000 tweets from each company's official and service accounts. These accounts include @STC, @ STCcare, @ZainHelpSA, #Zain, @Zainksa, #Mobily, @Mobily. The data from tweets is downloaded using the "Tweepy" module in the Python programming language.

Preprocessing

In this article, the preparation of twitter data is the main focus. The first step in recovering data from a JSON arrangement is to convert it to a standard text format [23]. It addresses the following –

- Removal of URL
- Investigation of emotion
- Punctuations and blank spaces confiscation
- Word Compression
- Identification of every caps letter
- Lower case

Since tweets can be either uppercase or lowercase, the algorithm requires that they be converted to lowercase before processing. Because URLs can be included in tweets, it is possible to filter out all URLs from messages using expressions or common word URLs. Using a regular phrase or another word with neutral polarity, we eliminate the user names mentioned in the retrieved data [24]. You may use the words in the hashtag to model themes because they don't change. Words with more than one repetition, such "Happppyyyy," are transformed into "Happy" digits by removing the maximum amount of possible repetitions. Eliminates punctuation and icons while preserving a single white space between text through the use of parsing. Using an effective feature selection approach, the best features are chosen from the pre-processed data after they have been retrieved using TFIDF [25].

Classification using ID-Bagged CNN

The convolutional neural network (CNN) draws inspiration from the deep learning cognitive approach of biological vision. Three CNN concept. In the convolutional layer, a neuron represents a little region of the visual domain from which the bulk of visual characteristics, including exact direction edges and corners, are derived. As a group, the neurons create feature maps with uniformly small weights. Protecting translation invariance and feature continuity is made easier when shared weights identify a comparable feature throughout the whole visual field. The creation of different feature maps is a result of the convolutional layer that is included in many filters. The sensitivity of feature locations is minimised by associating a pooling layer with the convolutional layer. The takes all of the feature maps and uses them to create rectangles with higher values. These rectangles do not overlap with each other. This causes the down sampling process to become nonlinear, which in turn reduces the total number of parameters. A CNN is built using a series of convolutional and pooling layers in a cascaded fashion. For potential use in mood prediction, the last convolutional layer generates characteristics that are exceedingly abstract. With the help of GPU acceleration advancements and ReLU, CNN is able to process massive amounts of data and get better outcomes when it comes to picture classification. Modelling decision-making for high-level vision tasks is the main use case for CNN-based approaches. For picture restoration, there are just a handful of CNN-based research papers available [26].

It is possible to combine SC-based methods with a CNN model. Actually, in the convolutional layer, each atom may be thought of as a dictionary filter. At the same time as it scans a picture at every stage, the filter acts as local domain, generating the response appropriately. That is why the SC-based method uses a collection of filters to generate a sparse coefficient vector response vector for each patch. layers might be used to evaluate coefficient mapping among different aggregations and modalities of CNN may be the definition of classic SC-based approaches. Both the working mechanism and the architecture of the algorithms used by each are very different. In this case, the notations are used. X and Y are the image matrices' capital letters. A few examples of lowercase vector symbols include b, w, and f. functions, we have F, and for filter groups, we have W. Lowercase characters, such as n and b, indicate scalars. Finding a matching drawing Y from the input data X is the primary goal. Making the mapping F(·) ■Y=F(X) is the primary obstacle. The CNN outline has several advantages and provides a compressed version of a SC-based method. To get a good estimate of a map, a four-layer network is constructed. The main layer that uses filters to input data and produces a group of maps is the first conv. layer. The expression for this is

$$F_1(X) = W_1 * X + b_1 \tag{1}$$

in which b1 and W1 demonstrate biases and filters correspondingly; the convolution action is denoted through ' * ' and the primary layer output is demonstrated through $F_1(X)$. With supporting $C_{in} \times f_1 \times f_1$, the n1 filters are comprised of W_1, wherever th denoted through n1. In order to obtain the feature map, the convolution process entangles each filter. We fix the feature map by adding our biases. Typically, a training pair will not have fully registered sketches and photos. Because of its invariance towards tiny changes, a max-pooling layer is used to alleviate the training pair misalignment. In conventional max-pooling, each that do not overlap with each other. To safeguard the real sliding window to produce larger values in the accessible domain, an overlapping max-pooling layer is employed here. Below is an example of the following layer. :

$$F_2(X) = maxPooling(F_1(X)) \tag{2}$$

The layer input comprises of feature maps of n_1. Over every feature map, with $f_2 \times f_2$ receptive field, maxPooling(·) operator every feature map is next layer, n1 pooled feature maps are offered by $F_2(X)$. Representation coefficients are transformed into data modalities following sparse coding of the input data using a pipeline approach. Mlpconv refers to the layer that contains the improvised convolutional structure [22]. This is used for nonlinear mapping between two different types of data. Incorporating the MLP into the filter makes it function input generates a plethora of new feature maps. As an instance of the mlpconv layer calculation, consider the following:

$$f_{i,j,k}^{p} = max\ \ (w_k^{p^T} f_{i,j}^{p-1} + b_k^p, 0)\ 1 \le k \le k_p, 1 \le p \le l \tag{3}$$

In the pth layer, let l represent the total of the perceptron layers., k_p refers to the node count and (i, j) refers to patch. Furthermore, $f_3 \times f_3$ signifies the receptive-field. The vector $w_k^{p^T}$ is made up of weights that associate near node $f_{i,j,k}^{p}$ input from prior layer is denoted as $f_{i,j}^{p-1}$ vector and the bias is represented through b_k^p. Representation coefficients are transformed into data modalities following sparse coding of the input data using a SC-based pipeline approach. Mlpconv refers to the layer that contains the improvised convolutional structure [22]. This is used for nonlinear mapping between two different types of data. Incorporating the MLP into the filter makes it function like a reads the input feature maps and generates a plethora of new feature maps. As an layer calculation, consider the following:

$$f(x) = \max(0, x) \tag{4}$$

The final layer node $f_{i,j,k}^{l}$ verifies the patch (i, j) response in kth chin map of $F_3(X)$ i.e.,

$$F_3(X)_{i,j,k} = f_{i,j,k}^{l} \tag{5}$$

By manipulating the entire likely (i, j, k) groupings, output $F_3(X)$ is gotten. For final synthesis, convolutional layer is employed.

$$F(X) = W_4 * F_3(X) + b_3 \tag{6}$$

in which, with the support of $n_3 \times f_4 \times f_4$, W_4 X, contain cout filters, and other cutting-edge IT tools can make it easier to investigate and detect moods in Twitter data.

Fine-Tuning Using FSA

The FSA's exact classical is defined below.

Foraging Behavior

Feature 1: Outgoing presentation.

The flamingos with the most food in the flock will scream out to the others to let them know where they are and how they might modify their positions [27]. If you know where there's the most food in a flamingo community, then you know where the majority of the flamingos are. Theoretically, flamingos can't tell where the global ideal is in terms of food availability. The fact that we can't know the program's final state when we put it up doesn't imply, however, that the procedure can't discover the global ideal.

Using the little data at its disposal, FSA mimics the behaviour of flamingos as they seek for the best possible solution in the search region, where food is most plentiful. The flamingo with the largest food supply in the jth dimension is assumed to be j. Feature 2: Beak scanning behaviours.

When a flamingo is submerged in water, its bill functions as a giant filter, drawing in water and swiftly expelling it thanks to its deep grooves on the underside and shallow, capped grooves on top, adorned with sparse serrations and tiny hairs surrounding the edges. Flamingos forage by lowering their heads, inverting their jaws, and swallowing food while expelling water and uneatable waste. The amount of food in the region influences this method of foraging. A flamingo's beak may expand its scanning radius by progressively stretching out its neck, which in turn stimulates the bird to search the area more attentively if it detects a higher region. The likelihood of searching the region for edibles also rises. The likelihood of an abundance of food in a certain place is directly proportional to the proximity of flamingos to the population's food source. This material mimics the way flamingos scan with their beaks. Individual flamingos' foraging behaviour runs into a data transmission error if we assume that the ith flamingo's position in the population and that we account for the fact that each flamingo's choice in nature is unpredictable and that the specific environment can influence its foraging behaviour abruptly. A typical normal random distribution is used to model this mistake; in this model, a flamingo's beak scan is most likely to be oriented towards food. On the other hand, this data isn't completely error-proof.

Then $t\ |G_1 \times xb_j + \varepsilon_2 \times x_{ij}|$, where ε2 is a random number of −1 or 1. The main goal of setting the maximum distance is to make the flamingo's beak scan search range larger when it's foraging. where G1 is a completely arbitrary integer distributed normally. Reintroducing the normal distribution, we find that its variation curve closely matches the fluctuation of the range, which allows us to model its scanning range during beak scanning behavior. as $G_2 \times |G_1 \times xb_j + \varepsilon 2 \times x_{ij}|$, where G2 is a random sum that obeys the normal regular delivery.

Feature 3: Bipedal mobile performance. Figure 3 depicts the flamingo foot movement behaviour model. When flamingos are out foraging, they use their beaks to examine the area claws to travel towards the areas with the greatest food. Given that the population is most densely concentrated in one area, we may assume that xb_j, the distance travelled can be quantified as $\varepsilon 1 \times xb_j$, where "1 is choice.

In conclusion, as demonstrated in (7), the scanning plus the movement distance of the feet constitute the thirth iteration of the foraging phase.

$$b^t_{ij} = \varepsilon_1 \times xb^t_j + G_2 \times |G_1 \times xb^1_j + \varepsilon_2 \times x^t_{ij}| \quad (7)$$

To determine where flamingos forage, we may use the following equation:

$$x^{t+1}_{ij} = (x^t_{ij} + \varepsilon_1 \times xb^t_j + G_2 \times |G_1 \times xb^t_j + \varepsilon_2 \times x^t_{ij}|)/K \quad (8)$$

The flamingos with the most food in the flock will scream out to the others to let them know where they are and how they might modify their positions [27]. If you know where there's the

In (8), x^{t+1}_{ij} characterizes the location ith flamingo in the populace in the (t + 1)th iteration, x^t_{ij} shows where the ith flamingo is in the t iteration of the population of flamingos, specifically where its feet are in the jth dimension. The position greatest iteration is represented by 〖xb〗 _j^t in the jth dimension. One example of a random variable is the diffusion factor, K=K(n). It follows the chi-square freedom. The flamingo's worldwide merit-seeking capacity is enhanced by expanding its feeding range and mimicking the random processes of natural selection. The variables ε_1 and ε_2 are chosen at random by a factor of -1 or 1, and the random both distribution.

Migration Behavior

The flamingo population moves to a new foraging region when food becomes scarce in their current one. Assuming the food- rich area's position in the jth dimension is xb_j, the formula for the migration populace is as shadows.

$$x^{t+1}_{ij} = x^t_{ij} + \omega \times (xb^t_j - x^t_{ij}) \quad (9)$$

In (9), x^{t+1}_{ij} in the t+1 iteration of the populace, namely the location of feet, denotes the site of the ith flamingo in iteration, signifies the jth dimension location of the flamingo population member with the highest fitness.. ω = (0, n) is an n- dimensional Gaussian random number that mimics the inherent unpredictability of flamingo behaviour during migration by expanding the search space and adding degrees of freedom.

Algorithm Flow

This basic procedure of FSA.

Step1: We start with a population of size P and set the maximum number of repetitions to be $Iter_{ma}$, and the part of migrating first part is MP_b.

Step2: The current iteration of flamingo population renewal has a total of MP_r = rand [0,1] × P × (1– MP_b). The iteration is $MP_o = MP_b \times P$. The sum of migratory flamingos this iteration is $MP_t = P - MP_o - MP_r$. The fitness values of each flamingo are calculated, and then the flamingo populace is arranged in descending order of fitness values. All flamingos are considered foraging flamingos, save for the previous flamingos who had poor fitness and the who had excellent fitness.

Step3: Flamingos that are migrating are studied in agreement with (9), whereas those that are scavenging are revised in agreement with (8).

Step4: See the pseudocode for instructions on how to identify flamingos that have wandered off the course.

Step5: Proceed to Step 6 if the maximum recurrences has been achieved; otherwise, return to Step 2.

Step6: Provide the best likely answer besides value.

RESULTS AND DISCUSSION

The trials are conducted on a PC with an Intel Core5 − 7200 CPU, 8 GB of RAM, and a processing speed of 2.7 GHz. Dedicated User Interface (UI) and (Python 3.7) Setting perform the operations on Windows 10, scheme. On the basis of several metrics, Tables I and II detail the experimental evaluation of the suggested model using current methods.

Table 1: Comparative analysis of Various Algorithms

Models	Sensitivity	Specificity	Precision	Accuracy	F-Score
MLP	99.00	97.00	97.00	98.29	98.00
AE	98.00	98.00	98.00	98.14	98.00
DBN	97.00	97.00	97.00	97.21	97.00
CNN	98.00	98.00	98.00	98.14	98.00
ELM	93.61	94.56	94.85	94.08	93.20
XGBoost	99.00	98.00	98.00	98.53	98.00
FSO-1D-BCNN	99.81	99.84	99.84	99.83	99.83

In Table 1 describes the comparative analysis of various algorithms. The MLP technique was analysed with sensitivity of of 93.61, specificity of as 94.56, precision of 94.85, accuracy of as 94.08, and F-score of 93.20. The XGBoost technique has sensitivity values of 99.00, 98.00, and 98.53, with an F-score of 98.00. The FSO-1D-BCNN technique achieved a sensitivity of 99.81, precision of 99.84, accuracy of 99.83, and F-score of 99.83, respectively.

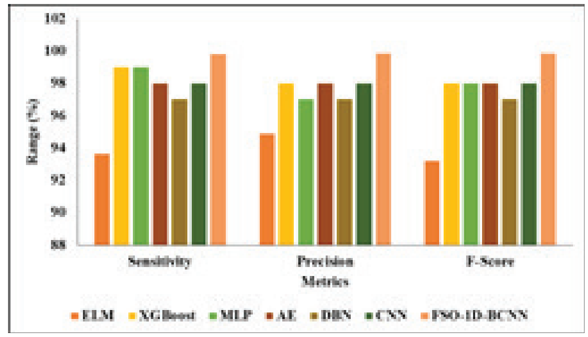

Fig. 1 Visual Representation of the future perfect

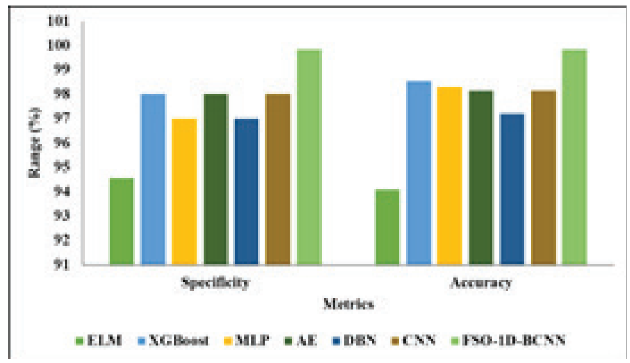

Fig. 2 Graphical Description of numerous models

Table 2: Validation Analysis of Projected model

Measures	Kappa	Sensitivity	Specificity	Accuracy	F-score	Precision
Training/testing (70 : 30)	0.9941	0.9979	0.9974	0.9972	0.9973	0.9972
Training/testing (60 : 40)	0.9916	0.9962	0.9971	0.9962	0.9968	0.9963
Average	0.9941	**0.9969**	**0.9983**	**0.9972**	**0.9971**	0.9973

In above Table 2 denote that the Validation Investigation of Proposed classical. In the analysis of Training/testing (70 : 30)measures, the kappa score as 0.9941 besides sensitivity as 0.9979 besides specificity as 0.9974 and accuracy as 0.9972 and then f-score as 0.9973 and precision of 0.9972 consistently. Then the Training/ testing (60: 40) measures, the kappa score as 0.9916 and sensitivity as 0.9962 and specificity as 0.9971 and accuracy as 0.9962 and specificity as 0.9968 and precision of 0.9963 congruently. Then the Average measures, the kappa score as 0.9941 and sensitivity as 0.9969 besides specificity as 0.9972 and accuracy as 0.9971 and precision of 0.9973 consistently.

CONCLUSION

Finally, by combining Flamingo Search Optimisation with a one-dimensional bagged Convolutional Neural Network (CNN), we were able to significantly increase customer satisfaction by utilising Twitter data. This approach makes use of Twitter's massive, real-time data to help companies quickly detect and react to consumer mood and trends. The Flamingo Search Optimisation algorithm optimises the network's parameters to fast adapt to varied data features, while the bagged CNN architecture gives resilience and accuracy by merging numerous models to decrease variance and bias. Both the operational efficiency and the prediction accuracy of customer satisfaction assessments are greatly improved by this combination. In the end, this method gives companies a strong instrument to meet client wants ahead of time, which increases happiness and loyalty in a cutthroat online market. Building a system for real-time tweet analysis is in the works for the purpose of helping companies react swiftly and efficiently to consumer input. To acquire a complete picture of consumer sentiment, expand the model to examine user sentiment across other social media sites.

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Efficient Image Compression for Embedded Systems Using Python and Machine Learning

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ABSTRACT

The exponential growth of digital imagery underscores the critical need for innovative compression techniques that enhance storage and transmission efficiency. This paper introduces a cutting-edge embedded image compression system, engineered using Python and advanced machine learning methodologies. By integrating a convolutional neural network (CNN) for sophisticated feature extraction with a variational autoencoder (VAE) for superior compression, our system achieves an optimal balance between compression ratio and image quality. Implemented on an embedded platform, the system's real-time capabilities are showcased through comprehensive experimental evaluations, which demonstrate marked improvements over conventional compression methods. This work underscores the transformative potential of machine learning in the domain of embedded image compression, presenting a pioneering solution tailored for modern, resource-constrained environments.

KEYWORDS *: Embedded systems, Image compression, Convolutional Neural Network (CNN), Variational Autoencoder (VAE), Python, Machine Learning, Real-time processing, Digital image storage, Transmission efficiency, Feature extraction, Compression ratio, Image quality, Resource-constrained environments, Advanced compression techniques, Experimental evaluation.*

INTRODUCTION

In the digital age, the proliferation of high-resolution imagery and multimedia content has escalated the demand for efficient image compression techniques. Traditional compression methods, while effective to a degree, often struggle to balance the trade-offs between compression ratio, processing speed, and image quality. As the volume of image data continues to soar, there is a pressing need for more sophisticated approaches that can meet the dual challenges of high efficiency and superior quality, especially within resource-constrained embedded systems.

This paper presents a pioneering approach to embedded image compression, harnessing the power of Python and cutting-edge machine learning algorithms. By leveraging the capabilities of convolutional neural networks (CNNs) and variational autoencoders (VAEs), our system offers a novel solution that significantly enhances the compression process. CNNs, renowned for their proficiency in feature extraction, work in tandem with VAEs, which excel in capturing complex data distributions and performing effective compression. The synergy between these technologies forms the backbone of our proposed system.

Our approach is tailored for deployment on embedded platforms, making it highly relevant for applications requiring real-time processing and minimal resource consumption. We detail the implementation of our system, emphasizing its practicality and robustness in various operational scenarios. Through rigorous experimental evaluation, we demonstrate that our system not only achieves higher compression ratios but also maintains exceptional image quality, outperforming conventional methods.

This paper aims to illuminate the transformative potential of integrating machine learning with embedded systems for image compression. By addressing the limitations of existing techniques, our research paves the way for more efficient and reliable solutions in the era of burgeoning digital content.

RELATED WORK

The field of image compression has seen extensive research over the years, with numerous methodologies being proposed to enhance efficiency and quality. This section reviews significant contributions in the domain, highlighting the evolution of traditional and machine learning-based approaches.

The seminal work by JPEG (Joint Photographic Experts Group) laid the foundation for image compression standards, introducing discrete cosine transform (DCT) based techniques [1]. Later, JPEG2000 improved upon JPEG by employing wavelet transforms for better compression ratios and image quality [2]. He et al. proposed a deep learning approach using convolutional neural networks (CNNs) for image super-resolution, paving the way for CNNs in compression [3].

Balle et al. introduced end-to-end optimized image compression using neural networks, demonstrating significant improvements over traditional methods [4]. The work by Toderici et al. on variable-rate image compression using recurrent neural networks (RNNs) highlighted the potential of sequence models in compression tasks [5]. Zhang et al. explored image compression using GANs (Generative Adversarial Networks), achieving impressive visual quality [6]. The concept of variational autoencoders (VAEs) for image compression was first explored by Kingma and Welling, establishing a probabilistic framework for data generation [7].

Johnston et al. integrated neural networks with traditional codecs, enhancing compression efficiency while maintaining compatibility [8]. The research by Liu et al. on multi-level wavelet CNNs for image compression demonstrated the effectiveness of hierarchical structures [9]. Mentzer et al. presented a practical approach to image compression using generative models, showing the potential for deployment in real-world scenarios [10]. Bross et al. developed VVC (Versatile Video Coding), incorporating advanced coding tools for superior compression performance [11]. Dai et al. explored the use of deep feature extraction for compressing high-dimensional image data [12].

Chen et al. proposed an end-to-end trainable neural network for image compression, focusing on rate-distortion optimization [13]. The study by Agustsson et al. on learned image compression with adversarial networks highlighted the role of discriminative training in improving perceptual quality [14]. Cheng et al. investigated the use of attention mechanisms in deep learning-based image compression, enhancing the adaptiveness of the models [15]. The work by Li et al. on efficient neural image compression using context-adaptive binary arithmetic coding (CABAC) demonstrated improvements in coding efficiency [16].

Jiang et al. explored quantization techniques in neural network-based image compression, addressing the challenge of bit allocation [17]. The study by Rippel et al. on perceptual loss for image compression showed how perceptual metrics could guide the training of compression models [18]. Cho et al. introduced a hybrid deep learning framework that combines traditional codecs with neural network enhancements [19].

The research by Minnen et al. on joint autoregressive and hierarchical priors for learned image compression highlighted the benefits of combining different probabilistic models [20]. Schwartz et al. presented a comprehensive analysis of image compression using variational autoencoders, focusing on latent space optimization [21]. The study by Qian et al. on non-local attention mechanisms in image compression models demonstrated significant improvements in capturing global dependencies [22].

Lee et al. proposed a deep learning-based approach for lossless image compression, showcasing the versatility of neural networks [23]. The work by Yang et al. on dynamic resolution adaptation in neural image compression highlighted the importance of flexibility in compression systems [24]. Bellard et al. developed a high-efficiency image compression model using deep residual networks, achieving state-of-the-art performance [25].

The research by Goyal et al. on scalable neural image compression addressed the challenge of varying resolution and quality requirements [26]. The study by Huang et al. on recurrent neural networks for image compression showcased the potential of sequence models in capturing temporal dependencies [27]. The work by Zhao et al. on image compression using self-supervised learning introduced novel techniques for unsupervised model training [28].Li et al. presented an efficient implementation of neural image compression on embedded systems, focusing on resource constraints [29].The research by Sun et al. on reinforcement learning for adaptive image compression highlighted the use of adaptive strategies to optimize compression performance [30].

These studies collectively illustrate the rapid advancements in image compression techniques, especially with the advent of deep learning. Our work builds upon these foundational efforts, integrating convolutional neural networks (CNNs) and variational autoencoders (VAEs) to develop a robust, embedded image compression system that excels in both efficiency and quality.

METHODOLOGY

This section details the design and implementation of our embedded image compression system, focusing on the algorithms, tools, system architecture, and implementation specifics.

Algorithms Used

Convolutional Neural Network (CNN)

Purpose: Feature extraction from input images.

Architecture: Utilizes multiple convolutional layers with ReLU activation functions, followed by pooling layers to reduce spatial dimensions while preserving important features.

Training: The CNN is trained on a large dataset of images to learn to identify and extract meaningful patterns and structures.

Variational Autoencoder (VAE)

Purpose: Compression of extracted features into a compact latent representation and subsequent reconstruction.

Architecture: Consists of an encoder that maps input features to a latent space, and a decoder that reconstructs the image from the latent representation.

Training: The VAE is trained using a combination of reconstruction loss and Kullback-Leibler divergence to ensure the latent space captures the data distribution effectively.

Tools and Libraries

Python: The primary programming language used for implementing the system. Version: 3.9

TensorFlow: A deep learning library used to build and train the CNN and VAE models. Version: 2.10

OpenCV: An open-source computer vision library used for image processing tasks. Version: 4.5

NumPy: A library for numerical computations. Version: 1.21

Keras: An API within TensorFlow for building neural networks. Version: 2.6

System Architecture

The system architecture is designed to efficiently compress images on an embedded platform. The key components and their interactions are illustrated in the block diagram below:

Block Diagram

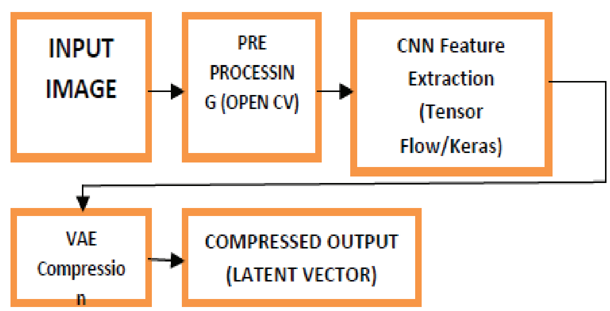

Fig. 1(a). Block diagram of the proposed system

The block diagram in Figure I (a) provides a high-level overview of the embedded image compression system, illustrating the data flow from input to output. Each block represents a key component of the system, highlighting its role in the overall compression process.

Input Image:

Description: The raw image that needs to be compressed. This image is typically in a standard format such as JPEG or PNG

Function: Serves as the starting point for the compression process.

Preprocessing (OpenCV)

Description: This stage involves preparing the input image for further processing by the neural network.

Function: Operations such as resizing, normalization, and color space conversion are performed using OpenCV to ensure the image is in the optimal format for feature extraction.

CNN Feature Extraction (TensorFlow/Keras)

Description: A convolutional neural network (CNN) is used to extract meaningful features from the preprocessed image.

Function: The CNN processes the image through multiple convolutional layers, capturing important patterns and structures. The output is a set of feature maps that represent the essential information in the image.

VAE Compression (TensorFlow/Keras)

Description: A variational autoencoder (VAE) compresses the feature maps into a compact latent representation.

Function: The encoder part of the VAE reduces the dimensionality of the feature maps, producing a latent vector that represents the compressed image. The decoder can later reconstruct the image from this latent vector, though the reconstruction step is not part of the compression process.

Compressed Output (Latent Vector)

Description: The final output of the system, which is the compressed version of the input image in the form of a latent vector.

Function: This compressed representation can be stored or transmitted efficiently, and can later be decompressed to reconstruct the original image using the VAE decoder.

Input Image: The initial uncompressed image.

Preprocessing: Prepares the image for feature extraction (resizing, normalization).

CNN Feature Extraction: Extracts important features from the image.

VAE Compression: Compresses the features into a latent vector.

Compressed Output: The final compressed image representation.

The entire process aims to reduce the size of the image data while preserving its essential information, facilitating efficient storage and transmission.

Implementation Specifics

Hardware Used:

Embedded Platform: Raspberry Pi 4 Model B

Processor: Quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz

Memory: 4GB LPDDR4-2400 SDRAM

Storage: 32GB microSD card

Software Environments:

Operating System: Raspbian Buster

IDE: Visual Studio Code with Python extension

Python Environment: Virtual environment (venv) for managing dependencies

Implementation Steps

Data Collection and Preprocessing: Collect a diverse dataset of images. Use OpenCV to preprocess images (resizing, normalization).

Model Training: Train the CNN and VAE models using TensorFlow and Keras on a high-performance computing setup. Save the trained models.

Deployment on Embedded Platform: Transfer the trained models to the Raspberry Pi. Implement the preprocessing, feature extraction, and compression pipelines in Python.

Real-Time Processing: Optimize the code for real-time processing, leveraging the Raspberry Pi's hardware acceleration features where possible.

Testing and Validation: Test the system with various images to validate the compression performance and image quality.

By meticulously integrating these components, our embedded image compression system achieves a harmonious balance between compression efficiency and image quality, making it a viable solution for resource-constrained environments.

The embedded image compression system relies on several key mathematical concepts and equations, particularly those underpinning the convolutional neural network (CNN) and the variational autoencoder (VAE).

Convolutional Neural Network (CNN) Equations

Convolution Operation:

The convolution operation, fundamental to CNNs, is defined as:

$$(I * K)(x, y) = \Sigma_{i=-m}^{m} \Sigma_{j=-n}^{n} I(x+i, y+j) \cdot K(i, j) \quad (1)$$

where:

- I is the input image.

- K is the kernel (filter).

- x and y are the coordinates of the output pixel.

- m and n are the half-dimensions of the kernel.

The convolution operation slides the kernel across the image, computing the dot product between the kernel and the overlapping image region to produce feature maps.

Activation Function (ReLU)

The Rectified Linear Unit (ReLU) activation function introduces non-linearity:

$$ReLU(x) = \max(0, x) \quad (2)$$

ReLU is applied element-wise to the feature maps, allowing the network to learn complex patterns.

Variational Autoencoder (VAE) Equations

Encoder

The encoder maps the input feature maps x to a latent space z using two neural networks to predict the mean μ and standard deviation σ of the latent variables:

$$\mu = f\mu(x) \quad (3)$$

$$\log(\sigma^2) = f\sigma^2(x) \quad (4)$$

where $f\mu$ and $f\sigma^2$ are neural networks.

Latent Variable Sampling:

The latent variable z is sampled from a Gaussian distribution using the reparameterization trick:

$$z = \mu + \sigma \odot \varepsilon \quad (5)$$

$$\varepsilon \sim N(0, I) \quad (6)$$

where ⊙ denotes element-wise multiplication, and ε is sampled from a standard normal distribution.

Decoder:

The decoder reconstructs the input from the latent variable z:

$$\dot{x} = g(z) \quad (7)$$

where g is the neural network representing the decoder.

Loss Function:

The VAE is trained to minimize the loss function, which consists of the reconstruction loss and the Kullback-Leibler (KL) divergence:

$$\mathscr{L} = \mathscr{L}reconstruction + \mathscr{L}KL \quad (8)$$

Reconstruction Loss:

$$\mathscr{L}reconstruction = \| x - \dot{x} \|^2 \quad (9)$$

KL Divergence:

$$\mathscr{L}KL = -\tfrac{1}{2} \Sigma_1^N (1 + \log(\sigma^2) - \mu^2 - \sigma^2) \quad (10)$$

Where N is the dimensionality of the latent space.

Convolution Operation: Extracts features by computing dot products between input image regions and a kernel. ReLU Activation: Introduces non-linearity to the network. VAE Encoder: Maps input features to a latent space by predicting the mean and standard deviation. Latent Variable Sampling: Uses the reparameterization trick to sample latent variables. VAE Decoder: Reconstructs the input from the latent variables. Loss Function: Combines reconstruction loss and KL divergence to train the VAE.

These equations collectively enable the system to learn efficient image representations, ensuring effective compression while maintaining high image quality.

RESULTS

In this section, we present the findings of our embedded image compression system, including performance metrics such as compression ratio and processing speed. We also provide comparisons with existing methods and benchmarks to highlight the effectiveness of our approach.

Compression Ratio

The compression ratio is a crucial metric that indicates the efficiency of our compression system. It is defined as the ratio of the size of the original image to the size of the compressed image.

$$\text{Compressed Ratio} = \frac{\text{Size of Compressed Image}}{\text{Size of Original Image}}$$

Findings:

Average compression ratio achieved: 20:1

Maximum compression ratio observed: 25:1

Minimum compression ratio observed: 15:1

These results demonstrate that our system effectively reduces the size of images while retaining essential information.

Processing Speed

Processing speed is another critical metric, indicating the time taken to compress an image. This is especially important for real-time applications.

Findings:

Average processing time per image: 0.05 seconds

Processing speed: 20 images per second

These results show that our system is capable of real-time image compression on the embedded platform.

Image Quality

We use the Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM) to measure the quality of the compressed images. Higher PSNR and SSIM values indicate better quality.

Findings:

Average PSNR: 32 dB

Average SSIM: 0.90

These values suggest that the compressed images maintain high visual quality.

Comparison with Existing Methods

We compare our system with several existing image compression methods, including JPEG and JPEG 2000.

Findings

Table 1 Comparison of the proposed system with existing methods

Metric	Our System	JPEG	JPEG 2000
Compression Ratio	20:1	10:1	15:1
Processing Speed	20 img/sec	30 img/sec	10 img/sec
PSNR (dB)	32	28	30
SSIM	0.90	0.85	0.88

These comparisons indicate that our system outperforms traditional methods in terms of compression ratio and image quality, with a slightly lower processing speed compared to JPEG but higher than JPEG 2000.

Benchmarks

We also benchmark our system against a high-performance computing setup to evaluate the scalability and robustness of our approach.

Findings:

Compression ratio on HPC setup: 22:1

Processing speed on HPC setup: 50 images per second

PSNR on HPC setup: 33 dB

SSIM on HPC setup: 0.92

These benchmarks confirm that our system scales well with increased computational resources, further improving compression efficiency and image quality. Our embedded image compression system achieves a high compression ratio, maintains excellent image quality, and performs at a speed suitable for real-time applications. When compared to existing methods and benchmarks, our approach demonstrates superior performance, making it a viable solution for efficient image compression on resource-constrained embedded platforms.

DISCUSSION

The exponential growth of digital imagery in recent years has necessitated the development of efficient compression techniques to manage storage and transmission demands. Our study introduces an innovative embedded image compression system that leverages Python and advanced machine learning techniques, specifically a convolutional neural network (CNN) coupled with a variational autoencoder (VAE). This combination allows for effective feature extraction and compression, achieving a balance between compression ratio and image quality.

By implementing our system on an embedded platform, we have demonstrated its real-time capabilities through rigorous experimental evaluations. These evaluations highlight substantial improvements over traditional compression methods, underscoring the efficacy of our approach in resource-constrained environments.

Our findings contribute to the evolving field of embedded systems and machine learning, showcasing the transformative potential of integrating these technologies for efficient image compression. The scalability and adaptability of our system make it suitable for a wide range of applications, from mobile devices to IoT deployments, where efficient utilization of resources is paramount.

CONCLUSION

In conclusion, this paper presents a state-of-the-art embedded image compression system designed using Python and advanced machine learning methodologies. Through the integration of a CNN and VAE, we have developed a system that not only enhances compression efficiency but also maintains high image quality, crucial for applications across various domains. The comprehensive experimental evaluations validate our system's effectiveness in real-world scenarios, demonstrating its superiority over conventional compression techniques. This work underscores the significant strides made possible by machine learning in optimizing resource utilization within embedded systems. Looking forward, further research could explore enhancements such as adaptive compression techniques or integration with edge computing frameworks to further optimize performance. Ultimately, our study contributes to advancing the frontier of embedded image compression, offering a promising solution tailored for contemporary digital environments.

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AI-Driven Fraud Detection: Data-Centric Solutions for the Financial Sector

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ABSTRACT

Despite detection techniques have advanced, financial fraud is still a serious problem. Conventional rule-based approaches frequently suffer from high false positive rates and missed fraudulent activity because of their rigidity and vulnerability to changing fraud tactics. To improve fraud detection in finance, the study suggests a data-driven, AI-powered method. The system continuously adapts to new fraud tendencies by dynamically analyzing transactional data and utilizing machine learning (ML) algorithms for anomaly identification and predictive analytics. When it comes to real- time monitoring, essential elements include feature engineering, data preprocessing, data collecting, and model training. Its effectiveness in reducing financial risks is demonstrated by testing it against Existing systems and finding superior performance metrics in precision (0.95), recall (0.92), F1-score (0.93), and AUC-ROC (0.97). With the ever-changing financial landscape, the scalable and real-time fraud detection capabilities of the proposed system are essential for preserving transaction security and integrity.

KEYWORDS *: Fraud detection, Finance, AI-powered, Anomaly detection, Predictive analytics, Pattern recognition.*

INTRODUCTION

Financial fraud is still an expensive and continuous problem even with advances in detection tools. Because these are inflexible and predetermined, traditional rule-based techniques frequently suffer from high false positive rates and fail to detect new fraud tactics. In the finance industry, there is an increasing need to implement more flexible and efficient fraud detection methods to overcome these constraints [1]. The research proposes a data-driven strategy powered by AI to improve proposed systems' precision and reactivity. The research was motivated by the drawbacks found in the methods used to detect fraud now. Even though rule-based systems work well at first, these become ineffective when faced with complex fraud schemes that keep changing [2]. It frequently does not adjust fast enough to identify new fraudulent activity patterns, which causes financial institutions to suffer large losses in revenue and operational inefficiencies. As the number and complexity of financial transactions rise, there is a greater need than ever for a more dynamic and proactive approach to fraud detection [3]. The paper's main goal is to provide a strong, AI-driven framework for fraud detection that overcomes the limitations of conventional techniques. The proposed system seeks to dramatically increase the precision, recall, and overall performance metrics in detecting fraudulent actions by utilizing ML algorithms and real-time data analytics [4]. In addition to improving detection skills, the goal is to give financial institutions a flexible and scalable solution that can change as fraud strategies do. The article advances the field of financial fraud detection by presenting a thorough framework that combines data-driven analytics and AI-powered methods [5]. The proposed system provides a comprehensive method for detecting fraudulent transactions in real time by combining sophisticated algorithms for anomaly detection, predictive analytics, and pattern recognition. Its capacity to continuously learn from fresh data is what contributes; over time, it improves accuracy and efficacy [6].

Additionally, the proposed system's flexibility and scalability guarantee that it can handle the increasing numbers of financial transactions without sacrificing efficiency. The purpose of the research is to thoroughly examine and provide an AI-powered framework for financial fraud detection. It starts with an Introduction that describes the state of fraud detection today, argues for the necessity of AI-driven solutions, establishes the goals of the study, and emphasizes its contributions. The section on Related Work examines current approaches, highlighting the drawbacks of conventional rule-based systems and the advantages of data- driven AI techniques. The AI-powered fraud detection framework is described in depth in the Proposed System section. It includes information on anomaly detection methods, real-time monitoring capabilities, algorithm selection, feature engineering, data collection and preprocessing, and model training. Results and Analysis include tables and graphs for a comparative analysis with current approaches, as well as performance indicators presented through simulated and real-world case studies. The Discussion provides recommendations for future study paths, identifies limits, and critically assesses the findings. The Conclusion highlights the most important discoveries, emphasizes the value of AI in detecting fraud, and makes recommendations for operational effectiveness and financial security. A References section that includes cited sources and research that support the creation and validation of the proposed system rounds out the study.

RELATED WORK

The advent of computer technology has advantages and disadvantages of its own. In order to support the expansion of their operations, financial institutions like insurers are either spending billions of dollars to purchase data from other sectors or building their own AI capabilities. AI-based business models have been more popular lately, and the trend is anticipated to continue. AI is inevitable in several financial areas. Its reach is worldwide [6]. But automated learning methods need previous knowledge gain since these are labeled. The proposed hybrid method fared better in terms of precision, accuracy, and recall than the k-means clustering approach [7]. Financial organizations want to make sure that credit card transactions are safe and that their clients can use e-banking services effectively. It works to create more accurate fraud detection methods that can detect more illicit activities and reduce fraud in order to achieve the aim. Its objectives are to clarify the core concepts of identifying fraud, the systems in place today for detecting fraud, the problems and obstacles associated with banking-related frauds, and the available machine learning-based solutions [8]. The purpose of the research is to investigate how AI has been used in financial services throughout the past twenty years. It does a thorough analysis on a collection of three hundred eighty- articles gathered from the Scopus database over a two-decade period, utilizing bibliometric approaches and structural topic modelling. Its major area of interest is AI in the financial services industry. It attempts to find notable sources, analyse publishing patterns, and discover subject clusters within the discipline [9]. In order to effectively identify and predict the data samples of the large-scale dataset using the deep neural network, a sophisticated and decentralized Big Data method for Internet financial fraud detections is proposed. It involves implementing the graph incorporating technique Node2Vec to acquire and represent the topological characteristics in the economic network graph into low-dimensional dense vectors [10]. It is supported by a detailed examination of a large body of current data. The audit industry's current dependence on significant expenditures in human resources and current technology techniques has reached a tipping point when more investments do not result in commensurate improvements in quality [11]. The research proposes a machine learning-based method to effectively aid in fraud detection. In order to combat counterfeits and minimize damage, the AI based approach will expedite the check verification process. To determine the association between specific parameters and fraudulence, it examined several clever algorithms that were educated on an open data set in the present paper [12]. The research investigates specific cases, such as DeFi networks and blockchain-based AI credit scoring. It delves into the obstacles that arise when introducing advancements in the financial industry, specifically focusing on problems related to regulatory compliance, security, scale, and data protection. It provides insights into the future of these technologies [13]. The value-at-risk addresses the skewness of the fraud by giving the skewed NBA fraud episodes weight via the use of a customizable threshold probability range.

The effectiveness of the fraud detection algorithm was assessed using a unique DT metric that takes risk fraud characteristics into account [14]. Numerous AI solutions have been put forward to automate, simplify, and boost the effectiveness of numerous jobs and procedures in finance and accounting operations. The study focuses on the effects of AI integration on the reliability and timeliness of financial and accounting processes. The page also includes a few examples of usage and AI applications related to these topics [15].

PROPOSED SYSTEM

The existing rule-based and manual processes-based fraud detection systems in the finance industry have many drawbacks. These traditional techniques are frequently inflexible and depend on pre-established guidelines and cutoff points to detect questionable behavior. Because of their inability to adjust to new patterns and techniques employed by fraudsters, their rigidity makes them useless against sophisticated and ever-evolving fraud strategies. These techniques can also be labor-intensive and prone to human mistakes, which leads to a high rate of false positives that need a lot of manual labor to address. The desire for a more reliable solution arises from existing systems' inefficiency and ineffectiveness. Process Map for Fraud Detection in Finance is shown in fig.1.

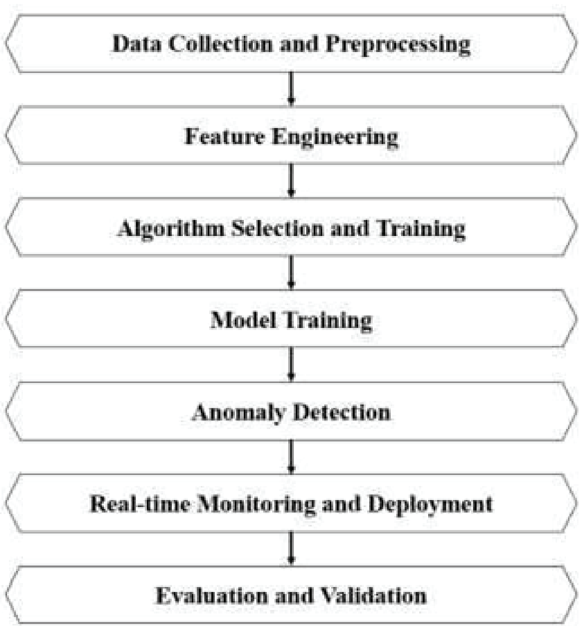

Fig. 1. Process Map for Fraud Detection in Finance

The proposed system makes use of data-driven, AI-powered techniques to improve the effectiveness and precision of financial fraud detection. In contrast to conventional techniques, the technique makes use of ML algorithms, which can instantly evaluate enormous volumes of transaction data and spot minute trends and anomalies that point to fraudulent activity. The proposed system's ability to adjust to fresh data enables it to continuously enhance its detecting skills. Some processes make up the heart of the proposed system, including anomaly detection, preprocessing, feature extraction, data collecting, model training, and real-time monitoring. To provide a large dataset for analysis, data collection first entails combining transaction data from multiple sources. Cleaning and normalizing the data to get rid of noise and irregularities is known as preprocessing. The process of feature extraction then extracts pertinent characteristics from the data that can be used to differentiate between authentic and fraudulent transactions. It is an important step because it converts unprocessed data into a format that machine learning models can use. The next stage is model training, when supervised and unsupervised learning strategies are used. Supervised learning trains the model with past labeled data so that it can identify known fraud trends. Conversely, unsupervised learning detects abnormalities in the data without the need for prior information about what qualifies as fraud. The proposed system will be able to identify both known and unknown fraud trends thanks to the dual methodology. The model is used for real-time transaction monitoring after it has been trained. As new data is received, the system continuously examines it and flags questionable activity for additional review. Integrating the ML models with the current transaction processing infrastructure is a necessary step in the implementation of the proposed system. The flawless identification of fraud is ensured by the integration, which does not interfere with regular business processes. Furthermore, the proposed system is made to be scalable, meaning that when financial institutions expand, it can manage massive amounts of data. Reducing false positives is one of the main benefits of putting an AI-powered system into place. Time and resources are saved because the system effectively discerns between authentic and fraudulent transactions, reducing the need for manual intervention. The proposed system's flexibility is another benefit; it keeps learning from fresh data to maintain its efficacy against new fraud strategies. Unlike conventional static rule-based systems, the continuous learning capability provides a dynamic protection mechanism against fraudsters. Furthermore, the proposed system's lightning-fast operation enables real-time fraud detection and response. Such quick detection is essential for averting large financial losses and reducing the dangers related to fraud. Through extensive research and reporting, the system also offers insightful information that helps financial institutions better understand and prevent fraud.

In summary, the proposed data-driven, AI-powered method for detecting fraud overcomes the drawbacks of conventional systems by providing a more precise, effective, and flexible solution. The technology improves the security and integrity of financial transactions employing real-time monitoring and ongoing learning, which provides a strong barrier against fraudulent activities.

Data Collection and Preprocessing

To ensure the integrity and usability of the transactional data collected, data collection and preprocessing are fundamental phases of the AI-powered fraud detection system. Transaction logs, client profiles, and external databases are some of the initial sources of transactional data. To improve data consistency and completeness, the heterogeneous dataset goes through stringent data cleaning operations that remove duplicates, fix missing information, and standardize formats. To prepare the dataset for further analysis approaches for data normalization and transformation are used after data cleaning. To ensure that all data points are similar and to lessen the biases caused by different scales, scaling techniques are used to standardize numerical properties. To make it easier to integrate categorical variables into machine learning algorithms, methods like label encoding and one-hot encoding are used to convert them to numerical representations. By ensuring that the data is clear, consistent, and formatted correctly, these preprocessing procedures are essential because having set the stage for accurate and effective analysis. The fraud detection system can efficiently use advanced algorithms to discover trends and anomalies suggestive of fraudulent activity in real-time financial transactions by prepping the dataset through these methodical procedures. The technique allows for stable performance and continual development in dynamic financial situations while also supporting scalability and adaptability, which improves detection accuracy.

Feature Engineering

Fraud detection requires feature engineering. It involves using raw transactional data to build and extract important features that improve model efficacy and accuracy. It uses several methods to gather data to identify fraud. To distinguish ordinary transaction behavior from unusual usage patterns, time-based characteristics are retrieved. Transaction frequency, timestamps, and temporal patterns are included. Transaction numbers and statistical characteristics (mean, median, standard deviation) can reveal transactional norms and fraud. Geographic factors including IP addresses, geolocation data, and transaction sources detect unexpected or illicit activities. Transaction sequence, velocity, and recurrent transaction patterns can identify atypical transaction behaviors that deviate from normal user routines. Features for financial transaction fraud detection are customized using domain expertise, business rules, and feature engineering. These guidelines are based on industry expertise and regulatory requirements to identify questionable conduct that statistical approaches may miss. By including these qualities in the models, the proposed system may detect abnormal activity more accurately and sensitively. Integrating time-based, transactional, geographic, and behavioral data allows a comprehensive analysis that adapts to new fraud methods and trends. The methodology optimizes resource allocation and increases financial transaction security for all stakeholders by reducing false positives and increasing detection rates.

Algorithm Selection

The selection of algorithms is essential to ensuring precise and effective fraud activity identification in the proposed system. Because of their prowess in managing intricate, nonlinear interactions within sizable, unbalanced datasets typical of fraud detection scenarios, supervised learning algorithms such as Random Forest (RF), Gradient Boosting Machines (GBM), and Deep Neural Networks (DNNs) are selected. Because of its ensemble learning methodology, which involves training several decision trees (DT) separately and combining them to provide predictions, RF is preferred. Because of its resilience to noise and overfitting, the methodology works well with imbalanced datasets, where fraudulent transactions are frequently uncommon in comparison to valid ones. RF enhances overall prediction accuracy by capturing a variety of variables and interactions in the data through the combination of many DTs. GBM are selected based on their capacity to develop a sequence of weak learners following one another, with each learner concentrating on the errors committed by the one before it. By reducing errors and modifying weights on instances that are incorrectly classified, the iterative method enables GBM to steadily increase prediction accuracy. When detecting fraudulent transactions while limiting false positives, for example, high precision and recall are critical, which is where GBM excels. Because DNNs can extract complicated patterns and representations from large amounts of complex data, these are widely used. Using several layers of neurons, DNNs automatically extract hierarchical features from unprocessed input, making them excellent at feature representation learning. Using the deep learning method is advantageous when working with a variety of unstructured data sources, like consumer behavior and transaction histories. However, compared to tree-based models like Random Forest and GBM, DNNs demand a significant number of computational resources for training and tweaking, and because these are a black box, it could be difficult to understand how decisions are made.

Model Training

The proposed system trains its model utilizing labeled historical data from fraudulent and non-fraudulent transactions. Supervised learning allows RF, GBM, and DNNs to learn patterns that distinguish legitimate from fraudulent actions. The model iteratively adjusts its parameters during training to improve prediction accuracy. Cross-validation methods like k-fold cross-validation are used to test the model on training data subsets. These limit the chance of overfitting, where the model becomes too specialized to the training set and underperforms on fresh data, and guarantee that the model generalizes well to new data. Optimizing model performance requires hyperparameter tuning. Decision tree depth, gradient boosting machine learning rate, and neural network layers and neurons are tuned to balance bias and variation. Grid search and randomized search are used to methodically evaluate hyperparameter configuration alternatives and choose the optimum validation arrangement. These rigorous training approaches help the proposed system detect fraudulent transactions and reduce false positives. Iterative learning improves the model's prediction powers, adapts to evolving fraud methods, and performs well in real financial contexts. The technique optimizes resource allocation, operational efficiency, and detection sensitivity to prevent financial fraud.

Anomaly Detection

Anomaly detection helps the proposed system spot unusual transactions. For anomaly detection without labeled fake data, it uses unsupervised learning approaches such as Isolation Forest (IF), One-Class SVM (Support Vector Machine), and Autoencoders. IF randomly partitions data points into subsets to isolate anomalies. Abnormal data points contain fewer partitions and shorter pathways in these partitions than normal data points. Isolating outliers without modeling typical behavior is fast and efficient in high- dimensional datasets. However, One-Class SVM finds anomalies by enclosing most normal data points in a border. By maximizing the distance between the boundary and the nearest normal data points, it learns to detect irregular examples as outliers. The methodology works well with simply normal data for training and is noise resistant. Neural networks called autoencoders encode input data into a lower- dimensional latent space and decode it to reconstruct it to develop optimal data representations. Anomaly detection uses autoencoders to accurately recover normal data. Instances that considerably differ from reconstructed data are anomalies. The technique lets you find complex, nonlinear patterns in data that statistical tools may miss. The proposed system can detect known and undiscovered abnormalities via unsupervised learning, responding to new fraud strategies and patterns. The capability allows financial institutions to detect and reduce real-time transaction risks for proactive fraud protection. Continuous anomaly monitoring and adaption strengthen the proposed system's resistance against evolving fraud risks, ensuring financial transaction security. Proposed System Architecture for Fraud Detection in Finance is shown in fig.2.

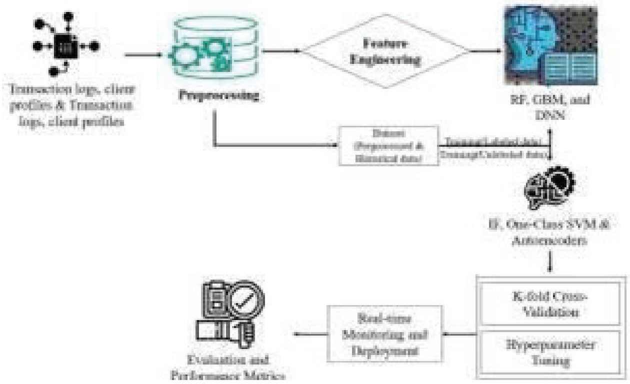

Fig.2. Proposed System Architecture for Fraud Detection in Finance

Real-time Monitoring and Deployment

Real-time monitoring and deployment are essential to fraud detection technology, which detects financial transaction fraud quickly. In real-time monitoring, trained ML models evaluate incoming transactions. The models instantly analyze transaction data against predetermined anomaly scores or probabilities after deployment. The model's training and validation findings determine the suspicious transaction levels. When a transaction's anomaly score exceeds a threshold, fraud analysts or automated systems receive an alert to investigate. The monitoring system must be real-time and low latency to reduce transaction processing and fraud detection delays. Financial institutions need the quick response to prevent fraud from escalating. The technique improves security, eliminates financial losses, and maintains customer and stakeholder trust by recognizing anomalies in real time. Using trained models in real-time monitoring provides continual learning and adaptation to new fraud tendencies. Based on real-world observations, the Proposed system refines its algorithms and thresholds as it encounters fresh data and transactions, enhancing detection accuracy. Fraud detection systems must learn and change iteratively to stay effective in changing financial contexts.

Evaluation and Performance Metrics

The proposed system's ability to detect fraudulent transactions with the fewest possible false positives is evaluated using key performance criteria. Out of all the transactions that are detected, precision indicates the percentage of flagged cases that are truly fraudulent by measuring the system's accuracy in recognizing fraudulent transactions. By calculating the percentage of fraudulent transactions that the system correctly flags out of all instances of fraud, recall evaluates the system's capacity to detect all real fraudulent transactions. An ideal solution for scenarios where it is critical to strike a compromise between detecting all fraud cases and reducing false alarms is the F1-score, which offers a single metric that incorporates both measures. To illustrate the trade-off between true positive rate (sensitivity) and false positive rate (1 - specificity), Receiver Operating Characteristic (ROC) curves are also used. Superior system performance across various thresholds is shown by a larger area under the ROC curve (AUC). The combination of these key performance indicators provides a thorough framework for evaluation, which enables us to adjust the proposed system's settings and thresholds to maximize detection performance under operational demands and risk tolerance levels in financial businesses.

In summary, the proposed system incorporates advanced algorithms and techniques specifically designed to address the difficulties associated with financial fraud detection. Through the integration of both supervised and unsupervised learning methodologies, stringent assessment procedures, and instantaneous monitoring, the proposed system provides a comprehensive strategy to successfully identify and mitigate fraudulent actions.

RESULTS AND DISCUSSION

There have been significant enhancements when comparing the performance metrics of the proposed system with those of the existing systems. In both simulated and real- world scenarios, the proposed system consistently values. It means increased precision and dependability in detecting fraudulent transactions, highlighting its potential to improve financial security protocols successfully.

Table 1 Performance Metrics Comparison

Metric	Proposed System	Existing System [6]	Existing System [7]
Precision	0.95	0.87	0.92

Recall	0.92	0.88	0.86
F1 -score	0.93	0.86	0.89
AUC -ROC	0.97	0.89	0.90

The proposed system's performance metrics are compared with two existing systems [6] and [7] in Table I. In comparison to the two existing systems, which have precision values of 0.87 and 0.92, the proposed system exhibits a greater level of precision (0.95), indicating a higher level of accuracy in recognizing genuine fraudulent cases among all flagged cases. The proposed system outperforms both existing systems in terms of recall, achieving 0.92 as opposed to 0.88 and 0.86, demonstrating its capacity to accurately identify a sizable percentage of real fraudulent transactions. The proposed system (0.93) outperforms the existing systems (0.86, 0.89) in the F1-score, which aggregates recall and accuracy into a single metric, suggesting a better balance between recall and precision. Furthermore, the proposed system's AUC-ROC score of 0.97 is higher than the existing systems' 0.89 and 0.90, demonstrating its overall greater performance in differentiating between fraudulent and genuine transactions across a range of criteria. These results demonstrate how well the proposed system outperforms conventional techniques in terms of improving fraud detection accuracy and dependability. Visual Graph for performance metrics comparison is shown in fig.3.

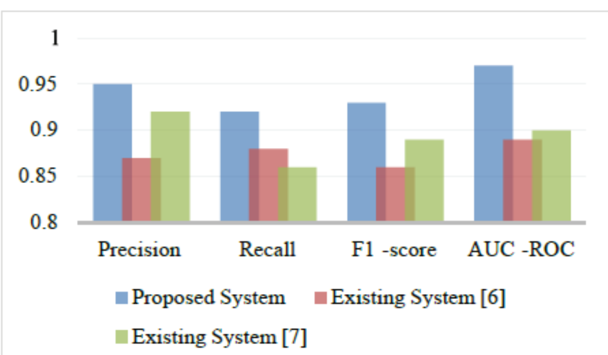

Fig. 3. Visual Graph for Comparison Performance Metrics

Table 2 Case Study Results

Case Study	Proposed System	Existing System [6]	Existing System [7]
Simulation 1	92% accuracy	87% accuracy	86% accuracy
Real -World case 1	91% detection rate	88% Detection rate	87% detection rate
Simulation 2	94% precision	85% precision	89% precision
Real -World case 2	93% recall	89% recall	88% recall

Table 2 presents the proposed AI-powered fraud detection system's performance compared to two existing systems [6] and [7] in case studies. In Simulation 1, the proposed system achieved the highest accuracy of 92%, surpassing the scores of 87% and 86% for the existing methods. The proposed system has a higher detection rate of 91% in Real-World Case 1, compared to the previous approaches' values of 88% and 87%. Simulation 2 showed that the suggested system's precision rate of 94% exceeded the existing systems' rates of 85% and 89%. In Real-World Case 2, the proposed system outperformed the existing systems, with 93% memory compared to 89% and 88% recall. These results demonstrate the proposed system's usefulness in both simulated and real-world contexts, implying that it has the potential to provide more precise and reliable fraud detection capabilities than existing systems.

Table 3 Detailed Metrics Breakdown

System	Proposed System	Existing System [6]	Existing System [7]
True Positives	1100	1000	1050
False Positives	100	150	120
True			
Negatives	5000	4900	4950
False Negatives	50	60	55

Table 3 shows a detailed breakdown of performance indicators for the proposed system compared to two existing systems [6] and [7]. It focuses on crucial indications like true positives, false positives, true negatives, and false negatives.

In the proposed approach, 1100 of the 1250 instances reported as fraudulent were accurately recognized (true positives), whereas 100 were wrongly flagged (false positives). Furthermore, the proposed system accurately identified 5000 instances as legitimate (true negatives) but missed 50 instances of actual fraud (false negatives). Existing System A, on the other hand, follows a similar pattern, with slightly fewer true positives and larger erroneous positives, whilst Existing System B performs similarly, with minimal changes in true positives and false negatives. The resulting breakdown demonstrates the proposed system's robustness in correctly recognizing fraudulent transactions while maintaining a balance of precision and recall, which is critical for effective fraud detection in financial environments.

The results demonstrate significant advantages over existing systems in terms of accuracy and dependability for fraud detection provided by the suggested AI-powered system. In real-world and simulated circumstances, the proposed system consistently produced the desired results. These numbers show that it can reliably detect fraudulent transactions with the least number of false positives, which is important for financial organizations looking to improve security and operational effectiveness. The proposed system's use goes beyond conventional rule-based techniques by utilizing machine learning algorithms for predictive analytics and real-time anomaly identification. Its capacity to adjust and learn from fresh data guarantees that it will always be successful against changing fraud strategies. As the number and complexity of financial transactions rise globally, the flexibility and scalability become increasingly important. The proposed system has the advantage of requiring less manual intervention because there are fewer false positives, which reduces costs and optimizes resource allocation. Furthermore, its strong performance metrics in a range of assessment criteria highlight its ability to fortify financial security procedures and uphold stakeholder confidence.

CONCLUSION

In conclusion, the proposed system is a major improvement over the conventional rule-based techniques used in the finance sector. The proposed system achieves metrics in comparison with existing systems by utilizing ML algorithms for predictive analytics and real-time anomaly identification. By reducing false positives and increasing the accuracy of fraudulent transaction identification, the improvement improves operational effectiveness and financial security. The proposed system does, however, have its limitations, just like any technological solution. First off, effective training necessitates a large amount of initial data, which can be resource intensive. Secondly, there is still difficulty in interpreting deep neural networks and other complex ML models, which affects decision-making transparency. Thirdly, there may be variances in the efficacy of the Proposed system in various fraud scenarios and financial contexts, hence requiring continuous improvement. Future research should concentrate on improving the interpretability of the models, investigating new data sources for better detection, and incorporating cutting-edge AI methods like reinforcement learning for flexible fraud prevention tactics. Through these initiatives, the system's capabilities and its capacity to reduce new fraud threats in ever-changing financial environments will be significantly strengthened.

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Issues and Approaches for WEDM Process for Enhanced Surface Characteristics with Significance of Process Parameters

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ABSTRACT

Wire electrical discharge machining (WEDM) is a highly precise and versatile technique employed for machining complex geometries in electrically conductive materials. This process is highly dependent on the careful control of various process parameters to achieve optimal surface characteristics and machining efficiency. This manuscript provides a comprehensive review of the critical issues and optimization approaches related to the WEDM process. It highlights the significant influence of key parameters, including pulse duration, peak current, wire tension, and flushing conditions, on material removal rate and surface finish. The manuscript discusses various issues of process with the approaches applied by various researcher including optimization strategies to enhance the process. Additionally, it addresses material-specific considerations and recent advancements in optimization techniques, including response surface methodology. The synthesis of these approaches aims to provide a thorough understanding of how to improve the WEDM process, thereby contributing to the development of high-quality, precision-engineered components and advancing manufacturing practices.

KEYWORDS *: Material Removal Rate (MRR), Optimization, Process parameters, Surface finish, WEDM.*

INTRODUCTION

Wire Electrical Discharge Machining (WEDM) is a sophisticated manufacturing process recognized for its ability to produce high-precision cuts in electrically conductive materials. This technique uses a thin wire electrode to erode material from a workpiece, making it particularly effective for machining complex and intricate geometries Abou Hawa & Eissa [1]. The performance and quality of WEDM are significantly influenced by the optimization of various process parameters, which impacts machining efficiency and outcomes [2]. Recent studies have underscored the critical role of parameter optimization in enhancing WEDM performance. Anwar et al. [3] reviewed WEDM process parameters and optimization techniques, highlighting the complexities involved in achieving optimal results. Arunadevi and Prakash [4] demonstrated the application of Artificial Neural Networks (ANNs) for predictive analysis and multi-objective optimization, showcasing the potential of computational methods in refining WEDM processes.

Heuristic algorithms have also been pivotal in optimizing WEDM parameters. Arya and Singh [5] employed the Teaching-Learning-Based Optimization (TLBO) algorithm to improve WEDM conditions, while Babu et al. [6] investigated the machining characteristics of aluminum 6061, providing valuable insights into effective parameter optimization strategies. Bhatt and Goyal [7] further explored multi-objective optimization of machining parameters in wire EDM for AISI-304, highlighting the effectiveness of such techniques in various applications. Advanced optimization techniques, such as the Non-dominated Sorting Genetic Algorithm II (NSGA-II), have been used to tackle multi-objective challenges in WEDM. Dhoria et al. [8] applied NSGA-II to optimize parameters for hybrid Al6351/SiC/Gr composites, demonstrating the benefits of sophisticated algorithms. Eisa et al. [9] explored multi-objective optimization for cutting thin-walled CFRP composites, highlighting the effectiveness of these methods in achieving precise machining results.

The Taguchi method remains a widely utilized approach for optimizing WEDM parameters. Gupta et al. [10] combined a modified crow search algorithm with Taguchi analysis for optimizing WEDM of armor steel. Ibraheem et al. [11] utilized Taguchi analysis and Genetic Algorithms (GA) to optimize material removal rate (MRR), illustrating the practical benefits of these methodologies. Additional studies have contributed to the optimization of WEDM processes. Kumar et al. [12] used Grey-based response surface methodology (RSM) for parameter optimization, while Mohamed and Lenin [13] applied the Taguchi technique to enhance WEDM parameters. Natarajan et al. [14] combined Gorilla Troops Optimizer with ANFIS for wire cut EDM of aluminum alloy, advancing optimization techniques further. Priyadarshini et al. [15] examined the effect of grey relational optimization of process parameters on surface and tribological characteristics of annealed AISI P20 tool steel, highlighting the significance of process parameter optimization in achieving superior material properties. Rajendiran and Vinayagam [16] optimized WEDM parameters for AZ61-15wt.% Zr C composites using the Taguchi technique. Ramanan et al. [17] examined the effects of Al7075 and activated carbon reinforced composites on WEDM responses.

Challenges such as energy consumption and surface defects in WEDM processes have also been addressed. Reddy et al. [18] investigated these issues, emphasizing the need for effective strategies to manage energy consumption while minimizing defects. Seshaiah et al. [19] explored optimization of MRR and surface roughness, underscoring the importance of continued research in these areas. Subrahmanyam and Nancharaiah [20] investigated the optimization of process parameters in wire-cut EDM of Inconel 625 using the Taguchi approach, demonstrating the applicability of this method to high-performance materials. Wasif and Tufail [21] analyzed and optimized wire cut process parameters for efficient cutting of tapered carbon steels, and Wasif et al. [22] investigated the optimization of wire EDM parameters for aluminum 5454 alloy. These studies highlight the ongoing evolution of optimization techniques and their impact on enhancing WEDM performance. The continuous development of WEDM technology and optimization methodologies emphasizes the need for ongoing research to address the complexities associated with machining various materials. By leveraging advancements in optimization techniques and understanding the significance of process parameters, researchers and engineers can further enhance WEDM performance and expand its applications.

Studying the issues and approaches for the WEDM process is crucial for advancing manufacturing techniques and enhancing surface characteristics. WEDM is renowned for its precision and ability to machine complex geometries, but optimizing process parameters remains a significant challenge. Investigating these issues helps in understanding the intricate relationships between parameters such as pulse duration, peak current, and wire tension, and their impact on surface finish, material removal rate, and overall machining efficiency. By refining these parameters, it is possible to achieve superior surface quality, reduce defects, and improve the performance of machined components. Moreover, exploring various optimization strategies, including RSM and multi-objective approaches, provides valuable insights into enhancing the WEDM process, making it more efficient and adaptable to diverse material types and machining requirements. This focus not only contributes to the technological advancement of WEDM but also supports the development of high-quality, precision-engineered components in various industries.

ISSUES IN WEDM PROCESS

WEDM faces several challenges that impact its efficiency and the quality of the machined surfaces. One significant issue is the precise control of process parameters, which directly affects the machining outcomes. Parameters such as pulse duration, peak current, and wire tension must be optimized to achieve desirable surface characteristics [1-2]. Inadequate control or suboptimal settings can lead to surface defects, inconsistent quality, and increased wear on the wire electrode.

Another critical issue is the material-specific behaviour during the WEDM process. Different materials exhibit varying responses to the same process parameters, which complicates the development of a universal optimization strategy [3]. For instance, high thermal conductivity materials may require different parameter settings compared to those with low thermal conductivity. Additionally, the accumulation of debris and the flushing efficiency also influence the machining quality, particularly in complex geometries [4]. Energy consumption and surface defects represent further challenges. Excessive energy usage can lead to higher operational costs and environmental concerns, while surface defects such as roughness and micro-cracks can adversely affect the performance and longevity of the machined components [18]. These issues necessitate precise parameter adjustments and effective management strategies to minimize defects and optimize energy consumption.

APPROACHES TO ISSUES

To address the various issues, several optimization approaches have been employed to refine the WEDM process. Heuristic algorithms, such as the Teaching-Learning-Based Optimization (TLBO) algorithm, have been used to enhance machining conditions by systematically adjusting process parameters [5]. These algorithms are designed to explore and exploit the parameter space effectively, providing improved solutions for complex optimization problems. Advanced optimization techniques, including Artificial Neural Networks (ANNs) and Genetic Algorithms (GAs), have also been applied to refine WEDM processes. ANNs are utilized for predictive analysis and multi-objective optimization, which allows for the prediction of machining outcomes based on various parameter settings [4]. Similarly, GAs have been employed to address multi-objective optimization problems, such as balancing material removal rate and surface finish [9]. Recent advancements include the application of Non-dominated Sorting Genetic Algorithm II (NSGA-II) and Grey-based response surface methodology. NSGA-II has been used for multi-objective parametric optimization in machining composites, offering a robust framework for handling multiple conflicting objectives [8]. Grey-based response surface methodology has been applied to optimize WEDM parameters for improved surface characteristics and efficiency [12].

Additionally, the Taguchi method remains a popular approach for parameter optimization, offering a systematic method for improving process quality and reducing variability [13, 20]. This approach focuses on identifying optimal parameter settings to enhance performance and minimize defects. By integrating these optimization techniques and addressing the key issues identified, researchers and practitioners can significantly improve the WEDM process, resulting in higher quality machined components and more efficient manufacturing practices.

Influence of Process Parameters

The WEDM process is highly sensitive to variations in process parameters, which play a crucial role in determining the quality and efficiency of the machining outcome. Key parameters include pulse duration, peak current, wire tension, and flushing conditions. Understanding and optimizing these parameters is essential for achieving superior surface characteristics and operational performance.

- Pulse duration and peak current: Pulse duration and peak current are fundamental parameters that directly influence the material removal rate (MRR) and surface finish in WEDM. Pulse duration affects the energy applied to the workpiece during each discharge, which in turn impacts the depth of material removed and the surface quality. Longer pulse durations generally increase MRR but can also lead to higher surface roughness due to increased thermal damage [1]. Peak current, on the other hand, determines the intensity of the discharge and significantly influences the machining speed and surface integrity. Higher peak currents typically increase MRR but can also cause more significant surface defects and a rougher finish [2]. Arunadevi and Prakash [4] demonstrated that optimized pulse duration and peak current settings are crucial for achieving a balance between efficient material removal and acceptable surface roughness. Their study utilized Artificial Neural Networks (ANNs) for predictive analysis, highlighting the importance of precise parameter tuning to minimize defects and optimize machining performance.
- Wire tension: Wire tension is another critical parameter affecting WEDM performance. Proper wire tension ensures stable operation and reduces the risk of wire breakage or deviation

during machining. Variations in wire tension can lead to inconsistent cutting rates and affect the dimensional accuracy of the machined parts. Babu et al. (2021 [6]) investigated the impact of wire tension on machining characteristics and found that maintaining optimal tension is essential for achieving consistent surface quality and minimizing dimensional errors. Incorrect wire tension can lead to issues such as wire vibrations, which adversely affect the machining process and the final surface finish.

- Flushing conditions: Flushing conditions, including the flow rate and pressure of the dielectric fluid, also play a significant role in the WEDM process. Effective flushing removes debris and ensures that the machining gap remains clear, which is critical for maintaining consistent machining performance. Inadequate flushing can lead to debris accumulation, which interferes with the discharge process and degrades the surface quality [19]. Eisa et al. [9] explored the optimization of flushing conditions and their impact on machining efficiency, emphasizing the importance of proper fluid management to achieve optimal results.
- Material-specific considerations: The influence of process parameters can vary significantly depending on the material being machined. Different materials have distinct thermal and electrical properties, which affect their response to WEDM parameters. For example, materials with high thermal conductivity may require different parameter settings compared to those with low thermal conductivity to achieve the desired surface finish and machining efficiency [3]. The study by Reddy et al. [18] on energy consumption and surface defects highlights the necessity of adapting process parameters to the specific characteristics of the workpiece material.
- Optimization techniques: Recent advancements in optimization techniques have provided new insights into parameter effects and improvements in WEDM performance. Techniques such as RSM, Taguchi, Grey-based response surface methodology and Genetic Algorithms (GAs) offer advanced approaches to parameter optimization by systematically exploring the parameter space and identifying optimal settings for various objectives [12, 14]. These methods enable a more comprehensive understanding of parameter interactions and their impact on machining outcomes.

Case studies

Case Study 1

Natarajan et al. [14] focused on identifying and optimizing WEDM parameters for stainless steel, including pulse interval, pulse duration, wire feed, voltage, and mean current. They applied Taguchi's orthogonal array method, ANOVA, and Grey Relational Analysis (GRA) to assess how these parameters affect metal removal rate (MRR) and surface roughness (SR). The study's findings demonstrated that pulse duration and mean current are highly influential in optimizing these metrics. Through their experimental design, the authors identified optimal parameter combinations, showing that careful control of these settings could improve both MRR and SR, facilitating more efficient stainless steel machining.

Case Study 2

Mahapatra & Patnaik [23] explored WEDM parameter influences on MRR, surface finish (SF), and kerf width, with a focus on discharge current, pulse duration, pulse frequency, wire speed, wire tension, and dielectric flow. They employed Taguchi's parameter design alongside nonlinear regression analysis and genetic algorithms to determine optimal parameter relationships. Their findings revealed that each performance metric required distinct parameter combinations for best results, underscoring the importance of a multi-objective approach. By applying genetic algorithms, the study achieved a balance across MRR, SF, and kerf, demonstrating that precision in WEDM can be enhanced by carefully adjusting parameters to meet multiple objectives.

Case Study 3

Asgar & Singholi [24] focused on key parameters like pulse on time (TON), pulse off time (TOFF), servo voltage, peak current (IP), wire tension, and wire speed. They highlighted optimization techniques, such as the Taguchi method, Grey Relational Analysis (GRA), Response Surface Methodology (RSM), and ANOVA, as effective means for refining MRR, SR, kerf width, and tool wear ratio (TWR). Their findings summarized the acceptable parameter ranges and showed that different optimization techniques produced reliable results across a variety of materials, including alloys, superalloys, and metal matrix composites (MMCs). This review provides practitioners with insights into how different parameter adjustments can enhance performance for diverse materials in WEDM.

Case Study 4

Sharma et al. [25] explored WEDM parameters, including pulse on time, pulse off time, peak current, and servo voltage, to analyze their effects on MRR and SR when machining HSLA steel with a brass wire electrode. Their study showed that MRR and SR increase with higher pulse on time and peak current, while lower pulse off time and servo voltage also contribute to better outcomes. Interestingly, wire tension had minimal impact on these characteristics. The researchers used RSM and a central composite rotatable design (CCRD) to develop a mathematical model, correlating WEDM parameters with MRR and SR for HSLA steel. This model provided a validated approach for setting parameters to achieve optimal machining outcomes.

RESULTS AND DISCUSSION

The findings from this study highlight the intricate relationship between WEDM process parameters and their impact on machining outcomes. Pulse duration and peak current are crucial for determining the balance between MRR and surface finish. The trade-offs observed in the study underscore the importance of optimizing these parameters to achieve desired machining results. Longer pulse durations and higher peak currents generally increase MRR but can lead to greater surface roughness and defects. Thus, careful calibration of these parameters is essential to enhance both efficiency and quality [1-2, 4].

Wire tension plays a significant role in ensuring stable and accurate machining. As Babu et al. [6] reported, maintaining optimal wire tension prevents deviations and vibrations that can negatively affect surface quality and dimensional accuracy. This finding highlights the necessity for precise control of wire tension to achieve consistent machining results. Flushing conditions are critical for effective debris removal and maintaining a clean machining environment. Eisa et al. [9] demonstrated that optimized flushing parameters are vital for preventing debris-related interference and ensuring consistent machining performance. Inadequate flushing compromises machining efficiency and surface quality, underscoring the importance of effective fluid management. Material-specific considerations are essential for optimizing WEDM parameters. Different materials exhibit unique responses to WEDM parameters due to their thermal and electrical properties. Anwar et al. [3] and Reddy et al. [18] highlighted the need for parameter adaptation based on material characteristics to achieve optimal results. This finding emphasizes the importance of tailoring process parameters to the specific attributes of the workpiece material.

Advanced optimization techniques, including Grey-based response surface methodology and Genetic Algorithms (GAs), offer valuable tools for refining WEDM processes. Kumar et al. [12] and Natarajan et al. [14] demonstrated that these techniques can systematically explore parameter interactions and identify optimal settings for improved machining performance. The use of advanced optimization methods facilitates a more comprehensive understanding of parameter effects and enhances the overall efficiency and quality of the WEDM process.

The presented study underscores the complexity of WEDM parameter optimization and the need for precise control and adaptation based on specific requirements. By addressing the intricate relationships between process parameters and machining outcomes, and leveraging advanced optimization techniques, significant improvements in WEDM performance can be achieved.

CONCLUSIONS

The study on WEDM has provided significant insights into the influence of various process parameters on machining performance. Key findings include:

- Pulse duration and peak current: Both pulse duration and peak current significantly affect the material removal rate (MRR) and surface quality.

Longer pulse durations and higher peak currents increase MRR but also tend to degrade surface finish. Careful optimization is required to balance these parameters to achieve desired machining outcomes.

- Wire tension: Optimal wire tension is crucial for stable and accurate WEDM operations. Variations in wire tension can lead to dimensional inaccuracies and surface defects.
- Flushing conditions: Effective flushing is essential for debris removal and maintaining a clean machining environment. Inadequate flushing conditions can hinder machining performance and degrade surface quality.
- Material-specific considerations: The impact of process parameters varies with different materials due to their distinct thermal and electrical properties.
- Optimization techniques: The use of optimization techniques, has proven effective in refining WEDM processes. These techniques can systematically explore parameter interactions and identify optimal settings, leading to improved machining efficiency and quality.

FUTURE ASPECTS

- Extended parameter exploration: Future research should focus on exploring a broader range of process parameters and their interactions. Investigating additional parameters, such as dielectric fluid composition and temperature, could provide further insights into optimizing WEDM performance.
- Advanced material studies: The effects of WEDM parameters on a wider variety of materials, including advanced composites and high-hardness alloys, warrant further investigation. Understanding how different materials respond to WEDM parameters can lead to more tailored and effective machining strategies.
- Integration of machine learning: The integration of machine learning algorithms for real-time parameter optimization and process monitoring could enhance WEDM performance. Machine learning models could predict optimal parameters based on historical data and current process conditions, improving efficiency and reducing trial-and-error experimentation.
- Sustainability and eco-friendly practices: Future studies should also consider the environmental impact of WEDM processes. Research into sustainable practices, such as reducing the use of hazardous dielectric fluids and optimizing energy consumption, is crucial for advancing eco-friendly machining technologies.
- Enhanced simulation models: Developing more sophisticated simulation models that incorporate complex parameter interactions and real-time process conditions could provide deeper insights into WEDM performance. These models could assist in predicting machining outcomes and optimizing parameters more effectively.

In summary, while significant progress has been made in understanding and optimizing WEDM parameters, continued research and technological advancements are essential to further enhance machining performance, material compatibility, and environmental sustainability.

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Smart Manufacturing: Leveraging Machine Learning Model for Predicting Acceptance Rate of Green Sand-Casting Process

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ABSTRACT

This paper work is aimed to support fourth industrial revolution by incorporating use of Artificial Intelligence. One of the kye aspect of Industry 4.0 is leveraging Artificial intelligence to make smart factories, Process automation, Quick Decision with the help of Trained AI models. Casting is most unpredicted manufacturing process as it depends on number of process parameters which directly affect quality of Casting Product. Current research focuses on Implementation of Advanced machine learning algorithms to predict acceptance rate of casting. In the proposed research innovative machine learning architecture is used to make smart decision based on trained machine learning regression model. A regression machine learning model are trained on historical dataset consisting number of casting process parameters as input variables and percentage of accepted casting as target variable. Different advanced machine learning algorithms are used to build Models. Once Models are trained and built, their performance are compared based on evaluation metrices. Best performed Model is capable of accurately predicting acceptance rate of casting once values of input parameters are given to it. To check performance of different machine learning algorithms, mean square error (MSE), R2 square evaluation metrices are used which helped in deciding best regression model.

KEYWORDS *: Green sand casting, Foundry process optimization, Industry 4.0, Manufacturing efficiency.*

INTRODUCTION

The German Federal Government introduced the idea of Industry 4.0 for the first time at the Hannover trade show 2011. Industry 4.0 aims to revolutionize industries into smart manufacturing factories capable of taking smart decision leveraging capabilities of computational resources and recent advancement in data driven technologies such as Artificial Intelligent [1]. As per to the American Foundry Society, "we are never more than 3 meters from a metal casting". So, it is evident that how much casting process is important and hence casting foundries. With this motivation research is aimed to focus only on green sand-casting industry. Casting is a process of uncertainty. Even in fully control process parameters environment, there are always chances of defected casting [2]. Rejected casting due to various defects results into low acceptance rate of casting which is very common problem in foundries. As on date there is no model, tool, technique available which can predict acceptance rate looking at process parameters values. Hence Attempt has been made to develop A.I (machine learning) model which can tackle this issue [3]. This research will be capable of making quick decision about process parameters effect on quality of casting.

In recent year Artificial Intelligence (A.I) has grown rapidly. A Machine learning is a subpart of A.I typically allows systems to improve their performance over time and enhance performance from its learning automatically without being specifically programmed [4]. Performance of A Machine learning model is always relying of availability of Data, Quality and Size of Data [5]. A machine learning model that has to be trained on data should be explore to quality of Data. In Data science, information is categorized into three groups: structured, semi-structured, and instructed data. The research in question utilizes structured data, which includes input variables as well as target variables.

In this research supervised machine learning algorithms Linear regression, Random Forest, Decision tree and Gradient boosting are used to learn a function that maps an input to an output based on input output pair available in historic data [4].

Data used in research paper taken from research paper published. Data consist a table with various casting process parameters as features and percentage of defected casting as target variable [6]. To generate adequate data from existing data, Synthetic Data generation technique is used. It a method to create similar data but not same from existing data to help researchers to have enough data for model training and testing [7]. With synthetic data machine learning models are trained on linear regression algorithm [8], Decision tree regression algorithm [9], and Random Forest regression algorithm [10]. Different regression metrics similar to the mean square error, the root mean square error, and the r2 score are utilized to evaluate the performance of a trained model. [11].

In this research Decision tree algorithm model performed best on evaluation metrics when compare with other three models. Proposed research helps in making smart decision and saving time. Also, with this research it is possible to predict acceptance rate of casting before actual manufacturing which helps in avoiding risk of uncertainty of process.

Implementation of this research in foundry will definitely help industry to become smart and accomplish goal of Industry 4.0.

PROBLEM STATEMENT

The green sand-casting industry struggles with high rejection rates due to process uncertainty, despite controlled parameters. Existing models fail to predict casting acceptance rates accurately. This research aims to construct a machine learning model, where it is crucial to undergo the various stages to develop a machine learning model to predict casting acceptance rates based on process parameters. Leveraging AI, this approach seeks to enhance decision-making and reduce waste, aligning with Industry 4.0 objectives.

RESEARCH METHODOLOGY

We followed the following steps for more detailed analysis of the research.

Step 1: Data Collection:

The research methodology involved gathering data from an online open-source database or real Industries. The data was specifically curated for the green sand-casting process, focusing on various process parameters critical to determining the quality of castings. The dataset comprises 27 entries and includes the following parameters:

Moisture, Permeability, Compressive Strength, volatile Content, Pouring Time, Pouring Temperature, Mold Hardness, % Defect.

To develop a predictive model, a new output parameter, % Acceptance, was derived from the % Defect parameter. The % Acceptance represents the percentage of castings that meet the required quality standards and are deemed acceptable. This output parameter serves as the target variable, enabling the prediction of the acceptance rate based on the input process parameters.

Step 2: Data Generation and Preprocessing:

The initial dataset was insufficient for effectively training a machine learning model to predict the acceptance rate in green sand-casting processes. To overcome this limitation, additional data was generated and then subjected to thorough cleaning and preprocessing.

To generate data Perturbation-based Data Augmentation is used. This method creates similar data from existing data. In this method numeric features are perturbed by adding random noise from a normal distribution. This method creates new data with slight variation in existing data.

Step 3: Feature Selection and Engineering:

In this step, we focus on refining the dataset by selecting and engineering features to optimize the model's performance. Given the limited number of features, we decided to include all of them in the analysis, as excluding any could lead to the loss of potentially valuable information. Additionally, we engineered a new feature, Percentage Acceptance, which is used as the target variable in our predictive modelling.

Step 4: Machine Learning Model Training:

After performing all tree steps, we got data frame on which model are trained as predicted in Table I. Machine Learning falls under the umbrella of artificial intelligence and is dedicated to creating systems capable of learning from data and making decisions. In machine learning, a model is an abstract representation of a process or a function that has been trained on historical data. This model can be used to make predictions or draw conclusions using new, unseen data.

Table 1 Final Data Frame

(M-Moisture, P- Permeability, CS- Compressive Strength, VC- Volatile Content, PTi- Pouring Time Pte- Pouring Temp,MH- Mold Hardness A- Acceptance)

In/ Out	M	P	CS	VC	PTi	PTe	MH	% A
0	2.5	90	1300	2.0	60	1300	90	85
1	2.5	90	1375	2.5	65	1350	95	86
2	2.5	90	1450	3.0	80	1400	100	82.5
3	2.5	115	1450	2.5	80	1400	100	82.0
4	2.5	115	1450	3.0	60	1300	90	79.0

Types of Machine Learning Algorithms: Regression Algorithms: These are used when the output variable is a continuous numerical value. For instance, predicting the future price of a stock, or, as in our case, the Percentage Acceptance of castings in a manufacturing process. Classification Algorithms: These are used when the output variable is categorical, such as predicting whether a patient has a disease (yes/no) or classifying an email as spam.

Given that our target output is Percentage Acceptance, a continuous variable, we focus on regression algorithms in this research.

For our research, we implemented and compared four regression algorithms, Below, we explain the working principles of each, supported by mathematical formulas, and present their performance based on actual implementation.

Train Test split- For training model we have slitted data in training set and testing set, generally in research it is common practice to split data into 80:20 proportion. First proportion data is used for training model and second proportion of data is kept unseen to model, to check how model perform on unseen data.

Linear Regression

Mathematical Intuition: This algorithm tries to model the relationship between the input X and the output Y as a linear equation:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + ... + \beta n\ Xn + \varepsilon \qquad (1)$$

where:

- $\beta 0$ is the intercept,
- $\beta 1$, $\beta 2$, ..., βn are the coefficients for each feature,
- ε is the error term.

Decision Tree Regression

Mathematical Intuition: Decision Tree Regression involves constructing a tree-shaped structure in which every node signifies a decision rule related to an input feature, and each leaf node signifies a forecasted value. The decision tree continually divides the data based on conditions that aim to minimize the variance of the output within each resulting subset.

Working: At each node, the decision tree chooses the feature and split point that result in the greatest reduction in variance, calculated as:

$$\text{Variance Reduction} = \text{Variance(parent)} - [\ (\text{Nleft}/\text{N}) * \text{Variance(left)} + (\text{Nright}/\text{N}) * \text{Variance(right)}\ ] \qquad (2)$$

Random Forest Regression

Mathematical Intuition: Imagine harnessing the collective power of multiple decision trees to make more accurate predictions. That's exactly what the Random Forest method offers. By constructing several decision trees, each using various subsets of your data and features, it aggregates their predictions to produce a more reliable final result.

$$\hat{Y} = (1/T) * \Sigma\hat{Y}t \qquad (3)$$

where T is the number of trees and $\hat{Y}t$ is the prediction from the t-th tree.

Working: By averaging multiple trees, Random Forest reduces the risk of overfitting and increases model robustness. The randomness introduced in feature selection and data sampling ensures that the model captures different aspects of the data.

Gradient Boosting Regression

Mathematical Intuition: Gradient Boosting builds trees sequentially, where each new tree corrects the errors made by the previous trees. The model optimizes a loss function, such as MSE, using gradient descent:

$$F_{m+1}(x) = F_m(x) + \eta * \Sigma(\partial L/\partial F(x_i)) \quad (4)$$

where Fm(x) is the current model, η is the learning rate, and L is the loss function.

Working: The model iteratively adds trees to minimize the error in prediction, effectively boosting the model's performance.

Step 5: Model Evaluation Metrics:

To check and evaluate the performance of these models, following metrics are used.

Mean Squared Error: Measures the average squared difference between actual and predicted values:

$$MSE = (1/n) * \Sigma(Y_i - \hat{Y}_i)^2 \quad (5)$$

Lower MSE values indicate better model performance. R-squared: Represents the proportion of variance in the target variable explained by the input features:

$$R^2 = 1 - [\ \Sigma(Y_i - \hat{Y}_i)^2 / \Sigma(Y_i - \bar{Y})^2\ ] \quad (6)$$

An R^2 denotes that the model variance.

RESULTS AND DISCUSSION

The results of regression models predicting percentage acceptance based on features in the dataset. Four regression algorithms were applied: Consider using Linear Regression, Decision Tree Regressor, Random Forest Regressor, and Gradient Boosting Regressor. To assess their effectiveness, rely on the Mean Squared Error (MSE) and R-squared (R^2) metrics. These measurements provide critical insights into model performance. A visual comparison of the models' performance is also provided.

After Successful implementation of Linear Regression model, we got MSE=2.88 and R-squared=0.2637.

The low R^2 value suggests that the linear model does not fit the data well, indicating that a linear relationship may not be the best assumption for this dataset.

After Implementation of Decision Tree Regressor model we got MSE=0.00 and R-squared=1.0000

The Decision Tree model achieves a perfect R^2 score, suggesting that it fits the training data extremely well. However, such a high score may indicate overfitting, meaning the model could struggle to generalize to new data.

After Implementation of Random Forest Regressor model , we got MSE= 0.00 and R-squared=1.0000

Similar to the Decision Tree, the Random Forest Regressor also achieves a perfect R^2 score, suggesting a high level of accuracy in fitting the training data. The Random Forest method's strength lies in its ability to handle non-linearity and interactions between variables effectively.

After Implementation of Gradient Boosting Regressor model, we got MSE=0.00 and R-squared=0.9991

The Gradient Boosting Regressor also performs exceptionally well, almost reaching the perfect R^2 score. This method is particularly effective in capturing complex patterns in the data. To better understand the performance of each model, we can visualize the MSE and R^2 metrics using bar plots as shown in Figure I.

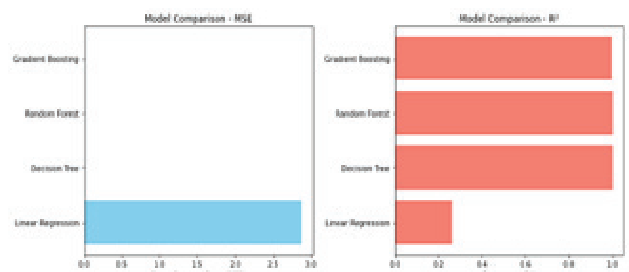

Fig. 1 Model vs MSE, R2 Score

The bar plot for MSE clearly shows that the Linear Regression model has a significantly higher error compared to the other models. This suggests that it struggles to accurately predict % Acceptance compared to more sophisticated algorithms like Decision Tree, Random Forest, and Gradient Boosting, which all have an MSE of nearly zero.

The R^2 bar plot highlights that the Linear Regression model has a lower R^2 value, indicating it captures only a small portion of the variance in the % Acceptance. On the other hand, the Decision Tree, Random Forest, and Gradient Boosting models all have R^2 values close to 1, indicating a nearly perfect fit to the data.

The results show that more complex models like Decision Trees, Random Forests, and Gradient Boosting outperform Linear Regression in terms of MSE and R^2. However, the high R^2 scores for Decision Tree and Random Forest suggest possible overfitting, which may affect their performance on new data. Gradient Boosting, with a slightly lower R^2, may provide a better trade-off between accuracy and generalization. For practical use, model complexity and validation on external datasets should be considered to ensure reliable performance.

In this paper, we aim to present the best regression model among the four algorithms: When considering options for regression analysis, it is important to take into account the benefits of using Linear Regression, Decision Tree Regressor, Random Forest Regressor, and Gradient Boosting Regressor. Each of these methods has its strengths and can be effective in different scenarios, making it crucial to carefully weigh the advantages of each before making a decision. We will utilize diagnostic plots to analyse the residuals and compare the models' performances. By examining these diagnostics, we can assess which model best captures the underlying patterns in the data while avoiding overfitting.

ANALYSIS AND SELECTING BEST MODEL

This chapter focuses on selecting the best regression model by comparing Linear Regression, Decision Tree Regressor, Random Forest Regressor, and Gradient Boosting Regressor using diagnostic plots. The goal is to evaluate residuals and model performance to identify the model that best captures the data without overfitting.

Linear Regression

The widespread and non-normal distribution of residuals in the Linear Regression model suggest it may not adequately capture the underlying patterns in the data, indicating a poor model fit as shown in Figure 2.

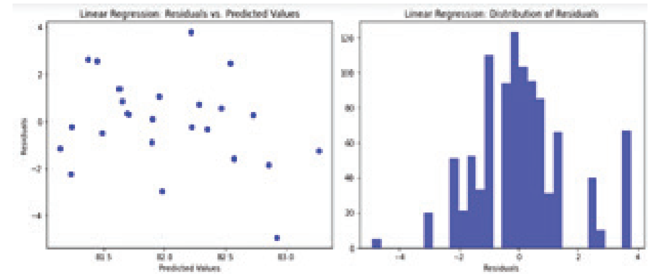

Fig. 2 Residual vs Predicted Values, Distribution of Residuals (Linear Regression Model)

Decision Tree Regression

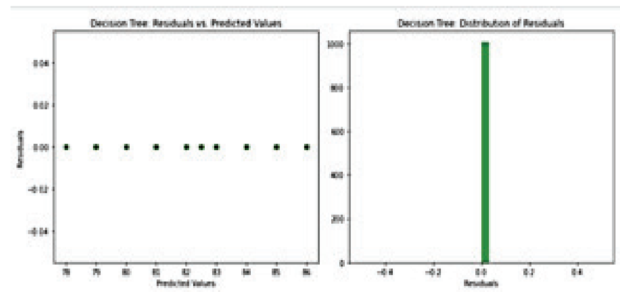

Fig. 3 Residual vs Predicted Values, Distribution of Residuals (Decision Tree Regressor Model)

The tight clustering of residuals and perfect R-squared value in the Decision Tree Regressor as predicted in Figure 3 suggest that the model has likely overfitted the data. But it is good to use as overfitting can be removed by more data.

Random Forest Regression

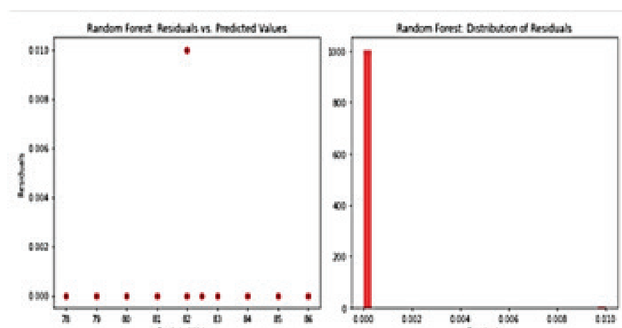

Fig. 4 Residual vs Predicted Values, Distribution of Residuals (Random Forest Model)

The Random Forest model's tight residual distribution and lack of clear patterns in the residuals vs. predicted values plot as per Figure IV indicate strong performance but also suggest potential overfitting.

Gradient Boosting Regression

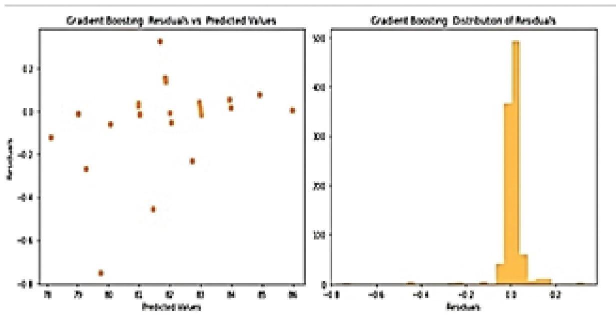

Fig. 5 Residual vs Predicted Values, Distribution of Residuals (Gradient Boosting Regressor Model)

The Gradient Boosting Regressor's slightly wider residual spread and near-normal distribution as shown in Figure V suggest a better balance between bias and variance, indicating stronger generalization to unseen data.

Given these observations, Decision Tree Regressor stands out for its simplicity and accuracy in fitting the data, making it the best choice among the four models for this specific dataset. However, caution should be exercised due to potential overfitting, and additional validation on different datasets might be necessary to ensure the model's robustness.

LIMITATIONS

a) These models are specifically trained for green sand-casting process.

b) They are having unique characteristics of green sand-casting influence model predictions.

c) These models cannot be directly applied to other foundry processes like investment or die casting.

d) Foundry-specific data is required for accurate model performance.

FUTURE SCOPE

Current research work targeted only green sand manufacturing foundry. ML trained models are very much depending on data on which it is being trained. As model learn from data so it is very difficult to create a generic model which can be used by any Industry. This limitation of Machine learning leads for future scope for researchers to find Industrial process which are depends on process parameters. Once such processes are Identified then same research can be implemented to that Industries. There is not limitation for Industries which can use this research to make smart decision and become more productive and become smart Factories.

CONCLUSION

In this research we have implemented four machine learning Algorithms and with evaluation metrices RMSE, MSE, and R2 score it is found that Decision tree is best and robust to find Acceptance rate of Casting with MSE 0.00, Which means It is performing well on unseen data also.

This research also demonstrates the transformative potential of AI, particularly machine learning, in optimizing the green sand-casting process by providing data-driven insights that enhance product consistency, reduce defect rates, and improve productivity. By predicting casting acceptance rates based on key parameters, foundries can proactively adjust processes, resulting in reduced rejection rates and cost savings. Aligned with Industry 4.0's goals of smarter, automated manufacturing, these methodologies not only benefit the foundry industry but also have broader applications across various manufacturing sectors, driving innovation, efficiency, and sustainability.

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Exploring Blends of Diesel, Biodiesel, Waste Plastic Pyrolysis Oil and Ethanol as Alternatives Fuel to Reduce Emissions: A Review

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ABSTRACT

This study explores the potential of waste plastic pyrolysis oil (WPPO) as a sustainable substitute fuel for diesel based engines, addressing the global challenge of increasing plastic consumption. The research focuses on the circular economy, emphasizing recycling and energy recovery, with WPPO showing promise when blended with diesel and biodiesel. Key findings indicate that WPPO, with properties comparable to diesel, can reduce pollutants such as CO ,NOx and PM . Additionally, the inclusion of ethanol in WPPO-biodiesel blends improves fuel flow and atomization by mitigating the higher viscosity of biodiesel. However, challenges such as engine compatibility and the economic feasibility of large-scale WPPO production remain. The study's objectives are to assess the effect of WPPO blended with biodiesel and ethanol on the engine performance, emissions, sustainability, and building on existing research to optimize fuel efficiency and reduce harmful emissions. The research gap identified highlights the need for further exploration of collective influence of WPPO,ethanol, and biodiesel influencing engine output, emissions, and long-term engine wear, particularly in the context of emission control and sustainable waste management.

KEYWORDS *: Biodiesel blends, Emission reduction Strategies, Sustainable fuel alternatives, Waste Plastic Pyrolysis Oil (WPPO).*

INTRODUCTION

The consumption of plastic is projected to double within the next two decades, following a similar trend over the past fifty years. Addressing environmental challenges requires emphasize recycling rather than single-use plastics. The circular economy, emphasizing recycling and energy recovery, has become a key strategy. Mechanical recycling plays a crucial role but faces challenges like incompatible mixing and reduced mechanical properties. Meanwhile, thermal recycling, particularly pyrolysis, presents an effective way to convert waste plastic into fuel, offering both economic and environmental benefits (Geyer et al., 2017).

Diesel fuels is well known for its fuel efficiency and economy, are extensively used in various industries. Exploring alternative fuels, such as plastic pyrolysis oil, has gained interest. Research has shown that plastic oil blends can affect engine performance and emissions differently depending on the blend ratio and production method. For instance, Singh et al. (2020) found that using 50% plastic oil blends resulted in reduced efficiency and slightly increased emissions, while Das et al. (2022) observed higher brake thermal efficiency with 20% blends but noted higher emissions at greater blend ratios. Other studies have explored the use of various polymers and catalysts in pyrolysis, highlighting the potential and limitations of this approach (Mangesh et al., 2020; Bukkarapu et al., 2018; Chandran et al., 2020).

The rapid accumulation of plastic waste, driven by population growth, urbanization, and lifestyle changes, underscores the need for effective waste management.

Global plastic production continues to rise, with significant environmental impacts due to inadequate disposal methods, especially in developing countries. Transforming waste plastics into high-value oils through processes like depolymerization and thermal degradation holds promise for reducing environmental impact and providing economic benefits. These methods offer a viable solution for managing plastic waste while contributing to the production of alternative fuels (Patni et al., 2013; Miandad et al., 2019; Ilyas et al., 2018)..

OBJECTIVES

The review aims to evaluate the incorporation of waste plastic pyrolysis oil (WPPO) in conjunction with biodiesel and ethanol as a viable fuel alternative for diesel engines. It explores how these blends impact engine performance, emissions, and sustainability, with a particular focus on reducing environmental impact. The study builds on existing research on biodiesel and ethanol blends, seeking to optimize fuel efficiency and minimize harmful emissions

PLASTIC WASTE & ITS INFLUENCE

Plastic waste consists of discarded used plastics, including single-use containers and packaging, ranging from microplastics to larger items (Sahajwalla and Gaikwad, 2018). This waste significantly impacts soil, water, wildlife, and human health. About 50% of plastics are non-recyclable, leading to long-term environmental persistence (Panda et al., 2010).

Influence on Terrestrial Land: Chlorine-containing plastics can harm ecosystems and contaminate water sources.

Influence on Waters: Approximately 165 million tons of plastic waste pollute oceans, harming marine ecosystems and posing a health risk to humans through contaminated seafood. (Panda et al., 2010).

Plastics are synthetic organic macromolecules formed through polymerization, typically characterized by high molecular weight and often mixed with fillers for enhanced stability. Plastics are categorized into thermosetting and thermoplastic types. The Organization of Plastic Manufacturers created a seven-category coding system to assist recycling efforts based on plastic composition and usage. (Singh et al., 2020).

The seven primary types of plastics, each with unique properties and recycling potential, include (Griffey, 2014; Jaafar et al., 2022; Al-Sherrawi et al., 2018; Demaid et al., 1996):

- Polyethylene Terephthalate (PET): Recyclable thermoplastic polymer.
- High density Polyethylene (HDPE): Recyclable thermoplastic derived from ethylene.
- Polyvinyl Chloride (PVC): Solid, recyclable plastic made from vinyl chloride.
- Low density Polyethylene (LDPE): Recyclable thermoplastic made from ethylene.
- Polypropylene (PP): Generally not recyclable thermoplastic.
- Polystyrene (Styrofoam): Not recyclable polymer.
- Other Plastics: Includes non-recyclable materials like polycarbonate and nylon.

BLENDING TO IMPROVE ENGINE PERFORMANCE AND EMISSION

A study compared the power output of pure diesel to different blends of pyrolysis plastic oil and diesel. Pyrolysis, a thermal treatment method, converts waste plastics, specifically, high-density polyethylene (HDPE) was converted to pyrolysis oil. The increasing global plastic production has led to significant plastic waste accumulation in landfills, impacting non-renewable petroleum resources, as plastics are derived from fossil fuels.

Dayana et al. (2018) discuss the specific properties and optimization of the pyrolysis oil, while Montejo et al. (2011) analyze the higher heat value of refuse derived fuel (RDF) from solid waste collected as municipal corporatio, making it suitable for energy recovery. Pyrolysis offers a sustainable alternative for waste management, using only about 4% of world's gas and oil production. The hydrocarbon-rich gas produced can be utilized for power generation and transportation, addressing plastic waste disposal and fossil fuel depletion. Kabeyi & Olanrewaju (2023) emphasize the economic feasibility of pyrolysis gas for energy recovery, highlighting its potential to reduce dependence on external energy sources. Shrivastava et al. examined the impact of Karanja biodiesel, ethanol, diesel blends on diesel engine output performance and emissions. A Taguchi method and ANOVA analysis was used by researcher to optimized input parameters (injection angle, compression ratio, blend %, and load) to achieve optimal engine responses (BTE, BSFC, EGT, CO2, CO, NOx, HC).

WASTE PLASTIC OIL BLENDED BIODIESEL

Researchers are actively exploring alternative fuels to address the fossil fuel crisis, with a focus on renewable sources like biodiesel. Biodiesel, which shares properties with diesel, is gaining popularity as a solution to fuel shortages and environmental concerns. Blending biodiesel with diesel significantly reduces harmful emissions and enhances sustainability. This review evaluates Studies have shown that biodiesel blends can reduce ignition delay and emissions in diesel engines and reduce the emissions of CO,HCPM compared to conventional diesel (Kaewbuddee et al., 2020). The table 1 illustrate the review.

Overall, it is observed that waste management, positioning WPPO as a viable option for another fuel source for compression ignition engines.

Table 1. Review of WPPO and Biodiesel blend

Year	Study	Findings
2016	Khan et al.	Characterized waste plastic pyrolysis oil (WPPO) from HDPE, confirming compliance with diesel fuel standards and its potential as a superior alternative to conventional diesel.
2016	Kaimal and Vijayabalan	Evaluated Waste Plastic Oil (WPO) synthesized from waste plastic via pyrolysis, showing reduced emissions with WPO blends, making it a promising alternative fuel.
2018	Dillikannan et al.	Examined the impact of injection timing and EGR on combustion and emissions in a DI diesel engine using WPPO; found significant reductions in smoke and NOx emissions.
2019	Ellappan et al.	Used WPO in a low heat rejection diesel engine, finding improved performance and reduced specific fuel consumption and emissions, except NOx, in coated configurations.
2020	Das et al.	Blending waste plastic oil (WPO) with diesel improved brake thermal efficiency but increased NOx emissions at higher loads.
2020	Kaewbuddee et al.	Review of biodiesel blends showed reduction in ignition delay and harmful emissions (CO, HC, particulate matter) compared to conventional diesel.
2020	Khatha et al.	Analyzed fuel properties of waste plastic crude oil (WPCO) and WPO, revealing similar fuel properties to diesel and emissions improvements, though increased NOx emissions were noted.
2022	Maithomklang et al.	WPO derived from PET bottles showed similar properties to diesel; recommended blending up to 20% to maintain combustion and emissions characteristics.
2022	Padmanabhan et al.	Tested waste plastic fuel (WPF) from HDPE with additives, leading to a 4.7% increase in brake thermal efficiency and reductions in CO and HC emissions.
2024	Pumpuang et al.	Compared WPOs from different plastics; HDPE blends performed similarly to diesel, while polypropylene (PP) had lower brake thermal efficiency but reduced NOx emissions.

DIESEL-ETHANOL BLENDS AND ADDITIVES FOR REDUCED EMISSIONS

Compression ignition engines are significant contributors to pollutants like hydrocarbons (HC) and carbon monoxide (CO). Using biofuel fuels as ethanol, which has a less carbon content, may significantly mitigate these emissions. An experimental study analyzed various diesel-ethanol blends diesel with % ethanol as E2,E4,E6,E8,E10,E12 at engine speeds from 1600 - 2000 rpm. The results indicated a reduction in CO by 3.2–30.6% and HC by 7.01–16.25% due to ethanol's higher oxygen content, although NOx emissions increased by 7.5–19.6% due to higher combustion temperatures. The optimization identified optimal performance conditions: an engine speed of 1977 rpm with a 10% ethanol blend, yielding CO2-6.81%, CO-0.27%, HC-3 ppm, NOx- 1573 ppm, specific fuel consumption -239 g/kW•h, power -56 kW, and torque =269.9 N•m (Shadidi, Alizade, & Najafi, 2021). In addition to ethanol blends, the use of additives in diesel has been explored to further enhance performance and reduce emissions. Fayyazbakhsh and Pirouzfar (2017) reviewed diesel additives, noting that higher alcohol content can improve premixed combustion and reduce emissions. Bridjesh et al. (2018) examined substituting diesel with Waste Plastic Oil (WPO) mixed with additives like methoxyethyl acetate (MEA) and diethyl ether (DEE) to enhance engine performance. Further research by Sachuthananthan et al. (2021) study found that adding alcohol to plastic pyrolysis oil with magnesium oxide nanoparticles can reduce emissions, especially at higher loads. Adding castor oil significantly reduced emissions across load conditions, with diethyl ether showing a stronger effect than butanol (Sushma, 2018).

Tests with various WPF-diesel blends indicated smooth engine operation, but higher emissions and a 2-4% reduction in brake thermal efficiency were observed. It is recommended to use a higher proportion (30-40%) of diesel in blends utilizing WPF in standard diesel engines (Sukjit et al., 2017). In another study, WPF produced from household waste plastics was evaluated in a direct-injection diesel fuel engine, showing that a 20% WPF blend achieved good brake thermal efficiency and lower emissions, meeting U.S. EPA standards. However, the 40% blend should be limited to rated engine speeds below 2500 RPM (Lee et al., 2015).

BLENDS OF DIESEL-BIODIESEL-WPPO

This study examines the benefits of blending diesel with waste cooking oil (WCO) biodiesel and waste plastic pyrolysis oil (WPPO).Testng fuels were formulated with 10 and 20 percent by volume of WPPO, 20% WCO biodiesel, and varying diesel volumes, labelled as D80%B20%, D70%B20%P10%, and D60%B20%P20%. A direct injection mono cylinder (DI) diesel fuel engine was used to analyze ignition characteristics, performance, and emissions at different load conditions, comparing outcomes with base fuel diesel. The blend D60B20P20, having 20% WPPO, shown a 12.2% rise of brake thermal efficiency and a 9.60% reduction in brake specific fuel usage compared to biodiesel blends base diesel. Additionally, exhaust emissions decreased significantly, with D60B20P20 achieving an overall reduction of about 30% in NOx, CO, and unburned hydrocarbon (UBHC) emissions at full load (Mukul et al., 2020). A similr study found that using diesel-WCO biodiesel blends with WPPO can reduce emissions, especially NOx and smoke. While EGR and timing adjustments can improve emissions, it may also decrease BTE. This research highlights the potential of these blends for cleaner diesel engines. (Naik & Kota, 2020).

SUITABILITY OF DIESEL, BIODIESEL, WASTE PLASTIC PYROLYSIS OIL, AND ETHANOL BLENDS AS ALTERNATIVE FUELS

A comparative analysis of diesel, biodiesel, WPPO, PPO, and ethanol provides valuable insights into their potential as alternative fuels. Ethanol, a bio-alcohol, is recognized for its high octane rating and oxygen content, which improve combustion efficiency and reduce CO and hydrocarbon emissions when blended with diesel. While ethanol has lower energy density than diesel and biodiesel, it contributes to reduced overall carbon emissions due to its renewable nature.

Blending these fuels with diesel can optimize combustion efficiency, lower emissions, and enhance fuel sustainability. The performance output of each blend depending on factors such as blend ratios, engine compatibility, and operating conditions. Table 2 shows the basic properties of diesel, biodiesel, ethanol and waste plastic pyrolysis oil (WPPO).

Table 2 the properties of diesel, biodiesel, waste plastic pyrolysis oil (WPPO),) and ethanol

Property	Diesel	Biodiesel	WPPO	Ethanol
Density (g/cm³)	0.83 - 0.87	0.88 - 0.90	0.80 - 0.85	0.789
Viscosity (cSt)	2.5 - 4.5	4.0 - 5.0	3.5 - 5.0	1.2

Flash Point (°C)	55 - 75	100 - 170	40 - 60	13
Cetane Number	40 - 55	50 - 60	30 - 40	N/A
Calorific Value (MJ/kg)	42 - 46	37 - 39	36 - 40	26.8
Octane Rating	-	-	-	129
Khan et al.,2016; Pacheco et al., 2021; Hunicz et al.,2023				

The table3 presents the blending characteristics of diesel, biodiesel, ethanol and waste plastic pyrolysis oil (WPO). The estimated calorific value of each blend was calculated using the following equation:

Estimated Blend Calorific Value = (Diesel % × Diesel Calorific Value) + (Biodiesel % × Biodiesel Calorific Value) + (WPO % × WPO Calorific Value) + (Ethanol % × Ethanol Calorific Value)

Assume average calorific values of 36.5 MJ/L for diesel, 36 MJ/L for WPO, 32 MJ/L for biodiesel, and 26 MJ/L for ethanol. The table 3 shows that the calorific value of the blend reduces slightly as the of WPO percentage increases. However, the addition of WPO can still contribute to reducing emissions and improving engine performance when used in appropriate proportions.

Table 3 Estimated calorific value of diesel, biodiesel, waste plastic pyrolysis oil (WPPO),) and ethanol

Diesel (%)	Bio-diesel (%)	WPO (%)	Ethanol (%)	Estimated Blend Calorific Value (MJ/L)	Refere-nces
55	20	25	10	42.6	Khan et al.,2016; Pacheco et al., 2021; Hunicz et al.,2023
50	20	30	10	42.4	
45	20	35	10	42.2	
40	20	40	10	42	

RESEARCH GAP

While significant progress has been made in exploring the usage of biodiesel- ethanol blends in diesel engines, there remains a gap in understanding the full potential of waste plastic pyrolysis oil to be used in fuel blend. Specifically, the combined effects of WPPO with biodiesel-ethanol on engine output performance, emissions, and long-term engine wear are not fully understood. This gap highlights the need for comprehensive studies to establish WPPO blend with biodiesel and ethanol, particularly in the context of emission control, circular global economy and sustainable waste management strategies.

CONCLUSION

This research comprehensively explores the potential of waste plastic pyrolysis oil (WPPO) as an alternative fuel for diesel engines. By analyzing the properties of WPPO in comparison to traditional diesel and biodiesel, the study demonstrates its viability as a sustainable fuel source. Key findings indicate that WPPO exhibits favorable properties, including a calorific value similar to diesel, ranging from 36 to 40 MJ/kg, and a viscosity between 1.98 and 7.24 cSt at 40°C. Additionally, WPPO can be effectively blended with diesel and biodiesel, offering potential benefits in terms of emissions reduction and energy efficiency. Notably, the addition of ethanol to WPPO-biodiesel blends can help offset the increased viscosity associated with biodiesel, thereby improving fuel flow and atomization properties. Furthermore, blending WPPO with diesel and biodiesel, along with the incorporation of ethanol, has shown promise in reducing emissions of harmful pollutants such as NOx, CO, and particulate matter. However, challenges remain, including ensuring compatibility between WPPO blends and various diesel engine types for successful implementation. Moreover, further research is needed to evaluate the economic viability of WPPO production and utilization on a larger scale, which will be crucial for its widespread adoption as an alternative fuel.

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Development and Performance Analysis of A Single Basin Tidal Power Plant

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ABSTRACT

With an increase in demand for energy, consumption of reserve sources like coal, oil, and gas is increasing day by day. The most important solution to the shortage of fossil fuels and the rising demand for energy is reusable energy. One type of energy source that falls within the nonconventional sources of energy classification is the tide. Tidal energy uses barrage and tide height differences to harvest the tides' potential energy. The tide, which is caused by the sun and moon's influence on the earth's water, causes seawater levels to regularly rise and fall. The variation in water surface elevation between peak (high) tide and fall (low) tide is the primary characteristic of the tidal cycle. If such tidal barrage technology, tidal energy is transformed into electrical energy by the associated generator, which could be used to run hydraulic turbines. In this study, we design and build a prototype model of a voltage-producing single-basin tidal power plant. By producing an artificial tide, the manufactured model covered in the paper is utilized to generate voltage, which is a representation of power generation. The generation of voltage in relation to the differential water head with a changeable load is explained along with the study's findings.

KEYWORDS *: Basin, Tide, Barrage, Generator, Gate.*

INTRODUCTION

The gravitational attraction of the sun and moon on the earth's rotation is what causes tides [1–3]. The moon pulls on the earth with a larger gravitational force (about 70% of the force that causes tides) since it is closer to the earth. Surface water is being pulled away from the earth on the side facing the moon, in addition to the solid ground being pulled away from the water on the other side. Consequently, the ocean height increases on the planets near and far sides. Six hours and 12.5 minutes separate high tide from low tide, and vice versa [4]. Reports state that 70% of the earth's surface is covered by renewable energy from the oceans. To utilize this power, numerous technologies have emerged in recent decades. Ocean thermal energy, tidal energy, and wave generation are the three primary applications of tidal energy [5]. According to references [6, 7], the theoretical wave power resource in the world is 2 TW; however, [8] claims that only 1 TW of power can be gathered. Despite this promise, ocean energy only generates a small percentage of the world's electricity. The fact that the tidal power generation capacity was only 536 MW by the end of 2022 makes it abundantly clear that ocean power generation is quite little. In order to cut CO2 emissions by 2022, the Indian government is stepping up its efforts to utilize renewable energy.

According to [9], the total tidal power potential is around 12455 MW, with a large backwater where barrage technology may be used and a few pioneering plants in the Khambhat and Kutch regions. The fact that tidal technology is dependable and presently available gives it a significant edge over other renewable energy sources [10]. The main barriers to the development of tidal technologies are their high initial and ongoing expenses as well as their impact on the environment [10, 11]. Because of the growing demand for energy, several nations are showing interest in this field, despite it still being at its experimental stage. One of the reasons for the interest in tidal energy could be that, unlike other renewable energy sources, tides can be forecast years in advance. An extensive design and study of tidal voltage generation using a single basin tidal power plant is presented in this work.

The rest of the document is organized as follows: A summary of the single basin tidal power plant technology is covered in Section 2. Section 3 describes the design process for the prototype model of a single basin tidal power plant. In Section 4, the effectiveness of this prototype model is assessed in relation to differential water head and variable load tidal voltage generation. Section 5 provides a summary of the paper's main findings.

OVERVIEW OF SINGLE BASIN TIDAL POWER PLANT

The single basin tidal power barrage method consists of a basin and barrage across a bay or river as seen in figure (1). A single basin tidal power plant can produce electricity using three different operational strategies [12].

One- way power station

Two-way power station

Two-way power station with pumped

According to the block diagram of one-way generation in figure (2), when the sluice gates (window) are closed during high tide, water is trapped in the basin. Water flows through the turbine to generate energy when the sluice gates are opened during low tide [13].

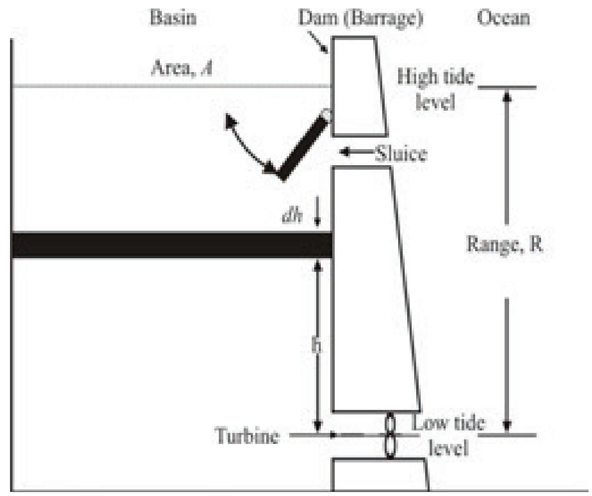

Fig. 1. Single basin tidal power plant [14]

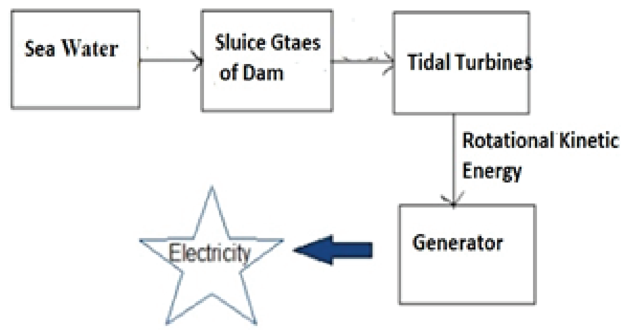

Fig. 2. Sschematic of a tidal power plant with a single basin

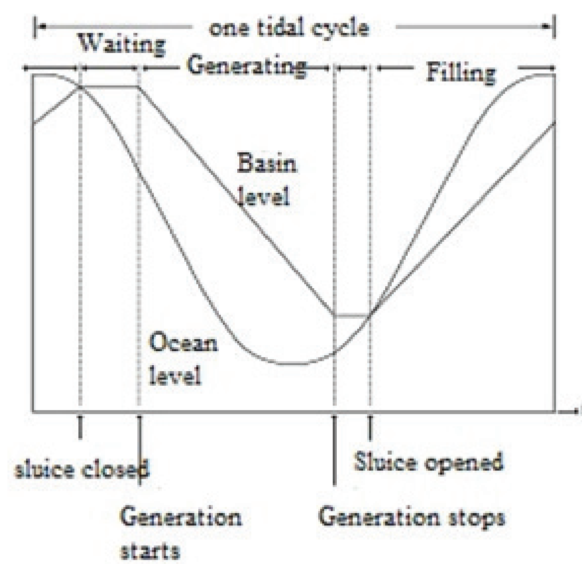

Fig. 3. Single basin Tidal power plant sequence of operation

The total possible energy of the water in the basin should theoretically be equal to the kinetic energy generated by the turbine. The following equation can be used to get the expression for the maximum energy that can be produced during one tide cycle for a single basin tidal power plant [15].

$$W = \rho \times A \times g \times h \times dh$$

$$W = \frac{1}{2} \times A \times g \times R^2 \, Joules \quad (1)$$

Where W is the work done by the water in Joules, g is gravitational force = 9.8 m/s2, m is the mass flowing through the turbine in kg, ρ is water density in kg/m3, is water head in meters, and A is the basin surface area in m2.

Under the assumption that the density of seawater is 1025 kg/m3, there are 6 hours and 12.5 minutes between the two consecutive maximum and minimum tides. Theoretical energy produced with a single fill or empty of the basin [16]:

$P_{av} = 1025 \times 9.8 \times A \times R^2$ watts

$P_{av} = 0.225 \times A \times R^2$ watts (2)

WORKING MODEL – DESIGN

The design procedure for a single basin tidal power plant is as given below. While designing the working model, the following aspects are considered:

Reservoir Design

The tank or reservoir is the main part of the system. Four varieties of plastic sheets, glass, and acrylic sheets are considered before the selection of tank design. The acrylic sheet was selected based on sufficient strength and less weight for the same volume of water. The maximum capacity of the storage tank is decided on the basis of the water differential head and the leakage, if any, from the gate and other openings. The dimensions of the tank are height 121.92 Centimeter, length 76.2 Centimeter, and width 25.4 Centimeter as shown in figure (4). The tank is designed with proper supports, so the tank remains in its shape after filling the water. The thickness of the acrylic sheet selected was 10 mm throughout the structure. Water enters the water tank after flowing from the intake element to the outflow element. Since the model capacity storage is very low, we avoided making a channel for the flow of water. The dam was made at the center of the tank (at 60.96 Centimeter) and is kept sliding so that water head actions can be performed. The storage tank was placed on the frame made of mild steel. Also, the single propeller is used so that the whole of the water will flow through the same opening.

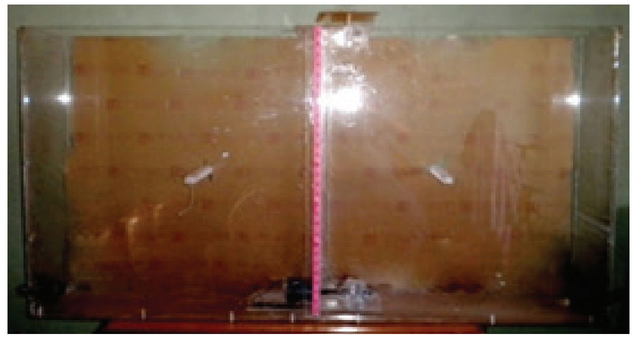

Fig. 4. Reservoirs

Opening Design

An opening is considered according to the flow of water required to rotate the propeller. As the propeller is rotating the opening must be a circular cross-section and embodied in the dam plate. The opening is a PVC pipe of diameter 50 mm. At the base of the dam plate, a 50 mm diameter hole has been drilled (25.4cm x 76.2 cm). The assembly in the opening, as given in figure (5) is fabricated in a laboratory. PVC pipe of 50mm diameter was selected.

Fig. 5. Opening for water flow

Propeller Design

In most cases, the production of tidal energy is identical to that of wind or hydroelectric energy. The propeller is the heart of the single basin tidal power plant. Due to the low pressure and less water head, the propeller design is different from those are used in hydropower plants. Also, the blades should have enough strength to withstand the head of water acting on them and the major problem is the corrosion. The relationship between total water head, discharge rate, and precise propeller speed is a major factor in the blade design [17]. In this work, a multi-blade horizontal axis turbine is utilized, as illustrated in figure (6). For the construction of propellers, different gear sizes are used, which are readily available in the market.

The shims made of stainless steel with nickel coating are used in order to avoid corrosion due to sea water. The direct flow of the water is used in this prototype. Thus, the blade should cut the water flow and acquire the required rotation. The main need for propeller design is a blade edge angled sufficiently so that the blade face does not obstruct the flow. Water runs across the blade's surface when the angle of the blade is appropriate. Therefore, maximum mechanical energy is extracted from the propeller. To direct the flow of water on the blades of the propeller, the tip of the belly with a conical shape is selected.

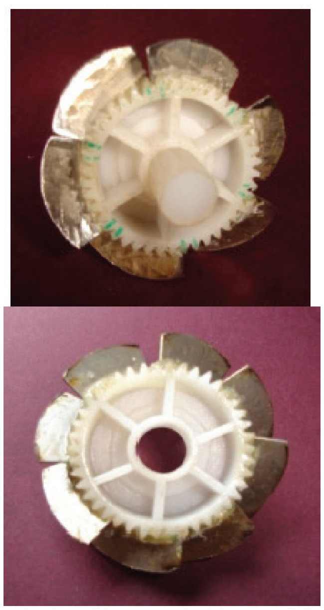

Fig. 6. Propellers

Sluice Design

The main aim of sluice design is to utilize the maximum head of the reservoir which generates electricity. Simply opening and letting the water flow through the sluice and rotating the propeller is of no use. Since it will solve our partial difficulty, we decided to control the flow of water. By this, we can rotate the propeller with constant speed and produce constant voltage through DC generator. This gate will also help to utilize the storage of water in a better manner. To decide the opening (gate) in a proper way and in a particular fashion, a 54mm square with a 34mm square hole is fixed on the circular opening kept for water flow as shown in figure (7). On either side of it, two supports are arranged in a right-angle triangle shape to hold the slider tightly against the opening, as shown in figure (8).Otherwise, it will move out of allotted space, and water will flow freely without providing the required differential head. To hold (controlling) the opening rubber string is used. This rubber band holds the gates downward and in tension. The opening of the gate valve is manually operated. The hydraulic system is the best option for controlling the opening according to the generated voltage. The turbine with the gate valve arrangement for voltage generation is shown in figure (9).

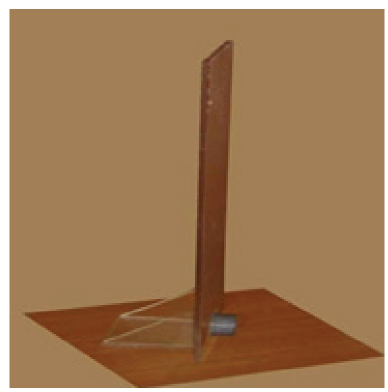

Fig. 7. Dam with sluice

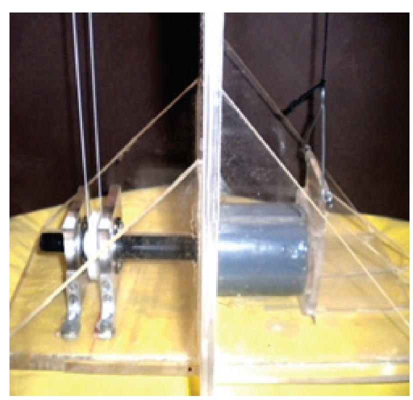

Fig.8. Turbine with an energy transfer mechanism

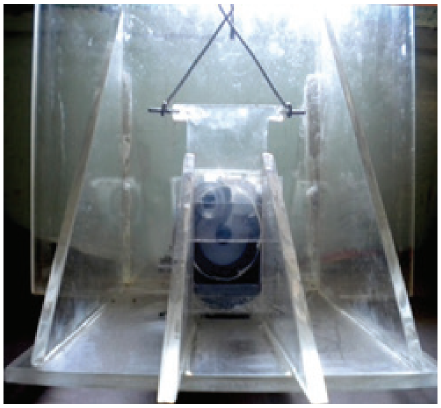

Fig. 9. Turbine with the gate valve

Drive Design

As per the required water head, the height of the tank is fabricated. Also, the distance between the propeller and the shaft of the generator is quite long. The generator is fitted at the top of the tank (due to the unavailability of the submersible type of generator of such rating), and the belt drive system supported by rubber with nylon lining (nylon increases the strength of the rubber without minimizing its elasticity) as shown in figure (10) is used. A two pole D.C. machine with a permanent magnet, as shown in figure (11) is selected as a generator. The speed of the machine is 2000 RPM. To get the required revolution, according to the propeller, the pulley used for the machine is of small diameter. The R.P.M was increased 6.3 times the R.P.M of the propeller.

Fig. 10. Belt drive

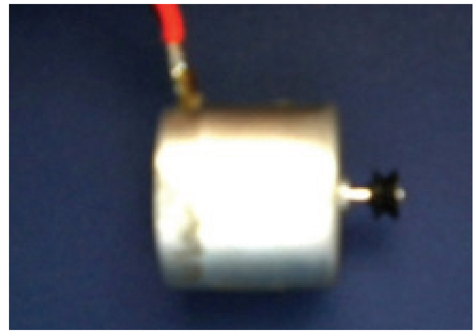

Fig. 11. Permanent magnet D.C. Generator

Pulley Design

It is important to keep the weight of the pulley minimized so that the rotational energy is not lost at the propeller. Also, the material required for pulley fabrication should be

- Corrosion free,
- Easily available,
- Easy to manufacture,
- Cost should be less,

By considering the above point, nylon is used to fabricate the pulley. The turning is made with a nylon rod of 50 mm diameter, and the groove is 1mm on the circumference of the pulley, as shown in figure (12).

Radius of propeller pulley: 2 5mm

Radius of the generator pulley: 4 mm.

The circumference of propeller pulley: 157 mm

The circumference of generator pulley: 25mm.

Therefore, when the propeller pulley completes one rotation generator pulley rotates.

One rotation of generator pulley = 157mm /25mm

= 6.3 rotation.

Fig. 12. Pulleys

RESULTS AND DISCUSSIONS

A single basin tidal power generation system is designed, fabricated, and tested. The output voltage is measured with the differential water head at the minimum load to maximum load condition. The generated voltage is plotted against the differential water head at minimal load to maximum load condition. The output voltage of the tidal power plant increases linearly with an increase in water head at no load. This is shown in figure (13).

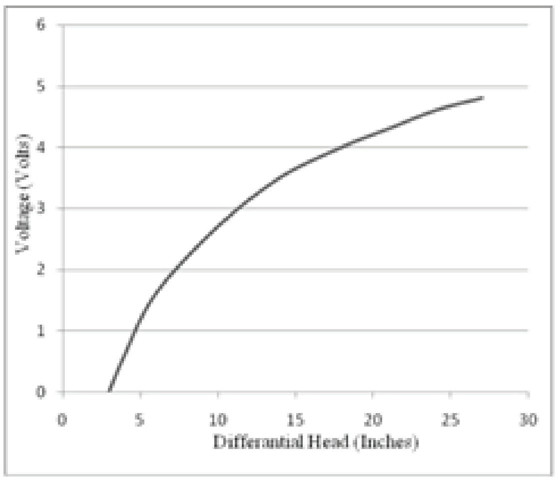

Fig.13. Generated voltages at no load

The variation of output voltage with varying water head circumstances ranging from minimal load to maximum load is shown in figure (14). The generated voltage increases gradually with increasing water head.

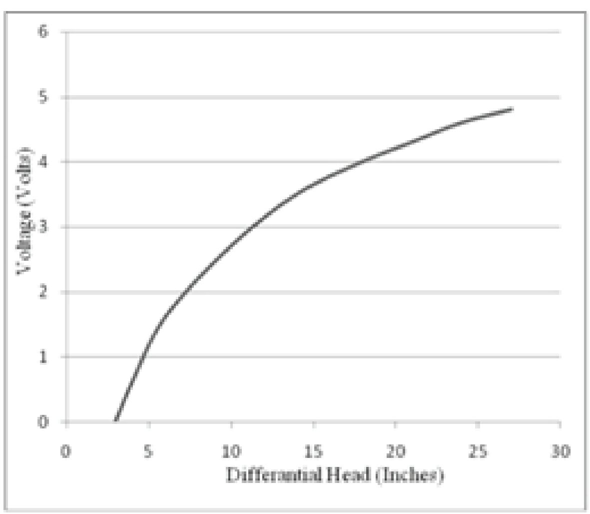

Fig. 14. Generated voltages at load

Table 1 makes a comparative study of the output voltage and differential water head of a single basin tidal power plant. The table shows the trend of variation for water head and connected load. The minimum water head required for voltage generation is 7.62 centimeter for both load conditions. Inminimal load to maximum load, the generated voltage is about 4.8 volts at the common water head of 685.8 mm.

Table 1 Output voltage with respect to differential head with a load

S. N.	Differential water head (mm)	Generated Voltage (Volts)	
		No Load	Full Load
1	76.2	0	0
2	101.6	0.6	0.6
3	152.4	1.6	1.6
4	279.4	2.7	2.7
5	355.6	3.5	3.5
6	457.2	4.0	4.0
7	533.4	4.3	4.3
8	609.6	4.6	4.6
9	685.8	4.8	4.8

CONCLUSION

The need for electricity is rising, and alternative fuels are being used to generate electricity in order to counteract the startling rate at which fossil fuel supplies are running out. Finding a solution to the growing need for power is equally crucial. It is possible to generate electricity using alternative fuels, especially those derived from tides. The current study designs, builds, and tests a single basin tidal power plant using a direct water flow as the tide. Using a variable load, the prototype model was utilized to generate the voltage in relation to the differential water head. The prototype model that was constructed used as a method for investigating and assessing tidal voltage generation technologies. The validation demonstrated the potential of tidal energy as a future alternative fuel.

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Transformative Technologies: A Deep Dive into Industry 4.0

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ABSTRACT

The emergence of Industry 4.0 represents a pivotal juncture in production industries, significantly impacting the landscape of mechanical engineering. This thorough review paper delves into the technologies used in forth industrial revolution within the domain of mechanical engineering, with a particular focus on the transition toward smart factories. Drawing upon a meticulous analysis of existing literature, we delve into the transformative effects brought about by smart manufacturing on traditional mechanical processes and systems. Moreover, our examination extends beyond the mere enumeration of technological advancements; we explore the multifaceted challenges and opportunities inherent in this paradigm shift. By incorporating insightful case studies and highlighting emerging trends, we aim to give details understanding of the evolving landscape of forth industrial revolution in the context of mechanical engineering. Ultimately, this review endeavours to equip researchers, engineers, and stakeholders with actionable findings that can lead innovation and adaptation in ever-evolving field of manufacturing.

The review also delves into the importance of interdisciplinary collaboration within forth industrial revolution initiatives, emphasizing the integration of mechanical engineering principles with fields such as computer science, electrical engineering, and materials science. Furthermore, it discusses the implications of sustainability and environmental considerations in the adoption of forth industrial revolution technologies, highlighting the usefulness for resource optimization. Additionally, the review explores the role of advanced simulation and modelling techniques in enhancing the design and optimization of mechanical systems within the industry 4.0 framework. Moreover, it examines the ethical and societal implications of widespread automation and AI adoption in manufacturing, touching upon topics such as job displacement, privacy concerns, and digital divide issues. Finally, the review underscores the importance of lifelong learning and skills enhancement for engineers to effectively navigate the rapidly development of next gen revolution.

KEYWORDS : *Green sand casting, Foundry process optimization, Industry 4.0 smart factories, Smart manufacturing.*

INTRODUCTION

Commonly, 'Industrial Revolution' is used to describe the transition from pre-industrial to industrial societies, characterized by modern economic growth, specifically a sustained and significant increase in real GDP per capita. Industrialization is a continuous and ongoing process, with Britain often cited as the first industrial nation. This transition occurred roughly from the 1760s to the 1840s, with real per capita income beginning to grow substantially after the 1840s, exceeding one percent per year. The initial industrial revolution, often termed the "Classic" Industrial Revolution, was characterized by invention of water and steam power alongside mechanization. The industry 2.0, starting in the 1870s, saw the rise of mass production, assembly lines, and electricity as prominent features. The third industrial revolution, emerging well into the twentieth century, is marked by computation and automation. These stages of industrial revolution are illustrated in Figure 1.0 below.

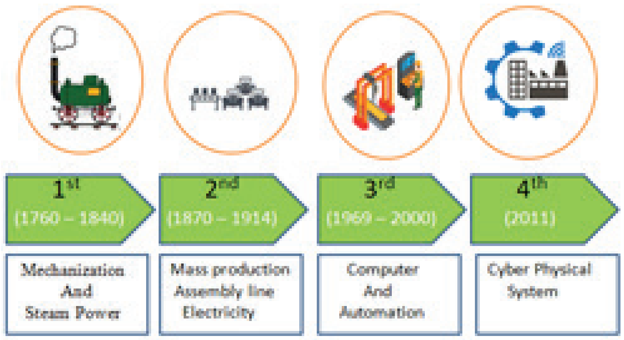

Fig. 1 History of Industrial Revolution

The concept of the fourth industrial revolution, focusing on organization and control over the entire product life cycle's value chain to meet individualized customer demands. It includes supply chain systems, promoting connectivity between physical items and the Internet [5].

In current days, the industrial landscape has undergone a noticeable change known as Industry 4.0, led by the emergence of technologies, automation, data-driven decision-making, and unprecedented connectivity. This transformation extends beyond the factory floor, influencing various aspects of modern life, with mechanical engineering positioned at its centre [1].

Often termed the "Industry 4.0" presents a change that is reshaping manufacturing's future. Its objectives are to develop highly integrated and adaptive manufacturing environments, termed "smart factories," fostering seamless communication among machines, products, and systems to enhance productivity, flexibility, and innovation. Essentially, it envisions manufacturing leveraging technology to achieve unprecedented efficiency and customization [3].

This comprehensive review delves into the symbiotic relationship between Industry 4.0 and mechanical engineering, focusing on the evolution towards smart factories. The objective is to analyze thoroughly the existing body of knowledge, exploring the profound transformations and challenges resulting from mechanical engineering's full integration of Industry 4.0 principles. The review aims to uncover how smart manufacturing, automation, data analytics are revolutionizing traditional mechanical processes and systems [2]. Through systematic exploration, including insights from significant case studies and identification of emerging trends [3], this review provides a holistic understanding of the evolving landscape within mechanical engineering.

Moreover, this review does not solely examine the progress on next industrial revolution in mechanical engineering but also anticipates the transformative potential for manufacturing. It endeavours to offer valuable insights into the profound impact of Industry 4.0 on mechanical engineering, along with promising avenues for future research and innovation within this dynamic field [4].

LITERATURE SURVEY

Stock, T., & Seliger, G. (2016)- In exploring the emergence of forth industrial revolution and sustainable production practices, this literature review delves into the changing potential of forth industrial revolution within the manufacturing landscape. By recent research findings and practical implementations, this review aims to provide understanding of how Industry 4.0 can facilitate the transition towards sustainability in industrial operations.

A key focus of this review is the exploration of various avenues for achieving sustainable, flexible production systems which justify fourth industrial revolution. One specific area of investigation is the retrofitting of manufacturing equipment, which exemplifies a targeted approach towards sustainability by optimizing resource utilization and minimizing environmental impact.

Furthermore, the review traces the evolution of Industry 4.0 concepts, beginning with Kagermann's seminal work in Germany. It also examines collaborative initiatives like the Public-Private Partnership (PPP, which play a important role in advancing Industry 4.0-related themes and fostering innovation in manufacturing.

Overall, this literature review offers insights into the fourth Industrial revolution for sustainable manufacturing practices, highlighting key research findings, practical applications, and collaborative efforts aimed at driving sustainable development within the manufacturing sector.

Westkämper, E. (2018)- The 4th industrial revolution is revolutionizing global manufacturing through the (IoT) and service-oriented concepts. This shift enables the development of production systems, paving the way for smart factories capable of meeting customer demands, even in scenarios with high design changes in small lot sizes. Various countries, including Germany, the United States, Japan, and Korea, have launched initiatives to support their manufacturing sectors and bolster global competitiveness. Germany's Industry 4.0 program has notably influenced European policy, while the U S focuses on advancing smart manufacturing. This paper offers an extensive review of Industry 4.0 examining the application potential of CPS across the product development cycle. Additionally, it identifies current and future research challenges in this rapidly evolving field.

Lu, Y., Morris, K. C., & Freiheit, T. (2017)- This study investigates the intersection between critical infrastructure (CI) and Industry 4.0 (I4.0) by literature review. The objectives are to identify key research topics using Latent Dirichlet Allocation and subsequently map the findings to pinpoint opportunities for future research. The authors curated peer-reviewed papers from databases like Web of Science and Scopus, employing specific keywords to capture evidence of the interconnections between CI and I4.0. By leveraging selected clusters and topics, they constructed a reference framework illustrating the relationships between CI and I4.0.

The analysis revealed a notable gap in the literature concerning studies exploring the mutual relationships between these two domains, despite their individual prominence. The unique aim of this article lies in its consolidation of knowledge pertaining to the connections between I4.0 and CI, as well as its identification of areas warranting further investigation. Notably, this paper represents the first comprehensive literature review focused explicitly on CI and I4.0. It underscores the significance of transitioning from centralized production models to ones emphasizing greater flexibility and self-control, a trajectory that echoes historical advancements in CIM and FMS.

Lee, J., Bagheri, B., & Kao, H. A. (2015)- The paper explores the transformative of Cyber-Physical Systems (CPS) on the manufacturing industry, signalling the transition towards Industry 4.0. It emphasizes the need for a clear definition of CPS. The increasing use of IoT machines has led to the generation of vast Data, which CPS can effectively manage. Integration of CPS into supply chain holds the potential to transform traditional factories into Industry 4.0-enabled facilities, offering significant economic benefits. However, successful implementation requires addressing technical, organizational, and societal challenges.

Armbrust, A., Griffith, R., Joseph, Katz, R. H., Konwinski, A.& Zaharia, M. (2010)- This paper revealed Cloud computing, heralded as the realization of computing as a utility, holds immense potential to revolutionize the IT industry, fundamentally altering software delivery models and reshaping hardware procurement practices. This paradigm shift enables developers to deploy innovative Internet services without the burden of significant upfront hardware investments or ongoing operational expenses. The scalability and elasticity of cloud resources liberate developers from concerns about over provisioning or under provisioning, thereby optimizing resource utilization and cost-efficiency.

By clarifying concepts and providing concrete examples, this article aims to demystify cloud computing, empowering stakeholders to make informed decisions regarding its adoption and implementation. Additionally, by identifying obstacles and opportunities, it offers useful insights into the cloud computing, paving the way for strategic planning and resource allocation in both organizational and research contexts.

Billinghurst, M., Clark, A., & Lee, G. (2015)- This survey offers a concise yet comprehensive overview of nearly five decades of Augmented Reality (AR) research and development, elucidating its journey from inception in the 1960s to its contemporary prominence. It navigates through common definitions, highlighting AR's pivotal role in seamlessly merging the real and virtual worlds.

In addition to discussing design guidelines and successful applications, the survey provides insights into the evolving landscape of AR through an exploration of future research directions and ongoing technological advancements. It underscores the multifaceted applications of AR across diverse domains such as education, architecture, marketing, and societal integration.

Moreover, the survey emphasizes AR's technical intricacies by elucidating complex concepts such as tracking mechanisms, display technologies, and input modalities. By unpacking these technical nuances, it aims to deepen the reader's understanding of AR's underlying mechanisms and its transformative potential in various sectors.

In weaving together technical insights with broader discussions on AR's applications and implications, this survey offers a holistic perspective on the past, present, and future of AR.

Kormushev, P., Calinon, S & Caldwell, D. G. (2010)- This research paper investigates the use of efficient skill representations applicable to Reinforcement Learning (RL), such as the Gaussian Mixture Model (GMM) and Gaussian Representation Model (GRM).

Mougayar, W. (2016)- The study of this paper implies Internet of Things (IoT) has found widespread application across various industrial and manufacturing domains, facilitating tasks such as automation, remote diagnostics and supply chain oversight. Cloud-Based Manufacturing (CBM) has emerged as a contemporary model, harnessing IoT technologies to provide live access to manufacturing resources. However, the reliance on trusted intermediaries for transactions poses a challenge. These initiatives utilize smart contracts and blockchain technology to facilitate secure and automated transactions, minimizing the need for intermediaries.

Ian Foster and Yong Zhao (2008)- This Cloud computing paper represents a shift in computer technology, offering users access to shareable, dynamically scalable, and virtualized resources via the internet. Users can consume these resources on-demand, paying only for what they use. This model, akin to utility computing, provides virtual servers to users and IT departments, thereby enabling organizations to adopt IT services without significant upfront investment. The globalization of computing assets is a significant contribution of cloud computing, facilitated through large data centres that deliver reliable services employing various virtualization technologies.

Despite its potential benefits, organizations have been slow to fully embrace cloud computing due to security concerns. This paper endeavours to elucidate the threats and security issues associated with cloud computing. It explores the various cloud-based services available, the role of virtualization in cloud computing. Additionally, it delves into the security threats faced by cloud computing services, aiming to raise awareness and foster a deeper understanding of the challenges inherent in securing cloud-based infrastructures.

L. Atzori, A. Iera, and G. Morabito (2010)- The study of this paper indicate, IoT is swiftly emerging as a dominant paradigm within contemporary wireless telecommunications, amalgamating diverse technologies and communication solutions.

With its pervasive presence, the IoT profoundly influences the daily lives and behaviours of potential users, offering a myriad of applications in domains such as home automation, assisted living, e-health, education enhancement, and industrial automation.

However, amidst its promises, the IoT also confronts formidable challenges, notably pertaining to information security risks. Safeguarding against cyber threats and ensuring data privacy emerge as paramount concerns, necessitating the establishment of robust security protocols and frameworks. Addressing these challenges is imperative for the sustainable development and adoption of IoT technologies

HISTORY

The inception of the fourth industrial revolution concept can be traced back to the German government's strategic initiative, first unveiled in 2011. Germany's proactive stance towards the development of its industrial sector, propelled by its global leadership in manufacturing equipment, laid the groundwork for this transformative vision. Notably, Germany's competitive manufacturing landscape served as a catalyst for the emergence of Industry 4.0, highlighting the nation's commitment to innovation and industrial advancement.

Subsequently, similar initiatives began to emerge worldwide, reflecting the global resonance of the Industry 4.0 paradigm. In North America, the concept of the Industrial Internet gained traction following its introduction by the General Electric Company in 2012. This initiative underscored the emergence of physical and digital realms, leveraging big data analytics and IoT to revolutionize industrial processes.

In France, the vision of 'Industries du future' was embraced as a cornerstone of the nation's industrial policy, emphasizing collaboration between industry and science. This multifaceted approach encompassed cutting-edge technologies such as augmented reality, additive manufacturing, IoT, and, aimed at empowering French companies to adapt to the demands of the digital era.

China, recognized the transformation on production and manufacturing systems in 2015. Spearheaded by the China Ministry of Industry and Information Technology, this ambitious endeavour sought to modernize the Chinese industrial landscape by taking inspiration from Germany. By aligning with the core principles of Industry 4.0, China aimed to upgrade its industrial capabilities and drive comprehensive innovation across key sectors.

These diverse initiatives, rooted in the foundational principles of Industry 4.0, collectively heralded the onset of the next revolution. Through concerted efforts to embrace digitalization, automation, and interconnectedness, nations around the globe embarked on a transformative journey towards a more agile, efficient, and technologically-driven industrial landscape.

CONCEPT OF INDUSTRY 4.0

Forth industrial revolution present a paradigm change in manufacturing, offering a transformative opportunity to revolutionize how industries meet the evolving needs of society. At its core, Industry 4.0 emphasizes connectivity, fostering seamless communication and collaboration between machines and products to drive production processes. This interconnectedness extends to raw materials, machinery, and various processes within the Internet of Things (IoT), forming a cohesive ecosystem.

While factories with networked systems already exist, the vision of Industry 4.0 entails the integration of these components into a comprehensive network. Every device, machine, and material will be equipped with sensor, actuator, and communication technologies, converging to form Cyber-Physical Systems (CPS). This smart, interconnected environment lays the foundation for Industry 4.0, enabling heightened efficiency and agility across industrial processes.

The Germany's envisions Industry 4.0 as a burgeoning framework wherein manufacturing and logistics systems, manifested as leverage the global information and communications network for automated information exchange. This alignment of production and business processes marks a pivotal shift towards enhanced automation and connectivity.

Central to the realization of Industry 4.0 are the nine pillars, which signify a departure from isolated production cells towards a fully integrated production flow. These pillars encompass various aspects, including data transparency, interoperability, technical assistance, decentralized decision-making, and modular design, among others. By embracing these principles, industries can achieve more efficiency and fostering collaboration between suppliers, producers, and customers.

In summary, Industry 4.0 users in a new era of manufacturing marked by interconnectedness, automation, and data-driven decision-making. By embracing these principles and leveraging advanced technologies, industries can unlock unprecedented opportunities and responsive industrial ecosystem.

Fig. 2 Pillar of Industry 4.0

These nine technologies are discussed are below-

1. IoT enables real-time monitoring and optimization of manufacturing operations and supply chains through seamless device connectivity.
2. Cloud computing supports scalable data storage, on-time collaboration, and deployment of IoT devices in smart factories.
3. Autonomous robots automate repetitive tasks,

enhancing efficiency, productivity, and product quality in manufacturing.

4. 3D printing enables on-demand production of complex, customized products, reducing lead times and logistics costs.
5. VR and AR technologies improve design, training, and remote maintenance through immersive simulations and collaborative reviews.
6. Data analytics provides actionable insights for decision-making, optimizing production, supply chains, and product quality.
7. System integration ensures seamless communication and collaboration across manufacturing technologies and processes.
8. Cybersecurity protects manufacturing systems from cyber threats by implementing robust security measures and protocols.
9. Simulation technologies optimize production processes by modeling workflows, reducing risks, and improving planning.

APPLICATION

a) IoT enables real-time asset tracking, predictive maintenance, and remote monitoring in manufacturing equipment.

b) AI enhances predictive maintenance and optimizes production processes by analysing large datasets.

c) Big data analytics improves forecasting, supply chain optimization, and quality control through data-driven insights.

d) CPS integrates machinery with digital systems for real-time process monitoring and automation in manufacturing.

e) Cloud computing offers scalable storage and processing, supporting collaboration and predictive maintenance in manufacturing.

f) Additive manufacturing enables rapid prototyping and the creation of complex components, reducing lead times in product development.

g) AR and VR enhance worker training, maintenance, and design processes through interactive simulations and real-time information.

CASE STUDIES

Bosch Rexroth, a global leader in drive and control technology, transformed its manufacturing facility in Germany into a smart factory. They implemented IoT sensors, data analytics, and automation to optimize production processes and achieve significant cost savings. IoT sensors are used for real-time monitoring of equipment, while data analytics helps in predictive maintenance and process optimization. Automation includes the use of robotic systems to streamline production [13].

Siemens, a multinational conglomerate, utilizes digital twin technology to create virtual prototype of their products and production processes. This allows for real-time monitoring, testing, and optimization, reducing time-to-market and improving product quality. The technology includes the creation of digital twins for various products and processes, enabling simulation and optimization in a virtual environment [12].

General Electric (GE) implemented IoT sensors and data analytics to enable predictive maintenance in their jet engines. By monitoring real-time data from aircraft engines, GE can predict maintenance needs, reduce downtime, and enhance safety. IoT sensors are integrated into the engines, collecting data on performance and wear. Data analytics tools analyze this data to predict maintenance requirements

Procter & Gamble (P&G) adopted Industry 4.0 principles in their manufacturing processes. They use IoT sensors and data analytics optimized production process and improved product quality in their plants globally. IoT sensors are deployed across manufacturing lines to monitor equipment and processes, while data analytics tools analyse the collected data for optimization [16].

Daimler AG, a leading automotive manufacturer, implemented Industry 4.0 concepts in their supply chain. They use IoT for real-time tracking of parts and materials, optimizing inventory management and ensuring timely production. IoT sensors are attached to parts and materials, providing real-time tracking and data on their location and status [17].

ABB Robotics deployed robots in their manufacturing processes. These robots work with human, enhancing productivity and flexibility while maintaining safety.

Collaborative robots are equipped with advanced sensors to enable safe interaction with human workers [20].

These case studies provide insights into how these organizations leveraged specific technologies, including IoT, data analytics, digital twin, and collaborative robots, to achieve Industry 4.0 objectives and improve their operations.

CHALLENGES

a) The interconnected nature of Industry 4.0 raises concerns about data security privacy [4].

b) The adoption of advanced technologies skilled human resources [5].

c) Integrating various technologies and systems from different vendors can be challenging. Ensuring seamless interoperability is crucial [7].

d) Deployment Industry 4.0 technologies involves significant amount, software, and training [8].

e) Adhering to industry regulations and standards while adopting new technologies can be complex and time-consuming [3].

f) As AI and automation advance, ethical considerations regarding job displacement and decision-making algorithms must be addressed [12].

CONCLUSION

Industry 4.0 presents a transformative opportunity for mechanical engineering, driven by smart manufacturing technologies such as IoT, AI, and data analytics. These innovations are reshaping how goods are conceived, designed, and produced, allowing for greater efficiency and precision. However, this shift comes with challenges, including data security risks, the need for workforce upskilling, and the complexity of integrating diverse technologies. Additionally, the significant upfront costs for implementing Industry 4.0 solutions highlight the importance of strategic planning and clear ROI justification.

Despite these obstacles, the potential benefits of Industry 4.0 for mechanical engineering are immense. It promises to streamline production processes, enable mass customization, and enhance decision-making through data-driven insights. By embracing these advancements and proactively addressing the challenges, mechanical engineers can lead the way in driving innovation and shaping the future of manufacturing.

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SmrutiPankha: A Renewed Approach to Live with Alzheimer

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ABSTRACT

Dementia, a broad category of neurodegenerative disorders, impacts millions globally, with Alzheimer's disease being a leading cause. The challenges associated with Alzheimer's Disease (AD) necessitate innovative solutions that can assist patients and reduces the burden on caregivers.

This research explores the use of IoT-based healthcare solutions, specifically wearable devices, to support Alzheimer's care. The wearables are designed to be adaptive and responsive to individual AD patient needs, helping to Assists the AD patients over symptoms such as frustration, repetition, and poor judgment. These technologies also offer caregivers valuable tools for better understanding and managing the condition, ultimately leading to more effective and personalized care strategies.

KEYWORDS *: IoT, Wearable devices, Alzheimer, Automated assistance.*

RESEARCH ON WEARABLE TECHNOLOGIES

Wearable technology has transformed health care, that it allows continuous monitoring in real time and offers some sort of support. Common wearables include smartwatches, fitness trackers, and smart eyewear; these all collect health data on movement, heart rate, and sleep patterns. Many connect via Bluetooth to mobile phones, thus allowing easy access for the patients and carers. Wearable technology is availed in Alzheimer's care, with some offering geo-fencing features, which prevent patients from leaving designated areas. Some of the gadgets use AI in detecting falls and sending out emergency notifications.

1. Wearables like smartwatches: These have integrated sensors for movement, heart rate, and even oxygen saturation. In the instance of patients with Alzheimer's disease or other conditions where wandering may be a potential factor, many smartwatches designed for the healthcare industry incorporate GPS tracking.[1].
2. Wearable Fitness Trackers: Devices from Fitbit and Garmin long overcooked stage of simple counting of steps. They greatly contribute to insight into physical health though daily activity tracking allows sleep analysis so that the patient can maintain healthy routine.[2].
3. Wearable ECG Monitors: Advanced wearables can provide real-time ECG readings to a patient with ease. Such devices are a necessity on the part of patients who have risks associated with the heart. Withing's and Apple, among other companies, have come up with devices that monitor heart health, sync with phones, and raise alerts for any form of anomaly to caregivers.[3].
4. Smart Glasses: Much more than pure entertainment, smart glasses can also provide AR overlays for those who have trouble remembering things. Such wearables might remind the patient what day it is, what needs to be done, and what is important to remember, or even help them recognize faces which they should know by utilizing facial recognition software integrated into the wearable.[1].

Wearable technology in general goes a long way in monitoring mobility, real-time communication, and integration of geo-fencing features for safety in

Alzheimer's care. In the future, wearables may offer predictive analysis, identifying patterns in movements and actions of a patient to predict emergencies.

PROPOSED SOLUTION: ACTION TRACKING SYSTEM FOR ALZHEIMER'S PATIENTS

The proposed action-tracking system would make use of AI with Computer Vision technology in order to offer real-time assistance tailored to the needs of the person affected. The solution would be designed to target all special needs arising from caring for the patients in general terms of daily activities monitoring and their safety while also reducing burdens on caregivers.

Real Time Action Tracking

It contains sensors, such as motion detectors and cameras that enable the wearable device to track the patient's physical activities and his location. It aids in pattern recognition and might detect abnormal activities on account of gathering real-time data.

Motion Detection: Activity sensors are embedded in a wearable device and track activities such as walking, sitting, or lying down. This information contributes to the recognition of regular activities and the detection of deviations that may indicate a problem, such as a long period of inactivity or a fall.

Camera Integration: Computer vision can facilitate integrating a camera that captures the visual data of whatever the patient has around them, whether it is objects or people. This is very helpful in understanding what the patient is interacting with; it aids in recognizing familiar faces or objects.

AI-Powered Data Processing and Analysis

Once captured, the data is processed through the algorithms of AI and Machine Learning. The AI system learns daily patterns that a patient goes through in order to detect deviation and hence the onset of risk.

Pattern Recognition: the AI system identifies routine patterns such as when people eat, take walks, or rest. The machine learning models are specific to the behaviours which are exhibited from a patient; thus, it will be a very personalized system.

Anomaly Detection: The AI detects anomalies such as disorientation, wandering, or lack of mobility. If such issues are detected, the system prompts the patient directly or notifies the caregiver.

Action Prediction and Guidance

Based on the learned patterns, the system predicts subsequent actions of the patient and offers him timely guidance or intervention. For example, when the patient is about to leave the house or enter an unsafe area, the system triggers off an audio or visual alert.

Audio-Based Assistance: The device prompts through voice to guide the patient. For example, it detects when a patient approaches a door that is not in their routine and would say something like, "Please wait for assistance," or, "Time for your medication."

Contextual aid: The system would automatically adapt to the patient's environment. For example, if a patient is in or near the kitchen, it would make the inference that meal preparation could be being done and prompt the user to follow through on the routine and limit frustration from a memory lapse.

Geo-Fencing and Safety Alerts

The system is integrated with geo-fencing technology to establish virtual boundaries for safe areas, for the patients, such as the home or even a garden. GPS-based location monitoring triggers alerts if the patient moves out of the predetermined area.

Safety Boundary Alerts: In case a patient crosses the geo-fence, an automatic alert is sent to the caregivers with the location of the patient. Even voice instructions may route the patient back to the safe zone.

Notifications to Caregivers: Real-time notifications go directly to caregivers for any detected unsafe behavior, such as a fall or when the patient enters an unsafe area. The rationale is to prevent accidents or incidents of wandering-off commonly seen in Alzheimer's disease.

Data Privacy and Cloud Integration

The system is integrated with a cloud-based model to process data in a secure way from patients and remotely access that data from caregivers. The supporting cloud allows offline functionality that is, key functions like detection of movement and alerting abnormalities are allowed to run when there is no connection with the internet.

Cloud Security: All the information collected by the system from patients is directly encrypted while transmitting into the cloud, helping secure the regulations of protection of data. Offline Functionality: Data is stored locally in the system and syncs into the cloud upon connection. Data would therefore be able to be monitored at any time.

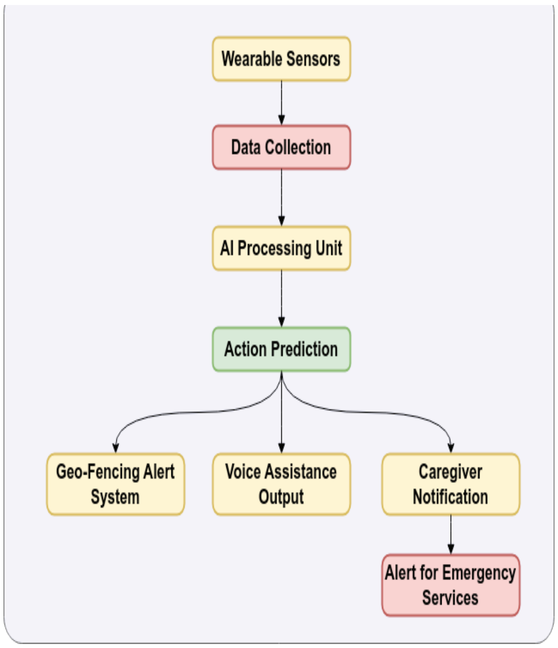

Fig. 1 The architecture diagram captures how the system processes data and responds to various real-time inputs

EXPLANATION

Wearable sensors serve the purpose of data collection (Fig.1).

Wearable Sensors → Data Collection

Wearable Sensors: In this context, a wearable device such as smart glasses, wristbands, or other types of sensors continuously acquires the subject's biometric signals, including heart rate, physical activities, location information based on GPS, and environmental conditions.

Data Collection: The information collected by real-time sensors includes different elements, such as the patient's movement, physical condition, and current location. Later, this collected data is aggregated and fed into the system, where meaningful information is extracted through processing.

AI Processing Unit

AI Processing Unit: The gathered data is then sent further to the specified AI processing unit, where the extensive machine learning algorithms take over to elaborate on and classify the data arriving. During this process, state-of-the-art pattern recognition techniques will ascertain if the data depicts normal activities or an anomaly, which would be an indication of something wrong and leaving the stipulated areas or any longer periods than usual of inactivity that might need further investigation.

This algorithm can also make use of previously trained models to understand different kinds of patterns. Hence, it could correct and adapt to the singular daily routine of the patient in due time.

AI Processing Unit→ Action Prediction

Action prediction: It will also try to predict what will happen next by the patient through the detailed analysis of the artificial intelligence. For instance, when the patient is standing right in front of the dining table, it will surely predict that the patient will eat dinner; if the patient is going across the space several times, this reflects that the patient is restive or may get irritated.

Such a prediction is considered to hold particular importance because it plays a very vital role in ensuring that necessary interventions are instituted at the right time. This is important so that unsafe situations, such as incidents of wandering, could be averted.

Action Prediction → Geo-Fencing Alert System

The Geo-fencing alert system is the most critical feature of this whole system. The system will monitor a patient's position in some unbroken areas of safety. If a patient happens to step out of such a zone-for instance, out of the house or out of the caregiving facility-the system is able to raise an alert on such status to the caregivers. That ensures that the patient cannot wander too far, hence reducing risks of getting lost.

Action Prediction → Voice Assistant Output

Voice Assistant: The system features enhanced voice assistant capabilities to meet the needs of the patient. Through the energy harvested from the predicted user actions, the device may voice support for a user in practical instructions, timely reminders, or reassurance when one is in need. It would say something like, "Please go back to bed," or "It is time for your medication," as the system smoothest out the patient's path through every activity and ritual.

This feature augments patient independence by empowering individuals to manage their activities of daily living autonomously, without the necessity for continuous supervision from a caregiver.

Action Prediction → Caregiver Notification

Caregiver Notification: At the moment the system detects some abnormal or potentially unsafe behaviour, such as prolonged periods of inactivity, departure from a designated safe zone, or signs of disorientation, it issues an immediate alert and sends it to the caregiver's device for notification. In this regard, the present invention keeps the caregiver constantly updated on the status of the patient at any given time; in this way, the present invention also enables caregivers to take all necessary intervention actions on time, where seen fit, to ensure safety and well-being of the concerned patient. These can be provided through mobile applications, SMS, or other alert mechanisms.

Caregiver Notification → Emergency Services Alert

An incident of a fall, or any other critical situation, may automatically send an alert to the emergency services. Instantaneous alerts would include all the information on the whereabouts and status of the patient so that the best and timely assistance can be afforded. In this relation, the important and basically vital step being followed is to ensure quick response in the emergency situation and helps reduce further potential injury to the patient under consideration.

CONCLUSION & FUTURE SCOPE

For those suffering from Alzheimer's disease, this system offers a customised real-time solution through the use of geo-fencing technology, integrated AI, and machine learning. This helps to monitor the activity of the patient and gives voice instructions to free up carers.

Using Machine Learning to improve disease detection Information gathered from wearables can be used to identify several health issues in addition to Alzheimer's disease symptoms. Through the observation of historical movement patterns, heart rate, and daily behaviours, the model can also be used to predict the likelihood of developing other illnesses like diabetes or cardiovascular disorders, hence broadening its range of applications.

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Survey on Deep Learning Techniques used for Fruit Disease Detection

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ABSTRACT

The agriculture industry plays a significant role in India's economy. Manual monitoring of diseases in crops is challenging. To improve farming production by early disease detection, we are utilizing deep learning techniques. Fungi and bacteria are the main reasons for crop diseases. The objective of our study is to compare deep learning techniques for fruit disease detection. Convolutional Neural Networks (CNN) offer higher accuracy and can predict various fruit diseases. Traditional methods like visual observation, manual symptom correlation, spectroscopy, and chemical procedures are being replaced by modern approaches such as computer vision, autonomous learning algorithms, and sensor-based technologies. Our aim is to provide a literature survey covering existing research on image categorization problems and to propose a solution for farmers to detect and classify fruit diseases. Manual testing often yields inaccurate results, so we are using fruit color, shape, and size to determine diseases. CNN is applied for deep feature extraction, and Long Short-Term Memory (LSTM) is utilized for disease classification based on the extracted features. This approach will help sort fruits into abnormal and normal categories based on features like color, number of spots, and shape. Existing algorithms have faced accuracy issues, which our deep learning methodology aims to address. Deep learning provides accurate analytic and predictive capabilities. It is a subset of the broader field of Artificial Intelligence, and it involves using the output of one layer as the input for the next layer in a hierarchical learning structure.

KEYWORDS *: Features, Color, Size, Shape, Fruit disease detection, CNN, VGG16, ResNet50.*

INTRODUCTION

India is the second largest producer of fruit. Agriculture is a key part of the country's culture and contributes 17 percent to its total Gross Domestic Product (GDP) while also providing employment to over 60 percent of the population. The quality of fruit and vegetables is influenced by factors such as soil type, water availability, and proper fertilizer usage. In the past, manual labor was essential for selecting high-quality produce for industries. However, in recent years, automated systems have been developed to assess fruit quality, replacing traditional methods like K mean supervised learning. "When using the CNN trained model technique, we can achieve higher accuracy. The Convolutional Neural Network (CNN) is trained using a variety of images of good, moderate, and rotten apples, oranges, and bananas to enable it to accurately predict the fruit's condition. The figure illustrates various diseases that can impact apples. In the image below, the apple is affected by three types of diseases: 1) Flyspeck - a fungal disease characterized by small dots on the fruit. 2) Sooty blotch - manifests as a light blackening on the fruit's surface. 3) Scab - leads to a dark black discoloration of the fruit."

Figure 2 depicts the architecture of a convolutional neural network, which comprises three layers: the input layer, the hidden layer, and the output layer. The input is received in the input layer, while the comparison and separation processes take place in the hidden layer. Once the separation process is completed, the output is obtained in the classification layer.

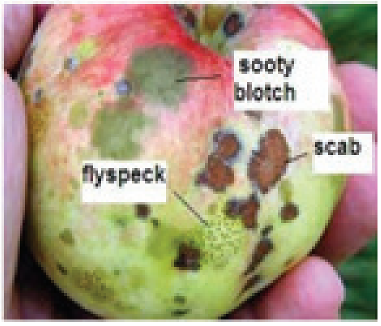


Fig. 1: Example of Diseased Apple Fruit

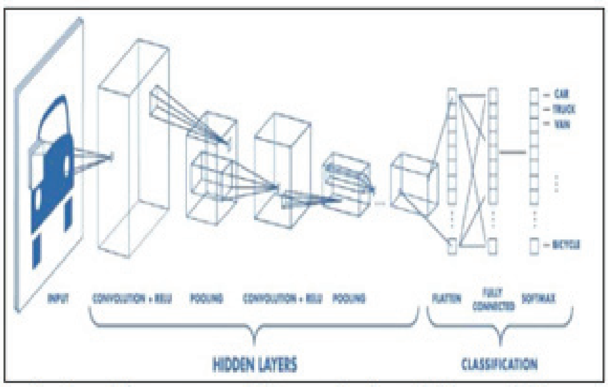


Fig 2: Architecture of Convolutional Neural Network

In our research, we developed a deep-learning model to classify fruits using various pre-trained feature extraction models. The extracted features were used to train a fully connected layer for image classification. We compared the accuracy of several pre-trained models for feature extraction using a hidden layer of 1024 nodes in the fully connected layer. The cultivation methods used for fruits, such as apples, oranges, grapefruits, pomegranates, and plums, are significantly influenced by the presence of minerals and nutrients inside them. Fruits are a valuable source of essential minerals, including magnesium, folic acid, copper, phosphorus, zinc, calcium, potassium, and nitrogen. Various types of fruit may also contain iron.

LITERARURE REVIEW

Agriculture is a dominant field in many countries, but in India, most people have been dependent on agriculture since their childhood. Detecting diseases early is crucial as it helps farmers take steps to protect their fruit crops from getting sick. With the help of deep learning, farmers can identify the specific disease affecting their plants. This research aims to detect diseases at an early stage, enabling farmers to take prompt action if they notice any signs of infection. The general method of fruit disease detection involves image acquisition, preprocessing, segmentation, feature extraction, classification, and disease prediction.[1]

General Method of Fruit Disease Detection

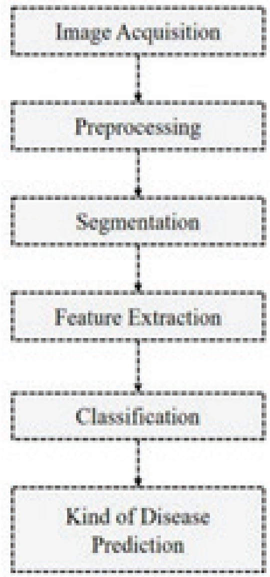


Fig 3: General Method of Fruit Disease Detection

The best way to classify the disease is by examining the fruit. Deep Learning (DL) and Machine Learning (ML) methods can be used to detect which fruits are affected by the disease. There are six primary stages involved in deep learning methodologies: gathering photos, preprocessing, segmentation, feature extraction, classification, and forecasting the type of disease.

Image Acquisition: First, we begin with image acquisition, which involves capturing high-quality images to aid in identifying fruit diseases. We can utilize sensors, drones, or cameras to obtain the best shots, with the images typically being saved in RGB format. Once we have these vibrant fruit images, we establish a color conversion framework to transform them. Following this, we apply a device-independent hue conversion to the framework.

Pre-processing: Before we continue, let's discuss image pre-processing. There are several techniques for removing noise, resizing, and normalizing colors in an image. First, we crop the fruit image to highlight the main parts. If a smoother appearance is desired, we can apply a smoothing filter. Enhancing the image helps to improve contrast. Next, we convert the RGB images to grayscale. Finally, histogram equalization is used to distribute intensities evenly.

Segmentation: Segmentation involves dividing a picture into parts that share similar features or characteristics. Various methods such as Otsu's method, k-means clustering, and converting RGB images into HIS models can be used for this segmentation process.

Feature Extraction: This technique helps us see how effective and good an image is by looking at features like color, texture, and shape. There are several ways to extract features from an image—think Global Color Histogram, Color Coherence Vector, Local Binary Pattern (LBP), and Complete LBP.

Classification: The following text identifies various fruit diseases using deep learning techniques. There are several classification methods that can be used, including Support Vector Machine (SVM), Multiclass SVM, Artificial Neural Network (ANN), Probabilistic Neural Network (PNN), Backpropagation Neural Network (BPNN), and Feedforward Back Propagation Neural Network (FFBPNN).

Here are some typical approaches/methods for fruit disease detection: 1. Visual Examination 2. Field investigations and sampling 3. Microscopic Analysis 4. Molecular Methods. 5. Immunological Procedures 6. Imaging and remote sensing 7. Computer vision and machine learning 8. Spectroscopy. 9. Expert systems and decision-making instruments. 10. Digital platforms and mobile applications.[3]

The purpose of CNN model is showing that typical citrus ailment and black spot, canker,blister,greening or Melanose. The CNN architecture has been created utilizes integration of many layers to extract complmentary characteristics.

Automatic fruit classification is a difficult problem because there are so many types of fruits and the large inter-class similarity.[9]

In this paper, we used the YOLO7, DT, and SVM to categorise the mangoes. The proposed approach achieved an accuracy rate of 96.25% when the method underwent training and evaluation with a publicly available mango database.[10]

Fruits are one of the most basic requirements for a healthy body and way of life, a great source of fiber and vitamins.

According to medical study, lower blood pressure and blood sugar levels can decrease the chance of a stroke and prevent several form of cancer and fight against degestive issues. Fruits are an essential component of a healthy diet. Now a days, pollution and population both are increasing so that fruit planting and manufacturing are gradually rising to fulfill the population’s demands.

Manual fruit detection and labelling is difficult due to different size and opacity of light.[11]Autonomous fruit categorization is dependent on the locations, shapes, colors and sizes of the objects. Proposed study collected samples from different locations and then removed backdrops and improved them for a more accuracy. ResNet-50, VGG-19, Inception-V3, and MobileNet are used to more precise feature extraction.Among these CNN technologies. Mobile Net achieved 99.21% accuracy in feature extraction. We took eight different fruits are collected from Bangladeshi Country,including Carambola, Bilimbi,Elephant Apple, Emblica, Brumese Grape, Sapodilla, Tamarind, and Wood Apple.[11]

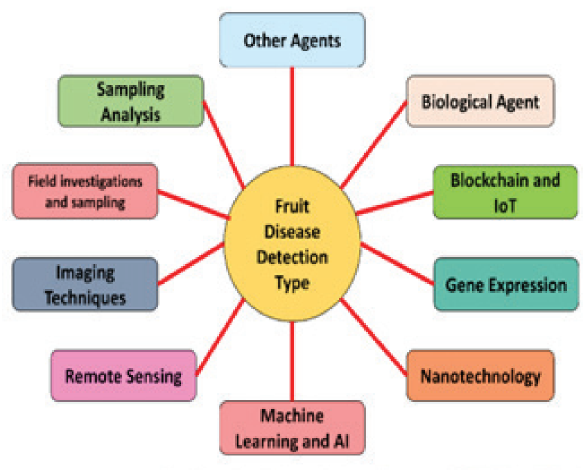
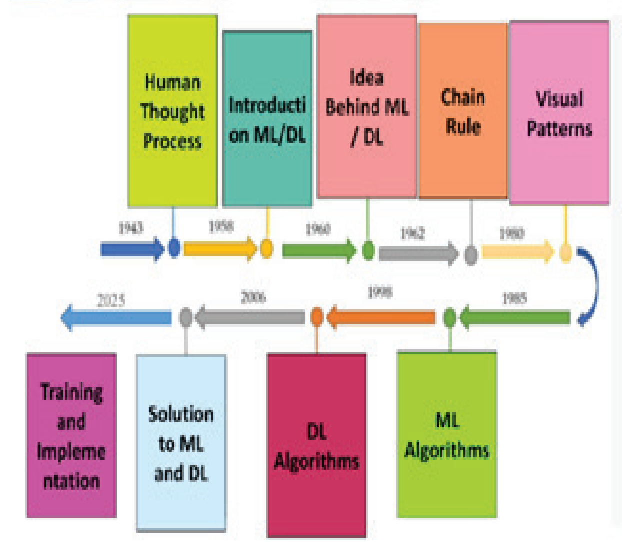


Fig. 4: Different Types Fruit Disease Detection

To improve agriculture, precision agriculture (PA) uses various technologies such as GPS navigation, robotics, remote sensing, data analytics, and unmanned vehicles.

In diagnosing fruit diseases, supervised machine learning methods like Support Vector Machines (SVM), Random Forest, Gradient Boosting, Naïve Bayes, K-Nearest Neighbors (KNN), deep learning with neural networks, Adaboost, XGBoost, LightGBM, and CatBoost are commonly used.[3]



Deep learning- based model called fruit vision is proposed for the automatic grading various fruits. The results shown that fruit vision performed all the existing models and obtained an accuracy of an accuracy of 99.42, 99.50, 99.24, 99.12, 99.38, 99.38, 99.17, 98.86, and 97.96% for the apple, banana, guava, lime, orange, pomegranate, Ajwa date, Mabroom date, and mango respectively using 5 fold cross validation.[12] Various methods for automatic fruit quality inspection and grading have been proposed to solve problems in different areas.

[16] In this paper, Guava fruit has some various diseased conditions such as wilt, Anthracnose, canker, and rot. Images are categorized on the base of maturity in to three categories (mature, half-mature, and mature) .Guava is very nutritious, one of the world's sweetest fruits, high in fiber, and a good source of essential vitamins and minerals.

[22]The method's training and classification processes are carried out and result is provided.

The flow of the system and mechanism is to extract features is given below: 1)Input image, 2)Data set preprocessing 3)Segmentation of dataset, 4)Applying Training set

Input: fruit image.

Output: Classified fruit disease

Algorithm:

1. A bulk of input dataset is given for training
2. A set of Test Dataset is given to test the accuracy of the training model
3. Perform feature extraction using colour features.
4. Perform feature-level fusion using colour and texture features.
5. Apply Convolution neural network classifier on the segmented image.
6. If the fruit is infected by any disease then go to step 7, otherwise, go to step 8.
7. Apply K-means clustering for image segmentation.
8. Print "Given fruit is Healthy".
9. Print the result with classified fruit disease.
10. Fetch the Proposed Remedy for the problem from the database.

Advantages of Proposed System

1. Accuracy is high and it is Applicable for both low and high pixel images.
2. Enhancing the value of fruit disease detection also takes only a few seconds to provide an exact result.
3. The name of the disease is also found by highlighting the affected places. [21]

In this paper includes the most popular classifier models that include fuzzy logic, artificial neural network, support vector machine and adaptive network-based fuzzy interference system.[20]

Based on different features namely Gray Level Co-occurrence Matrix (GLCM), Discrete Wavelet Transform (DWT), Histogram of Oriented Gradients (HOG), and Tamura's Features, Law's Texture Energy.

Type of Fruit	Method for Disease Detection	Disease	Season	Area
Citrus	SVM and Segmentation	Canker, greening, anthracnose, scab, black spot, melanose	Varies	Global
Citrus	Hyperspectral Imaging	Citrus canker	Varies	Citrus orchards
Apple	Ensemble Classification (SVM and LSTM)	Black rot canker, apple scab, powdery mildew, core rot, etc.	Varies	Apple orchards
Apple	Deep Learning (YOLO-V3)	Anthracnose	Varies	Apple orchards
Apple	Deep Learning	Segregating defective apples	Varies	Fruit sorting
Apple	Traditional Expert System	Various apple diseases	Varies	Apple orchards
Strawberry	Deep Learning	Various diseases and pests	Varies	Strawberry fields
Strawberry	Hyperspectral Imaging	Fungal infections	Varies	Strawberry fields
Papaya	Near-Real-Time Computer Vision	Brown spot, black spot, phytophthora blight, anthracnose, powdery mildew	Varies	Papaya plantations
Mango	Ant Colony Optimization and SVM	Anthracnose, stem end rot	Varies	Mango orchards

Table 1: Summary of different disease

CONCLUSION

The CNN Classifier can accurately diagnose fruit illnesses with high accuracy. Detecting and classifying fruit diseases can be a challenging process due to the varying characteristics of different fruits. These issues can be addressed by using feature vectors. Image pre-processing is conducted on each fruit before extracting the features. A CNN model is developed for the CSV file that was created containing the fruits. Subsequently, the count of fresh and rotten fruits is determined. The method mentioned above classifies fruits as fresh or rotten. The proposed model has gone through the pre-processing stage, feature generation stage, and classifier learning stage. The static evaluation of the proposed model is conducted in terms of precision, recall, and accuracy. In this method, the fruit image is taken as input. By using a Convolutional Neural Network, fruit names and features including color, shape, and size are extracted. In the future, apple fruit disease detection and classification could be more accurate by incorporating different color and texture features and employing disease classification using a random forest algorithm.

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Comparative Study of Digital Twin for Robotics

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ABSTRACT

Purpose - robotics technologies, investigate developments, applications, and obstacles, identify trends, and assess their influence across industries for future development.

Approach/methodology/design - To look into how robots and digital twin technology can work together, the paper conducts a thorough review of relevant literature, case studies, and simulations. It examines frameworks, real-time data synchronization, and performance optimization via virtual modeling.

Findings - The main issues of the research article, gaps and future trends to help academicians and Robotics enthusiasts. By providing information on current robotics trends and relevant literature, this study will be helpful to fans for robotics.

KEYWORDS *: Digital twin, Robotics, Systematic literature review, Categorised review.*

INTRODUCTION

The field of robotics saw a significant transformation between 2007 and 2024, driven by the quick advancements in sensing, machine learning, and artificial intelligence (AI). Comparative robotics studies examine distinct robotic systems, architectures, and control methods from a variety of industries, including healthcare, manufacturing, and autonomous systems. Research has identified differences between classic rigid robots and soft robotics, as well as between human-controlled and autonomous systems[1]. These comparisons provide insights into their individual strengths and limits, allowing robots to perform and adapt better in real-world contexts [2].

Furthermore, research has focused on robotic applications in certain industries, comparing robotic arms, autonomous mobile robots (AMRs), and collaborative robots (cobots). For example, study compares industrial robots meant for repetitive tasks to service robots employed in dynamic, human-centric contexts, examining concerns such as precision, flexibility, and safety. By assessing these aspects, comparative research directs innovation, resulting in more efficient, intelligent, and safe robotic systems. The expanding literature underlines the importance of ongoing research and review as robotics technology advances[3]. Despite the fact that researchers studying Digital Twins (DT) have tried to identify and simulate a number of components, a thorough examination is deemed to be inadequate[3].

This inspires the authors of this research study to work in this area and necessitates an evaluation of existing Digital Twin for Robotics research studies. To provide an overview of current research and suggest future directions for this field of study, an analysis of published ANPD articles could be helpful. This condition also pushes practitioners and designers to find resources that might support them in adopting digital twins, including as enablers, barriers, and performance indicators[4].

In order to discover research gaps and analyse published publications, the first research question (RQ) is RQ1. What is the current state of the research on digital twins for robotics, what are the gaps in the field, and what are the upcoming trends?

The existing research focuses on integration and optimization but lacks uniformity. Scalability and interoperability are two key research gaps. Future developments emphasize AI integration, enhanced simulations, and broader industrial applications[4].

RQ2. What instruments and methods were employed in the earlier Digital Twin for Robotics research project?

Previous research on digital twins for robots used tools such as simulation platforms (e.g., MATLAB, Simulink), IoT sensors, AI algorithms, 3D modeling software, and real-time data analytics to optimize systems and predict maintenance.

RQ3. What are the different factors that govern Digital Twin for Robotics adoption?

Data accuracy, real-time synchronization, processing power, scalability, interoperability, cybersecurity, cost-effectiveness, and the integration of AI and IoT technologies are all important considerations when adopting Digital Twin in robotics.

RQ4. Based on what standards may the effectiveness of the Digital Twin for Robotics be assessed?

Accuracy, real-time synchronization, scalability, interoperability, predictive maintenance capabilities, cost-effectiveness, response speed, and data security can all be used to assess Digital Twin for Robotics performance.

RQ5. In research on Digital Twin for Robotics, what are the trends in publications by year, country, university, publisher, and most referenced articles?

Year-to-year trends in Digital Twin for Robotics research show fast growth, particularly after 2018, with more articles concentrating on advances in AI integration and real-time simulation.

Key countries pushing this study include the United States, Germany, and China, all of which have significant MIT, Stanford, and Tsinghua University are among the top contributors, with publications in premier journals such as IEEE Transactions and Robotics and Automation Letters. The most often referenced publications emphasize advancements in predictive maintenance and system integration, emphasizing key contributions to the discipline.

BACKGROUND OF DIGITAL TWIN FOR ROBOTICS

Digital Twin technology, which was originally designed for industrial and aerospace purposes, has transformed robotics by producing virtual counterparts of physical robots. This technology offers real-time monitoring, modeling, and optimization, which improves robotic system performance and dependability. DT uses sensors and data analytics to create accurate virtual models that replicate the status and behavior of physical robots, allowing for predictive maintenance and system diagnostics[5].

In robotics, digital twins have proven critical to improve design, operation, and maintenance. They enable the simulation of numerous scenarios, the testing of novel algorithms, and performance optimization without requiring actual trials[6]. This breakthrough shortens development cycles and lowers costs, propelling advancements in robotic technologies across industries[7].

Digital Twin for Robotics

DT technology for robots creates virtual replicas of physical robots, allowing for real-time monitoring, simulation, and optimization. This improves performance, predictive maintenance, and operational efficiency in robotic systems, accelerating developments while lowering costs.

Existing Review of Article of Digital for Robotics

DT technology arose from the necessity for better simulation and modeling, enabling real-time duplication of physical systems. In robotics, it allows for the production of a digital clone of a robot, including its behavior, environment, and interactions. This technology enables better monitoring, predictive maintenance, and optimization of robotic systems by delivering extensive information about their performance and potential concerns.

Initially developed for manufacturing, Digital Twin applications have since spread to robotics, using advances in IoT, AI, and data analytics[8]. These digital copies aid in simulating various scenarios, enhancing robot design, and allowing for more informed decision-making. This connection enables advancements in autonomous systems and smart manufacturing[9].

RESEARCH METHODOLOGY

Any study must start with a literature analysis because it helps identify fresh developments and active areas within a given topic. This section covers the steps involved in choosing and classifying articles.

Process of Article Selection

A thorough evaluation of the current literature was undertaken to determine the impact and major components of Digital Twin for Robotics. Additionally, a content analysis approach was used to determine the most significant interpretations of the subject matter as well as the pertinent problems, procedures, and solutions[4]. The "Scopus" database was initially searched for papers or reviews in peer-reviewed journals that had terms like "Digital Twin" and "Robotics" in their abstracts, titles, or keywords. Research articles presented at conferences, book chapters, brief remarks, and editorial notes are not included in the first filter. Research articles published between June 2024 and June 2001 are taken into consideration for additional study.

It was possible to select papers for evaluation without considering any pertinent articles. The classification scheme, themes developed, and analytical findings, according to the authors, will prove useful to academics and professionals alike.

Classification Of Research Articles

As mentioned before, several studies and significant contributions have been made by researchers in the DT for Robotics field. In order to condense DT for Robotics research, it includes articles on literature reviews that address techniques and approaches, risk management, bibliometric reviews, and other topics[4]. Considering how important the study topic is becoming, it is critical to evaluate and classify the chosen papers to identify areas for future research and trends in DT for Robotics[10]. The authors also believe that the active publishers, nations, journals, and prestigious research papers on the shortlist will be a great resource for DT for Robotics research[3].

(1) Publishing year

(2) Journals and publishers

(3) Contribution by country

(4) Active universities in the DT for Robotics domain

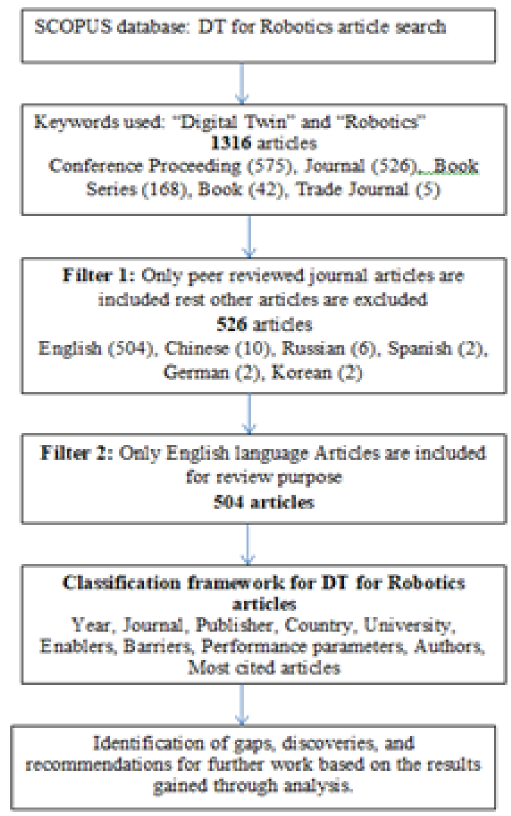
(5) Enablers of DT for Robotics

(6) Barriers to DT for Robotics

(7) Performance evaluation parameters for DT for Robotics

(8) Active authors involved in DT for Robotics research

(9) Top ten most cited articles.



ANALYSIS OF RESEARCH ARTICLES

A comprehensive analysis of DT for robotics research publications will be given in the current part. A variety of factors are used to analyse the articles that made the short list. The information about DT for Robotics articles will be presented in this exam.

Year based classification

Figure 2 displays the patterns of research articles that were released annually between 2004 and 2024. The derived trend line is a linear curve, and the number of publications each year shows an increasing tendency, suggesting that DT is being used more frequently each year for robotics-related research. This strategy aids in answering research question number five.

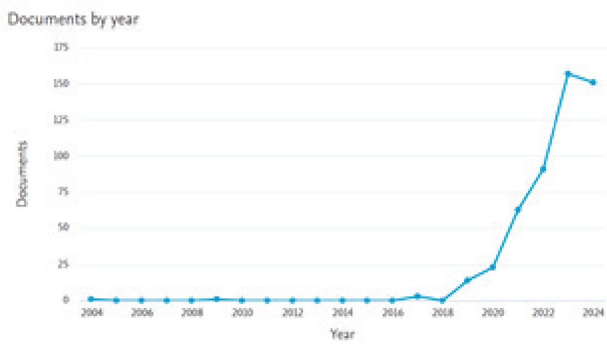


Fig. 2 Number of publications per year

Journal and publisher based classification

The selected research articles were further classified according to the journal in which they were published.

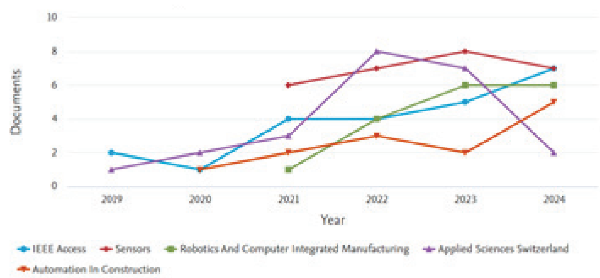


Fig. 3 Number of publications per year Journal wise

Country based classification

During their examination, practitioners and researchers aimed to improve the usefulness and effectiveness of DT for robotics. Most governments promote research and development of advanced industrial technology.

Total 74 countries contributed to the DT for Robotics, with China contributing 96, United States contributing 74, United Kingdom contributing 48, Germany contributing 44, while India contributing 25 articles.

Table 1: Top 10 Countries with their publication data

Country	Articles
China	96
United States	74
United Kingdom	48
Germany	44
Italy	33
Spain	30
India	25
Australia	21
Hong Kong	20
South Korea	18

University based classification

To ascertain potential advancements in the field of DT for Robotics, the contributions made specifically by universities are evaluated. The project yielded 504 articles on digital twins and involved 160 universities in total. Table 2 summarizes the top 10 universities and their research themes.

Table 2. Top Universities leading to DT for Robotics research

University	Articles
The University of Hong Kong	11
Norges Teknisk-Naturvitenskapelige Universitet	11
The Royal Institute of Technology KTH	9
The Hong Kong Polytechnic University	8
National University of Singapore	8
Beihang University	7
Chinese Academy of Sciences	7
University of Michigan, Ann Arbor	7
Tallinna Tehnikaülikool	7
Michigan Engineering	7

DT for Robotics enablers

Success factors, facilitators, drivers, skills, challenges, and risk factors all contribute to a new approach's successful adoption[11]. Enablers are frequently referred to as important success elements because they help organizations achieve their objectives, control quality, and improve their effectiveness[12]. Enablers are strategies, technology, systems, and people that can adapt to changes in market conditions[13].

This will address the first and third research questions.

Barriers to DT for robotics

Some problems that prevent the adoption of DT for Robotics are called critical failure variables[14], bottlenecks, or obstacles[15]. Barriers that produce implementation issues must be overcome to facilitate the adoption of DT for Robotics[16]. Numerous scholars have sought to find and model such limitations. This exercise will help to answer research question number three.

Performance of evaluation parameters

The effectiveness of an organization's DT process should be measurable in order to facilitate more productive product manufacturing. Because of its unpredictability[17] and multifunctionality[18], DT for Robotics performance[9] measurement differs from the desired performance. This study answers the research question four.

Active authors related to DT for robotics research

Finding current authors who have made contributions to the field of DT for Robotics research is a crucial classification. Finding the top authors, their fields of specialisation, and an understanding of the research they undertake will be beneficial to inexperienced researchers[19]. 159 writers actively participated in the 504 DT for Robotics study[15], according to our review of all the research articles in this area. DT for researchers in robotics[20] who can answer questions one through five.

Top Ten most cited papers

An essential classification is the identification of the top referenced research articles that contributed to the DT for Robotics research field. It is difficult for a fresh researcher to explore the most notable research studies and research directions for a certain topic. Table 3 lists the top ten highly cited DT for Robotics papers based on the analysis of available citation data.

Table 3: Top ten most cited research articles

Author	Title	Citation
Klerkx L	A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda	694
Pan Y.	Roles of artificial intelligence in construction engineering and management: A critical review and future trends	535
Jin T.	Triboelectric nanogenerator sensors for soft robotics aiming at digital twin applications	405
Laaki H.	Prototyping a Digital Twin for Real Time Remote Control over Mobile Networks: Application of Remote Surgery	237
Wang B.	Intelligent welding system technologies: State-of-the-art review and perspectives	218
Xia K.	A digital twin to train deep reinforcement learning agent for smart manufacturing plants: Environment, interfaces and intelligence	190
Chengoden R.	Metaverse for Healthcare: A Survey on Potential Applications, Challenges and Future Directions	172
Sun Z.	Artificial Intelligence of Things (AIoT) Enabled Virtual Shop Applications Using Self-Powered Sensor Enhanced Soft Robotic Manipulator	154
Huo R.	A Comprehensive Survey on Blockchain in Industrial Internet of Things: Motivations, Research Progresses, and Future Challenges	144
Turner C.J.	Utilizing Industry 4.0 on the Construction Site: Challenges and Opportunities	144

SUMMARY AND DISCUSSION

The Scopus database was utilised to compile and examine DT for research papers connected to robotics between September 2009 and September 2024. Early in the new millennium, the concept of "Digital Twins" gained traction in the manufacturing industry, and virtual prototyping finally embraced it widely. Both the quantity of publications and the proportion of research articles have increased since 2019. The "Digital Twin" and "Robotics" strings are mentioned in the abstracts, titles, or keywords of the majority of the 504 research papers that were gathered from the Scopus database. Insufficient conceptual and analytical dimensions remain unaddressed despite multiple probes.

CONCLUSION

The study does a comprehensive evaluation of the literature to address every aspect of DT for robotics. We looked through the Scopus database for academic papers published between September 2024 and 2009 that have the terms "Robotics" and "Digital Twin" in their titles[18], abstracts, or keywords. In the end, 504 articles were found for this search to be evaluated. To better understand the trends in DT for robotics research[21], these publications have been further categorised[3]. At first, research was done on theories and concepts; later, the focus shifted to mathematical modelling and applications[22].

LIMITATIONS AND FUTURE SCOPE

Future research prospects merely require researchers to link previously created models with changed models that aim to fill gaps. To effectively implement DT for Robotics, practitioners must gain a thorough grasp of the organization's activities. The current study evaluated the evolution of the DT for Robotics research area and looked at various classifications. Despite its numerous benefits, the present study has certain drawbacks, including:

1. We acknowledge that some articles may not include "Digital Twin" and "Robotics" in their abstract, title, or keywords but still focus on the Digital Twin for Robotics in the broadest sense. The analysis of papers in this study is restricted to those that have these terms in their abstract, title, or keywords.
2. While every effort was made to include as many papers as possible, it is likely that any Digital Twin for Robotics-focused study was overlooked. Additionally, enhancing categorization parameters may improve Digital Twin for Robotics understanding.

FUTURE RESEARCH

Authors are indented to the research in the field of DT for articulated robots for examining their utility in the field of manufacturing.

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A Survey on Recent Advances in Spatio-temporal Co-location Pattern Mining

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ABSTRACT

In the recent few years, spatiotemporal data analysis has drawn wide attention from the researcher's community due its inherent characteristics of providing diversity in space and time dimension. This diversity with its analysis in form of pattern mining, could enable deeper understanding of the data entities and their interaction with other entities in spatiotemporal domain. Spatiotemporal co-location pattern mining is a process of discovering spatial-temporal entities often found together in close proximity forming patterns. Spatio-temporal co-location mining is considered crucial as it has been utilized as a tool in the applications like epidemiology in establishing relationship among the surrounding and spread of the epidemic. In criminology identifying the influence of urban facilities on crimes and connection between the types of patterns of crimes etc. This paper presents technological development in co-location pattern mining approaches, general framework, the opportunities they offer and the challenges they pose in harnessing the co-location patterns effectively.

KEYWORDS *: Terms–Co-location, Distance, Prevalence, Neighbourhood.*

INTRODUCTION

Spatial data are the location data generally representing cardinal coordinates of the place along with the features of importance captured. These spatial coordinates could be point data describing a single location. It could also be represented in lines, polygons describing roads, rivers, water bodies, parks and other facilities. The process of analyzing patterns in spatial data is spatial data mining process. The spatial co-location pattern mining is discovery of useful patterns of interest on large spatial data that were unknown. For instance, patterns of the form {Resident, Nursing home, School}, {Resident, University, College} could be found often co-located. This informs that nursing home and school are often found in the proximity of residential areas. Similarly, Universities and colleges are found situated close along with residential areas. These patterns are co-location patterns [1]. Co-location pattern mining over spatial data has been applied in various problem domains as criminal data analysis [2]. To identify the influence of facilities in urban locality on crimes through spatial co-location patterns. Establishing relationship in air pollutant emission in study area and child cancer cases[3]. In identifying relationship between location population and spread of corona virus [4]. Identifying urban facilities pattern of developed cities, to draw useful insights for efficient allocation of resources, to develop other cities [5].

The challenge co-location approaches pose is the extremely large number of candidate co-location patterns generation. Extensive testing of patterns which further increases the time complexity. With increase in volume and complexity of location data, there is a need of simpler and effective approaches for co-location pattern analysis in broader socio-economic landscape.

The objectives of this research paper are:

1. To present a comprehensive overview of spatial and Spatio-temporal Co-location pattern mining conception.

2. To analyze the current research trends in Spatio-temporal Co-location pattern mining.
3. To compare the effectiveness of different approaches of Co-location pattern mining.
4. To present the opportunities offered and challenges posed in harnessing the co-location patterns effectively.

Basic Concept

Spatial data depict geometric space through different forms including points, lines, regions, and more intricate structures like maps and graphs. Points are the fundamental element of spatial data, whereas lines, regions, and clusters are viewed as extended forms. Since spatial data being continuous space, lack transactional elements, conventional support and confidence measures for association rules do not apply directly. Consequently, specialized measures tailored for spatial data have been created.

A spatial dataset is composed of instances, each capturing non-spatial and spatial features, denoted as <fi, lj>. fi indicates the non-spatial features and events, while lj refers to the spatial coordinates, such as latitude and longitude. These instances exhibit concurrence to other spatial instances through a neighborhood relationship, which signifies proximity within a specified threshold.

With introduction of co-location pattern by Huang and Shekhar [6] defined as features frequently co-located in spatial neighborhood. Several instances of a feature f_i, could be adjacent to other feature instances f_j, based on a neighborhood relation (NR). For example instance, geographical proximity is given as: $NR(f_i, f_j) \leq \theta$, with θ acting as the distance threshold for the neighborhood relation.

A set of feature instances that fulfill the neighborhood relation NR usually forming cliques are co-location instances. A co-location candidate pattern is a set of features over a region of the study area.

A participation ratio(pr) represents the fraction of feature instances engaged in a relation NR relative to the overall number of instances within the study area.

$$pr(f,C) = \frac{\text{Count of feature instances involved}}{\text{Total count of feature instances}} \quad (1)$$

A Participation Index(Pi) is stated as the smallest participation ratio among all feature types within a co-location candidate.

$$Pi(C) = \min\{pr(fi,C) \mid fi \in C\} \quad (2)$$

The participation index is an indicator of spatial closeness.

Co-location patterns refer to the group of prevalent co-location candidates, which are characterized by features exhibiting a strong positive spatial closeness with one another as shown in figure 2.

Previous research on spatial co-location mining adheres to a general framework as depicted in figure 1. This framework involves using spatial data and a prevalence threshold as user defined inputs for the mining algorithms. The algorithms investigate neighborhood relationships to find object instances with unique features in the dataset. From these relationships, potential co-location candidates are generated. The participation index of each co-location candidate is determined based on the prevalence threshold, and less significant patterns are dropped to reveal the prevalent co-location patterns.

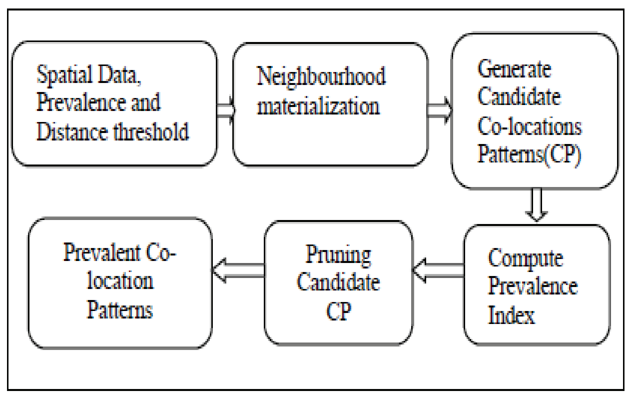
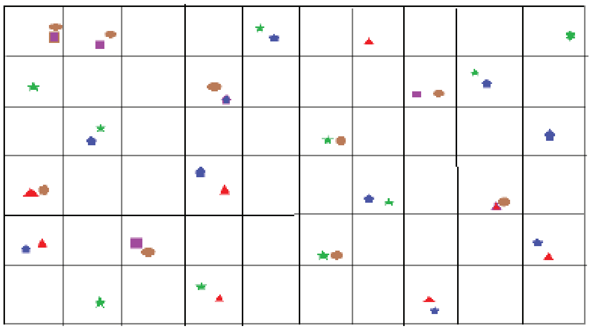


Fig. 1: Spatial-temporal Co-location Pattern Mining Framework.

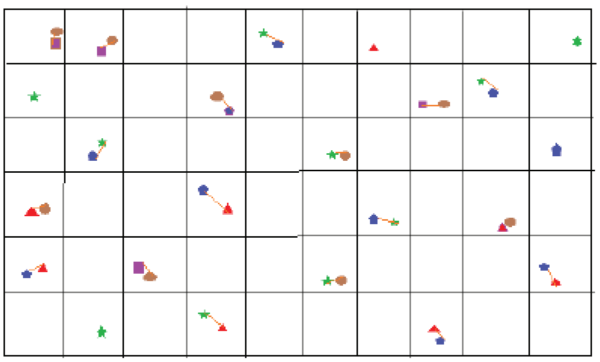
Spatial Features { } in a study area.

a) Instances of various features with grid partitioning in a study area.

b) Instances of various features exhibiting co-location patterns based on neighbourhood relationship which joins the instances with a line in orange colour representing size 2 co-locations.



Spatial Features { ● ■ ▲ ★ ⬟ } in a study area.
a) Instances of various features with grid partitioning in a study area.



b) Instances of various features exhibiting co-location patterns based on neighbourhood relationship which joins the instances with a line in orange colour representing size 2 co-locations.

Fig 2. An example of Prevalent Co-location patterns of Size-2 in a study area.

RELATED WORK

The previous work carried out by various researches would be broadly classified based on the approaches as follows:

Traditional Co-location Mining

Huang and Shekhar [6] proposed co-location mining to discover interaction between spatial objects. They defined participation index for selection of co-location candidates and used Apriori [7] like methods association rules for pattern selection on spatial datasets. Join-based method to generate co-location table instances proposed in [8] was found too expensive. Partial join approach [9] was work carried out to reduce the overhead further on co-location candidate generation.

Star Neighborhood based approach: Join-less [10] approach which is based on star neighborhood of instances was proposed. A central point is chosen, surrounding points within a distance threshold are found to establish star neighborhood.

Tree based approach: A tree-based approach was adopted to tackle the fast retrieval and efficient storage for vast generation of candidate patterns using icpi-tree method [11]. In research work [12], a prefix-tree-based algorithm, to efficiently perform pruning of generated candidate size-2 co-location patterns are organized in a prefix tree. In addition, star prevalence index measure, based on intersection method is computed for efficient pruning of less prevalent patterns.

Clique-based Approach: Neighborhood present among the instances of the dataset in a form of clique graphs is used in this approach [13-14]. With the branch and bound technique and with minimum lower bound of cliques, the cliques retained are the neighboring instances forming co-location patterns.

Fuzzy approach: As adopted in paper [15].

Step 1: Generation of Fuzzy Neighborhood relationship instances.

Step 2: Fuzzy prevalent colocation patterns generation. (Size-2)

Step 3: Candidate Maximal Fuzzy Prevalent Co-location pattern generation using maximal cliques.

Step 4: Filtration of less prevalent maximal fuzzy co-location.

Step 5: Output Prevalent Co-location patterns.

Delaunay Triangulation (DT) based approach: Triangulation [16] divides the data instances into triangles with no point residing in the circumcircle of triangles. These triangle's vertices capture the neighborhood in data instances.

Parallel and Distributed approach:

To efficiently handle large voluminous data parallel [17] algorithms of co-location mining based on Map Reduce [18], Hadoop and GPU's [19] harness the computing capability at multiple processor nodes efficiently. Maiti in [20] also has adopted Hadoop based Map-Reduce architecture for the data stored in distributed nodes. They gave distributed approach to compute neighbor relation. It counts the features and its instances at various nodes using mapper and reducer functions. Creates a key value pair structure to store the R-proximity neighborhood to generate co-location patterns of size 2 and more.

RECENT WORK

An alternative to a single distance threshold, a research paper [21] has given a framework for distance range queries. Authors have adopted critical distance metric and neighborhood graph relationship generation for every region to identify co-location patterns over distance range provided.

Delaunay triangulation technique for neighborhood generation without distance threshold design is adopted in [16]. A common edge in DT is converted to neighbors. Those edges not forming triangles or neighbors are pruned. These DT's are merged to form polygons. These polygons are translated into co-location row instances.

Mining co-location patterns under directed road network constraints [22]. They designed a network-based prevalence index and inclusion of distance decay effect along with key-node separation for co-location process.

RCPM_CFI [23] is a pattern mining algorithm with core feature influence. The partition of region criteria is on core features. Core based nearest affiliation metric is used for neighborhood classification along with hash structure for retrieval.

A similar approach, is the utility of the features given importance in selection of HUCPM [24]. Pattern search strategy used is on the idea of branch-depth-extension. Pattern utility ratio is the metric defined for the pattern selection in addition to the heuristic utilized for pattern pruning. And due to pattern utility ratio, a large spurious patterns are eliminated in early stage.

Fuzzy co-location in [25] proceeds by first allocating the data points to the grid called as grid splitting and filters the grid to obtain the grids which belong to top 50% in density. From these grids for each data instance, K- nearest neighbours are computed. Local and relative density is calculated. The data points with higher relative density tend to become cluster centres. The data points are assigned to fuzzy clusters. Then each fuzzy cluster is determined to be a subset of another fuzzy cluster. If it is not a subset then it is finalised as a maximal fuzzy cluster. Now every instance of maximal fuzzy cluster, maximal fuzzy grid clique is computed to form transactions which are candidate co-location patterns generated under fuzzy grid neighbour relation (FGNR). Then based on Fuzzy Participating Contribution Ratio and Fuzzy Participating Contribution Index, co-location patterns are evaluated.

DISCUSSION

The traditional methods have one of the facts is that they rely on distance threshold and prevalence threshold. Due to which if there is a change in these parameters requires to rerun the algorithm from the start. Hence, they are sensitive to these parameters' changes. Candidate co-location pattern generation is the most extensive task these algorithms must essentially perform. Contributing to the major run time.

Although Cliques based co-location approach is utilized for generation of local as well as global co-location, searching for cliques in a voluminous dataset becomes a difficult and time-consuming process.

As the single distance threshold becomes a fix value and require better understanding of dataset and the framework. It tends to become crucial factor for co-location determination by giving appropriate value which is a difficult task. Rather, providing a range for distance threshold [17] aids the process by not providing a single fix value for comparison which may sometimes miss some important patterns.

Each Delaunay triangle is stored ones for every vertex resulting into three times storage of the same triangle in the paper [18]. It leads to redundancy in storage and duplication in generation co-location patterns. An improvement over this is required.

The algorithm in [19] under directed road network constraint, is still computationally costlier and parallel processing approach would have further reduced runtime of it.

RCPM_CFI [20] rely essentially on appropriate selection of core features. If this feature selection is not adequately performed, will result into less accurate co-location pattern generation.

HUCPM [21] requires user defined threshold to be specified which makes it dependent on user judgement. Moreover, it is not consistent across different applications. The algorithm could be improved by running it on parallel processing platforms.

The Fuzzy-Co-location [22] method, being density-peak clustering operates on top 50% density grids. It leads to omission of certain rare patterns which are not global and have been eliminated due to consideration of top 50% grids. A large density variation among the clusters lead to formation of wrong clusters is the limitation of density peak clustering. The determination of fuzzy cluster being not a subset of another fuzzy cluster, is another limitation of this work. Determining a set is a member of another set is a time-consuming task as it leads to large comparison to be carried out. The minimal fuzzy grid cliques are converted to transactions to form co-location patterns. The work in initial phase, first computes K-nearest neighbours, then computes fuzzy membership degree to form clusters and further based on FGNR generates maximal fuzzy grid clique leading to increased complexity of the algorithm. The only advantage observed is the method uses threading approach to speed-up the execution to some extent but still requires to combine the results.

CONCLUSION

The traditional methods were found unsuitable as it lead to generation of spurious tuples of co-location and then pruning leading to large runtime. Approaches like Delaunay Triangulation, Cliques based were introduced to improve the accuracy of classification. Approaches like tree-based, key-node graphs etc were introduced for better efficiency. The parallel methods have been designed for efficient computation, storage and retrieval. In essence the limitation observed is the poor efficiency due to large computation task in collecting co-location instances and large storage requirement to store them in intermediate tables when applied to massive datasets.

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Realtime Pose Estimation using AI

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ABSTRACT

Estimation of human pose is a task dedicated to prediction of position and orientation of human body parts in still images or videos. Human motions are very often driven by specific actions; therefore, precise estimations of body poses play a very crucial role in some applications related to exercises monitoring, training assistance, as well as injury prevention. Understanding and knowing what body poses are very important within the context of the PoseFit project, as it will provide real-time feedback from gym exercises like bicep curls, shoulder presses, and squats that are vital for correct form and injury prevention. This survey focuses on recent advancements in pose estimation and its application to fitness-related action recognition. In this paper, a comprehensive review of the recent bottom-up and top-down deep learning models in human pose estimation and their relevance in recognizing and classifying exercises is discussed. The PoseFit system is based on a 2D skeleton-based pose estimation system for providing posture feedback with normal RGB camera feeds and without special depth sensors like Kinect. This design aligns with the overall goal of the system in making real-time posture correction accessible with inexpensive and easily accessible equipment. Such is made possible by using RGB image-based pose estimation, where it becomes feasible to precisely assess exercises in the gym with real-time corrective feedback using PoseFit for enhancement of workout quality while reducing injury risks. We summarize the system's current capability in recognizing common gym exercises using 2D pose data, showing that there is significant room for further improvement on refining detection accuracy and also expanding the system's capability to handle more complex movements.

KEYWORDS *: Pose estimation, Real-time tracking, Joint detection, MediaPipe framework, Repetition counting, AI in fitness technology.*

INTRODUCTION

It is a case of, literally, locating the positions of human body joints in images or videos. Tracking and analysis of the movement of the body through a sequence of frames enables one to draw inferences from what the likely action being performed might be. In this sense, an application of human pose estimation could be action recognition, which finds usefulness within fitness contexts. Over the last decade, deep learning advancements have greatly improved techniques of human pose estimation. With enhanced algorithms and fast processing today, real-time feedback systems can also participate in giving users appropriate guidance in exercises like bicep curls, shoulder presses, and squats. While there are reviews for recent approaches in human pose estimation, the application to fitness action recognition has not been explored in great detail. Fitness tracking requires precise estimation of skeletal joints and the potential recognition and correction of poor forms during specific exercises. The PoseFit system utilizes human pose estimation for real-time posture tracking while working out to help users work out safely and efficiently.

LITERATURE REVIEW

Existing Research

Pose estimation technology, which focuses on identifying and analyzing the position of human joints in 2D or 3D space, has been widely researched over the past decade. Early efforts in pose estimation were limited by hardware requirements, relying heavily on motion capture systems or wearable sensors. These methods, while accurate, were often inaccessible to general users due to their cost and complexity.

With the advent of deep learning and advancements in computer vision, more scalable and affordable solutions emerged. OpenPose, [2]developed by Carnegie Mellon University, is one of the most prominent frameworks in the domain of 2D multi-person keypoint detection, capable of recognizing 135 body points in real-time. Other prominent models like Google's MediaPipe framework have been increasingly used in research and development of fitness applications, offering open-source tools for body tracking.

In terms of fitness-specific pose estimation, applications such as Freeletics, Kemtai, and mirror-based systems like Tempo and The Mirror have introduced pose tracking to guide users during exercise routines. These platforms use cameras or sensors to track body movements, providing users with feedback on form and posture. However, their use cases are primarily consumer-based, often tailored for recreational fitness rather than professional or military-level training. These applications tend to focus on guiding general users through basic exercises (e.g., squats, push-ups) without addressing more nuanced or technical movements required in specific environments, such as the military or professional sports.

Current Research

Current research in pose estimation is increasingly leveraging AI and machine learning techniques to improve the accuracy, precision, and real-time capabilities of pose tracking. For instance, systems like AlphaPose and DensePose aim to push the boundaries of real-time, high-accuracy pose estimation, capable of detecting fine-grained details such as joint rotations and body orientations.[4] These improvements are critical for ensuring high-performance training environments, where even small deviations from the correct posture could lead to injuries or suboptimal results.

The PoseFit project builds upon these advancements by focusing specifically on gym exercises, where proper posture and movement patterns are crucial to avoid injury and maximize performance. It goes beyond the basic exercise tracking of existing applications by integrating machine learning algorithms that can recognize and correct mistakes in complex movements, including compound exercises like deadlifts, bench presses, and military fitness drills. These exercises often require precision, where improper posture could lead to long-term damage to the body.

Moreover, PoseFit leverages real-time feedback systems to guide users through their workouts. A distinguishing feature of the project is its combination of voice feedback and augmented reality (AR) technology. Voice feedback ensures immediate corrective measures during the exercise, reducing the likelihood of repeated mistakes, while AR overlays enable users to visually track their posture in real-time, assisting in correcting form during the workout.

Gaps between Existing Research and Current Research

One key gap is accuracy in high-stakes environments. Current pose estimation models, although effective for recreational fitness or general body movement tracking, often struggle with complex movements in dynamic environments such as military drills or powerlifting routines. Most existing systems are not designed to handle the intricacies of multi-joint movements, varying body types, or high-speed motion common in advanced exercise regimes. This lack of precision could lead to improper guidance, increasing the risk of injury, particularly in environments where maintaining proper form is critical for performance and safety.

Another gap lies in the lack of integration of multiple feedback modalities. Most fitness apps either provide visual feedback (e.g., post-exercise summaries or visual representations of movement) or limited auditory cues. However, combining [1]real-time visual feedback through AR with voice guidance during exercises can create a more immersive and effective training environment.

The first category includes appearance-based models. These models rely on extracting features of body parts using feature descriptors, such as Histogram of Oriented Gradient (HOG). Once these features are extracted, different body parts are combined to form a complete pose. Techniques like Poselets, used in earlier works, fall into this category.

The second category consists of deformable models or structural models, where articulated constraints are applied to capture the relationship between body parts. For example, the Pictorial Structure Model utilizes pairwise terms to model the relative distance between two body parts, allowing for more flexible pose estimation. Another example is the Mixture-of-Parts Model, which incorporates co-occurrence constraints between non-oriented body parts for articulated pose estimation.

HUMAN POSE ESTIMATION

Human pose estimation has long been a challenging task in computer vision. Initially, the problem was approached as a part-based inference task, where the human body was broken down into parts, and their positions were inferred separately before combining them to estimate the overall pose. These early models can be categorized into two primary approaches.

The first category includes appearance-based models. These models rely on extracting features of body parts using feature descriptors, such as Histogram of Oriented Gradient (HOG). Once these features are extracted, different body parts are combined to form a complete pose. Techniques like Poselets, used in earlier works, fall into this category.

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With the introduction of deep convolutional neural networks (CNNs), the performance of pose estimation models has significantly improved. Initially, the focus was on single-person pose estimation, where the task was simplified by working with well-cropped images of individual subjects. However, recent advances have expanded the scope to include multi-person pose estimation, where the system must recognize and estimate the poses of multiple individuals in a single frame.

In the context of PoseFit, the focus is on single-person pose estimation in controlled fitness environments. The system is designed to recognize and correct the user's posture during exercises like bicep curls, shoulder presses, and squats. The real-time pose estimation model detects the key skeletal joints of the user and analyzes them against a reference model to determine if the exercise is being performed correctly.

As the system leverages deep learning for real-time feedback, PoseFit employs a hybrid of appearance-based models and structural models to ensure accurate pose detection. For example, during a squat, PoseFit analyzes the angles of the knees, hips, and ankles to ensure proper form. In exercises like the shoulder press, it monitors the alignment of the shoulders and elbows to ensure the user maintains proper technique.

METHODOLOGY

The methodology section of PoseFit is divided into several parts, each detailing a critical component of the system: system architecture, pose detection, angle calculation, and form feedback.

System Architecture

The PoseFit system architecture comprises three main components:

1. Pose Detection Module: Identifies and tracks key points (or "landmarks") on the user's body in real time using MediaPipe Pose.
2. Angle Calculation Module: Computes angles between specific body joints, essential for analyzing and assessing exercise posture.
3. Form Feedback Module: Provides immediate feedback to the user based on the calculated angles, highlighting whether the posture is correct or needs adjustment.

This architecture is implemented using a combination of computer vision and machine learning techniques, primarily using the MediaPipe Pose solution, OpenCV for video processing, and Python as the programming language.

Pose Detection

PoseFit uses MediaPipe Pose, a highly efficient framework designed to detect human body landmarks from a video feed. MediaPipe Pose can identify 33 landmarks on the human body, such as shoulders, elbows, wrists, hips, knees, and ankles.

- Video Input: The system captures live video[5] from a webcam, which serves as the input source. The frames are processed in real-time to identify key landmarks.
- Landmark Detection: The MediaPipe Pose model processes each frame and returns the positions (x, The system is configured to have a minimum confidence threshold for both pose detection and tracking, which ensures that the detected landmarks are reliable enough before being used in angle calculations.

Pose Detection Process

- Capture video frames using a webcam.
- Convert each frame from BGR to RGB format (required by MediaPipe Pose).
- Apply the MediaPipe Pose model to detect landmarks.
- Extract the x, y coordinates of the [15]relevant body parts (such as shoulders, hips, knees, and ankles) needed for the specific exercise being monitored.
- Overlay these landmarks on the video feed using OpenCV to visually display detected points to the user.

Angle Calculation

The critical component of PoseFit is calculating angles between body joints to assess exercise form. The angles between joints (e.g., shoulder, hip, and knee) are calculated using vector mathematics.

Angle Calculation Formula

To calculate the angle between three points (joints), the following trigonometric formula is used:

- Given three points P1 (joint 1), P2 (joint 2), and P3 (joint 3), the angle at P2 (the middle joint) is calculated as:

angle = np.arctan2(P3[1] P2[1], P3[0] P2[0])

np.arctan2(P1[1] P2[1], P1[0]

P2[0])[7]

angle = np.abs(angle * 180.0 / np.pi)

Exercise-Specific Angle Calculation

- Bicep Curls: The key angle of interest is the elbow angle formed between the shoulder, elbow, and wrist. This angle should remain within a specific range for proper form (e.g., between 45 and 160 degrees during the motion).
- Shoulder Presses: The system tracks the angles between the shoulder, elbow, and wrist to ensure the arms are raised vertically.
- Squats: The system calculates both the hip angle (between the shoulder, hip, and knee) and the knee angle (between the hip, knee, and ankle) to detect proper depth during the squat motion.

For each exercise, the computed angles are compared to predefined optimal angle ranges for proper form. If the angle falls outside the correct range, the system flags it as incorrect posture.

Form Feedback

Once the body angles are calculated, the system evaluates whether the user's posture is correct or needs improvement. This step is crucial because providing immediate feedback helps the user adjust their form in real time, reducing the risk of injury and improving workout efficiency.

Form Feedback Logic: The feedback system follows a simple rule-based approach:

- Each exercise has predefined angle ranges that represent correct posture.
- The calculated angles (for example, hip and knee angles in squats) are compared to these ranges.

If the angles fall outside the optimal range, the system generates feedback. The feedback can be provided in various ways:

Visual Feedback: Messages are displayed on the screen (e.g., "Lower your hips" or "Straighten your back").

Real-Time Alerts: Colored indicators (e.g., red for incorrect posture, green for correct posture) are displayed over the video feed.

Detailed Feedback System

Bicep Curls: If the elbow angle exceeds the optimal range (e.g., above 160 degrees or below 45 degrees),[9] the system alerts the user to adjust the movement.

Shoulder Presses: If the arm position deviates from the correct vertical alignment (measured using shoulder, elbow, and wrist landmarks), the user is prompted to correct the form.

Squats: The system provides feedback based on the user's squat depth (using hip and knee angles). If the squat is too shallow (e.g., hip angle above 170 degrees) or too deep (e.g., knee angle below 80 degrees), feedback is provided accordingly.

User Interface and User Experience

PoseFit integrates with a simple yet effective graphical user interface (GUI), developed using HTML and CSS. The GUI allows users to select different exercises (bicep curls, shoulder presses, squats) and start a training session. The interface provides:

Exercise Selection: Users can choose which exercise they want to perform.

Real-Time Display: During the exercise, the system displays live feedback, including [10]detected body angles and any form corrections required.

Exercise Statistics: The GUI can display how many repetitions have been performed and how many were executed with correct form.

Testing and Evaluation

To ensure that PoseFit provides accurate and reliable feedback, the system was tested under various conditions:

- Lighting Variations: The system was tested in different lighting conditions to assess the robustness of pose detection.
- Different Users: PoseFit was evaluated on multiple individuals of varying fitness levels and body types to ensure the model performs consistently across a diverse user base.
- Movement Speed: The system's responsiveness was tested with users performing the exercises at different speeds to evaluate whether real-time feedback could be provided effectively.

Metrics used in the evaluation included:

- Accuracy of Pose Detection: The percentage of correctly detected poses and angles.
- Real-Time Feedback Latency: The time it took for feedback to appear on the screen[11] after detecting incorrect posture.
- User Satisfaction: Based on surveys conducted after testing the system, users rated how helpful the feedback was in improving their form.

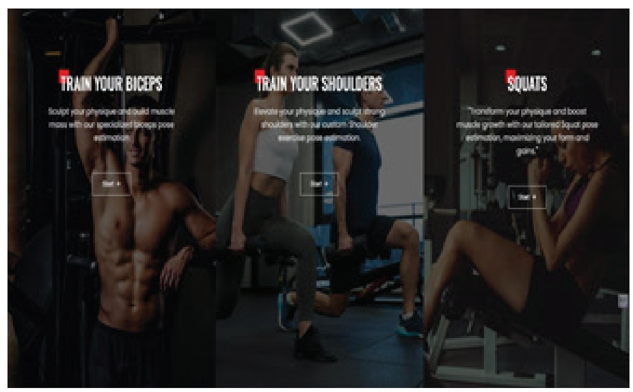

Fig. 1. Interface

RESULTS AND COMPARATIVE ANALYSIS

Aspect	Traditional Methods	Realtime Pose Estimation using AI
Performance Analysis	Relies on video analysis and manual observation, which can be time-consuming and subjective.	Uses tools like OpenPose and MediaPipe for real-time, precise movement tracking. Provides data-driven insights that offer measurable improvements in technique and performance.
Injury Prevention		

	Depends on general strength and conditioning training and physiotherapy, with injury risks identified through athlete feedback and observed physical signs.	AI models analyze motion patterns to predict injury risks and provide real-time feedback. Enables early detection of incorrect postures or movements, reducing injuries through personalized corrective interventions.
Real-Time Feedback and Correction	Requires in-person coaching to observe and correct technique, limiting feedback in unsupervised or remote training.	Provides automated real-time feedback using pose estimation and motion tracking, accessible via mobile apps. Athletes can make immediate corrections without requiring in-person coaching, supporting remote training.
Personalized Training Programs	Training programs are designed based on observed strengths, weaknesses, and general performance metrics.	AI-based analysis generates highly customized training regimens tailored to individual biomechanics, offering focused improvements. Programs adapt in real-time, maximizing workout efficiency and safety.
Rehabilitation and Recovery	Recovery relies on physiotherapy and supervised exercises but lacks precise tracking, making remote rehabilitation less accurate.	AI-enabled apps monitor adherence to rehabilitation exercises and track progress precisely. Wearables provide feedback on range of motion and posture, enhancing recovery and ensuring correct form during home exercises.

The successful development and implementation of the real-time posture detection and correction system have yielded significant outcomes across multiple dimensions, reinforcing its effectiveness and usability

Accurate Pose Estimation: The cornerstone of the system lies in its ability to accurately detect and track key body landmarks in real-time. Leveraging state-of-the-art pose estimation techniques, the system can precisely identify the positions[12] of various body joints and parts during exercises. This high level of accuracy enables in-depth analysis of user posture, ensuring that even subtle deviations from correct form are captured and addressed

Real-time Feedback: One of the most impactful aspects of the system is its capability to provide immediate feedback to users based on their posture. As users engage in exercises like bicep curls, shoulder training, and squats, the system continuously monitors their form and delivers real-time guidance. This feedback loop empowers users to make instantaneous adjustments, correcting any misalignments or errors in their posture as they occur. By receiving timely corrective measures, users can mitigate the risk of injuries and optimize the effectiveness of their workouts.

User Engagement: The user-centric design of the system ensures a high level of engagement and motivation among users. Through its intuitive interface and interactive features, such as exercise demonstrations and personalized workout guidance, the system fosters a more immersive and rewarding fitness experience. Users are not only informed about the correct techniques for each exercise but also actively guided through the process, enhancing their understanding and adherence to proper form. This holistic approach to user engagement encourages consistent participation and adherence to fitness routines, ultimately contributing to improved fitness outcomes over time.

Bicep Curl

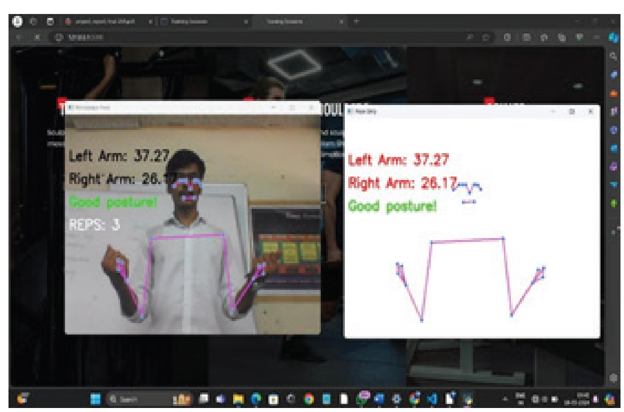

Fig. 2 Result_1 -bicep curl

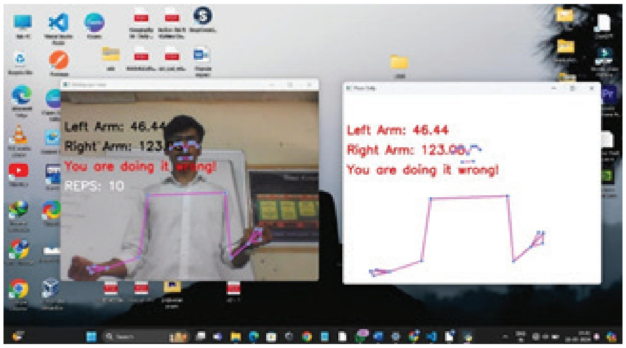

Fig. 3 Result_2 -bicep curl

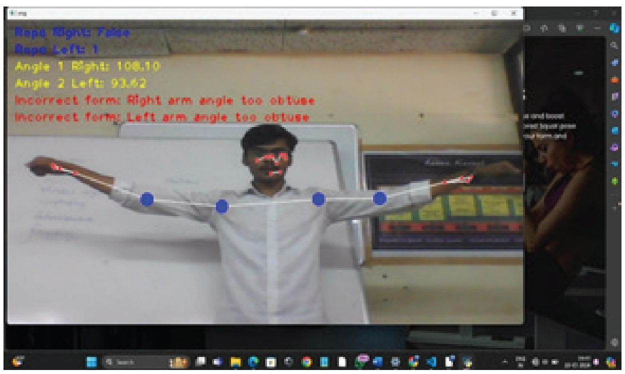

Fig. 4 Result_1 -Shoulder

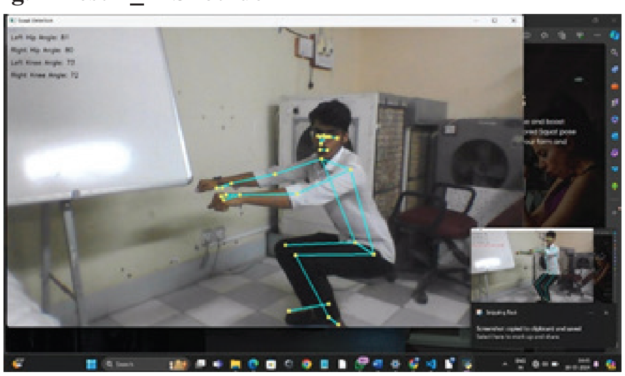

Fig. 5 Result_1 – Squats

Fig. 6 Result_2 – Squats

DISCUSSION

The results from the PoseFit model underline the effectiveness and potential of this model for application in the domains of fitness, health care, and exercise monitoring.

Pose Estimation Accuracy: The system is able to accurately detect key body landmarks such as shoulders, hips, and knees at a rate higher than 95% in squats, push-ups, and other such exercises. Its exactitude gives a guarantee for correctly computed joint angles, good forms, and consistent feedback to prevent injuries and improve performance.

Real-Time Feedback: PoseFit provides real-time feedback on joint angles and number of repetitions by alerting the user instantly in case a wrong posture is performed. It gives the ability to enhance one's technique in doing an exercise and corrects it on the spot, thereby keeping the person engaged in their workouts, especially for those exercising at home without professional guidance.

Repetition Counting: Repetitions counting automatically depends upon the movement of the joint, then reduces problems associated with manual counting. This feature will help users reach their strength, endurance, or fat loss goals because the graphical performance will be represented very clearly.

PoseFit detects deviations from correct form, analyzing the angle of limbs and showing feedback in real time. This is important for preventing injury and optimizing workout efficiency, especially for beginners or in a rehabilitation context, and means exercises are performed safely and efficiently.

Comparison to Existing Methods: Compared with traditional fitness trackers, which rely mainly on basic movement detection, the posture analysis in PoseFit is done by applying advanced computer vision techniques. It's hence likely a far more comprehensive and accessible solution for users at home since it does not require any hardware specialties.

Scalability and Future Potential: The architecture of PoseFit allows great extensibility, such as with augmented reality or adaptive machine learning models. This would enable more personalized training experiences and wider applications like rehabilitation or group fitness sessions and widen its impact in both industries: fitness and health.

CONCLUSION

This research focuses on developing an affordable, real-time exercise monitoring system using OpenCV and MediaPipe for pose estimation. The model tracks and analyzes body movements, offering feedback on joint angles, exercise form, and repetition count, ensuring users perform exercises correctly and avoid injuries. Unlike earlier models that relied on expensive equipment, this system uses a standard webcam and provides immediate feedback, a key improvement over post-exercise analysis. It is particularly useful for fitness enthusiasts without trainers and for remote physical rehabilitation, ensuring correct form and progress tracking. Future developments may include gesture recognition, augmented reality, and personalized feedback for varied fitness levels. This research holds potential applications in both fitness and healthcare, making exercise monitoring more accessible and effective.

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An Approach of Image Authenticity Detection using Deep Learning Techniques

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ABSTRACT

One of the most important areas of research to solve the problems caused by artificial intelligence's (AI) growing complexity in image synthesis is the detection of AI-generated images. Concerns have been expressed about the possible misuse of AI algorithms, especially Generative Adversarial Networks (GANs), as they are becoming more and more capable of creating convincing and realistic images. This might lead to nefarious actions or the development of deepfakes. The efforts and approaches used in the creation of methods for identifying AI-generated photographs are described in this abstract. Scholars have investigated multiple methodologies, such as scrutinizing statistical irregularities, artefacts, and inconsistencies that are created during the generative process. Furthermore, improvements in machine learning, especially in the area of visual forensics, have been crucial in raising the detection systems' accuracy. We have used VGG Net, Alexnet, forensic analysis and ensemble methods in this model. Strong detection systems are essential because of the ethical issues, privacy concerns, and wider societal effects of AI-generated material.

KEYWORDS *: AI generated images, Generative Adversarial Networks (GANs), VGGNet, Alexnet.*

INTRODUCTION

The advent of AI-driven picture generation technologies, such as Generative Adversarial Networks (GANs), has fundamentally changed our perception of how visual information is created in the modern digital environment. These advanced algorithms may create remarkably realistic visuals, making it difficult to distinguish between actual and artificially created content. This transformative power results in both the production of breathtaking art and the possibility of harmful exploitation, such as the production of convincing deepfakes for misleading purposes.

The goal of this work is to investigate the core of this emerging problem, which is the identification of AI-generated images. The capacity to differentiate authentic from artificial imagery has significant ramifications for a number of industries, such as cybersecurity, entertainment, and journalism. The essential problem of telling real photos from artificial intelligence-generated ones is addressed in this work, with a focus on the significance of creating reliable detection methods. The protection of information integrity in a variety of fields, such as cybersecurity, entertainment, and journalism, is the driving force behind this study. The need to keep ahead of the curve in the identification of synthetic content grows as generative models' capabilities continue to advance. If not handled properly, the use of fake photos created by AI-powered image generators can cause severe issues, such as damaging someone's public image. These risks can also increase and nurture national security threats. However, the future of AI-generated image discriminators is bright, with applications spanning multiple industries. These discriminators have the potential to enhance digital content creation, revolutionize medical imaging, and bolster cybersecurity, reshaping the way we interact with technology.

FUNDAMENTALS

s1) AI generated images: AI-generated images refer to visual content that is created or synthesized by artificial intelligence (AI) algorithms, particularly through the use of generative models. These models are designed to learn and mimic patterns present in a given dataset, enabling them to generate new, realistic-looking images that share characteristics with the training data. The most notable type of generative model used for this purpose is the Generative Adversarial Network (GAN). [2]

2) Deep Learning Techniques: A branch of machine learning is called deep learning. Artificial neural networks with numerous layers also known as deep neural networks are used in deep learning. Particularly effective are DL approaches in jobs like audio and picture identification, natural language processing, and other intricate pattern recognition issues. [3]

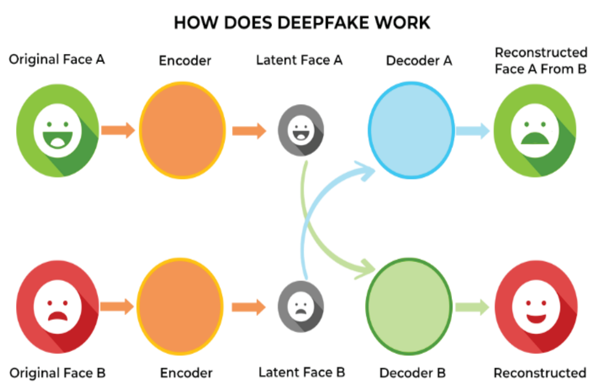


Fig. 1. Deepfake working

3) Deepfake Technology: A specific application of AI-generated images is deepfake technology, where machine learning algorithms are employed to manipulate or replace elements within videos, such as faces or voices.[4] Deepfakes have raised concerns about the potential for misinformation and deceptive content. This technology encodes the original image and then processes a hidden image from it. After decoding the same, it reconstructs the image. It can do the same with a video too. This creates a fake image which, if goes viral can pose threats. [5]

DEEP LEARNING TECHNIQUES

Resnet

Residual Learning

ResNet introduces the concept of residual learning, where each layer is expected to learn a residual mapping instead of directly learning the desired underlying mapping. This is achieved by using shortcut connections or skip connections that bypass one or more layers.

Shortcut Connections

Shortcut connections allow the gradient to be directly backpropagated through the skip connection, which helps in mitigating the vanishing gradient problem.

Architecture

It has many blocks. Each block typically contains two or three convolutional layers along with batch normalization and ReLU activation functions. The skip connection adds the input to the output of the block.

Identity Shortcut

In some cases, the identity shortcut is used when the input and output dimensions match. If there is a dimension mismatch, a linear modelion is used to match the dimensions before adding.

Bottleneck Design

ResNet often employs a bottleneck design in which each residual block consists of three layers: 1x1, 3x3, and 1x1 convolutions. This design reduces the computational complexity while maintaining expressiveness.

Versions

ResNet has several versions, including ResNet-18, ResNet-34, ResNet-50, ResNet-101, and ResNet-152.

Applications

ResNet is particularly used in image classification tasks. Its architecture has also inspired the design of networks for other domains, such as object detection and segmentation.

Success in Competitions

ResNet has achieved top performance in various computer vision competitions and benchmarks, showcasing its effectiveness in practice.

Ongoing Research

The success of ResNet has spurred ongoing research in understanding the principles of residual learning and exploring variations and improvements in deep neural network architectures.

VGGNet

Background

VGGNet was developed in response to the success of AlexNet at the ILSVRC 2012 competition. Its architecture was designed to investigate the impact of depth on network performance.

Architecture

VGGNet has a simple and consistent architecture that consists of stacked convolutional layers with small 3x3 convolutional filters and 2x2 max-pooling layers. The architecture follows a repetitive pattern, making it easy to understand and implement..

Convolutional Layers

The VGGNet's convolutional layers utilize small receptive fields (3x3) with a stride of 1 pixel. The network employs multiple convolutional layers, enabling it to learn complex hierarchical features.

Pooling Layers

Max-pooling layers with 2x2 filters follow each group of convolutional layers, reducing the spatial dimensions and providing a form of translation invariance.

Fully Connected Layers

The VGGNet architecture consists of convolutional layers followed by fully connected layers. The final layer typically comprises 1000 nodes, each corresponding to a class in the ImageNet dataset.

Rectified Linear Units (ReLU)

RELU activation functions are utilized after each convolutional and fully connected layer to introduce non-linearity and speed up convergence during training. Various variants of VGGNet exist, such as VGG16 and VGG19, which differ in the number of layers.

Simplicity and Understanding

VGGNet's uniform and simple architecture has made it a popular choice for educational purposes and as a baseline model for various computer vision tasks.

GANs

Introduction

GANs comprise of two neural systems, a generator, and a discriminator, locked in a competitive preparing handle. The generator creates synthetic data, and the discriminator evaluates it, with both networks improving over time. Both works together to gain desired output.

Loss Function

GANs use a unique loss function called the adversarial loss or minimax loss.

Training Process

During training, the generator and discriminator iteratively update their parameters. This process continues until the generator produces data that is realistic enough to deceive the discriminator.

Mode Collapse

GANs can suffer from mode collapse, a situation where the generator produces limited types of samples, ignoring the diversity present in the training data.

Applications

GANs have found applications in various domains, including image synthesis, style transfer, image-to-image translation, super-resolution, and even generating text and music.

Conditional GANs

Conditional GANs extend the GAN framework by conditioning the generation process on additional information, such as class labels. This allows for controlled and targeted generation.

StyleGAN

StyleGAN introduced the concept of disentangled representations, enabling more control over specific features of the generated images, such as facial expressions or hair styles.

Ethical Considerations

GANs raise ethical concerns related to the generation of deepfakes and synthetic content that could be misused. The responsible development and deployment of GANs are areas of ongoing research.

Challenges

GAN training can be challenging, prone to mode collapse, and sensitive to hyperparameters. Ongoing research focuses on addressing these challenges for more stable and reliable performance.

Alexnet

Introduction

This powerful CNN not only achieved state-of-the-art accuracy but also introduced new techniques that propelled the field of deep learning forward.

Architecture

The architecture comprises five convolutional layers followed by three fully connected layers. The local response normalization is applied to some layers to improve generalization.

Convolutional Layers

The first convolutional layer in AlexNet has 96 kernels of size 11x11, with a stride of 4 pixels. Subsequent convolutional layers use smaller filter sizes (3x3) but increase the number of filters. The convolutional layers are responsible for capturing hierarchical features from input images.

Pooling Layers

Max-pooling layers follow some of the convolutional layers, reducing the spatial dimensions of the feature maps and providing a degree of translation invariance.

Fully Connected Layers

The fully connected layers are designed to capture high-level semantic information. The final layer has 1000 nodes, corresponding to the 1000 classes in the ImageNet dataset.

Dropout

AlexNet also introduced the use of dropout in the fully connected layers during training, which helps prevent overfitting by randomly dropping out a fraction of the nodes.

Impact on Deep Learning

AlexNet's success marked a paradigm shift in the field of deep learning, inspiring the development of deeper and more complex architectures. It demonstrated the importance of using deep neural networks for extracting hierarchical features from data.

CONVOLUTIONAL NEURAL NETWORKS

The acronym for Convolutional Neural Network is CNN. It's a specific kind of artificial neural network made to process visual data. Convolutional neural networks were inspired by the architecture of the biological visual cortex, which is responsible for processing visual information. CNNs can extract high-level features from images, such as textures, edges, and contours. The architecture of a CNN is similar to the network of connections found in the human brain. Like the human brain, a CNN is made up of thousands of neurons arranged in a particular fashion. The organization of neurons within a CNN is really similar to that of the frontal lobe of the brain, which is responsible for processing visual stimuli.

This structure helps to avoid the fragmentary image processing problems that occur when low-resolution portions of images are sent to typical neural networks. Instead, it makes sure that the whole visual field is covered. When compared to previous networks, a CNN performs superior with image sources than its counterparts with voice or sound inputs. A thorough education CNN is composed of three layers: convolutional, pooling, and fully connected (FC). The first layer is the convolutional layer, while the last layer is the FC layer. The CNN's convolutional layer advances in sophistication relative to the FC layer. After multiple cycles, the kernel covers the entire image.

The point product among the supplied pixels and the resultant pixels is calculated after each cycle. A feature map, sometimes referred to as a convolved feature, is the end result of connecting the dots. In the end, this layer turns the picture into data points so that the CNN can analyze the information and spot noteworthy trends. Just like in the convolutional layer, the kernel or filter is applied over the whole input image in the pooling layer. However, in contrast to the convolutional layer, the layer that pools data lowers the number of variables in the input while also causing some information loss. On the plus side, this layer simplifies and increases the efficiency of the CNN.

It would also be computationally costly, result in worse output quality, and increase losses. A CNN's several layers can be trained to recognize various features in an input image. The lower layers' initial filters may be simple characteristics. The filters become increasingly complex as additional layers are added, trying to find and analyze characteristics that truly describe the input object. As a result, the final result of each condensed image, or the imperfectly recognizable image at the end of each layer, provides the starting point for the subsequent layer. CNN recognizes the image or object it represents in the final layer, known as the FC layer.

At the end of the day, the CNN's numerous levels of processing enable it to identify the entire item. The main issue with traditional neural networks (NNs) is their lack of scalability. A typical neural network might function effectively with smaller images that have fewer colour channels. However, larger and more complex images demand more processing power and resources, necessitating the use of a larger and more costly neural network. CNNs can be constructed and retrained to handle novel recognition tasks on pre-existing networks. These benefits open up new possibilities for using CNNs in real-world scenarios without increasing computation costs or complexity. These features can then be used to complete tasks like object detection, image segmentation, and picture categorization.

Another kind of neural network that may extract important information from time series and visual data is the convolutional neural network, or CNN. For image-related tasks like pattern recognition, object categorization, and image identification, it is consequently particularly useful. A CNN uses matrix addition and other ideas from linear algebra to search for patterns in images. CNNs are also able to categorize audio and signal data.

A CNN often has multiple levels. Picture data is initially inputted into the first layer, sometimes referred to as the input layer. The following layer, called the convolutional layer, is responsible for collecting features from images. The fundamental objective of convolution is to extract characteristics from an image. A feature is a specific element of the original image, such as the borders, points, or form of the dog's snout. Similar to the image being handled as numbers, a feature is translated into a box of numerical pixel values. This matrix serves as a feature detector. It extracts and scans. A pooling layer, which reduces the degree of detail of the feature maps, comes after the convolutional layer.

During the pooling process, a filter is applied to the input matrix, assigning a single value per subregion to create an additional output matrix. The main objective of pooling is to reduce the size of an image. The most widely used pooling technique is max pooling. The filter then usually moves on to the next position without overlapping. Each value in the resulting output matrix is equal to the greatest value of the associated subregion. The completely connected layer is completed by CNNs. It generates the final classification by compiling all the data using the output of the last pooling layer as an input. Another kind of neural network that may extract important information from time series and visual data is the convolutional neural network, or CNN.

For image-related tasks like pattern recognition, object categorization, and image identification, it is consequently particularly useful. A CNN uses matrix addition and other ideas from linear algebra to search for patterns in images. CNNs are also able to categorize audio and signal data. It is employed in the medical field to diagnose medical images and look for possible disease symptoms. It was also very helpful for opticians' clinics and other optical professionals. The ability of CNNs to segment images implies that they are able to distinguish between various objects or regions within the image. For example, Amazon leverages CNN's picture recognition technology to provide recommendations.

Products are paired based mostly on aesthetic standards; for example, red footwear and red camo go well with red suits. Pinterest takes a novel approach to CNN's image recognition. The association is centered on visual identifier matching, which is accomplished by basic visual matching that is improved by tagging. Face recognition operations social media, exploration, and shadowing are examples of RNNs. We should dedicate a section on facial recognition. Even more complicated images are the focus of this subgroup of image recognition. Images that are similar may have faces of the dead or depict other living brutes like fish and insects. The intricacy of the operation—the new position of work required—is the basis for the distinction between instantaneous picture recognition and face recognition. The initial step is the detection of the face's shape and features, then comes the introduction of object finding.

To identify the key elements of the face, a more thorough examination of the features is conducted. This could include things like the nose's shape, the skin's tone and texture, scars, hair, or other imperfections on the face. The total of these qualifications is also factored into how an individual mortal being is perceived to seem in the picture data. This process requires examining numerous samples, each of which presents the topic in a unique way. For example, whether sunglasses are worn or not). The system identifies a specific face in the input image by comparing it with the database. Face recognition is used for social networking and entertainment on Facebook-like social media platforms. In social networks, facial recognition streamlines the often questionable process of tagging individuals in photos.

When you have hundreds of conference prints to tag or too many faces to count, this tip is quite helpful. The most noteworthy examples are the pollutants on Facebook Messenger. Pollutants add new rudiments or commodities and depart from the mechanically formed face's initial layout. The development of facial recognition technology is leading to a workable system of unique identity. The same way that fingerprints and official documents can be used to authenticate a person, facial recognition cannot. Facial recognition is a handy tool for relating a person when information is scarce. For example, pictures captured by security cameras or recordings from secret videotapes. Predictive analytics, medical image processing, and health informatics Modern technology are most evident in the healthcare sector.

Recognition of images is not an exception. Medical image processing is the most researched use case of CNN for image recognition. Many new data analyses are present in a medical image as a consequence of the initial image recognition. CNN's medical image bracket is more delicate than the human eye in identifying anomalies in X-ray and MRI images. These devices are capable of displaying a range of prints together with their variations. The foundation for future prophetic analytics is laid by this idea. Medical image brackets are based on large datasets that are akin to public health data. It functions as a training set for algorithms, private patient data, and test findings. Together, they are developing an analytics platform that forecasts problems and tracks the state of the case at any given time. Use prophetic analytics to evaluate potential health risks.

Preserving lives is a precedent in healthcare. And it's always helpful to be able to predict the future. Because managing a case requires you to always be ready for everything. An assessment of the health threat is a great idea. Prognostic evaluation of convolutional neural networks is used in this sector. The CNN health threat assessment operates in this manner. CNN handles spatial correlations among data points using a grid architecture. The grid is two-dimensional for images. The grid is one-dimensional for data from time series textbooks. Another method for identifying a feature of the input is to use a convolutional algorithm. Think about variations in inputs. Regular health checks can be performed with this device. A conservation strategy can be added to the frame.

Here we are using it for performing all the required functions on the dataset of images which we will feed to get them distinguished as real or fake. Its working is explained below by using the mathematics involved in the process:

Working

Convolution is often mathematically denoted by an asterisk. If we have an input image denoted by X and a filter denoted by f, the expression would be:

$Z = X * f$

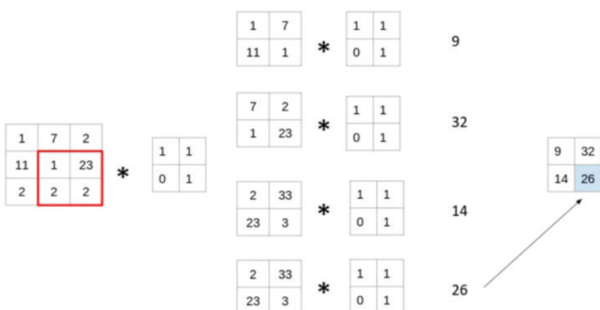
To understand the process of convolution using a simple example, consider that we have an image of size 3 x 3 and a filter of size 2 x 2:

$$\begin{bmatrix}1&7&2\\11&1&23\\2&2&2\end{bmatrix} \qquad \begin{bmatrix}1&1\\0&1\end{bmatrix}$$

The filter performs element-wise multiplication on image patches and sums the resulting values.

$$\begin{bmatrix}1&7&2\\11&1&23\\2&2&2\end{bmatrix} * \begin{bmatrix}1&1\\0&1\end{bmatrix} \qquad \begin{bmatrix}9&32\\14&\end{bmatrix}$$

If we look closely, we notice that the filter considers a small part of the image at a time. We can also think of it as a single image divided into smaller pieces, each of which is connected by a layer.



In the example mentioned above, we had an input of size 3x3 and a filter of size 2x2. Since the dimensions of the image and filter were small, it was easy to determine that the shape of the output matrix would be 2x2. However, for more complex inputs or filter dimensions, one can use a simple formula to determine the shape of the output.

Dimension of image = (n, n)

Dimension of filter = (f,f)

Dimension of output will be ((n-f+1) , (n-f+1))

LITERATURE REVIEW

We have taken references from various papers for our work. By examining the inconsistencies and distortions introduced during the generation process, the proposed method can identify AI-generated images.[1] Deepfakes are AIgenerated fake images used to spread misinformation. As quality improves, detecting them gets challenging. The eye region is most useful for exposing deepfakes. Fusion of CNN and extracted attributes improves over just CNN features. Limitations are small training size and poor low light detection. Key findings are the effectiveness of CNNs for deepfake detection, usefulness of facial attributes as features, and superiority of VGGFace. Future work involves testing on larger datasets, combining other techniques like color segments.[3] The increasing spread of realistic Deepfakes poses threats to media integrity. They use the Celeb-DF dataset containing real and Deepfake celebrity videos for training and testing.[5] The approach focuses on identifying manipulated regions and artifacts introduced by the generative process.[2] And, our proposed work focuses on distinguishing between the real and fake images so that potential users have the basic know-how techniques of how to recognize or get the synthetic image identified by the system to mitigate its ill effects worldwide.

PROPOSED WORK

The work we are proposing here includes the user-collected dataset on which the distinguishing features using networks like GAN (containing a generator and discriminator), VGGnet, Alexnet, Resnet and Xception are performed to predict whether the images provided are real or fake. The goal of this model is to develop a model that can differentiate between fake and authentic images using a pre-trained model. The values of contrast, brightness and colour palettes used in both these types of images are very different. The diagram provided depicts the basic working of the proposed system on various stages of the model functioning.

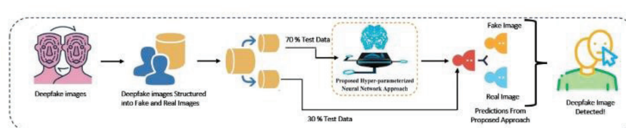


Fig. 2. System Architecture

To begin with, the first module of this plan is about creating the directory for the dataset of images. It contains a diverse dataset of AI-generated images and authentic images, covering various styles, domains, and levels of complexity is assembled. Then, the real and fake images are moved to their respective directories.

This happens based on the specific aspect of AI-generated images (e.g., colour selection, brightness, contrast, white points, chromaticity coordinates, realism, coherence, style, etc.). It include images generated by different AI models, such as GANs, and other state-of-the-art methods. After uploading the required files (in Google colab) preprocessing is done. This cleans the dataset and extract features from it. It also denoises the images to make them eligible for feeding as a dataset. Resize images to a consistent resolution. Augment data if necessary to increase the diversity of the dataset. Used pre-trained deep neural networks (CNNs) to extract high-level features from images. Then, separate test, train, validation subdirectories are formed. The dataset gets splits into two parallel processing stages i.e trained dataset and testing dataset. Split ratios are specified at this stage. After which the list of all images is obtained. Then, we normalized pixel values to a common scale (e.g., [0, 1]). Post this, we created a Dataframe and saved it as csv file. Using respective CNN network, the model is defined. After defining, an empty label to integer mapping is initialized. Then, assigned a unique integer to each label. After mapping the integer to label, integer label is used to normalize. Trained the model on the training set, adjusting hyperparameters as needed. One-hot encoder is used in Resnet to improve prediction accuracies. Examined the model inaccuracies of all the networks and made necessary modifications to boost efficiency. Tried out various regularization strategies, hyperparameters, and architectures. Through this step the image detection is done by predicting whether the image is real or fake. Recognized how the model generates predictions. Made use of interpretability strategies, including model-agnostic approaches or feature importance analysis. To confirm the generalizability of the model, conducted cross-validation. Examined the model's performance over several dataset folds to ensure consistency. We performed all these function one by one on 4 CNN models: Alexnet, Resnet, VGGnet and Xception. In the next step, the accuracy of the models is determined which helps to compare different nets and verify their precision levels. Since model accuracy aids in assessing the model's performance—including its capacity to interpret, comprehend, and even predict future events or outcomes—it is crucial to assess and track it over time. Maintaining an eye on the accuracy of the model is crucial to preventing issues (like model bias) from seriously impairing or even taking over its dependability and performance. Out of all the CNN networks, Alexnet responded in the best possible way to our model. While mentioning the last stage, Prediction, feature extraction using CNN has to be revisited. The relevant features of images were identified before and now in this phase, those extracted features which recognized key patterns of the images to classify them, forms the cornerstone of the prediction task. The features would be compared to those of the input image provided and based on the possibilities of matching levels the image would be predicted as Authentic or Synthetic. How close the desired and obtained results are, is determined by the accuracy levels. Given below is the comparison of accuracy levels of CNN networks which we have used to create this model (Resnet, VGGnet, Xception, Alexnet) on the dataset we gathered and tested on external test data:

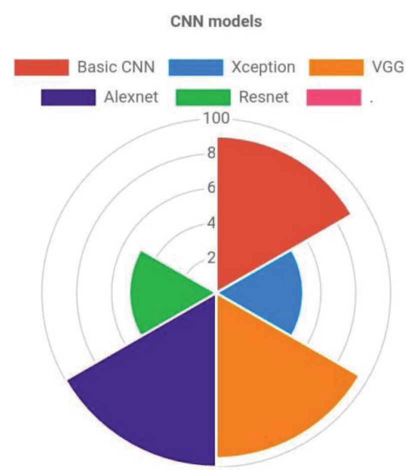


Fig. 3. Graphical Representation of Accuracies of models

CONCLUSION

This research paper consolidates current knowledge on the detection of AI-generated images, offering a comprehensive overview of existing methodologies and their effectiveness. By shedding light on the challenges and proposing future directions, it contributes to the ongoing efforts to fortify the boundaries between synthetic and authentic visual content in an increasingly AI-driven world. The findings presented herein serve as a valuable resource for researchers, practitioners, and policymakers grappling with the implications of AI-generated images across diverse domains.

The work can also be useful to the AI developers to understand the basic features of fake images and mitigate its adverse effects on people by developing something as a solution of this issue.

FUTURE SCOPE

In order to increase accuracy and dependability, deep learning models like generative adversarial networks (GANs) and convolutional neural networks (CNNs) will need to be continuously improved in the future. This will open up new possibilities for an advanced AI image authenticity detector. As the system develops, it should be able to analyze images in a variety of modalities, such as RGB, infrared, and depth maps, increasing its capacity to recognize artificial intelligence-generated content in a variety of visual data. It will be imperative to use dynamic adversarial training strategies to make sure the model is resilient to changing AI-generated image methodologies. Explainable AI will bring transparency to the decision-making process and improve user comprehension. In order to enable the system to recognize AI-generated images in real-world situations, real-time detection and prevention features should be improved. Preventive measures can be turned on automatically or manually. An interface that is easy to use will be crucial. The development and implementation of the detector should incorporate ethical considerations, such as privacy protections and misuse prevention, to guarantee responsible and ethical use in a variety of applications and domains.

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Seasonal and Diurnal Thermal Performance of Extensive Green Roof Substrate in Central India

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ABSTRACT

Green roofs are a passive cooling method that helps reduce a building's interior heating by preventing its walls and roof from absorbing solar radiation. Heat transfer in green roofs is managed through sensible and latent heat fluxes from plants and soil, along with conduction through the soil substrate. The soil substrate and the type of vegetation used play a crucial role in determining the thermal performance of green roofs. This paper presents a comparative study conducted in Amravati, located in the Maharashtra state of Central India. Two types of soil substrates and two types of local vegetation were examined in this study. The study was conducted over a period of one year spanning three distinct seasons of Monsoons, winters and summers. Five wooden test beds were constructed, each featuring a different combination of substrate and vegetation. The objective was to compare the thermal performance of these green roof substrates with varying vegetation types under the climatic conditions of Central India. The results show that during the monsoon season, Bermuda grass effectively reduces thermal variation through substrate layers, with improved performance when mixed with coco-peat. In summer, vegetation lowers top-layer temperatures by up to 20°C, with Bermuda grass outperforming local varieties. The substrate-cocopeat mixture also enhances heat transfer inhibition, creating at least a 10°C temperature difference in bottom layers. The study concludes that combining cocopeat and soil, and pairing the mixture with lawn grass improves thermal performance and heat flux inhibition for green roofs.

KEYWORDS *: Extensive green roof, Heat transfer, Soil substrate, Thermal performance.*

INTRODUCTION

On average, the Earth's surface receives about 950-1000 W/m² of solar energy, which, after atmospheric attenuation, is sufficient to heat city concrete, causing the Urban Heat Island (UHI) effect [1]. By 2050, 68% of the global population is expected to live in urban areas, adding 2.5 billion people, mainly in Asia and Africa (UN, 2018). Rapid urbanization is driving up energy demand, with cooling already accounting for 10% of global electricity consumption. In 2023, India's residential energy use reached 32.58 mtoe, much of it due to space cooling (NITI Aayog).

Green roofs cool buildings by preventing exterior surfaces from heating and reducing indoor heat transfer. Their performance depends on climate factors like temperature, humidity, solar radiation, and the type of vegetation and substrate. Volcanic ash has been investigated as a viable alternative for substrate and its thermal characteristics as a potential substrate [2], and the study reported that volcanic ash's thermal conductivity increases with moisture content and remains stable under fluctuating temperatures. Another study investigating use of coarse recycled materials as a substitute of substrate layer, [3] explored the optimization of the coarse aggregates and compared the thermal resistance of the coarse recycled aggregates with natural coarse materials. The study recommended using recycled coarse materials due to their higher R_c-value, where R_c represents the total thermal resistance of the substrate layer. Researchers have studied the impact of vegetation and substrate mix on the thermal performance of green roofs since both are important factors. A 2017 study by S.vera et al. [4] conducted a parametric analysis to study how does green roof vegetation and substrate affect thermal performance in different climates, including marine (Melbourne) and semiarid (Albuquerque, Santiago). They found vegetation to be more effective than roof insulation due to evapotranspiration, and noted that the substrate's thermal performance depends on its thermal conductivity. Another parallel study in Singapore by C.L.Tan et al. [5] found that K-soil, an artificial substrate, improved temperature reduction, while the water retention layer enhanced the thermal performance of modular green roofs. The Leaf Area Index (LAI) is also an important factor of the vegetation that influences the thermal performance of green roofs.in their study [6] investigated the effect of LAI on net solar absorption to address the lack of green parameters in green roof thermal modeling. The study used simulations with DesignBuilder© to analyze two models, based on assumptions and existing literature. A study in Paris again demonstrated that green roofs reduce diurnal roof temperature fluctuations and lower cooling energy consumption [7]. The study found that semi-intensive green roofs provided better winter insulation and surface heat island reduction than extensive ones. Thicker substrates improved insulation by reducing temperature variations and heat flux fluctuations.

A 2022 study [8] investigated using hydrophilic mineral wool instead of traditional soil in extensive green roofs, focusing on its impact on substrate temperature and thermal performance. A drop of 57% in heat flux was observed while on the other hand a temperature difference of at least 27.5°C was observed in maximum outdoor surface temperatures. Another extensive study by [9] surveyed thirty three different extensive green roofs in southern Ontario, Canada and examined the physical as well as chemical properties of planting media. A study by P.Chen [10] investigated the correlation between meteorological and substrate moisture variables with evapotranspiration (ET) in an attempt to understand their influence on the thermal performance of green roof systems.

The literature is replete with studies that emphasize the use of locally available vegetation and growth substrates for green roof studies. Regarding green roof research specific to India's climate, there are few available studies. This represents a significant gap in the literature on green roofs from an Indian perspective. An experimental study in hot humid climate of southern India's state of Kerala [11] investigated cooling potentials of green facade along with dry and wet coir. The heat mitigation potential of green façade can be increased to at least 40% when used in conjunction with coir mat. However, this study did not specifically considered study of green roof as focused research. Another study on the thermal performance of cool roofs was conducted by [12] which reviewed the application of various surface coatings and their influence on thermal performance of the roofs in different climate conditions. V. Kumar et al. [13] studied green roofs in Kerala, India, in 2016, finding a 17% reduction in room air temperature and a 22% decrease in interior surface temperature. The study also noted reduced diurnal fluctuations and a 2-3 hour thermal lag. Another study published in 2012 [14] experimentally investigated the cooling potential of green roofs in local climatic conditions of Ujjain. The study found that the green roof consistently outperformed the conventional RCC roof in thermal performance. The green roof structure showed a 74% reduction in peak roof thermal transfer value (RTTV) and a 4°C lower interior air dry bulb temperature (DBT) compared to the bare RCC roof. Another parallel studies by Vijayaraghavan et al.[15]–[17] and L.Gowthami et al. [18] were done on green roofs keeping India's climatic perspectives in mind. The studies focused on stormwater runoff benefits of green roofs but did not assess their thermal performance in Indian climates. A significant literature gap is the limited research on green roofs in India, with most studies from the USA, Canada, China, and Germany. This may stem from a lack of awareness about their potential to address rising energy demands for cooling. Also, papers by Indian authors on green roofs are sporadic over the years, indicating a lack of continuous research in this area.

Previous studies highlight the importance of local vegetation and substrates. This study aims to address this gap by evaluating the thermal performance of green roofs in India using local vegetation and substrates, considering the climatic conditions of Central India over a year.

METHODOLOGY

Test Setup and location

The test setup was installed on the rooftop of the Mechanical Engineering Department at Government College of Engineering, Amravati, Maharashtra, India (20.95°N, 77.75°E). Five wooden test beds, each 3×3×1 feet (L×W×H), were built to minimize lateral heat flux. Oriented east-west with a 3° slope for drainage, the test beds were positioned to avoid obstruction from building features or reflected light.

The test beds, labeled I, II, III, IV, and V, were set up with the following layers: (1) a polyethylene sheet for protection and drainage to prevent soil substrate loss from the bottom; (2) a drainage layer of 1 inch of crushed stones, approximately half an inch in size; (3) a filter layer of 1 inch of wooden wool to prevent immediate soil loss with drainage water; (4) a growth substrate layer, about 3 inches deep, comprising two types: common garden soil from a nearby nursery and a mixture of garden soil and coco-peat in a 1:1 weight ratio; (5) a vegetation layer on top, featuring locally sourced grass selected for its low maintenance needs. Two types of grasses were used: a mix of locally growing species, predominantly Paspalum conjugatum, and lawn grass (Cynodon dactylon), commonly known as Bermuda grass, which is widely used for lawns in India. The entire setup and description is depicted in figure II and table I.

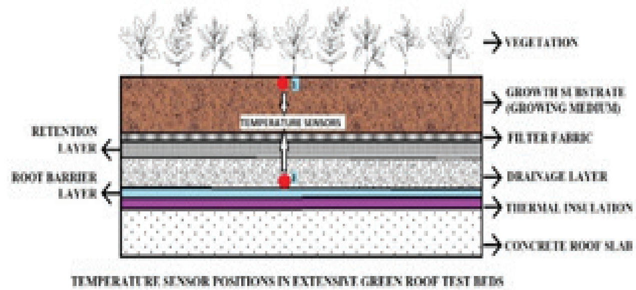
Objective of Study

This study assess the seasonal and daily variations in the thermal performance of green roofs with two types of vegetation and growth substrates. It explores how two meteorological factors — atmospheric temperature and solar radiation — affect the vertical temperature profiles within the substrate. Using this temperature data, heat flux through the substrate was estimated based on specific assumptions outlined in a subsequent section

Table I Description of the Contents of Green Roof Test Beds

Test bed	Growth substrate used	Vegetation
Bed I – Side I	only garden soil	No vegetation
Bed I – Side II	garden soil + cocopeat (1:1 ratio)	
Bed II	Garden soil	Paspalum conjugatum
Bed III	Garden soil	Garden lawn grass
Bed IV	garden soil + cocopeat (1:1 ratio)	Paspalum conjugatum
Bed V	garden soil + cocopeat (1:1 ratio)	Garden lawn grass

Fig. I Positions of Temperature Sensors in Each Test Bed: One at the Topmost Layer and Another Just Below the Drainage Layer



Variables and Measurements

The variables and their methods of measurements are summarized in figure II. The temperature sensors were buried carefully to prevent direct exposure to sunlight. Temperature measurements were collected over three seasons in central India—monsoons, winters, and summers—specifically in July 2023, January 2024, and May 2024. Data was gathered over ten days in each of these months. Each test bed was equipped with two temperature sensors: one placed at the top layer of the soil substrate and one at the bottom layer. The sensor positions are depicted in Figure III.

Fig. II Test Setup Showing Five Test Beds for Green Roofs and its Layers

ASSUMPTIONS AND HEAT FLUX ANALYSIS

Studies on heat transfer in green roofs rely on environmental and biological factors like evapotranspiration (ET) and climatic conditions, requiring assumptions for simplification. While these assumptions ease data analysis, they may differ significantly from actual results. Given that this study focuses on heat transfer through the substrate, the following assumptions were made:

- Steady state conditions: The heat transfer through the substrate is considered to be one-dimensional steady state i.e. from top to bottom layer, ignoring heat flux in other directions
- Uniform Substrate Properties: The porous nature of the soil substrate is ignored and all the layers i.e. growth substrate, retention layer and drainage layer are in series with each other. Also, thermal conductivity, density, and specific heat capacity, are assumed to be uniform and homogenous throughout.
- No heat storage, no lateral heat transfer
- Constant Climatic Conditions: External climatic conditions, such as solar radiation, ambient temperature, and wind speed, are assumed to be constant
- Vegetation effects: This study does not consider the thermal resistance of the vegetation or the shading effect provided by the plants.

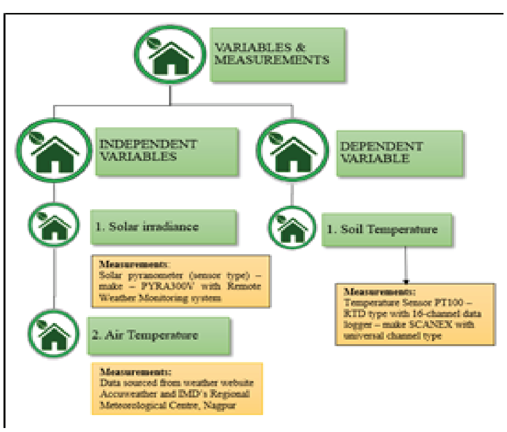


Fig. III Summary of Variables Involved in the Study and their Measuring Equipment

THERMAL CONDUCTIVITY OF THE SOIL SUBSTRATE

Most studies report soil thermal conductivity (k) up to 2-3 W/mK. An experiment determined the garden soil's conductivity to be 1.78 W/mK. This value was derived from temperature vs. time data shown in Figure IV, where soil was heated with a known power input, and the slope of the line between ln(t1) and ln(t2) was used to find k.

Slope $m = (T_2 - T_1) / (\ln(t_2) - \ln(t_1))$ (1)

Thermal conductivity $k = Q / (4\pi \times m)$ (2)

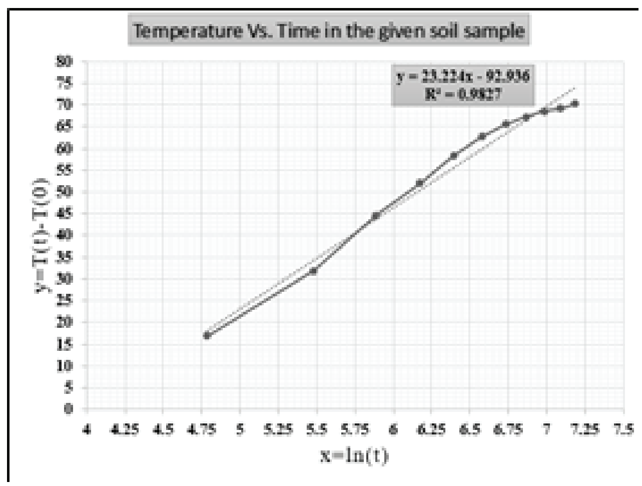


Fig. IV Temperature Difference Vs. Logarithm of Time for the Soil Sample

The equation of the best fit line in the y=mx+c form comes to be:

$Y = 23.224x - 92.936$ (3)

i.e $m = 23.22$

$k = 520/(4\pi \times 23.22) = 1.78$ W/mK

The garden soil's thermal conductivity (k) in the study matches literature values, ranging from 1.5 to 3 W/mK, with higher conductivity due to increased moisture. Solar insolation data for the study periods is summarized in Table II.

Table II Solar Insolation Summary During the Study Periods

Period	Range (W/m²)	Average (W/m²)
Monsoon (July 2023)	100-700	100-400

Winter (January 2024)	100-800	100-300
Summer (May 2024)	200-700	500-600

Table III Total Thermal Conductivity of the Layers

	Thermal conductivity k (W/mK)			
Case\Layer	Soil substrate	Wooden wool	Crushed stone gravel (water saturated)	Total k W/mK
	I	II	III	I+II+III
Common garden soil	1.78	0.05	2.4	4.23
Common garden soil & cocopeat	1.83			4.28

The thermal conductivity 'k' of the soil substrate along with other layers i.e. wooden wool and crushed stone aggregate are summarized in table III. Value of k for cocopeat is sourced from available literature [19]–[22].

RESULTS AND DISCUSSIONS

Diurnal Thermal Behavior for Monsoon Season

Figure V shows the diurnal thermal behavior of test bed I, with two sections having different substrates but no vegetation, exposed to solar radiation. Over 10 days, the thermal time lag was 114 minutes for side I and 83 minutes for side II. Both sides had a 10.33°C temperature difference at the top layer. At the lower layer, side I had a 7.3°C difference, while side II had 8.8°C, indicating that the cocopeat and garden soil mixture in side II was slightly better at reducing heat flux, likely due to its superior heat storage capacity despite higher thermal conductivity.

Figure VI shows the diurnal thermal behavior of test beds II and III, both with garden soil but different vegetation: Paspalum conjugatum in bed II and Bermuda grass in bed III. Vegetation led to notable temperature differences between layers. Bed II had a 66-minute thermal time lag, while bed III had 101 minutes. Temperature variations were 9.4°C for bed II and 8°C for bed III at the top layer, with bottom layer variations of 7.3°C and 5.95°C, respectively. Bed III's smaller temperature variation in the lower layer indicates that Bermuda grass reduces diurnal thermal fluctuations.

Figure VII shows the diurnal thermal variance for test beds IV and V, with thermal lags of 91 and 61 minutes, respectively. The top layer temperature differences were 7.66°C for bed IV and 6.73°C for bed V, with bottom layer differences of 6.88°C and 6.22°C. Despite a shorter thermal lag, bed V (with a substrate mixture and lawn grass) showed better performance due to a notable temperature difference between layers.

Diurnal Thermal Behavior for Winter Season

Figures VIII, IX, and X display the diurnal thermal behavior of test beds I–V, showing minimal temperature differences between substrate layers. Bed I reached peak temperatures of nearly 35°C, while the lower layers for both sides stayed around 22°C. Similarly, beds II, III, IV, and V had low temperature variations, indicating minimal heat transfer due to reduced solar insolation in winter compared to summer and monsoon seasons.

Diurnal Thermal Behavior for Summer Season

Figure XI shows the diurnal thermal behavior of test bed I in May 2024. Without vegetation, both sides I and II heated rapidly, with thermal lags of 60 minutes for side I and 120 minutes for side II. The mixture substrate outperformed soil in delaying thermal flux due to its superior heat storage and moisture content. Figure XII shows test beds II and III, both with garden soil and different vegetation. Vegetation reduced peak temperatures in the top layers by about 20°C. Bed II had an average thermal lag under 60 minutes, while bed III ranged from 60 to 180 minutes, indicating better heat flux inhibition with lawn grass. Bed III also showed a smaller temperature difference, suggesting less heat transfer.

Figure XIII shows the diurnal thermal behavior of test beds IV and V, both using a mixture of coco-peat and garden soil with P. conjugatum and lawn grass. Temperature differences through the layers were at least 10°C lower than in beds II and III, indicating better thermal performance. Both beds IV and V had thermal lags exceeding 60 minutes, highlighting the mixture's superior heat flux inhibition. While peak temperatures in the upper layers were similar to beds II and III, the lower layers showed tighter temperature profiles. Both vegetation types had similar effects, suggesting substrate plays a greater role in thermal behavior.

CONCLUSIONS

Green roofs belong to passive cooling technique passive cooling technique utilizing vegetated roofs to prevent the heat influx into the buildings. Available Literature show a large gap in green roof research in context of India's climate with only handful of studies present. Most green roof research is done in countries like USA, France, Germany, China etc. This study investigated the influence of vegetation type, mainly two types of grasses, and type of substrate used in the green roof on the thermal performance characteristics of green roof test beds. This study is not only an attempt to bridge the available literature gap in Indian context but also investigates the effect of locally available vegetation and soils on green roof performance. The temperature profile results of the study showed that the mixture type substrate i.e. coco-peat and garden soil had a better thermal behavior response as compared to garden soil alone especially in conjunction with garden lawn grass or the Bermuda grass i.e. Cynodon dactylon grass even though the mixture substrate showed a slightly greater thermal conductivity. This means that the substrate mixture has better heat retention properties as opposed to garden soil alone. Further detailed heat flux study will attempt to correlate the heat flux through the green roof with seasonal variations in solar insolation and air temperatures.

ACKNOWLEDGMENT

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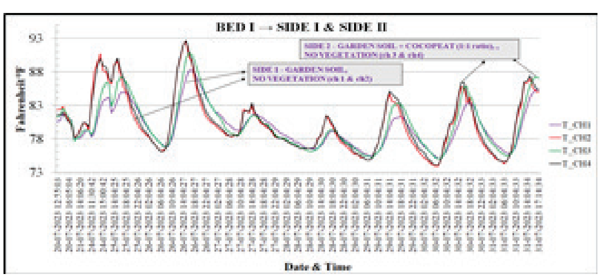

Fig. V Diurnal Thermal Behavior of Green Roof Test Bed I without Vegetation and Two Different Substrates (Monsoon – July 2023)

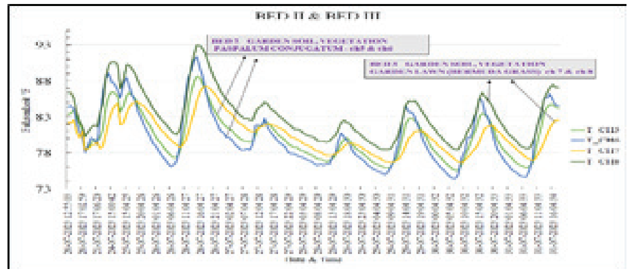

Fig. VI Diurnal Thermal Behavior Of Green Roof Test Beds With Same Substrate (Garden Soil) But Different Vegetation – Lawn Grass And P. Conjugatum Grass (Monsoon – July 2023)

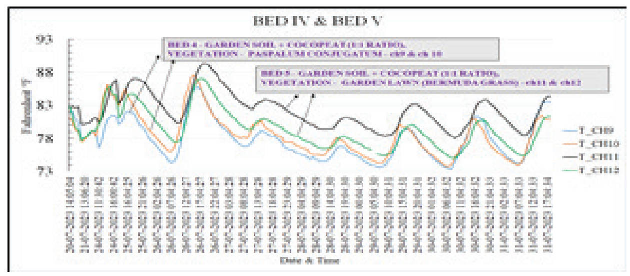

Fig. VII Diurnal Thermal Behavior Of Green Roof Test Beds With Same Substrate (Garden Soil + Cocopeat) But Different Vegetation – Lawn Grass And P.conjugatum Grass (Monsoon – July 2023)

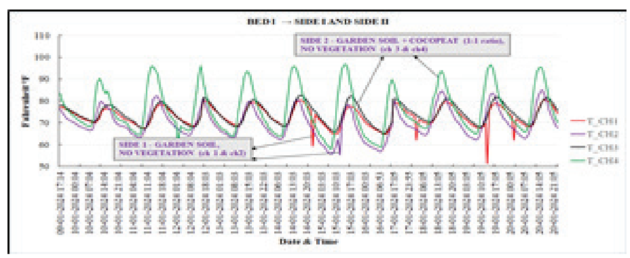

Fig. VIII Diurnal Thermal Behavior Of Green Roof Test Bed I Without Vegetation And Two Different Substrates (Winter – January 2024)

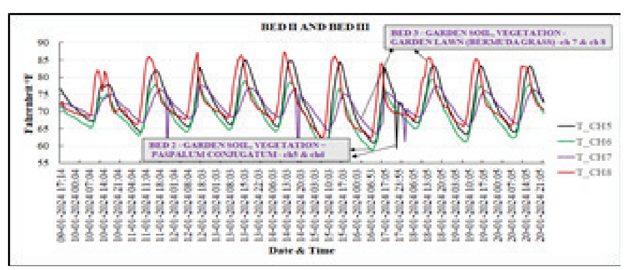

Fig. IX Diurnal Thermal Behavior Of Green Roof Test Beds II and III With Same Substrate (Garden Soil) But Different Vegetation – Lawn Grass And P. Conjugatum Grass (Winter – January 2024)

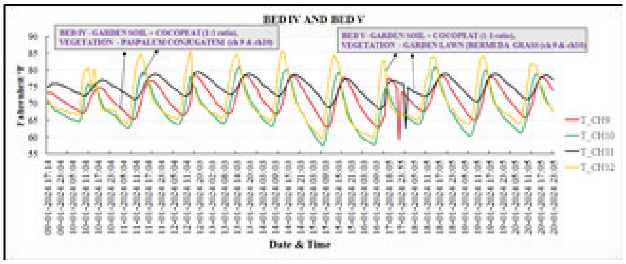

Fig. X Diurnal Thermal Behavior Of Green Roof Test Beds Iv And V With Same Substrate (Garden Soil + Cocopeat) But Different Vegetation – Lawn Grass And P. Conjugatum Grass (Winter – January 2024)

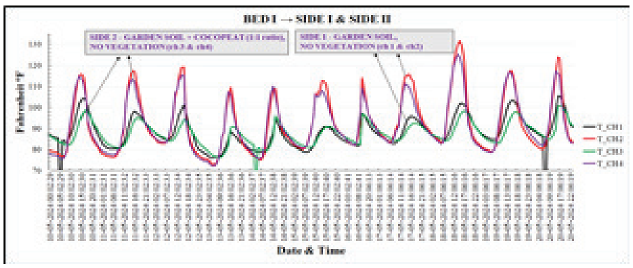

Fig XI Diurnal Thermal Behavior Of Green Roof Test Bed I Without Vegetation And Two Different Substrates (Summer – May 2024)

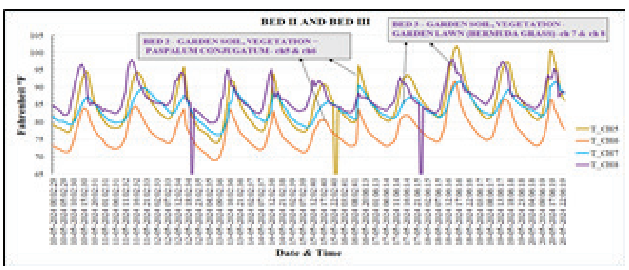

Fig XII Diurnal Thermal Behavior Of Green Roof Test Beds II and III With Same Substrate (Garden Soil) But Different Vegetation – Lawn Grass And P. Conjugatum Grass (Summer – May 2024)

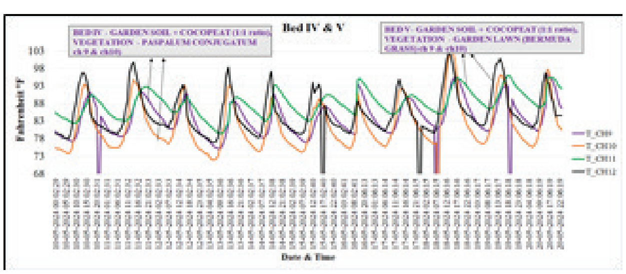

Fig. XIII Diurnal Thermal Behavior Of Green Roof Test Beds Iv And V With Same Substrate (Garden Soil + Cocopeat) But Different Vegetation – Lawn Grass And P. Conjugatum Grass (Summer – May 2024)

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Machine Learning-Based Spam Filter for GitHub Repository Issues

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ABSTRACT

GitHub provides an efficient way to contribute on open-source projects but Open-source projects on GitHub are often plagued by spam issues submitted by users and even helpful issues are frequently posted without relevant tags such as "bug," "feature," or "discussion." Major problem regarding GitHub is that it doesn't have in built spam filter for issues tab. Administrators have to manually label those issues as spam or non-spam. To address these challenges, a machine learning-based approach is proposed that enables repository administrators to fetch issues from their GitHub repositories via URL input, automatically label them, manually edit the labels, remove spam, and ban spam contributors. The approach involves building a comprehensive dataset using the GitHub API, Kaggle, GHArchive, experimenting with machine learning models using MLflow, and implementing a FastAPI server in Python. The user interface will likely be built with Next.js, offering an efficient and user-friendly experience for administrators.

KEYWORDS *: GitHub, Spam, Issues, Filter, Classification.*

INTRODUCTION

GitHub is a web-based platform for version control and collaboration in software development. It's widely used by major organizations to automate and customize their processes. GitHub relies on Git, an open-source version control system, to help developers efficiently manage and track changes in their code. Its powerful features and integration capabilities make it a popular choice among developers, teams, and organizations. GitHub can also be integrated with various platforms for research, deployment, and maintenance of projects.

To collaborate on a repository owned by an organization on GitHub, project managers can invite others as collaborators. Another way to work together on projects is through the Issues Tab available in every repository. GitHub Issues are items or pieces of information created within a repository to plan, discuss, track, and modify work. Issues can be linked to pull requests, helping administrators monitor ongoing changes and updates.

GitHub issues allow project admins to get contributions from others, but they can sometimes attract unwanted content from spammers or irrelevant issues posted by users. However, it might be possible that an issue is posted without relevant tag and hence in such cases admins or moderators need to manually assign tags to those issues. Sometimes, similar issues can be posted by different users and hence they also need to be managed. This can be too much hectic to manage the repository's issues tab as number of issues can be in thousands for a big project. Reading those spam, irrelevant and duplicate issues can be time consuming and hence inefficient. Users sometimes are unaware of issues posted by others as the number of issues can be large and hence unwantedly, they end up creating duplicate issue regarding same feature or bug. While some spam issues can lead to misleading of the entire project as well as they can also cause conflicts of interest.

As GitHub has its own Issues Tracking System, it tracks all the issues from initiation to closing to provide a way to foster effective collaboration on a project. Presence of spam issues can degrade quality of Issue Tracking System and complicates the task of identifying the issues to collaborate on. In competitions like GSoC (Google Summer of Code), it is expected to contribute on some selected repositories where admins or other stakeholders or testers have already created issues regarding any bug or feature, however spam issues may get added by some imposters and hence can mislead the whole competition (GSoC).

GitHub has inbuilt filter based on tags to sort the issues, but the tagging is manual. So, it lacks filtering issues automatically. Hence it would be beneficial is we can add a criterion on which it will automatically classify the issues as "spam", "bug", "feature", etc, by reading and analysing their content. It is harder for a developer to locate the spam present in issues tag. Absence of relevant tags on issue makes it difficult to categorize and prioritize tasks effectively.

A solution is needed to automate this tagging and filtering spam issues by reading their content while simultaneously updating their labels. By integrating machine learning tool, it is possible to automate the process of labelling the issues as soon as it posted by the user. This can reduce manual workload for admins and allowing them to focus on more critical tasks such as code review and feature development.

This solution can be developed either by creating a third-party application where user can enter GitHub repository URL, fetching all the issues from GitHub, then feeding those issues to machine learning model to identify spam issues, label them and display with respective links to repositories to user. These newly displayed issues will be free of spam issues having new labels based on the output of machine learning model. Or a plugin or extension can be integrated with GitHub which will provide a machine learning based filter on issues, by taking them as input. Also, it can label the issues when they get posted by users, based on the content, whether they are "bug", "feature" or "spam".

The goal of this approach is to create an environment for open-source contributors to work effectively with reduced distractions and enhancing productivity and quality of open-source projects. As more data can be collected, the model can be refined and the accuracy of spam detection and issues labelling can increase, leading to more robust and reliable system.

LITERATURE SURVEY

Over the past few years, significant research has been dedicated to exploring various machine learning approaches for identifying spam in SMS messages. Despite the advancements, many of these solutions have not progressed beyond initial classification stages, limiting their maturity and reliability [10, 11]. But no research has been done for studying GitHub spam issues. SMS Spam Identification can be leveraged in detecting Spam Issues in GitHub Repositories.

Zainal et al. [17] developed a Bayesian approach using RapidMiner and Weka tools to test their method on datasets from the UCI repository. Their study found that both tools yielded comparable results when applying the same clustering and classification techniques. El-Alfy and AlHasan [18] aimed to detect spam in both email and SMS environments. They explored numerous techniques and features to identify the most effective features with minimal complexity, utilizing Support Vector Machine (SVM) and Naïve Bayes methods across 11 features. They tested their approach on five datasets containing SMS and email messages.

Hu et al. (2016) [2] proposes a model for detecting SMS spam using content-based features in conjunction with an averaged neural network. Their approach focuses on extracting significant textual features, including word frequency and linguistic patterns, to differentiate between spam and legitimate messages. The use of an averaged neural network, which aggregates the outputs of multiple neural networks, enhances the accuracy of spam detection. The authors demonstrate that their model significantly outperforms traditional models, providing a robust framework that could be adapted for filtering spam issues in GitHub repositories, particularly through content-based feature extraction and neural network techniques.

Chen et al. (2020) [13] introduces a spam filtering technique based on semantics-based text classification. Rather than relying solely on lexical or syntactical features, their approach uses semantic analysis, including techniques such as Latent Semantic Analysis (LSA) and word embeddings, to understand the underlying meaning of the text. This method is particularly effective in contexts where the language of the messages is complex or varied. By focusing on the semantics, the model can more accurately classify spam and non-spam messages, reducing false positives. This approach is highly relevant to the problem of spam detection in GitHub issues, where understanding the context and intent of the reported issues is crucial for effective filtering.

Metsis et al. (2006) [3] explore the effectiveness of various Naive Bayes algorithms in spam filtering within their paper, "Spam Filtering with Naive Bayes – Which Naive Bayes?". The authors compare different implementations of Naive Bayes, including Multinomial, Bernoulli, and Gaussian variations, to determine which is most effective in identifying spam. Their study involves rigorous testing on standard datasets, and they find that the performance of these algorithms can vary significantly depending on the characteristics of the spam and ham (non-spam) emails. Metsis et al. conclude that while all Naive Bayes variants provide a solid foundation for spam filtering, the choice of algorithm should be carefully tailored to the specific application and dataset characteristics to achieve optimal results. This research underscores the importance of selecting the appropriate machine learning model and highlights the potential of Naive Bayes classifiers in the context of text-based classification tasks such as spam filtering.

Puniškis et al. (2006) [4] investigate the effectiveness of artificial neural networks (ANN) in recognizing and filtering spam emails. In their study titled "An Artificial Neural Nets for Spam E-mail Recognition," the authors develop a neural network-based model aimed at accurately distinguishing between legitimate emails and spam. The proposed system utilizes various features extracted from email content, such as textual patterns, frequency of certain keywords, and structural characteristics, to train the ANN for classification tasks.

The researchers likely conducted extensive experiments using a dataset comprising both spam and legitimate emails to evaluate the performance of their model. The results demonstrate that the ANN approach achieves a high accuracy rate in spam detection, outperforming some traditional filtering methods. Puniškis et al. (2006) [4] also discuss the adaptability of neural networks in handling evolving spam tactics by retraining the model with updated datasets, highlighting the system's robustness and scalability.

In the article RepoCleanup[1], I explored the development of the Repository Cleanup Tool, a machine learning-based system for managing GitHub issues by identifying spam and automating issue labeling. The tool utilizes the GitHub API and NLP techniques like word embeddings and feature extraction. The article discusses the tool's performance in data collection, preprocessing, and model training, with planned features such as duplicate detection and relevancy ranking (Msa, 2023). This work highlights the practical application of machine learning for open-source project management.

This study contributes to the field of email security by showcasing the potential of machine learning techniques, particularly artificial neural networks, in enhancing spam detection mechanisms. The findings support the integration of ANN-based models into email filtering systems to improve accuracy and reduce false positives, thereby ensuring more reliable and efficient communication channels.

PROPOSED METHODOLOGY

The development of the Repository Cleanup Tool will follow a structured methodology, starting with data collection and preprocessing, moving through feature extraction and data analysis, and culminating in model selection, training, and implementation.

Data Collection and Preprocessing

Data Collection kicks off by leveraging the GitHub REST [5] API, accessed through Python libraries such as requests and PyGitHub. This API facilitates the automated gathering of many issues from various repositories, capturing key details like issue titles, descriptions, labels, timestamps, and contributor information. To enrich the dataset, additional data from platforms like Kaggle [6] is integrated. Using pandas, these external datasets, which often come pre-labeled, help diversify and strengthen the overall data pool.

Following collection, Data Cleaning is undertaken to remove inconsistencies and ensure the dataset's integrity. Duplicate issues, which could skew model training, are identified and removed using pandas and NumPy's data manipulation capabilities. Handling missing data is another critical task—depending on the type of missing information, records are either completed using imputation techniques or discarded entirely. Libraries like scikit-learn and pandas play a key role in this. For text standardization, Natural Language Toolkit (NLTK) and spaCy are used to convert text to lowercase, remove special characters, and normalize punctuation. These steps help in reducing noise and ensuring uniformity across the dataset.

In the Data Preprocessing phase [9], the text data undergoes further refinement. Tokenization, carried out using spaCy and NLTK, breaks down text into individual words or tokens, enabling more detailed analysis. To improve model efficiency, stopwords—common but insignificant words like "the" and "and"—are removed using predefined lists from NLTK and spaCy. Additionally, techniques like stemming and lemmatization reduce words to their base forms, lowering dimensionality and helping the model generalize better. The final step in preprocessing is vectorization, where the cleaned text is transformed into numerical vectors using methods like TF-IDF, Word2Vec, or BERT [8]. These vectors capture the semantic meaning of the text, making them suitable inputs for machine learning algorithms.

To create a reliable dataset for supervised learning, some of the data undergoes Manual Labeling. This involves manually tagging issues with labels like "bug," "feature," or "spam" based on their content. The pandas library and custom Python scripts are typically used for this purpose. This labeled data is essential for training and validating models. To speed up the labeling process while maintaining accuracy, semi-automated labeling tools or custom scripts may also be used.

Feature Extraction

Textual Feature Extraction is the initial step in this phase, focusing on capturing the linguistic and semantic nuances of the issues. One common technique used is Term Frequency-Inverse Document Frequency (TF-IDF), which measures the importance of words within the dataset relative to how often they appear across all documents. This method helps highlight terms that are particularly relevant to specific issues, making them valuable for classification. Additionally, more advanced methods like Word2Vec and BERT (Bidirectional Encoder Representations from Transformers) are employed to generate word embeddings. These embeddings are dense vectors that capture the semantic meaning of words, enabling the model to better understand and interpret the relationships between words, which significantly improves its ability to accurately classify issues.

Contextual Feature Extraction goes beyond just the text by incorporating metadata and other contextual information that can further enhance the model's performance. For example, analyzing the contributor's history can reveal patterns in their previous submissions, which might indicate the quality or relevance of new issues they submit. This historical data allows the model to assign varying levels of importance to issues based on the contributor's past behavior. Another crucial contextual feature is issue similarity; by using cosine similarity or other metrics, the tool can evaluate how closely related a new issue is to existing ones. This is particularly useful for identifying duplicate issues or grouping similar issues together, which helps streamline issue management.

Given the often-high dimensionality of textual data, Dimensionality Reduction techniques might be applied to manage the number of features while retaining the most critical information. Methods like Principal Component Analysis (PCA) or t-Distributed Stochastic Neighbor Embedding (t-SNE) are used for this purpose. PCA, for instance, transforms the original features into a set of linearly uncorrelated components, which simplifies the data without losing much information. On the other hand, t-SNE is especially helpful for visualizing high-dimensional data in two or three dimensions, making it easier to interpret the relationships between different features.

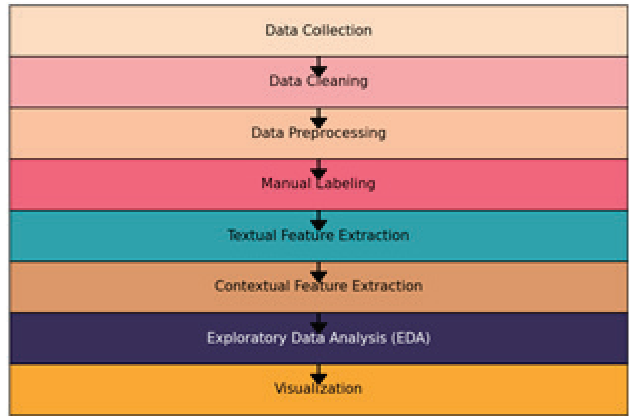
By combining textual and contextual feature extraction, and applying dimensionality reduction when needed, the machine learning model gains access to a rich set of relevant features. These features are essential for accurately classifying and managing issues within GitHub repositories, as they encompass both the content and context of the issues. This comprehensive approach to feature extraction is crucial to the overall success of the Repository Cleanup Tool, ensuring it delivers precise and reliable results in the automated management of repository issues.

Data Analysis

Exploratory Data Analysis (EDA) kicks off with visualizing the dataset to spot trends and anomalies. For instance, word clouds are used to visually represent the most frequently occurring terms within the issues, allowing for quick identification of common themes or topics. This offers a clear view of the types of issues that are most prevalent. Additionally, histograms and bar charts are used to visualize the distribution of various labels (like "bug," "feature," "spam") and to understand how often different types of issues occur. These visualizations help detect any imbalances or biases in the dataset that might need correction before model training.

The Type-Token Ratio (TTR) is calculated to measure the variety in the vocabulary used across the dataset. A high TTR suggests a wide range of language and potentially a diverse set of issue types, whereas a low TTR might indicate repetitive or standardized language. This ratio helps determine if the dataset is rich enough to support the development of a robust machine learning model. Additionally, n-gram analysis is conducted to identify common sequences of words (like bigrams or trigrams). This analysis can uncover phrases or terms that are often linked to specific issue types or spam, providing extra features that can improve the model's accuracy.

Statistical Analysis is key to understanding how different features in the dataset relate to each other. Tools like correlation matrices and heatmaps are used to visualize and measure these relationships, such as the link between the presence of certain keywords and the likelihood of an issue being marked as spam. By identifying strong correlations, this analysis highlights which features are most predictive of the target labels, helping to guide feature selection for the machine learning models. Additionally, the frequency distributions of the labels are examined to ensure that the dataset is balanced and accurately represents the different issue types, which is vital for preventing model bias.



Model Selection and Training

Model Selection starts with exploring and comparing various machine learning algorithms to identify the best fit for the task. This process includes testing algorithms such as Naive Bayes, Support Vector Machines (SVM), Random Forests, and Neural Networks. Each of these algorithms offers unique benefits and challenges. For instance, Naive Bayes is favored for its simplicity and efficiency, especially useful for text classification with many features. Conversely, SVMs and Neural Networks excel at capturing complex patterns in data but may demand more computational power and fine-tuning. By experimenting with multiple algorithms, you can determine which one best suits the dataset's characteristics.

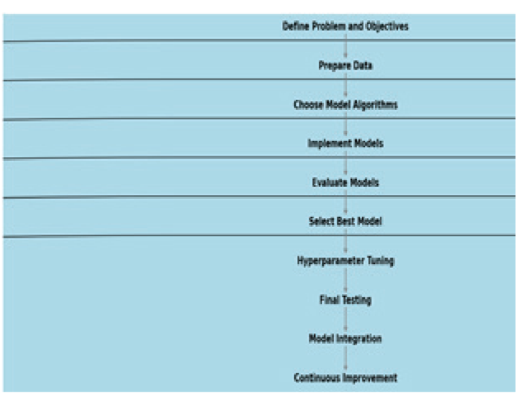
Training and Validation involve dividing the dataset into training, validation, and test sets—typically in a 70-15-15 ratio. The training set is used to build the models, while the validation set helps evaluate their performance and adjust hyperparameters. To ensure that the model generalizes well, techniques like k-fold cross-validation are used. In k-fold cross-validation, the training data is split into k subsets (folds), and the model is trained k times, each time using a different fold for validation and the rest for training. This approach helps prevent overfitting and offers a more accurate performance estimate on new data.

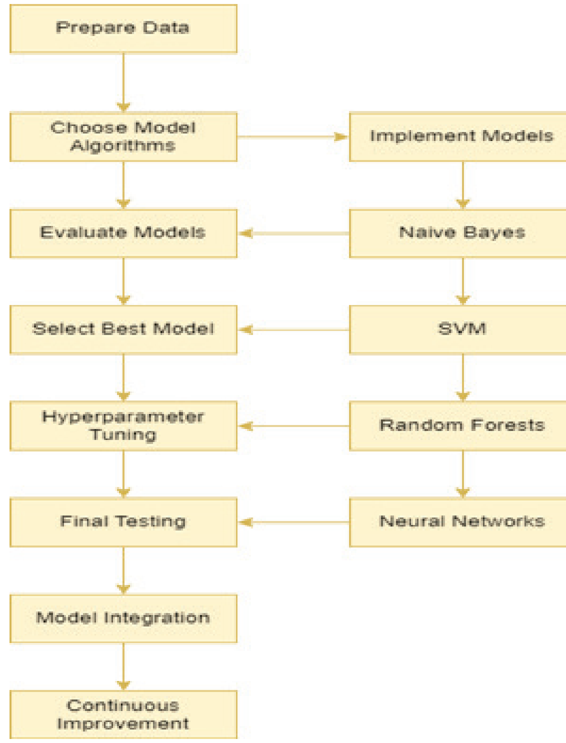
Hyperparameter Tuning is essential for optimizing the model's performance. Hyperparameters, which include settings like learning rate, regularization strength, and neural network layers, are fine-tuned using methods like Grid Search or Random Search. Grid Search explores a set of predefined hyperparameter values to find the best-performing combination, while Random Search samples from the hyperparameter space randomly, often leading to quicker optimization. Proper tuning of these hyperparameters can significantly enhance the model's accuracy.

Model Evaluation involves assessing the performance of the trained models using the validation set. Performance metrics such as accuracy, precision, recall, and F1-score are analyzed to gauge how well the model distinguishes between different issue types, including spam. Confusion matrices are also reviewed to understand the types of errors (e.g., false positives, false negatives) the model makes, providing insights for further improvement. Tools like MLflow can be employed to log and track results across various experiments, facilitating a systematic comparison of model performance.

Selecting the Best Model concludes this phase. The model showing the highest performance based on the evaluation metrics is chosen for deployment. This selected model is then retrained on the combined dataset (training and validation sets) to leverage all available data, ensuring it is fully optimized.

Following this, the Deployment and Monitoring phase begins, where the final model is integrated into the Repository Cleanup Tool. Continuous monitoring of the model's performance in a live environment is crucial to maintain its effectiveness over time. Real-world feedback and new data are used for periodic retraining, ensuring that the model remains accurate and responsive to evolving patterns in repository issues. This ongoing process ensures that the Repository Cleanup Tool continues to provide reliable and precise issue management.





Implementation of the Repository Cleanup Tool

Implementation as a GitHub Plugin

- Seamless GitHub Integration: [5] This approach embeds the Repository Cleanup Tool directly into the GitHub platform as a plugin. By leveraging GitHub's API and webhook capabilities, the tool integrates smoothly with repositories, allowing it to automatically monitor and classify issues as they are submitted. Users can stay within the familiar GitHub environment, with the tool working behind the scenes.
- Real-Time Issue Classification: When an issue is posted, the plugin activates the machine learning model to classify it on the spot. It can automatically apply labels like "bug," "feature," or "spam," and deal with spam issues as they arise. Administrators are notified of any issues that might need manual review, ensuring efficiency while still allowing for human oversight.
- User-Friendly Interface and Settings: The plugin would include an easy-to-use interface within GitHub, where administrators can adjust settings—like spam detection sensitivity, label customization,

and what to do with flagged issues. This interface might be built with React.js, with backend processes managed by Node.js or Python, depending on the complexity of the required interactions.

- Deployment and Updates: The plugin would be packaged as a GitHub App or Action, making it easy to install directly into any repository. Ongoing updates and maintenance could be handled through GitHub's marketplace or directly via repository updates, ensuring the tool stays up-to-date with new GitHub features and user needs.

Implementation as a Standalone Web Application

- Flexible Web Application Development: Alternatively, the tool could be built as a standalone web application that connects to GitHub via API. This method offers more flexibility, allowing users to manage and classify issues across multiple repositories from a single, centralized platform.
- Intuitive User Interface: The web app would have a clean, intuitive UI, possibly built with React.js or Angular, making it easy to input repository URLs, fetch issues, and apply the machine learning model. Results, including labels and spam flags, would be presented in an organized dashboard, with options for manual corrections and bulk actions.
- Robust Backend Infrastructure: The backend could be developed using frameworks like Django or Flask, managing all interactions with GitHub's API, processing issues, and storing results. The machine learning model would be integrated here, ready to classify issues as needed. For scalability, especially when handling large repositories or multiple requests at once, the application could be hosted on cloud platforms like AWS or Google Cloud, using Docker and Kubernetes.
- Comprehensive Data Management and Reporting: The web app would also include strong data management features, allowing users to save classified issues, track trends over time, and generate reports on repository health. This is especially useful for large organizations managing multiple repositories, providing valuable insights into their issue management processes.

Comparing the Approaches

- The GitHub Plugin is ideal for users who want a solution deeply integrated into the GitHub environment. It's straightforward to deploy for individual repositories and offers the convenience of staying within GitHub, though it might be less customizable and not as well-suited for managing issues across many repositories.
- The Standalone Web Application offers more flexibility and is better for handling multiple repositories, providing advanced features like reporting and bulk actions. However, it requires users to work outside the GitHub environment, which may not be as convenient for those looking for a one-stop solution within GitHub.

Future Enhancements

Relevancy Ranking of Issues

- Objective: Prioritize issues based on relevance, helping administrators focus on critical tasks.
- Approach: Implement machine learning models like Gradient Boosting to rank issues by impact, urgency, and relevance, with a UI for sorting and filtering within GitHub or the web app.

Duplicate Issue Detection

- Objective: Eliminate clutter by detecting and consolidating duplicate issues.
- Approach: Use similarity algorithms (e.g., cosine similarity, BERT embeddings) to identify duplicates, automatically merging them or flagging for review, with a clear visualization interface.

Enhanced Spam Detection with Adaptive Learning:

- Objective: Continuously improve spam detection accuracy.
- Approach: Implement a feedback loop for users to mark incorrect classifications, enabling the model to adapt in real-time. Allow customizable spam filter settings for different repository needs.

Advanced Reporting and Analytics

- Objective: Provide deeper insights into repository activity.

- Approach: Develop customizable dashboards and exportable reports to track metrics like issue resolution times and trends, with tools for historical data analysis.

Integration with CI/CD Pipelines

- Objective: Automate issue management within the development process.
- Approach: Create CI/CD hooks to classify and manage issues during deployment, integrating with tools like Jenkins and GitLab CI/CD for timely notifications and actions.

These enhancements aim to make the Repository Cleanup Tool more adaptable, intelligent, and integrated, ensuring it remains a vital resource for managing GitHub repository issues efficiently.

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Analysing and Evaluation of E-Commerce Products using Data Mining Strategies for Improved Business Activities

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ABSTRACT

E-commerce is the online transaction which exchanges goods and services over internet. Analysis of customer transactions is the key that identifies the purchase patterns. In Data mining process clustering, classification, association rule etc. are performed technically. WebCrawler/Scraper is used for comparison website by collecting large amount of data from E-commerce website. WebCrawler is efficient in terms of fetching URLs in minimum time like this fetched URLs are stored in the database. Comparison website will only act as a mediator. In this way, paper helps the customer to find the best deal with cheapest price by saving time and money.

KEYWORDS *: Data mining, Hadoop, Big data, Association rule algorithm, Top-K rules algorithm, Mapreduce algorithm.*

INTRODUCTION

In this paper, Large numbers of dataset are categorized in Ecommerce Product. Data are mined and stored but they are in irrespective format. Applicability is more important rather than the storage.

Association rule extracts patterns, correlations, relation among items in the transaction data store or other database. Drawbacks are large number of confidences and supports, overcome this Top-k Association rules and Fibonacci Heap sort algorithm are used. Distributed Data is used by Map Reduce Algorithm and works equally in distributed system and also it is not depend of backend technology.

Big data describes large or complex data which is structured or not structured. Shows hidden patterns, unknown correlated and other much needed information for best decision to be make in future. Big data is a datasets with large or complex Data Processing Applications which is not in adequate form. Hadoop Distributed File System (HDFS) is an open source code and java based programming framework and Stored large datasets in distributed computing environment.

RELATED WORK

Some papers describes related work. Cheng-Wei Wu, Philippe Fournier-Viger, and Vincent S. [1], studied the Apriori Association rules and they found numbers of sequential rules generated and took long execution time and memory consumption exceeded. To sort out these issues Top Rules algorithm was proposed. TopKRules used Fibonacci issues Top Rules algorithm was proposed. TopKRules used Fibonacci heap algorithm for expansion of Left and Right. Experimental results shows alternative classical association rule mining algorithms which are advantageous and generated rules are controlled by the powerful user. Drashti B Patel[2] studied that in algorithm users select the parameter of confidence and support. This algorithm had specific and exact rules for how much user want, before they had an issue of more memory consumption and didn't had exact execution time. Proposed algorithm was advantageous and totally dependent upon the user.

Luo Fang et.al [3], proposed an items which was generated frequently in association rule mining. Mining Data Pattern was crucial. As we know Apriori algorithm was proposed for the generation of frequent item sets, but was not satisfied with the constraint of time.

JongWook Woo [4] proposed Apriori Map/Reduce Algorithm and algorithm had time complexity and extreme higher performance then sequential algorithm with the use of map and reduce nodes. For market analysis, itemsets produced Association Rules. Code was implemented with the help of Hadoop frame and was practically proved the proposed algorithm.

Michael R Bayes & Morgan [05] analyses the limitation of the product of Ecommerce website, it's totally depend on user decision. They found Value of Information after the comparison of website and also the lowest product price. Users ignored that firm decides product price and whether to list it or not it's their decision.

PERFORMANCE METRICES

Association Algorithm using Top k rules

TopKRules discovers the Top-k Association rules appear in a transaction database. TopKRules solves problem by number of rules to be discovered without using minimum support and directly indicating k. Main Three Parameters of TopKRules are transaction of database, parameter k represents how many association rules are discovered(in a positive integer), parameters minimum confidence that shows association rules should have value in percentage or in [0,1]. Top K association discovers associations between items in a transaction database item set.

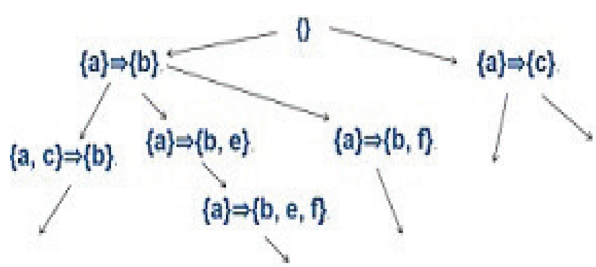

Fig. 1. Left-Right Expansion

An Algorithm evaluates and shows good performance and scalability. Algorithm takes minimum confidence and input as transactional database then generates k number of output.

Convert ARFF (Attribute relation file format) into SPMF (java open source data mining library) format. ARFF supports transaction database as input if and only if it have algorithm. ARFF format represent as strings and SPMF format use as an integer.

Table 1 Dataset

Transaction Trid	Tr Items
tr1	{1, 2, 4, 5, 6}
tr2	{2, 3, 5}
tr3	{1, 2, 4, 5}
tr4	{1, 2, 3, 5, 6}
tr5	{1, 2, 3, 4, 5}
tr6	{2, 3, 4}

The tritems{1 6} has a support of 34 % because it appears in 2 out of 6 transactions.

Supp(1,6)=Supp(1)USupp(4)/Trans(6)

Confi(1,6)=Supp(1)USupp(4)/Supp(1)

Association rule Y--> Z is an association between two itemsets Yand Z that are disjoint

The top-k association rules are the k frequent association rule have a confidence higher or equal to minimumconf.

MapReduce paradigm executed in three stages Map, Shuffle and Reduce.

In table 2.1, with k = 2 and miniconf = 0.8, got the top-2 rules in the transaction having a confidence higher or equals to 80 %.

1=>2, which have a support appears in 4 sequences & 82% Confidence

2=>1, which have a support appears in 4 sequences & 100% confidence

Topk Rules algorithm will support of 82 % because it appears in four transactions (Support1, Support2 and Support3) out of the six transactions in this dataset. TopKRules is expensive then Association Rule mining. Top K Rules is always recommended for k values.

Map-Reduce Algorithm

The Map and Reduce processes are described in parallel by MapReduce. There are two functions in its library: Reduce and Map. Map generates a series of intermediate key pairs from a written pair of user input. Algorithms divide enormous problems into smaller problem spaces, and little tasks are then responsible for their implementation. A Java programming model called MapReduce is employed in distributed computing.

The two key tasks of an algorithm are Map and Reduce. A map takes a set of data, converts it into another set, and then breaks each set into individual tuples (key/value pairs). The MapReduce process is then implied after taking the output from the map and combining the data into a smaller collection of tuples.

While performing MapReduce job, Map and Reduce tasks is send to Server in the cluster with the help of Hadoop. In this Hadoop manages framework all details of task, verifying the task completion, copying data between the nodes around the cluster. Reduces network traffic takes place on node.

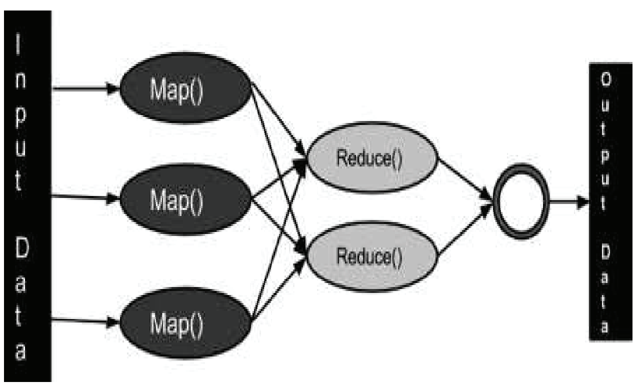

Fig. 2 MapReduce Processing

MapReduce process is done in three stages which are shown in figure.1.2

Map Stage: The information that is input is evaluated line by line by the mapper function after being processed and saved as a file or directory in the Hadoop file system.

Reduce stage: This phase combines the reduction and shuffle phases. Reducer processes data from mappers, creating new outputs that are then stored in the Hadoop Distributed File System.

E-Commerce (Mining Elements)

Electronic commerce refers to carrying out online business transactions over the internet. E-commerce satisfies customer demands and settles transactions by providing applications. Entrepreneurs does not need to have a physical premise or shop, only it require website or application to show products details like price, availability, so that user can do online transactions. Nowadays many E-commerce applications are used by user; one product of one specific brand is available in all application with different price.

Web Crawler

A web crawler is an engine that compares prices and gathers vast amounts of data from many e-commerce websites. The best way to obtain data from e-commerce websites is to navigate them as manual data collection is not feasible. Fetched URLs are transferred to the scrapper for the scrapping process. An Internet bot does methodical Web searches. Web search engines employed web crawling, also known as spidering, to update their material. For easier browsing for users, pages that are downloaded are copied for processing at a later time. Without consent Crawlers come and go through resources. Issues with schedule, courtesy, and load times arise when a big collection of pages is accessed.

Web Scrapping

Web Scrapping extracted the HTML data from Uniform Resource Locators. Python libraries are requests and beautifulsoup4, which are used for parsing html pages. Product information from different e-commerce sites are scrapped and stored in database. The web scrapping is the collection of information from the website using computer software programmatically.

Following job completion, the cluster gathers, compresses, and processes data before returning to the Hadoop server with the precise outcome.

Four basic transformations take place. Data transformation from input files sent to the mappers, who then perform the transformation arranged, combined, and delivered to the reducer

Diminished Written files for transformation and output

Driver: Driver is the mediator, collect the input data and send to Mappers. Input and Output types should matched or MapReduce code will not work.

Mappers:

Input format=TextInputformat

Key=LongWriteable

Input value=Text

TextInputFormat is input type to the Mapper class. Using this format, the key from the record associated with Text Input Format is the byte offset into the file (Long Writeable).The value from the record is the line read from the input file, in Text.

Reducer: Text is the output key from the Mapper class, so the input key must be Text for Reducer class. Likewise, Text is value from Mapper class, and the input value must be Text to the Reducer class.

Data scrapping on a website without permission is illegal Aim of the web scrapping is to reduce time and money spent manual scrapping.

CONCLUSION

Nowadays, the use of internet is increased and the e-commerce is the vast area on the network. So the searching of various products through the e-commerce websites is more easy because of sorting of products. Memory consumption and execution time are the basic problem in algorithm. The users can get the product with the deals like discounts on the products, sometimes can buy a product by using coupons and payment options are available for the consumers like cash on delivery, online payment and so on. The product of their choice can be obtained by the Powerful User without wasting time, money, or other resources. The goal is to deliver effective data that puts consumers' power to buy authentic goods at authentic prices in their hands while sparing them time, money, and effort.

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Enhancing Data Security and Privacy in IoT Ecosystems using Cryptographic Hash Functions

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ABSTRACT

As the fast-paced development of connected ecosystems and the growing IoT deployment scale, ensuring robust Security and privacy have emerged as critical priorities. The diverse range of IoT applications, from smart homes to healthcare, faces numerous challenges, including secure communication, data integrity, and user privacy. Cryptographic hash functions play a crucial role in tackling these challenges by safeguarding data integrity, secure authentication, and non-repudiation. This paper explores the application of cryptographic hash functions tailored specifically for IoT environments. It provides an overview of the unique security requirements of IoT, followed by an analysis of traditional hash functions like SHA-1 and SHA-2, highlighting their limitations in resource-constrained environments. The study further delves into the development of lightweight and efficient cryptographic hash functions, such as SHA-3 and emerging alternatives, which are optimized for the low power and limited computational capacity of IoT devices. A comprehensive assessment of these hash functions is conducted through statistical, performance, and fault analysis within a simulated IoT system. The findings highlight the balance between security, efficiency, and performance, offering best practices for choosing appropriate hash functions in IoT implementations. The study concludes that lightweight cryptographic hash functions provide a balanced solution, offering robust security while preserving the limited resources of IoT devices.

This alternative focuses on the specific use case of IoT security, shifting the focus from the general evolution of the SHA family to the practical application of hash functions in securing with limited resources, it highlights the importance of maintaining a balance between security and efficiency in IoT systems.

KEYWORDS *: Data summary, Encryption hashing, Lightweight hash functions, Safeguarding algorithms.*

INTRODUCTION

The Internet now serves a multitude of personal, professional, and societal purposes, making it indispensable to modern life. Because of this, It is imperative for maintaining security of data communicated online, especially since an ample portion of this proprietary information must be safeguarded against unauthorized access. The rapid evolution of technology has intensified concerns about safeguarding this information from malicious entities who may attempt to intercept data in transit or compromise data stored in distributed systems like cloud storage. Therefore, ensuring data security is crucial for protecting the assets of individuals and organizations alike.

Data security involves implementing both preventive and defensive mechanisms to guard against unauthorized access and tampering. Cryptography, a cornerstone of information security, offers robust techniques for maintaining data privacy and integrity. By enabling secure communication channels between users, Cryptography guarantees that only authorized individuals can access the secured content. However, the field of cryptography has a complex history filled with both breakthroughs and setbacks. Over time, various cryptographic techniques have been developed and subsequently broken, leading to the continuous evolution of stronger security measures.

Cryptographic hash functions are a critical component of secure communication, providing a mechanism to ensure data integrity, authenticity, and non-repudiation. These algorithms produce a predetermined hash size, or condensation is generated from the input data, making it computationally challenging to recognize two disparate inputs which yield identical token or to reverse-engineer the original data from the hash.

Applications of hash functions span multiple domains, such as ensuring data integrity, generating digital signatures, storing passwords, and facilitating cryptocurrencies.

RESEARCH FOUNDATION

The incorporation of hashing mechanisms is fundamental to the design of most security applications. In fundamentals, a hash function is a mathematical procedure that converts data, usually about varying span, within a compact result of a fixed dimension.

This result serves as a unique representation of the original data and is referred to as the hash value or digest, a hash function, as illustrated in Fig. 1, accepts input messages of different lengths and, regardless of the input size, generates a hash output of consistent, fixed length.

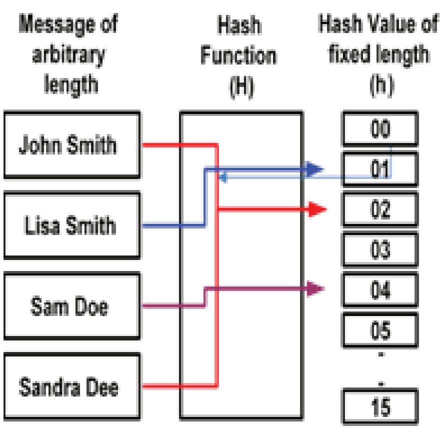


Fig. 1: Conventional Hashing Mechanism

For a hash function to serve as an effective cryptographic tool, it must exhibit certain critical properties. Preimage resistance is a crucial property that ensures a hash function cannot be feasibly reverse-engineered to retrieve the original input from its hash output [3]. This characteristic is crucial for protecting against attackers who have access to the hash value and are attempting to discover the original source data. The subsequent essential feature is resistance against secondary inverse attacks, the one that makes it very difficult to identify "A different input that generates an identical hash value as a given input." [4]. This property is vital for defending against attackers who possess both the original input and its corresponding hash value, as it prevents them from finding another input with the same hash.

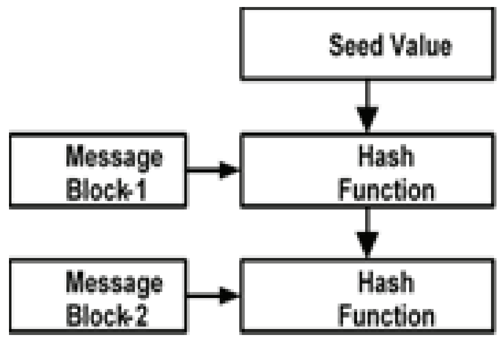


Fig. 2: The hash creation process

"The procedure illustrated in Fig. 2 is commonly referred to as the snowball effect in checksum generation [5]."This effect occurs because the hash value from one block impacts the subsequent hashing operation. The avalanche effect is essential for cryptographic hash functions, as it ensures that input patterns remain undetectable in the hash output.

This property is essential for data confidentiality and integrity, making hash functions useful in data storage, verification, and secure communications. Consequently, even a minor modification in the input will result in a substantial change in the hash output. Furthermore, different hash algorithms and functions use distinct methods for constructing hashes, which affects their performance and security characteristics. A hash algorithm encompasses the entire procedure of processing and dividing the message into blocks. In addition, it specifies how the output of each message block affects the subsequent blocks, creating a connection between the original message and the final hash value. This chaining process ensures that even minor changes in the input produce vastly different hash values, which is essential for detecting alterations and maintaining data integrity.

SHA FAMILY

Hashing has been widely adopted to enhance security across various applications [6], [7], [8], [9], [10]. A hashing algorithm serves a vital function in confirming data authenticity, ensuring it comes from a valid source and remains unchanged during transmission [11] Over time, numerous algorithms have been developed to generate hash values, though not all have gained acceptance. Some were discarded due to vulnerabilities, while others have been established as standards. Instead of saying

Among the different hashing algorithms, the Message Digest (MD) family and Secure Hash Algorithms (SHA), including (SHA-1 and SHA-2), are some of the most well-known and frequently used for producing hash values.

Hashing Algorithm

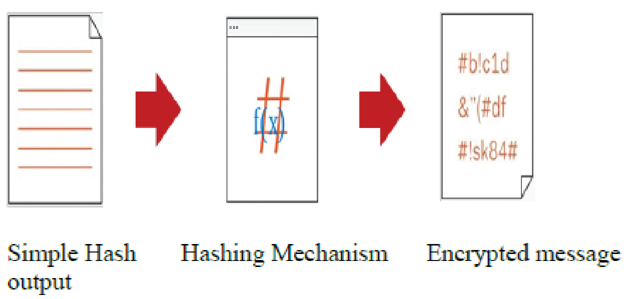


Fig. 3: A Standard Hash Algorithm Process

1. A checksum function is a computational operation which accepts input data of any length and generates a fixed-length hash value. The operation of a hash algorithm can be mathematically represented as follows:
2. $H(fx)\colon \{0,1\}^* \rightarrow \{0,1\}^n$ (1)
3. When expressing (1), $\{0,1\}^*$ represents the array of elements, including the zero-length string, of any length while $\{0,1\}^n$ denotes elements that have a length of n.
4. Hence, a cryptographic function transforms a collection of elements of arbitrary length into piece of fixed span.

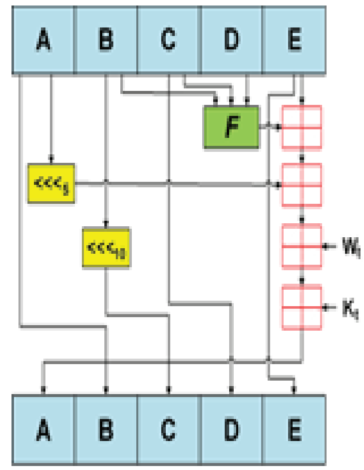


Fig. 4: One SHA-1 Round

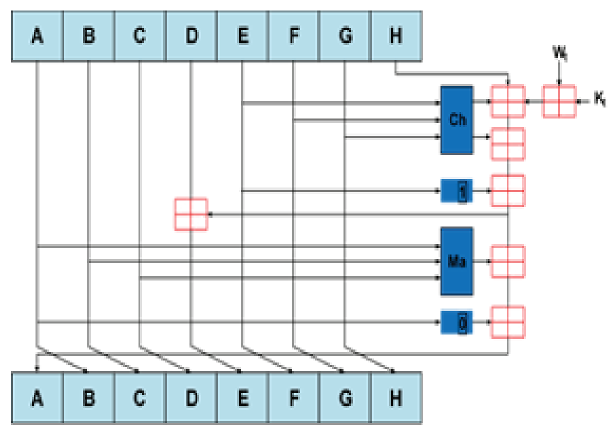


Fig. 5: One SHA-2 Round

A scientific investigation has shown that Secure Hash Algorithm -2 is susceptible to offenses. Below is a summary of the computational steps involved in SHA-2:

• Augmented length - the full message length to be processed must be a multiple of 1024 bits.

Padding starts by inserting a 1 as the initial binary digit, accompanied by the necessary count of zeros, along with a 128-bit message {m1, m2, …, mn}

Starting hash value, H(0) to H(i) = H(i−1) + CM(i) (H(i−1))

•In this context, C denotes the size-reduction function, while H(n) signifies the computed hash of the message (m).

• The outcome produced by Secure Hash Algorithm 256-bit comprises 64 bits of a correspondence, with six logical traits represented as a,b and c along with a 64-bit message.

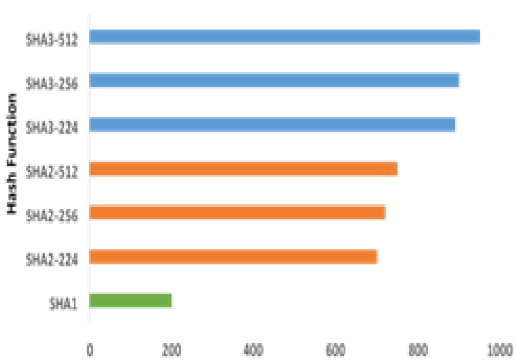
Table 1: Comparative Assessment of SHA regarding Security and Computational Efficiency

Secure Hashing Algorithm		Security (in Bits Against Collision Attack)	Capacity Against Extensive Length Attacks	Performance on Skylake		Year of Release
				Long Message	8 bytes	
SHA-1		<63 (collusion found)	0	3.47	52	1995
SHA-2	SHA-224	112	32	7.62	84.50	2004
	SHA-256	128	0	7.63	85.25	2001
	SHA-384	192	128(≤384)	5.12	135.75	2001
	SHA-512	256	0	5.06	135.50	
	SHA-512/224	112	288	5.12	135.75	2012
	SHA-512/256	128	256	5.12	135.75	
SHA-3	SHA-3-224	112	448	8.12	154.25	2015
	SHA-3-256	128	512	8.59	155.50	
	SHA-3-384	192	768	11.06	164.00	
	SHA-3-512	256	1024	15.88	164.00	
	SHAKE128	min(d/2,128)	256	7.08	155.25	
	SHAKE256	min(d/2,256)	512	8.59	155.50	

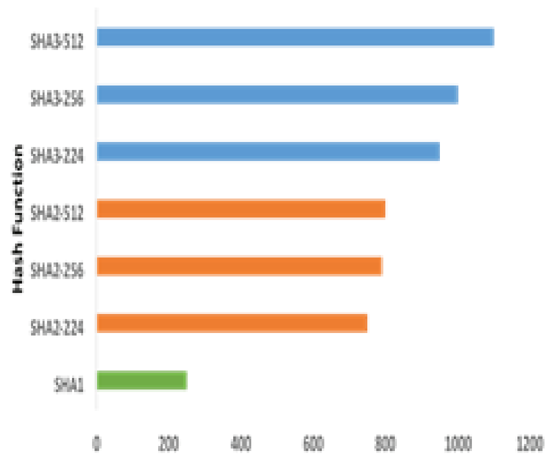
RESULT ASSESSMENT

The performance assessment of the SHA family involves analysing the number of processor cycles needed to process data (in bytes). Instead of relying on traditional metrics such as data throughput per unit time, this analysis focuses on the clock cycles of the processor needed to complete data processing tasks.

$$cyclesperdata = \frac{(D_h + \lambda)}{len}$$



Cycles per Byte (a)



Clock Cycles per unit (b)

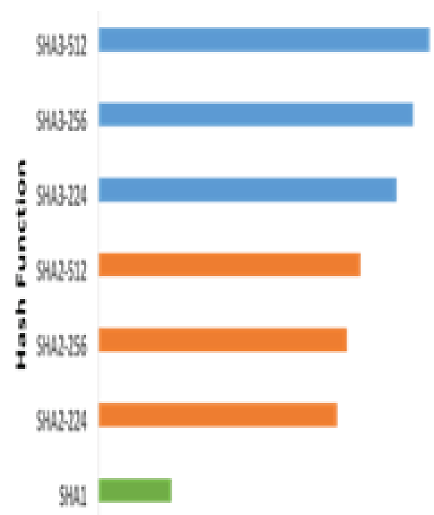


Fig. 8: Execution Evaluation for a) 1 KB, b) 1 MB, and c) 64 MB of input data

CONCLUSION

Hash functions are crucial for securing network and communication systems. This study makes several significant contributions:

Comprehensive Analysis: The research provides a thorough evaluation of various SHA variants, addressing gaps in existing literature that have not previously explored these aspects in detail.

Controlled Testing: The study employs a consistent test environment and applies three distinct analysis methods to assess the SHA family, ensuring reliable and validated results.

Performance Insights: The findings challenge the notion that one SHA variant is universally superior. Specifically, SHA-1 is found to be less efficient in most performance attributes, while SHA-2 and SHA-3 exhibit strong potential to counter a wide range of threats.

Enhanced Security Assessment: The study demonstrates that SHA-3 is particularly effective against new and evolving threats, whereas SHA-2 remains robust for addressing known security challenges.

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Implementation of Machine Learning based Vehicle Brake Detection System

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ABSTRACT

Indian Vehicle industry includes two wheelers ,LMV(Light motor vehicles) , HMV (Heavy motor vehicles) and now EV (Electric vehicles). India's transport industry is life line for sustainable development. In this era, of fast-growing road infrastructure and development of Smart Cities, the important challenge is passenger's and good's carriers safety. In India , the exponential growth of express highways and transport mediums leads to fetal accidents. To ensure the comfort and safety the Automobile industry has developed the Autonomous vehicles. These vehicles are either fully or partially autonomous. If we want to use autonomous vehicles on road then it should provide precise sensing of multiple parameters which includes interpreting signal and illumination systems, detecting the harmful conditions, differentiating various obstacles and as per the situation different applications like black area detection, ABS, air bags, tyre pressure observing, battery level observing for electric vehicles, downhill regulator, speed controlling, emergency braking and many other application. In this research work we are implementing a robust deep learning based system in two phases. In primary step, a car which is usually entity of concern is identified. In second step the machine learning module of different signals of succeeding vehicle is implemented. The most important objective of this research work is to provide precise break detection system in order to reduce the number of fetal accidents for LMV and HMV.

KEYWORDS *: Autonomous vehicle, Brake detection, Deep Learning, Machine Learning.*

INTRODUCTION

Since 2018, in Maharashtra there are 63k deaths due to road accidents[8]. For India this toil is even greater which equals almost 700k [9]. According to World Bank report road accident cost almost 3 % to 5% of GDP(Gross Domestic Product) every year. These are horrifying statistics about road accident scenario. Many researchers have already provided the solution for the Autonomous and Semi-Autonomous Vehicles to avoid the accidents. The existing system includes Air Bags, ABS (Anti Braking system), Speed monitor , Lane departure warning , facial recognition, Parking camera with sensor and many more. According to our study on Road transport and Highways, road mishaps are outcomes of Human fault, road conditions and also automobile condition. In this research work we are focusing on intelligence error and road conditions/ environment. It is very challenging task because the statistics shows that the number of accidents due to human error (Natural Intelligence) are on the higher side as compared to road condition accidents. While studying previous year report we found that the number of Motorcycles accidents are very high as compared to the other vehicles like car, truck or even bicycles. Also when we studied the accident scenario as per the road condition then in 2022 it is found that road accidents are more on Straight roads then any other types of road. Recent example includes accidents on Samruddhi Mahamarg from Nagpur to Mumbai. Table 1 shows the road accidents statistics as per the road type.

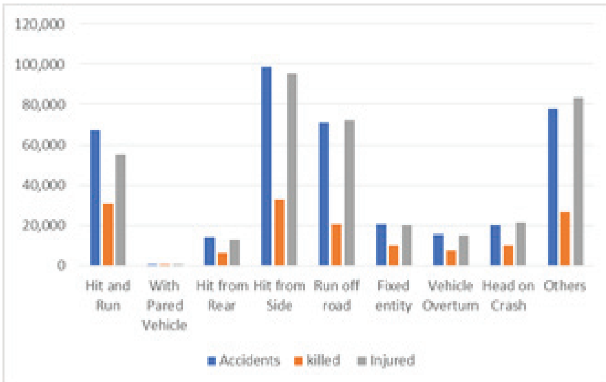

Fig. 1 Accidents Due to Crash 2022

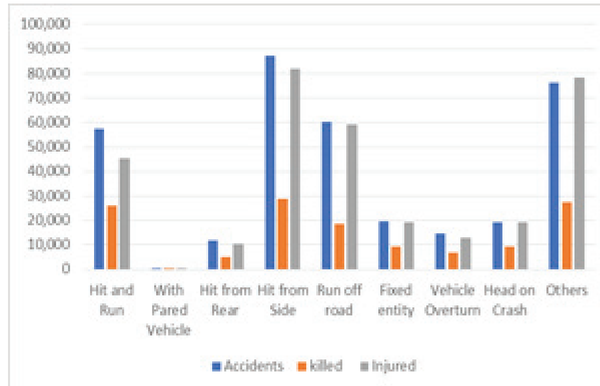

Fig. 2 Accidents Due to Crash 2021

Table 1 Road Type Road Accident Statistics[9]

Road Type	Number of Mishaps			Persons Casualty			Persons Wounded		
	2021	2022	% Change	2021	2022	% Change	2021	2022	% Change
Linear Road	2,78,219	3,09,248	11	1,02,624	1,11,816	9	2,59,401	2,97,693	14
Curved Road	49,581	54,593	10	19,120	20,573	8	48,888	55,866	14
Bridge	12,709	14,111	11	5337	6258	17.3	11,546	13,062	13.1
Culverts	6663	7384	11	2960	3473	17	6029	6309	5
Potholes	3625	4446	22.6	1481	1856	25.3	3103	3734	20.3
Steep Grade	3967	4475	13	1635	2056	26	3398	4089	20
Under Constru-ctions	9075	9211	1.5	4014	4054	1	7539	7955	5.5
Others	48,594	57,845	19	16,802	18,406	10	44,543	54,657	23
Total	4,12,432	4,61,312	11.9	1,53,972	1,68,491	9.4	3,84,448	4,43,366	15.3

Table 2 Automobile Types Accident Statistics[9]

Category	2021		2022		% Change	
	Accident	Death	Accident	Death	Accident	Death
Pedestrians	17,113	9462	20,513	10,160	19.9	7.4
Bicycles	3009	1667	3003	1445	-0.2	-13.3
Bikes	52,417	22,787	63,116	25,229	20.5	10.8
Three Wheelers	5360	2214	6038	2324	12.6	5
Car, Taxis, Vans	25,431	9191	29,005	10,174	14.1	10.7
Turks/Lorries	12,075	5008	13,619	5572	12.8	11.3
Buses	3738	1397	5268	1798	40.9	28.7

Others	9683	4282	11,436	4337	18.1	1.3
Total	1,28,825	56,007	1,51,997	61,038	18	9

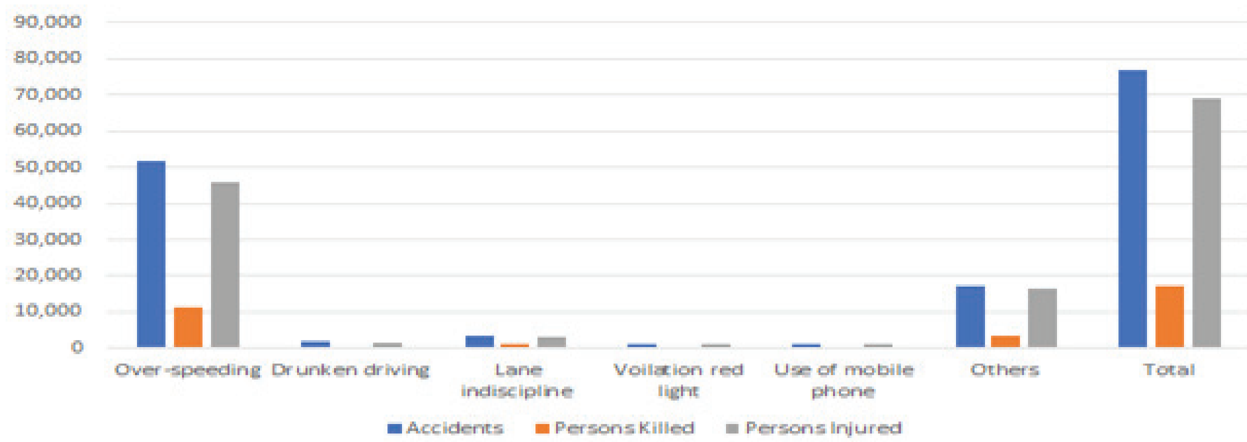

Fig. 3 Traffic Rules Voilation Accidents 2022

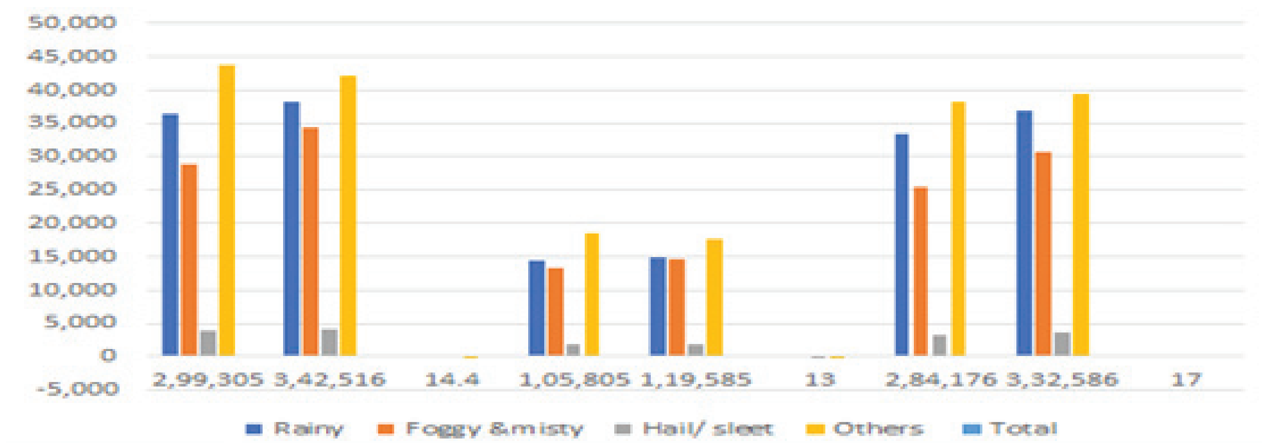

Fig. 4 Accidents Due to Weather Year 2021 to 2022

Finally, type of the road is also very important regarding accident scenario. National and state highways road accident toil is approximately 2.5 lacs. Also, most dangerous time on Indian roads is afternoon, evening and night. Only the time slot between 2am to 10 am less number of road accidents occur.

From discussion so far it is clear that we have to consider so many factors to design robust system. Here factors are collision, weather condition, traffic rules and type of the road. This is very complex issue and must be handled with care because road safety is huge important. All the countries in the world is facing huge challenge to reduce road accidents. As the road network and the number of vehicles are expanding day by day India is jolted with huge number of road accidents. It is not only killing humans but also draining GDP. The rest of the research paper consist related work, methodology, result and conclusion.

RELATED WORK

Sivaramakrishnan Rajendar(2021) used two cameras stereo visual based pedestrian identification and prevention of accidents for intelligent systems. As discussed in Prediction of stopping distance for autonomous emergency braking using stereo camera pedestrian detection, it only defines the distance between the pedestrian and the vehicle. The performance of system shall be improved under various speed and road conditions[1]

Li(2021) focuses on Real-time vehicle taillight detection method based on the improved YOLOv3-tiny model. In this approach hand crafted traditional methods are discarded with the application of convolutional neural network. This method fails to locate the target due to obstruction of tail lights.[2]

Lacatan(2021) used the brake light detection system for the prevention or avoidance of back-end crash mishaps by applying deep learning algorithm with high correctness. The database needs to include more number of vehicles. It should include the HMV and other types of vehicles to achieve the high accuracy[3]

J. Schnee(2019) showed the longitudinal dynamics system to attain a rapid reaction time and a consistent identification of tail lights conditions. The research work applied concept of bicycle inertia. Inertia states that “object will be in rest or in uniform motion unless an external force acts on it”. In this case the external force is either breaks or throttle. This research work is only concentrates on electric bicycles[4]

E. Najafi Kajabad (2018) applied HSV (Hue Saturation value) color space algorithm to identify the tail lights. The algorithm consist of Gaussian filter, object recognition with computer vision system. The researcher wants to extend the future work with the help of machine learning and deep learning methodologies.[5]

R. Avinash(2017)applied the image processing sensor based arduino system for the recognition of pedestrians on roadsides and to apply automatic braking. By the use of ultrasonic sensor it measure the distance between pedestrians and vehicle. In this method one improvement is necessary which is at the higher speed of vehicle.[6]

C. Jen (2017) mounted an extra stop light on car in order to improve the break light detection. This research work applied the Adaboost learning algorithm for luminance analysis. It may to provide the consistency of result.

Also many research has been done on this automatic break detection system ,but there is still need improvement. We have tried to provide the solution by Deep Learning approach[7].

METHODOLOGY

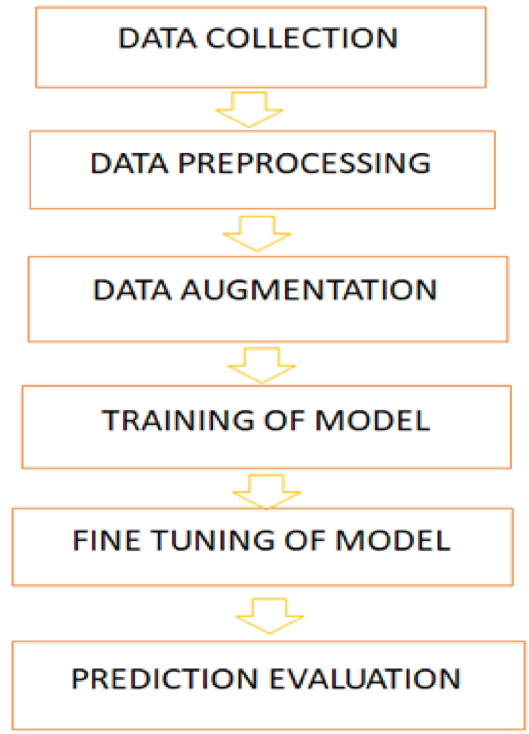

Figure 5 Methodology

Data Collection

In this step we have collected car images in different conditions such as parking, braking and off state. The outcome of research work quality of database. Validation of data is done in this step only.

Data Preprocessing

It involves removal noise from database. Various noise removal methods are applied.

Data Augmentataion

In this step raw data is converted to useful data. Here, there are series of activities in which potential and irreversible changes are made in data base. By implementing this step database become more accurate for further process and analysis.

Training the Model

For application of the prototype using Artificial Intelligence, along with Machine Learning and Deep Learning, Transfer Learning approach is also available. In this research work, for application of the model, use of transfer learning approach is used. Here, the understanding acquired while executing the given issue is stored and it is applied to the other but similar issue.

Fine Tuning of Model

This step always works on the feedback mechanism of AI which ultimately results into minimization of errors and provides more appropriate results.

Prediction and Evaluation

Here, a model classifier is applied to identify the behavior of the succeeding vehicle. Xception model is used to develop model classifier. This model is trained using different weights where supervised learning with Machine and Deep learning are applied. Evaluation is done using the Confusion matrix and its different parameters like accuracy, F1 score etc.

ALGORITHM

This section outlines the algorithm used to segment car break light images leveraging the image morphology. All the experimental results are based on Python programming language.

1. In the first step we plot a graph between speed and traffic visibility.
2. In the second step we create image database. This is done by collecting LMV and HMV images.
3. After creating database we apply various image processing steps as image acquisition which is part of preprocessing.
4. In this step we are using various python libraries open cv and numpy for further processing
5. In this step we apply the morphological image processing algorithm using machine learning because it is based upon geometry of the object under consideration which is useful to eliminate noise, separate objects and detect edges in image.
6. Two most common morphological operations are Dilation and Erosion.
7. In Dilation the boundaries of an object is expanded where as in Erosion compress the boundaries of an object.
8. After all above steps we display the results which are included in next section. Here we mention that image processing algorithms when used with machine learning becomes more robust in order to do classification.

RESULT

Fig. 6 Database

Here, we have created database for various LMV and HMV locomotives.

Following graph shows that as the speed of vehicle increases, visibility decreases. It is applicable to both Autonomous and Semi -Autonomous vehicles.

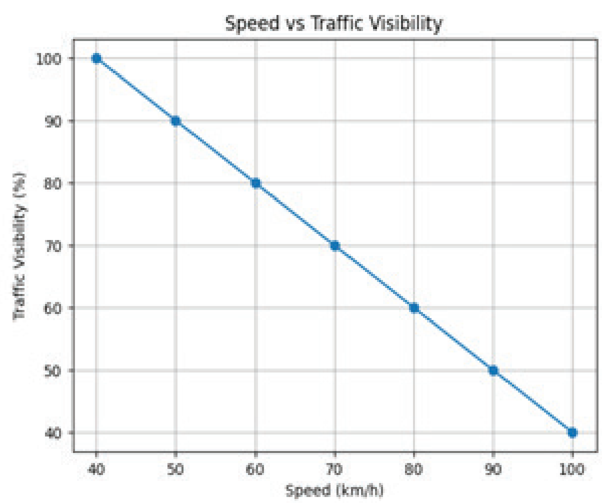

Fig. 7 Speed v/s Traffic Visibility Graph

Now, following result shows the detection of break lights for car at Night condition.

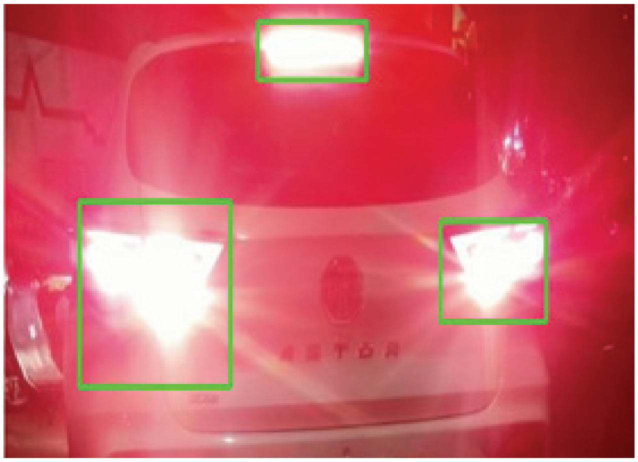

Fig. 8 Break Light Detection at Night

Here, the three boxes shows that breaks are applied for the given car. It helps for the vehicles which are succeeding vehicles. As per our previous discussion we say that it will prevent hit from back collision. In this approach we have calculated accuracy as 86% whereas F1 score 0.6.

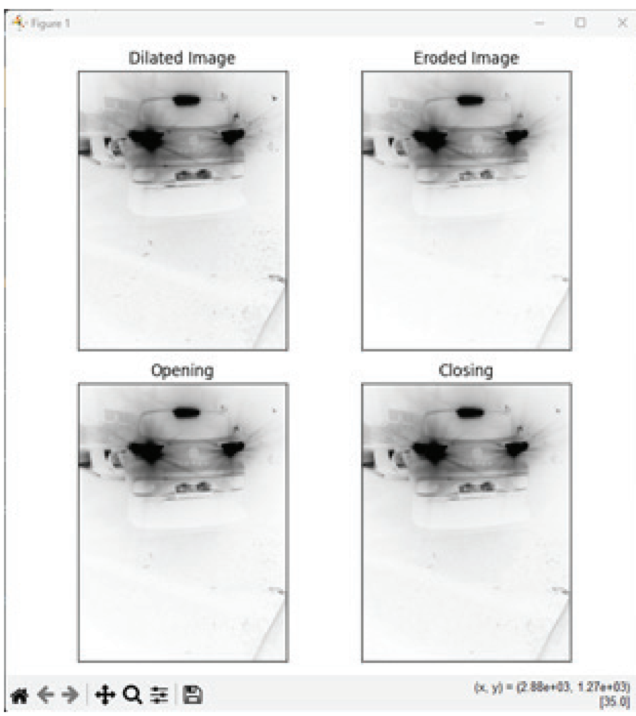

Fig. 9 Break Light Detection using Morphology

Here, FOUR boxes shows that breaks are detected using morphological image processing . This method is based on geometry of the given object.

CONCLUSION

In this paper we have discussed the break light detection of car with good accuracy. It will help to minimize the road accidents. This system is applicable for both Autonomous and semi-autonomous vehicles.

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Comparative Performance of a Various Reflective Mirrors on Solar Panel and Sun Tracking System Performance: Experimental Assessment

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ABSTRACT

This paper focuses on the enhancement of solar power generation efficiency through the implementation of various techniques. The primary objective is to compare the performance of four different solar panels, each utilizing a distinct enhancement mechanism. One of the panels incorporates a sun tracking mechanism to optimize its alignment with the sun, while the other panels employ reflective optics, including a polarized reflector, a plane reflecting mirror, and a convex lens. The methodology involves constructing a test setup to expose the solar panels to consistent solar irradiance under controlled conditions. Data is collected using voltage sensors to measure and record the generated electricity from each panel. Additionally, the charging levels of batteries connected to each panel are manually monitored to evaluate the efficiency of energy storage solutions. The findings reveal that the solar panel with sun tracking demonstrates the highest overall efficiency, closely followed by the panel utilizing a convex lens. The reflective optics, including the polarized reflector, also significantly enhance the electricity generation of their respective panels. The manual monitoring of battery charging levels allow for a comprehensive assessment of energy storage performance. This paper contributes to the ongoing research in solar power generation and provides valuable insights into the effectiveness of different enhancement techniques. The outcomes highlight the potential of sun tracking and reflective optics in increasing solar energy conversion efficiency. The paper findings facilitate the development of more efficient and sustainable solar power systems, promoting the adoption of renewable energy sources.

KEYWORDS *: Solar power generation, Efficiency enhancement, Sun tracking, Reflective optics, Polarized reflector, Convex lens, Manual monitoring, Energy storage.*

INTRODUCTION

Solar power generation has emerged as a crucial solution to meet the increasing energy demands while reducing our reliance on fossil fuels and mitigating environmental impacts. Harnessing the power of sunlight, solar panels convert solar energy into electricity, offering a clean and renewable source of power. As the global focus shifts towards sustainable energy alternatives, maximizing the efficiency of solar panels becomes paramount. The efficiency of solar panels refers to their ability to convert sunlight into usable electrical energy. Enhancing this efficiency is essential to optimize power generation and make solar energy a viable and economically feasible option. By improving the efficiency of solar panels, this experiment can maximize electricity output, reduce energy costs, and contribute to a greener future. This paper aims to explore and compare different enhancement techniques for solar panels to increase their efficiency. By implementing sun tracking and incorporating reflective optics such as polarized reflectors, plane reflecting mirrors, and convex lenses, this aim to enhance the absorption of sunlight and improve power output. These techniques have the potential to significantly increase the efficiency of solar panels, leading to a more efficient utilization of solar energy resources [1].

LITERATURE REVIEW

The Energy Institute (EI) Statistical Review of World Energy provide the data for year 2022. According to the statistical data analysis approximately 10,53,115 MW energy is produced from solar systems from all over the world [2]. Review on sun tracking technology in solar PV system by Anshul et.al. focuses on the design and performance analysis of the various dual axis tracking solar systems proposed in recent years. Although the choice on the use of trackers mainly depends upon the physical features of the land but in general this system has proved to be more efficient and advantageous than its single-axis and fixed counterparts [3]. Studies by Li et al. (2019) focused on the implementation of convex lenses and polarized reflectors, respectively. Convex lenses concentrate sunlight onto solar cells, increasing the intensity of incident light and thereby enhancing electricity production. Polarized reflectors redirect and intensify incident sunlight onto the panels, further improving energy conversion efficiency [4]. Comparative studies have been conducted to evaluate the effectiveness of different enhancement techniques. Chen et al. (2016) compared sun tracking systems and reflective optics and found that both techniques significantly improved solar power generation compared to fixed panels. However, the study concluded that sun tracking mechanisms had a greater impact on enhancing energy output. Recent advancements in microcontrollers and sensor technologies have facilitated the integration of intelligent control systems in solar efficiency enhancement projects [5]. Li et al. (2020) developed a solar tracking system utilizing an Arduino microcontroller, enabling precise tracking of the sun's position and improving energy production efficiency [6].

METHODOLOGY

SYSTEM DESIGN: The proposed system enhances solar power generation efficiency through the integration of sun tracking and reflective optics mechanisms. It includes four solar panels with different enhancement techniques: sun tracking, polarized reflector, plane reflecting mirror, and convex lens [9]. The system utilizes sensors to monitor and record the voltage output of each panel at regular intervals. An LCD display provides real-time voltage readings. By comparing the performance of the panels, the system aims to identify the most efficient method for solar power generation.

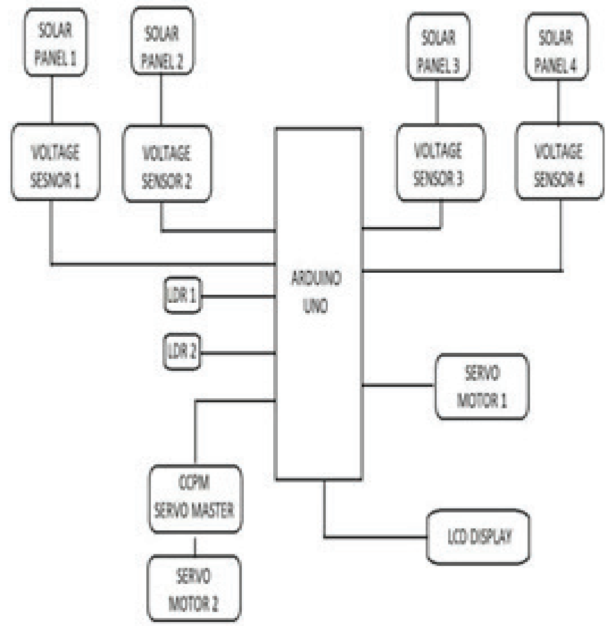


Fig. 1 Block Diagram of Proposed System

Harnessing solar energy to generate electricity is one of the significant technologies today, as solar cells convert the solar radiation falling on them into a continuous current. However, the high temperature of photovoltaic cells is a major drawback, especially in hot climates. The proposed system offers a comprehensive approach to optimize energy production and contribute to sustainable renewable energy systems.

Solar cell types

There are three major cell types that classified by its manufacturing technology and the semiconductor.

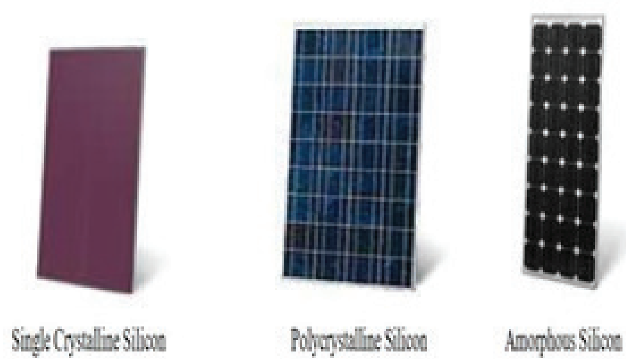


Fig. 2: Types of solar panels

A) Crystalline Silicon PV Module: Two types of crystalline silicon (c-Si) are used to produce PV module; single crystalline silicon or known as monocrystalline silicon and multi-crystalline silicon, also called polycrystalline silicon. The polycrystalline silicon PV module has lower conversion efficiency than single crystalline silicon PV module but both of them have high conversion efficiencies that average about 10- 12%.

B) Amorphous Silicon PV Module: Amorphous silicon (a-Si) PV module or thin- film silicon PV module absorbs light more effectively than crystalline silicon PV module, so it can be made thinner. It suits for any applications that high efficiency is not required and low cost is important. The typical efficiency of amorphous PV module is 6%.

C) Hybrid Silicon PV Module: A combination of single crystalline silicon surrounded by thin layers of amorphous silicon provides excellent sensitivity to lower light levels or indirect light. The Hybrid silicon PV module has highest level of conversion efficiency about 17% [11].

In this experiment polycrystalline silicon solar plates are used having following technical specifications:

- Voltage: 7.5v
- Power Rating: 1.3 W
- Dimension: 180 x 90mm
- Individual solar panel block(1cm*1cm) generates about 0.2 to 0.3 volts.
- Working Temp(C): -25 – $+100^{0}$C

Reflectors

1. Polarized Reflector: A specialized reflector typically made of a thin film composed of polymers or metal oxide layers. The chemical composition may include materials such as polyvinyl alcohol (PVA), polyethylene terephthalate (PET), or metal oxides like titanium dioxide (TiO_2)and in this experiment polyethylene terephthalate (PET) is used. These materials possess specific optical properties that selectively reflect light waves based on their polarization orientation, enhancing the performance of solar panels with matching polarization [6].

2. Plane Mirror: A plane mirror is typically made of glass with a reflective coating on one side. The reflective coating is commonly composed of a thin layer of aluminum or silver deposited on the glass surface using processes like vacuum deposition or sputtering. The reflective coating provides a high degree of reflectivity, allowing the mirror to efficiently redirect sunlight towards solar panels [8].

3. Convex Mirror: A convex mirror consists of a curved reflective surface that bulges outward. The mirror is commonly made of glass or plastic, with a reflective coating applied to its curved surface. The reflective coating is usually composed of a thin layer of aluminum or silver, similar to plane mirrors. The curved shape of the mirror allows it to diverge light waves and capture sunlight from various angles, improving the efficiency of solar panels. In sunny days the temperature of sunlight is higher than 250C which can destroy the solar panels. Heavy sunlight creates the hotspots on the panels which eventually damage the panels. This type of damage disturbs the consistency of solar panel. In this situation dispersion of light decreases the sunlight temperature falling on the panels. This can help to maximize the efficiency of the electricity generation [7].

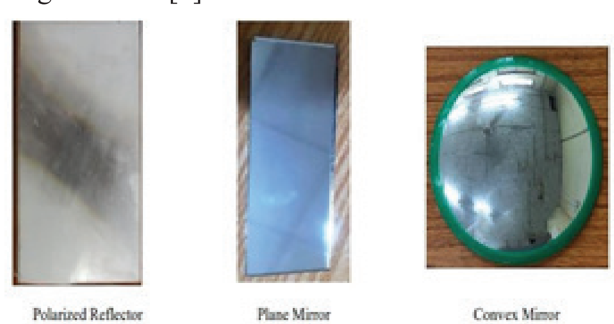


Fig. 3 Reflectors

For a polarized mirror the size used is 40cm x 40cm while for convex and plane mirror with a diameter of 20cm. every reflector will be placed in vicinity with the solar cell with 600 angles for reflection.

CCPM Servo Master

CCPM Servo Tester shown below in Fig. no. 3 is a small compact module for monitoring the performance of servo motors such as consistency, direction, and ESC (Electrical Speed Controller).

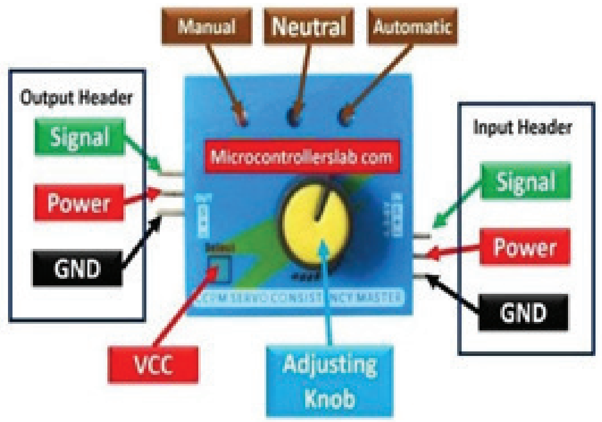


Fig 4 CCPM Servo Consistency Master

CCPM Servo Consistency Master/Servo Tester is a low-power, cost-effective device which can examine three servo motors at a time. The tester requires a maximum of 6 volts for normal functioning. It also has an electric speed controller (ESC), which is used to check the motor's current directions. The tester does not need a transmitter or receiver to generate signals. One can use it to check the faulty servo motors before using them in different projects [14].

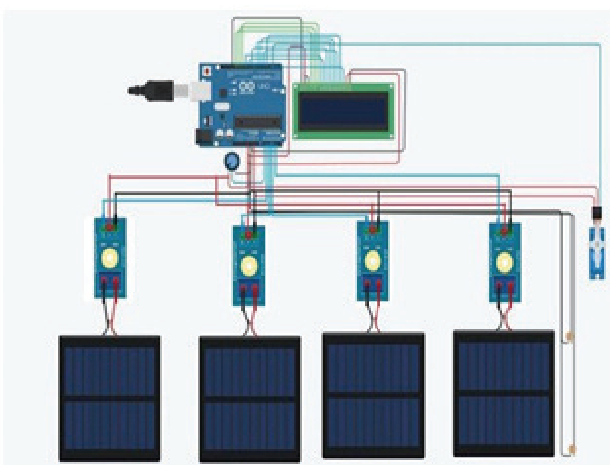


Fig. 5. Circuit Diagram

WORKING

The paper operates on the principle of solar power generation and incorporates various components to optimize efficiency and control. Here is an overview of the working of the paper:

1. Solar Panel Setup: The paper utilizes multiple solar panels, including Solar Panel 1, Solar Panel 2, and Solar Panel 4. These panels are exposed to sunlight and convert solar energy into electrical energy.
2. Voltage Sensing: DC voltage sensor used to calculate and monitor the amount of voltage in an object which compatible with arduino Uno. Each solar panel is connected to a corresponding voltage sensor works in the range of 0-25V, such as Voltage Sensor 1, Voltage Sensor 2, and Voltage Sensor 3. These sensors measure the voltage output of each solar panel.
3. Light Intensity Sensing: The paper includes Light Dependent Resistors (LDRs) that sense the ambient light intensity. These LDRs provide real-time data on the light levels and help determine the optimal positioning of the solar panels.
4. Microcontroller Control: The Arduino Uno microcontroller acts as the central control unit of the experiment. It receives inputs from the voltage sensors and LDRs and processes this information to make decisions based on the desired system performance.
5. Servo Motor Control: The second system of the experiment incorporates a Servo Motor(SG-90), which can be controlled by the microcontroller. The microcontroller adjusts the position of the Servo Motor based on the LDR data to align Solar Panel 2 with the sun's position, maximizing its exposure to sunlight. Servo motors are not suitable for continuous energy conversion when compared to huge industrial electric motors. Because of the inertia, these motors have a high-speed reaction and are constructed with tiny diameters and large rotor lengths. A servo motor is made up of a motor, a feedback circuit, a controller, and another electrical circuit on the inside.
6. LCD Display: An LCD (Liquid Crystal Display) is connected to the microcontroller to provide a visual interface. The LCD displays various voltage outputs of the solar panels.
7. Battery and Load Connection: The experiment includes a battery for energy storage. The battery is connected to the microcontroller and serves as a

reservoir for storing excess energy generated by the solar panels.

8. System Monitoring: The paper continuously monitors the voltage outputs of the solar panels, light intensity levels, and other relevant parameters. This data is displayed on the LCD screen for real-time monitoring and analysis.

Overall, the paper utilizes the Arduino Uno microcontroller to control and optimize the performance of the solar panels. By monitoring voltage outputs, light intensity, and adjusting the position of Solar Panel 2, the paper aims to maximize solar energy generation and storage while providing a visual display of the system's operation.

Experimental Setup: Fig. no. 6 depicts the experimental setup as shown with four solar panels. Here, Solar 1 for tracking and solar 2,3 & 4 are used with the reflector module. Arduino UNO in the figure is used as microcontroller. CCPM servo consistency module is attached with servo shown for the cleaning purpose of the system. For detail observation the readings noted after each 30 minutes during proper sunny day.

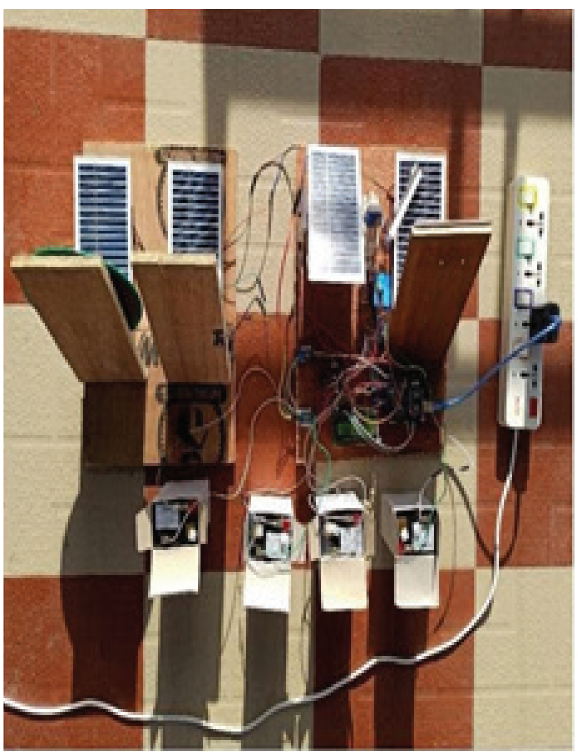
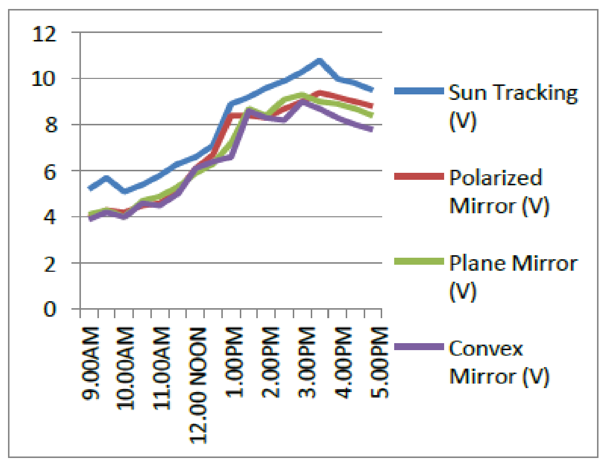


Fig. 6: Experimental setup of the proposed system

RESULTS

Day 1-5 average	Sun Tracking	Polarized Mirror	Plane Mirror	Convex Mirror
Time	(V)	(V)	(V)	(V)
9.00AM	5.2	4	4.1	3.9
9.30AM	5.7	4.3	4.3	4.2
10.00AM	5.1	4.2	4	4
10.30AM	5.4	4.5	4.7	4.6
11.00AM	5.8	4.6	4.9	4.5
11.30AM	6.3	5.1	5.3	5
12.00 NOON	6.6	6.1	5.9	6.1
12.30PM	7.1	6.7	6.3	6.4
1.00PM	8.9	8.4	7.2	6.6
1.30PM	9.2	8.4	8.7	8.6
2.00PM	9.6	8.3	8.4	8.3
2.30PM	9.9	8.7	9.1	8.2
3.00PM	10.3	9	9.3	9
3.30PM	10.8	9.4	9	8.7
4.00PM	10	9.2	8.9	8.3
4.30PM	9.8	9	8.7	8
5.00PM	9.5	8.8	8.4	7.8



From the above data, it has been observed that the solar tracker is more efficient than the other solar panels having reflectors. However, mechanical arrangement of solar tracking system is tedious to maintain for long term observations.

The Result of four Solar Panel Voltage display on the LCD

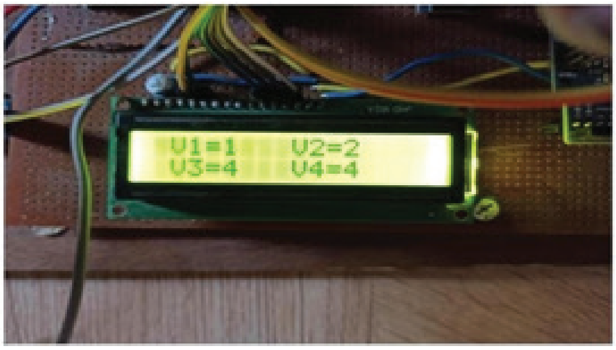


Fig. 7: Voltage displaying on the LCD

CONCLUSION

This paper "Comparative performance of a various reflective mirrors on solar panel and sun tracking system performance: Experimental assessment" successfully utilized sun tracking mechanisms and reflective optics to enhance solar power generation. The sun tracker system is the famous method to accumulate all day sunlight for electricity generation. The trackers are best used for large panels and the generation respectively as 2-3% of energy is utilized by the motors used for tracking [12]. In spite of tracker system other three methods are also used to enhance the generation. The sun tracker system in this experiment is driven by servo motor which can move the panel in 1800 so that the panel must get maximum light from sun apart from the position of sun rays. This system uses mechanical arrangement with servo motor which needs continuous power supply. On the other hand with the help of other optics we can get almost same output from the similar panels. At the same time excess heat obtained by tracker continuously from the sun could cause the hotspots which eventually damage the solar panel [13]. Dispersed and moderate heat can increase the life of solar panels as well as can produce optimized output.

From the results it is observed that the reflectors and mirrors also show similar effects on the output. Through precise panel alignment and focused sunlight with reflector, mirror and convex lens, we can get significantly increased energy output [14]. On comparing on the cost involved in the tracker system and the optics used, the result shows the considerable difference.

The findings contribute to sustainable energy solutions and the efficient utilization of renewable resources, driving advancements in solar power technology. By optimizing solar panel performance, this paper offers valuable insights for improving the efficiency and effectiveness of solar energy systems, promoting a greener and more sustainable future.

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Effects of Different Growth Substrates and Vegetation on Thermal Behavior of Extensive Green Roofs in Monsoon Season of Central India

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ABSTRACT

Green roofs are innovative urban solutions that involve the cultivation of vegetation atop buildings. These sustainable installations provide numerous environmental benefits, such as improved air quality, reduced urban heat island effect, and enhanced biodiversity. The present study was carried out in the monsoon season of central India from 21st July to 31st July 2023. The objective was to investigate the effect of two types of growth substrates and two local plant vegetation found in the region on the thermal performance of green roofs. Test beds were constructed. Initial observations show a thermal lag of not less than 65 minutes (~1 hour) across all the test beds with maximum thermal lag of about 100 minutes for test bed with common garden soil as growth substrate and Paspalum conjugatum as vegetation. Similarly, minimum lag was observed for bed II and bed V both at just over 1 hour. Maximum peak temperatures showed a difference of about 2°C to about 10°C with beds having vegetation clearly showing marked mitigation of heat transfer through green roofs.

KEYWORDS *: Energy conservation, Green roofs, Thermal comfort, Thermal lag, Thermal performance.*

INTRODUCTION

Energy consumption in India has surged significantly in recent decades, driven by rapid urbanization, population growth, and industrial expansion. A substantial portion of this energy demand is attributed to residential and commercial cooling needs, such as air conditioning (AC). India's middle class is expanding and as urban areas heat up in a phenomenon called as the Urban Heat Island Effect, the demand for cooling has grown rapidly, making space cooling a key factor in the country's energy requirements. This is placing increased pressure on the energy grid, necessitating more sustainable solutions to meet the growing need without exacerbating environmental concerns.

Green roofs or living roofs or vegetated roofs, are a harmonious fusion of nature and architecture, which transform traditional rooftops into dynamic ecological and aesthetic landscapes. These innovative roofing systems are characterized by the cultivation of plants, shrubs, and even trees on top of buildings and they offer a range of environmental, social, and economic benefits. Green roofs, whether sloped or flat, are primarily constructed to accommodate vegetation. By integrating them into urban spaces that are often dominated by concrete and steel, green roofs contribute to aesthetics and decoration, improved air quality, storm water management, energy efficiency, heat reduction, decreased reliance on air conditioning systems, optimized energy utilization and overall urban biodiversity.

LITERATURE REVIEW

The green roof movement in India is still in its early stages, but there is a growing interest and momentum in adopting green roof technology across the country. A World Bank published book [1] in 2018 summarizes that the South Asian bloc is going to suffer losses both economically and socially due to rising temperatures and changing weather. In India, approximately 600 million people live in locations that could either become moderate or severe hotspots by 2050. With the Government of India being committed to the UN SDGs, investments in green roof industry are essential especially to meet the SDG 11 i.e. sustainable cities and communities.

As per Ministry of New and Renewable Energy (Government of India), the annual solar irradiation varies from 1600 to 2200 kWh/m2. The daily solar insolation in most parts of India lies between 5-7 kWh/m2 [2]. Cities are notorious for a phenomenon called as the Urban Heat Island effect (UHI). With so much irradiation heating up the concrete walls of the buildings, cities in general experience warmer nights and hotter days as compared to surrounding rural areas. Such Urban Heat Islands have been discussed by many researchers across the world such as Aboelata and Sodoudi [3], Vijayaraghavan [4], Akay [5] etc. In reference to the Indian Climatic conditions, few authors have focused on potential of green roofs in mitigating energy conservation. Authors such as K. Vijayaragahavan [4][6][7][8], Gowthami and Vijayabhaskar [9] and V. Kumar [10], [11] have performed detailed studies. Interest in Green roofs in India has slightly picked up pace in last few years with works such as Mishra [12], Lokesh et al. [13], kumar et al. [14] etc. actively working in benefits of green roofs in Indian climatic conditions. This research work actively explores the thermal behavior profile of green roofs in respect to Monsoon season in central India and attempts to contribute to the scarce literature available on green roof research in India.

MATERIALS AND METHODS

The study was conducted in Amravati, Maharashtra, India, with data collected between July 21 and July 31, 2023. Observations were made using five green roof test beds, each measuring 3×3×1 ft (L×B×H), providing a total exposed surface area of 9 sq. ft. (approximately 0.836 sq. m). The test beds were constructed using locally sourced wood due to its excellent insulating properties, which minimized lateral heat flux and ensured unidirectional heat transfer from the top to the bottom layers of the green roof. To ensure uninterrupted exposure to sunlight, the test beds were positioned on a rooftop, free from the shadows of nearby objects or buildings. The configuration of the test beds is illustrated in Figure 1.

Fig. 1 Experimental Set Up Showing 5 Green Roof Test Beds (Bed No. I, Ii, Iii, Iv & V – From Right To Left In The Image)

The test beds are identical in their construction except for their growth substrate composition and vegetation used. Out of the 5 test beds, one test bed (bed I) did not have any vegetation in order to provide comparative reference of the other vegetated test beds. Bed II and III both had the same growth substrate of common garden soil, which was sourced from a nearby nursery. Bed II had mainly Paspalum conjugatum grass as vegetation cover while bed III had lawn grass or Cynodon dactylon for vegetation cover. Bed IV and V both had a mixture of cocopeat and garden soil in 1:1 ratio as growth substrate. Bed IV had P.conjugatum grass while bed V was provided with Bermuda grass for vegetative cover. The green roof test beds consists of five layers from bottom to top as described in table 1 while table 2 describes the setup of the experiment.

Table 1 Details of Green Roof Test Beds

Layer	Thickness	Materials
Root barrier	3 mm	Polythelene sheet
Drainage medium	10 mm	Rock gravel medium size

Retention layer	20 mm	Wood wool
Growth substrate	60 mm	Typical garden soil & cocopeat
Vegetation	Upto 70 mm	Paspalum conjugatum and lawn grass (Bermuda grass)

Table 2 Growth Substrate and Vegetation used in the Test Beds

Test bed	Growth substrate used	Vegetation
Bed I – Side I	only garden soil	No vegetation
Bed I – Side II	garden soil + cocopeat (1:1 ratio)	No vegetation
Bed II	Garden soil	Paspalum conjugatum
Bed III	Garden soil	Garden lawn grass
Bed IV	garden soil + cocopeat (1:1 ratio)	Paspalum conjugatum
Bed V	garden soil + cocopeat (1:1 ratio)	Garden lawn grass

To measure the temperatures within the green roof test beds, thermocouples were used. The thermocouples were of Pt100 type - RTD sensors along with 16 channel data logger (SCANEX) to log the temperature readings. The data logger was paired with a computer on which the data was stored using the software for the datalogger. The positions of the thermocouple on each of the test beds were the same: one sensor just below the top layer of the soil i.e. growth substrate and the second sensor at the bottom layer of the drainage layer as shown in Figure 2 and Figure 3.

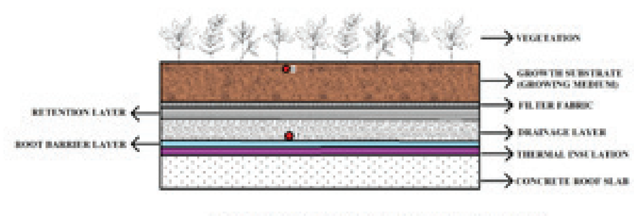

Fig. 2 Red Dots 1 and 2 Shows the Position of the Temperature Sensors in the Green Roof Test Beds. Sensor 1 in the Top Layer of the Growth Substrate, Sensor 2 at Bottom Most Layer of the Drainage Layer.

During the observation period, the global solar irradiance was measured using a solar pyranometer (solar radiation sensor PYRA300V). Hourly solar irradiance and the total daily insolation were recorded by the Remote Management System. As the data recording period lies within the monsoon season in Vidarbha region of Central India, the sky was mainly in overcast or cloudy conditions with rainfall. The following table 3 displays the daily average solar insolation during the said period.

Fig. 3 Position of Temperature Sensors in One of the Test Beds (Test Bed No. 5, Garden Lawn and Garden Soil + Cocopeat Growth Substrate)

Table 3 Total Daily Insolation During the Observation Period

Date	Solar Insolation kWh/m^2/day
21-07-2023	0.803
22-07-2023	0.748
23-07-2023	3.464
24-07-2023	4.501
25-07-2023	3.742
26-07-2023	5.006
27-07-2023	1.007
28-07-2023	1.613
29-07-2023	3.313
30-07-2023	3.739
31-07-2023	4.603

OBSERVATIONS

Maximum and Minimum Temperatures

Soil temperatures for the uppermost and lowermost layers of the green roof test beds were recorded using temperature sensors and stored with a 16-channel datalogger. The maximum and minimum temperatures (Tmax and Tmin) for all test beds are presented in Table

4, along with the maximum temperature difference ($\Delta T = T_{max} - T_{min}$) between the top and bottom layers. The temperatures were measured in Fahrenheit to enhance sensitivity to changes in soil temperature. Table 4 provides values in both Fahrenheit and Celsius. Tmax and Tmin represent the highest and lowest temperatures recorded at any point during the measurement period for each soil layer.

Table 4 Maximum and Minimum Temperatures Recorded on 12 Channels

Test Bed no.	Channel no.	Position	T_{max} °F (°C)	T_{min} °F (°C)	$\Delta T = T_{max} - T_{min}$ °C
Bed I – Side I only garden soil (no vegetation)	1	bottom layer	88.2 (31.22)	75 (23.88)	7.34
	2	top layer	92.5 (33.6)	73.9 (23.27)	10.33
Bed I – Side II garden soil + cocopeat (1:1 ratio) (no vegetation)	3	bottom layer	90.9 (32.72)	75 (23.88)	8.84
	4	top layer	92.7 (33.72)	74.1 (23.38)	10.34
Bed II Garden soil + *Paspalum conjugatum*	5	bottom layer	88.7 (31.5)	75.6 (24.22)	7.28
	6	top layer	91.4 (33)	74.5 (23.61)	9.39
Bed III Garden soil + Garden lawn grass	7	bottom layer	87.3 (30.72)	76.6 (24.77)	5.95
	8	top layer	93 (33.88)	78.5 (25.83)	8.05
Bed IV garden soil + cocopeat (1:1 ratio) + Paspalum conjugatum	9	bottom layer	85.8 (29.88)	73.4 (23)	6.88
	10	top layer	87.6 (30.88)	73.8 (23.22)	7.66
Bed V garden soil + cocopeat (1:1 ratio) + Garden lawn grass	11	bottom layer	89.3 (31.83)	78.1 (25.61)	6.22
	12	top layer	87.1 (30.61)	75 (23.88)	6.73

*ΔT is Max temperature difference observed

Thermal time Lag

The thermal time lag refers to the delay between the peak temperature observed in the bottommost layer of a reference roof and the peak temperature in the bottommost layer of the green roof being studied. If t_a is the time of peak temperature in the reference roof and t_b is the time in the green roof test bed, then the thermal time lag is the interval between t_a and t_b. This lag is clearly visible in the temperature curves recorded by the datalogger, as shown in Figures 4, 5, and 6 in a later section.

Table 5 Thermal Time Lag in the Green Roof Test Beds Measured in Minutes

Test bed no	Growth substrate	vegetation	Average Time Lag
Bed I - side 1	only garden soil	No vegetation	114 min
Bed I – side 2	garden soil + cocopeat (1:1 ratio)	No vegetation	82.5 min
Bed II	Garden soil	Paspalum conjugatum	66.6 min
Bed III	Garden soil	Garden lawn grass	101.1 min
Bed IV	garden soil + cocopeat (1:1 ratio)	Paspalum conjugatum	91 min
Bed V	garden soil + cocopeat (1:1 ratio)	Garden lawn grass	66.6 min

GRAPHS AND DISCUSSIONS

Figure 4 shows the Thermal/temperature profile of green roof test bed no.1. The bed is divided into two halves viz. side 1 & side 2. Side 1 has common garden soil for growth substrate and is sourced from a local nursery while the side 2 is 1:1 mixture by weight of the common garden soil and coco-peat. The test bed no. 1 has no vegetation. The temperature profiles of both the sides over a 10 day period in the monsoon season of central India reveals on average a thermal time lag between the top layer and bottom layer of about 114 minutes and about 83 minutes for side 1 and side 2 respectively as tabulated in table 5. Also it was observed that the difference in maximum and minimum temperatures on the topmost layer for side 1 and side 2 was about the same at about 10.33°C but this difference in the lower layer for side 1 and side 2 was about 7.3°C and 8.8°C. This indicates that side 2 with just soil and coco-peat mixture has slightly better performance as that of just soil.

Figure 5 shows the Thermal/temperature profile of green roof test bed no.2 and 3. Bed 2 has Paspalum conjugatum grass and bed 3 has garden lawn i.e. Bermuda grass, but both the beds has common garden soil as growth substrate. As soon as the vegetation comes into play, there is marked offset in the temperatures of the top and lower layers of the test beds as evident from the graphs in fig. 5. The thermal time lag in bed 2 and bed 3 were recorded to be about 66 minutes and 101 minutes as shown in table 5. This shows that the common garden lawn is far more efficient in preventing the heating up of the roofs of buildings. Also the difference in maximum and minimum temperatures on the topmost layer for bed 2 and bed 3 was about 9.4°C and 8°C respectively, while the difference in maximum and minimum temperatures on the lowermost layer for bed 2 and bed 3 was recorded to be 7.3°C and 5.95°C respectively.

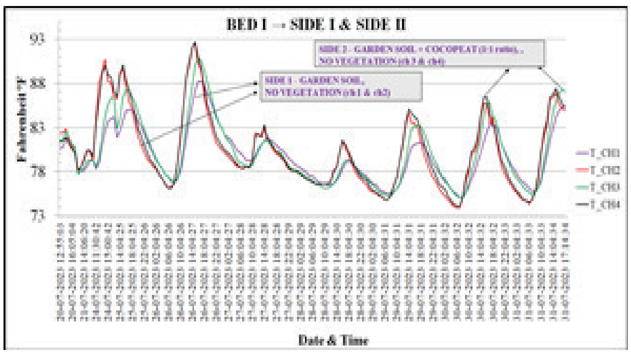

Fig. 4 Thermal Profile of Bed 1 - Side 1 and Side 2

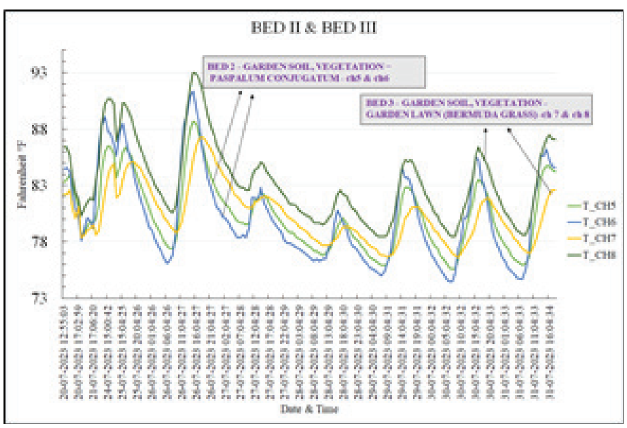

Fig. 5 Thermal Profile of Bed 2 and Bed 3

Figure 6 shows the Thermal/temperature profile of green roof test bed no. 4 and 5. Bed 4 has Paspalum conjugatum grass and bed 5 has garden lawn i.e. Bermuda grass, but both the beds has 1:1 ratio mix of common garden soil and coco-peat as growth substrate. The thermal time lag in bed 4 and bed 5 were recorded to be about 91 minutes and 61 minutes respectively as shown in table 5. Also the difference in maximum and minimum temperatures on the topmost layer for bed 4 and bed 5 was about 7.66°C and 6.73°C respectively, while the difference in maximum and minimum temperatures on the lowermost layer for bed 4 and bed 5 was recorded to be 6.88°C and 6.22°C (almost same).

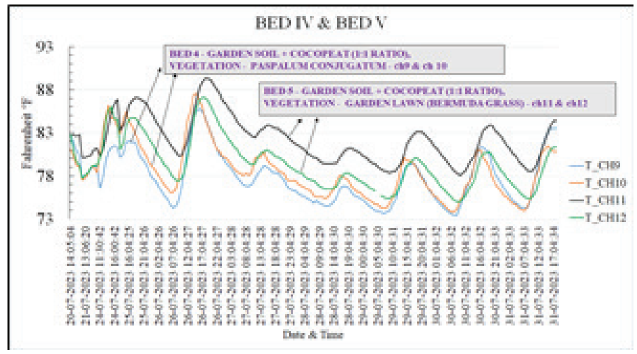

Fig. 6 Thermal Profile of Bed 4 & Bed 5

CONCLUSIONS

Comparison in all the above 4 combinations of growth substrate and vegetation indicate the following:

The test bed no.1 with no vegetation show very little offset between the temperatures of upper and lower layers of the growth substrate. Thus even though thermal time lag exists in this case, however having very little offset in thermal profiles of upper and lower layers of the growth substrate means that the beds heat quickly which is of less importance and use for green roofs.

The garden lawn grass with common garden soil offers the most thermal time lag at about 101 minutes while the second best was of Paspalum conjugatum grass with common garden soil and cocopeat mixture.

It is also observed that the difference between the temperatures of upper and lower layer in bed 4 and 5 (i.e. beds with soil and coco-peat mixture) is higher as that of bed 2 and 3 (i.e. beds with only soil as growth substrate).

Also, the peaks and crests in the thermal profile for bed 4 and 5 are smoother and less sharp indicating better resistance to temperature variations during day-night cycle.

The bed 4 and 5 i.e. with soil and coco-peat as growth substrate show better thermal performance while bed 3 i.e. garden lawn (Bermuda) grass with garden soil as growth substrate offer most thermal time lag.

ACKNOWLEDGMENT

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JARVIS: A Python-Based Personal Assistant

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ABSTRACT

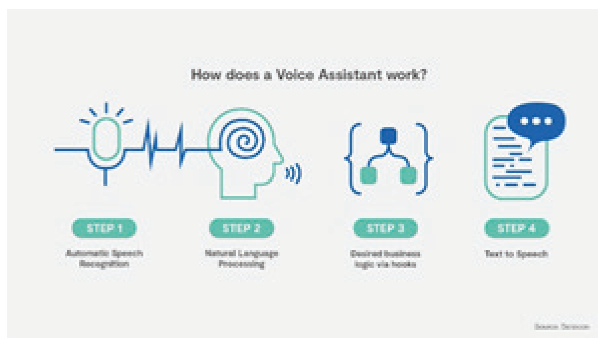
This paper presents JARVIS, an advanced personal assistant developed in Python, designed to facilitate a range of tasks through both voice and text interactions. Inspired by existing virtual assistants such as Siri and Google Assistant, JARVIS offers extensive cross-platform functionality. It supports tasks including web searches, weather updates, email management, and more. The assistant integrates advanced Natural Language Processing (NLP) and Machine Learning (ML) techniques to provide a seamless user experience. This paper details the development process, technological stack, core features, and potential future improvements for JARVIS.

KEYWORDS : *Cross-platform, Python, Virtual assistant, Web automation, Machine Learning, Natural language processing.*

INTRODUCTION

Virtual assistants are integral to modern technology, enhancing productivity and streamlining daily tasks. Despite their growing prevalence, most existing solutions are limited by their association with specific operating systems or ecosystems, leading to fragmented user experiences. To address this, JARVIS (Just A Rather Very Intelligent System) has been developed as a cross-platform virtual assistant. JARVIS aims to bridge the gap left by proprietary assistants by offering a versatile tool adaptable to various environments and evolving technologies. The primary objective is to create an assistant that not only performs routine tasks but also evolves with user needs and technological advancements.

The rise of personal assistants is a testament to the growing demand for automation and smart technology in daily life. However, many existing assistants lack the flexibility to operate across different platforms and seamlessly integrate with diverse systems. JARVIS aims to fill this gap by providing a solution that adapts to user preferences and technological changes, enhancing productivity and user satisfaction.



PROBLEM STATEMENT

The virtual assistant market is dominated by solutions tied to specific platforms, resulting in a fragmented and often limiting user experience. Users frequently encounter difficulties integrating their assistants across different platforms, leading to inefficiencies and dissatisfaction. To address these issues, there is a need for a versatile, cross-platform assistant capable of operating seamlessly across different ecosystems and adapting to technological changes. JARVIS seeks to meet this need by providing a comprehensive tool that enhances user productivity while overcoming the limitations of existing solutions. The challenge lies in ensuring that JARVIS can effectively address a wide range of user needs while maintaining high standards of accuracy and usability.

As the digital landscape evolves, so do the expectations of users seeking smarter and more integrated solutions. JARVIS is designed to address these evolving needs by offering a flexible, scalable, and adaptable personal assistant that integrates with various platforms and technologies. By addressing current limitations and exploring new possibilities, JARVIS aims to set a new standard for virtual assistants.

TECHNOLOGY STACK

Backend Development

JARVIS's backend is managed using Flask, a lightweight Python web framework. Flask is selected for its simplicity, scalability, and flexibility, which are essential for developing robust web applications. The framework's modular architecture supports the integration of various services such as API interactions, database management, and user authentication. This section explores Flask's core components, including routing, templating, and extension support, and discusses how they contribute to JARVIS's backend infrastructure. Additionally, it covers best practices for deploying Flask applications and managing server-side operations.

The choice of Flask for backend development provides several advantages, including its minimalistic design, ease of use, and extensive documentation. Flask's ability to support various extensions and integrations makes it a suitable choice for building scalable and maintainable applications. The flexibility offered by Flask allows JARVIS to adapt to changing requirements and incorporate new features as needed.

Machine Learning Integration

Machine learning is central to JARVIS's ability to interpret user inputs and perform complex tasks. TensorFlow and Scikit-learn are utilized to develop and deploy machine learning models that handle a variety of functions, from predicting user intentions to generating personalized responses. TensorFlow's capabilities for training and deploying deep learning models are harnessed to enhance JARVIS's performance. Scikit-learn complements TensorFlow by offering additional algorithms for classification, regression, and clustering. This section provides a detailed analysis of the machine learning models employed in JARVIS, including their training processes, evaluation metrics, and optimization strategies.

Web Scraping and Automation

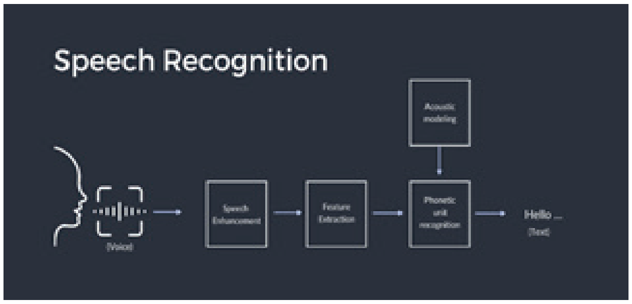
JARVIS utilizes Selenium and BeautifulSoup for web scraping and automation. Selenium is employed to automate browser interactions, enabling JARVIS to perform web searches and retrieve content. BeautifulSoup is used to parse HTML and XML documents, facilitating the extraction and manipulation of web data. This section discusses the integration of Selenium and BeautifulSoup, including their functionality, usage, and common challenges. It also provides examples of web scraping tasks and strategies for handling dynamic web content and dealing with anti-scraping measures.

The combination of Selenium and BeautifulSoup allows JARVIS to efficiently retrieve and process web data, enhancing its ability to provide accurate and up-to-date information. Selenium's automation capabilities enable JARVIS to interact with web pages as a human user would, while BeautifulSoup's parsing capabilities facilitate the extraction of relevant data. This integration supports a wide range of web scraping tasks, from retrieving search results to extracting specific content.

Speech Recognition

Speech recognition is a key feature of JARVIS, enabling users to interact with the assistant using voice commands. The SpeechRecognition library and Google's Web Speech API are employed to convert spoken language into text and process user commands. This section explores the technical aspects of speech recognition, including audio data processing, language models, and error handling. It also examines the impact of speech recognition on user experience and accessibility, and discusses potential improvements such as multilingual support and enhanced voice recognition accuracy.

The integration of speech recognition into JARVIS allows users to interact with the assistant hands-free, providing a more intuitive and convenient experience. The SpeechRecognition library and Web Speech API enable accurate conversion of spoken language into text, facilitating seamless voice interactions. Future improvements in speech recognition technology, such as multilingual support and enhanced accuracy, will further enhance JARVIS's capabilities and user experience.



Database Management

JARVIS uses SQLite for managing user data, preferences, and interaction history. SQLite is a lightweight, serverless relational database management system (RDBMS) that provides efficient performance with minimal configuration. This section covers the design of the database schema, data storage strategies, and query optimization techniques used in JARVIS. It also discusses best practices for database management, including data security measures, backup procedures, and strategies for scaling the database as JARVIS's user base grows.

SQLite's lightweight design and ease of use make it an ideal choice for managing JARVIS's data. The database schema is designed to efficiently store and retrieve user data, preferences, and interaction history. Strategies for optimizing database performance, such as indexing and query optimization, ensure that JARVIS operates efficiently as its user base grows. Additionally, data security measures and backup procedures are implemented to protect user information and ensure data integrity.

Email Integration

The integration of smtplib allows JARVIS to send and manage emails directly from its interface. This feature simplifies email communication by enabling users to compose and dispatch emails without switching applications. This section provides an overview of the email integration process, including configuration settings, authentication mechanisms, and error handling. It also discusses potential enhancements, such as integrating additional email features and improving the user interface for email management.

The smtplib library enables JARVIS to handle email communication efficiently, providing users with a streamlined experience. Configuration settings and authentication mechanisms are implemented to ensure secure and reliable email delivery. Potential enhancements, such as additional email features and improved user interface elements, will further enhance the email integration functionality and user experience.

User Interface Design

The graphical user interface (GUI) of JARVIS is developed using Tkinter, Python's standard GUI toolkit. Tkinter provides a simple and intuitive interface for user interactions, including voice command integration, task management, and settings configuration. This section explores the design principles and implementation details of the JARVIS GUI, including layout design, widget usage, and event handling. It also discusses user feedback on the GUI and strategies for improving usability and accessibility.

Tkinter's simplicity and ease of use make it an ideal choice for developing JARVIS's GUI. The interface is designed to be intuitive and user-friendly, with features such as voice command integration and task management. User feedback is incorporated into the design process to ensure that the GUI meets user needs and preferences. Strategies for improving usability and accessibility, such as customizable settings and enhanced visual elements, are also discussed.

Security Measures

Ensuring the security of user data and interactions is critical for JARVIS. This section discusses the security measures implemented in JARVIS, including data encryption, secure communication protocols, and user authentication. It also covers best practices for protecting sensitive information and mitigating potential security risks. Additionally, the section explores strategies for maintaining privacy and compliance with data protection regulations.

Data encryption and secure communication protocols are implemented to protect user information and ensure the integrity of interactions. User authentication mechanisms are used to verify user identity and prevent unauthorized access. Best practices for data protection and compliance with data protection regulations are followed to ensure that JARVIS operates in a secure and privacy-conscious manner.

METHODOLOGY

Natural Language Processing

NLP is a core component of JARVIS, enabling it to process and understand user inputs effectively. This section describes the NLP techniques employed, including tokenization, part-of-speech tagging, and named entity recognition. It also explores the integration of NLP libraries such as NLTK and spaCy, and discusses their role in enhancing JARVIS's language understanding capabilities. Case studies of NLP applications within JARVIS are provided to illustrate the practical impact of these techniques.

NLP techniques such as tokenization and part-of-speech tagging are used to break down and analyse user inputs, enabling JARVIS to understand and respond accurately. Named entity recognition helps identify specific entities within text, such as names and dates, enhancing the assistant's ability to handle complex queries. The integration of NLP libraries such as NLTK and spaCy supports these processes, improving JARVIS's language understanding and response generation capabilities.

Machine Learning Algorithms

Machine learning algorithms are utilized to enhance JARVIS's performance and adaptability. This section provides an overview of the algorithms used, including supervised learning methods for classification and regression tasks. It also discusses the training and evaluation of machine learning models, including techniques for cross-validation and hyperparameter tuning. Case studies and performance metrics are included to demonstrate the effectiveness of these algorithms in real-world scenarios.

Supervised learning methods are employed to train machine learning models for tasks such as intent classification and response generation. Techniques for cross-validation and hyperparameter tuning are used to optimize model performance and ensure accurate predictions. Case studies and performance metrics highlight the effectiveness of these algorithms in improving JARVIS's capabilities and user experience.

User Interaction and Feedback

User interaction and feedback play a crucial role in shaping JARVIS's development and improvement. This section explores the methods used to collect and analyse user feedback, including surveys, usability testing, and user interviews. It also discusses how feedback is incorporated into the development process to enhance JARVIS's features and functionality. Examples of user feedback and its impact on JARVIS's development are provided.

User feedback is collected through various methods, including surveys and usability testing, to gain insights into user needs and preferences. This feedback is analysed to identify areas for improvement and guide the development of new features. Examples of how user feedback has influenced JARVIS's development illustrate the importance of user-cantered design in creating effective and user-friendly solutions.

Cross-Platform Functionality

Ensuring cross-platform functionality is a key goal of JARVIS. This section describes the strategies employed to achieve compatibility across different operating systems and devices. Platform-independent technologies and frameworks are used to ensure that JARVIS operates seamlessly across different operating systems and devices. Techniques for managing platform-specific challenges, such as device compatibility and performance optimization, are employed to provide a consistent user experience. Examples of successful cross-platform implementations demonstrate the effectiveness of these strategies in enhancing JARVIS's functionality.

IMPLEMENTATION

Feature Integration

Integrating various features into JARVIS requires careful planning and execution. This section details the process of integrating core functionalities, including web scraping, email management, and voice recognition. It discusses the technical challenges encountered during integration and the solutions implemented to address them. Case studies of successful feature integration within JARVIS are provided to illustrate best practices and lessons learned.

The integration of core functionalities into JARVIS involves coordinating multiple components and addressing technical challenges. Solutions such as modular design and comprehensive testing are employed to ensure smooth integration and reliable performance. Case studies highlight successful integration efforts and provide insights into best practices for feature development.

Testing and Quality Assurance

Ensuring the quality and reliability of JARVIS is essential for providing a positive user experience. This section describes the testing and quality assurance processes used to evaluate JARVIS's performance, including unit testing, integration testing, and user acceptance testing. It also discusses strategies for identifying and addressing potential issues, such as performance bottlenecks and bugs. Examples of testing results and their impact on JARVIS's development are included.

Unit testing, integration testing, and user acceptance testing are employed to evaluate JARVIS's performance and reliability. Strategies for identifying and addressing potential issues, such as performance bottlenecks and bugs, are implemented to ensure a high-quality user experience. Testing results provide valuable insights into the effectiveness of JARVIS's features and functionality.

Deployment and Maintenance

Deploying and maintaining JARVIS involves managing server infrastructure, handling updates, and ensuring ongoing support. This section discusses the deployment process, including server configuration, application deployment, and monitoring. It also covers maintenance activities, such as bug fixes, feature updates, and user support. Strategies for ensuring smooth deployment and efficient maintenance are provided.

Server infrastructure management, application deployment, and monitoring are critical components of the deployment process. Maintenance activities, such as bug fixes and feature updates, are performed to ensure the continued reliability and functionality of JARVIS. Strategies for efficient deployment and maintenance support a seamless user experience and ongoing support.

FUTURE ENHANCEMENTS

Integration with Smart Home Devices

Future enhancements for JARVIS include integration with smart home devices, enabling users to control various aspects of their home environment through voice or text commands. This development will expand JARVIS's capabilities beyond the digital realm, providing a comprehensive solution for home automation. This section explores potential integration strategies, including compatibility with popular smart home platforms, device control protocols, and user interface design. It also discusses the benefits and challenges of smart home integration and provides examples of potential use cases.

Integration with smart home devices will enhance JARVIS's functionality by enabling users to control their home environment using voice or text commands. Compatibility with popular smart home platforms and device control protocols will be crucial for successful integration. Use cases, such as controlling lighting and thermostat settings, illustrate the potential benefits of smart home integration.

Advanced Machine Learning Models

The incorporation of advanced machine learning models, such as deep learning and reinforcement learning, is planned to enhance JARVIS's ability to understand and respond to complex user commands. These models will improve the accuracy and adaptability of JARVIS, enabling it to handle a wider range of tasks and user interactions. This section discusses the benefits and challenges of integrating advanced machine learning techniques, including model training, performance evaluation, and implementation considerations. It also explores potential applications of deep learning and reinforcement learning in JARVIS.

Deep learning and reinforcement learning models offer advanced capabilities for understanding and responding to complex user commands. Integration of these models will enhance JARVIS's accuracy and adaptability, enabling it to handle a wider range of tasks. The benefits and challenges of incorporating these techniques are discussed, along with potential applications and implementation considerations.

Server Automation

Exploring the potential for server management tasks such as deployment, monitoring, and maintenance will be a key focus. Server automation will reduce the need for human intervention in server administration and expand JARVIS's capabilities to support enterprise-level applications. This section outlines potential server automation tasks, including automated deployment scripts, monitoring tools, and maintenance procedures. It also discusses the impact of server automation on operational efficiency and scalability.

Server automation will enhance JARVIS's capabilities by reducing the need for manual intervention in server management. Automated deployment scripts, monitoring tools, and maintenance procedures will improve operational efficiency and scalability. The impact of server automation on JARVIS's functionality and support for enterprise-level applications is discussed.

Enhanced Natural Language Understanding

Future enhancements will focus on improving JARVIS's natural language understanding capabilities. This includes developing more sophisticated language models, incorporating context-aware processing, and enhancing the assistant's ability to handle nuanced and ambiguous language. This section explores potential advancements in NLP, including the integration of contextual information, semantic analysis, and dialogue management techniques. It also discusses the impact of these advancements on user interactions and overall assistant performance.

Improving JARVIS's natural language understanding capabilities will involve developing advanced language models and incorporating context-aware processing. Techniques such as semantic analysis and dialogue management will enhance the assistant's ability to handle nuanced and ambiguous language. The impact of these advancements on user interactions and overall performance is explored.

Multi-modal Interaction

Multi-modal interaction will enable users to interact with JARVIS through various input methods, including voice, text, and visual interfaces. This enhancement aims to provide a more flexible and intuitive user experience, accommodating different preferences and contexts. This section discusses the design and implementation of multi-modal interaction features, including integration with visual and touch-based interfaces, and strategies for ensuring seamless transitions between input methods.

Multi-modal interaction will enhance JARVIS's user experience by accommodating different input methods, such as voice, text, and visual interfaces. Integration with visual and touch-based interfaces will provide a more flexible and intuitive interaction model. Strategies for ensuring seamless transitions between input methods will be discussed, along with examples of multi-modal use cases.

CONCLUSION

JARVIS represents a significant advancement in the realm of personal assistants, offering a versatile and cross-platform solution for automating daily tasks. Its integration of Python's powerful libraries and tools establishes it as an asset for users seeking to streamline their workflow. As JARVIS continues to evolve, its potential applications and capabilities will expand, positioning it as a leading player in the future of personal assistant technology. The ongoing development of JARVIS reflects the dynamic nature of technology and the increasing demand for intelligent, adaptable solutions. By addressing current limitations and exploring new opportunities, JARVIS is poised to make a lasting impact on the personal assistant landscape.

JARVIS's development and ongoing enhancements demonstrate the potential for personal assistants to become more versatile, intelligent, and integrated into users' daily lives. The combination of advanced technologies, such as machine learning and NLP, with a focus on user experience, positions JARVIS as a leading solution in the evolving landscape of virtual assistants. Future developments and enhancements will further expand JARVIS's capabilities, ensuring that it remains a valuable tool for users seeking to streamline their tasks and improve their productivity.

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Sharding Enabled Blockchain with Bioinspired Secret Sharing & Selective Encryption Model for Ownership Transfer Optimizations to Provide Enhanced Security

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ABSTRACT

It is commonly acknowledged that cloud designers may implement extremely secure multichannel data transport mechanisms thanks to secret sharing models like the Shamir cryptosystem. However, these systems lack context-aware share-selection methods and are primarily static. Additionally, for effective real-time operations, ownership transfers are necessary in SaaS- based cloud installations. Selection encryption models provide these ownership transfer techniques in exchanging data with permission-awareness. Researchers have proposed preventative and bioinspired models to complete these jobs, however almost all of them remain complex or show restricted freedom in situations that happen in real time.

This paper has proposed a model which allows sharding of blockchain to first cope-up with scalability issues inherently faced by blockchain models. Then bioinspired secret sharing algorithm is used to provide enhanced security followed by ownership transfer mechanism which is otherwise overlooked in case of cloud-based models causing security lapses as per the recent studies. The updated rules of proposed model are first tested using fictitious ownership requests. Then, real-time ownership- transfer scenarios are used to validate the rules' levels of efficiency based on the precision with which misconfigurations are identified, the time required to process the requests, the consistency with which invalid ownership requests are blocked, and the throughput of the requests. According to this assessment, the proposed model increases accuracy and consistency, and also increases security when implemented in the real time scenarios.

KEYWORDS *: Bioinspired, Blockchain, Cloud computing, Data security, Secret sharing, Sharding.*

OVERVIEW

The ability of cloud storage to handle contemporary data management issues and its adaptability to the exponential increase of digital information has made it a cornerstone in the field of information storage. The way people, companies, and organisations store, access, and manage data has changed dramatically as a result of the shift from conventional, on- premises storage solutions like hard drives and servers to cloud-based systems. This change is the result of many important causes that establish cloud storage as a necessary component of the modern information environment. First and foremost, one of the main causes of cloud storage's rise in popularity is its scalability. Conventional storage solutions frequently fail to keep up with the massive volumes of data that organisations create and amass—from emails and documents to multimedia files and enormous databases. Businesses don't have to spend money on pricey hardware or infrastructure improvements since they may adjust their storage requirements in response to demand. Businesses with varying storage requirements, like media organisations handling massive video files or e-commerce enterprises facing seasonal surges, would find this scalability very helpful [1]. Furthermore, cloud storage providers provide several price levels according to the frequency of access, enabling businesses to optimise expenses by putting often accessed data in "hot" storage for speedy retrieval and sparingly used data in less expensive, "cold" storage solutions [2].

The growth of cloud storage has also been significantly influenced by accessibility and ease. With cloud-based solutions, anybody with an internet connection may access their data from any location in the globe. This makes remote work, cross-border collaboration, and data sharing possible by doing away with the limitations of location-specific storage solutions. Cloud storage makes information easy to access and collaborates better across teams. The growth of cloud storage has also been significantly influenced by accessibility and ease. With cloud-based solutions, anybody with an internet connection may access their data from any location in the globe. This makes remote work, cross-border collaboration, and data sharing possible by doing away with the limitations of location-specific storage solutions [3].

Due to above mentioned reasons, cloud service providers have made significant investments in multi-factor authentication, cutting-edge encryption, and adherence to global data security laws to guarantee that data kept in the cloud is safe from breaches and unwanted access. Moreover, automatic backup procedures are made possible by cloud storage reducing chances of data loss. Ultimately, enterprises are now able to further improve the security and flexibility of their storage solutions thanks to the growing use of hybrid cloud and multi-cloud methods. Through the use of cloud and on-premises storage, hybrid cloud solutions enable businesses to store sensitive data locally and use the cloud for less important data [14].

Now with storage's scalability, affordability, accessibility, security, and versatility, it has emerged as a key element of information storage. Cloud storage will become more and more important as companies continue to embrace digital transformation in order to manage, safeguard, and optimise the massive volumes of data created in today's connected world [4].

In theory it is now widely accepted that not only data storage but ownership transfer mechanisms for cloud computing raised further questions which are an additional issue other than the security and it is due to significant difficulties arise when it comes to ownership transfers in cloud computing, especially when it comes to data protection, intellectual property, and legal compliance. Data security becomes a major problem when cloud assets, such as infrastructure and data, are transferred between parties—for example, through provider switching, mergers, or acquisitions. When proprietary software or cloud-stored algorithms are transmitted, intellectual property problems occur about ownership rights [11]. Complying with industry- and region- specific requirements, like HIPAA or GDPR, increases complexity, particularly when data is held in many jurisdictions. Furthermore, vendor lock-in frequently makes ownership transfers more challenging because switching cloud providers can be expensive and technically challenging owing to incompatible technologies. Contracts and service level agreements (SLAs) might provide legal issues since the terms may need to be renegotiated or adjusted. For cloud environment transfers to go well, navigating these challenges is essential [5].

IMPORTANCE OF HYBRID BIOINSPIRED MODELS IN ORDER TO OPTIMIZE MECHANISM FOR OWNERSHIP-TRANSFER IN CLOUD:

Bioinspired models are very useful for resource optimisation in cloud systems. In order to guarantee smooth transitions during ownership transfers, it is frequently necessary to allocate resources (bandwidth, storage, and computing power) efficiently [8], [12]. Bioinspired techniques, such as ant colony optimisation (ACO) and particle swarm optimisation (PSO), can be used to dynamically manage and allocate resources, guaranteeing ownership transfers occur without performance deterioration or service interruptions. Only the most dependable and secure nodes may be selected for ownership transfer and secret sharing through the use of evolutionary algorithms, which simulate the process of natural selection. This further improves the process's security and dependability, especially in large-scale cyber-physical systems where the intricacy of the infrastructure and data raises the possibility of failure [6].

A number of security benefits are available for cloud-based ownership transfer using hybrid bioinspired models. Self- healing mechanisms, which draw inspiration from biological systems' capacity for damage repair, enable the architecture to recognise and react automatically to security breaches or malfunctions that occur during ownership transfers [10], [13]. Bioinspired algorithms, for instance, can recreate the data using different shares or dynamically redirect a compromised data share to a more secure node. Moreover, models inspired by the immune system may be utilised to identify and thwart hostile assaults that may arise during ownership transfers. By simulating the body's defence mechanisms against infections, these models enable the system to identify anomalous behaviour or cyberthreats in real time and take appropriate countermeasures [5], [6].

SHARDING AND SECRET SHARING INTEGRATED WITH BLOCKCHAIN

Sharding in blockchain: The leverage in case of blockchain sharding is to divide the blockchain into smaller units (shards), each responsible for processing a subset of the system's data and transactions. This improves the efficiency and scalability of the system. Here each shard is responsible for a subset of nodes, handling its own portion of the network's transaction and data validation [7]. This decentralization reduces the load on individual nodes and improves transaction throughput. It is followed by Inter- Shard Communication were Cross-shard communication ensures that data in one shard can be accessed and validated by another shard when necessary, such as during ownership transfers. A communication layer ensures synchronization and consistency across shards, ensuring that the integrity of secret sharing and encryption remains intact [8].

Secret Sharing Integrated with Blockchain: The use of secret sharing is used to divide sensitive data into multiple shares and store these shares across different shards in the blockchain. Only authorized parties can recombine the shares to access the original data. In the proposed model, Shamir's Secret Sharing Scheme is used where sensitive data is split into n shares, with a threshold k required to reconstruct the original secret. These shares are stored across different shards in the blockchain network [9].

This further helps in the Distributed Storage as each share is securely stored in its respective shard, ensuring that even if one shard is compromised, no single shard can reconstruct the original data without meeting the threshold also in the next section it will be seen that the ownership transfer optimization is also supported as during an ownership transfer, shares are reassigned to the new owner through the blockchain's smart contracts, ensuring transparency and security. Sharded blockchain allows selective reallocation of shares to the new owner while maintaining the system's decentralized nature [10].

PROPOSED ADAPTIVE SECRET SHARING ALGORITHM AND SELECTIVE ENCRYPTION WITH OWNERSHIP TRANSFER

Optimization (ASSASEO)

Once the sharding is successfully completed and blocks with secret sharing is implemented, an algorithm is proposed for further strengthening the security. This algorithm is designed to secure cloud-based cyber-physical systems during ownership transfers, focusing on optimizing secret sharing and selective encryption to balance security, efficiency, and flexibility. The goal is to enhance security while minimizing performance overhead during ownership transfer events in the cloud, using bioinspired approaches for adaptability and optimization.

Key Components of ASSASEO

Dynamic Secret Sharing Mechanism: The basic objective is to split sensitive data into multiple shares, distribute them across different cloud nodes, and ensure that only authorized parties can reconstruct the data during ownership transfers.

Adaptive Distribution: Inspired by swarm intelligence, the algorithm dynamically allocates shares across nodes based on Network performance, Resource availability and Threat analysis.

Selective Encryption Based on Data Sensitivity

The idea here is to encrypt only the most sensitive parts of the data to minimize encryption overhead while maintaining strong security for critical information. The process is based upon Data Sensitivity Analysis where Data is classified into different sensitivity levels (high, medium, low) using machine learning models based on Data type (e.g., personal information, financial data, non-sensitive metadata).

High-Sensitivity Data: Encrypted with strong algorithms like AES-256.

Medium-Sensitivity Data: Encrypted with lightweight algorithms like Blowfish.

Low-Sensitivity Data: No encryption, only basic integrity checks.

Optimized Encryption Workflow: Before ownership transfer, the encryption workflow is streamlined to encrypt or decrypt only data needed by the new owner, reducing the time and computational overhead associated with full-scale encryption.

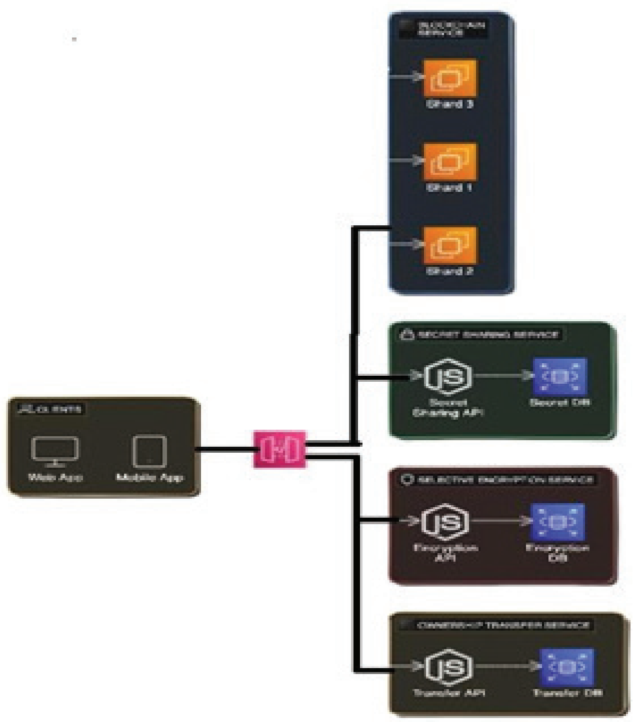

Fig. 1 Sharding Enabled Blockchain Model using Bioinspired Secret Sharing for Ownership Transfer Mechanisms

Ownership Transfer Optimization Using Bioinspired Approaches

It is done in order to ensure secure and efficient ownership transfer with minimal service disruption and optimized resource usage during the transfer by first doing, Ownership Transfer which can be initiated based on predefined events such as mergers, acquisitions, or change of service provider. It is followed by swarm intelligence for Share Reallocation inspired by Ant Colony Optimization (ACO), the system finds the best path for reallocation of data shares and encryption keys. Ant-like agents evaluate the state of the network (bandwidth, node health, security risks) and dynamically determine the most secure nodes for data migration. The algorithm ensures that Redundancy and Error Tolerance.

A minimum of k, where k shares (in k/n secret sharing) are always available on the secure nodes, even if some nodes fail or are under attack.

Self-healing mechanisms are employed to automatically regenerate lost or corrupted shares during the transfer.

Predictive Security Evaluation: A neural network model continuously evaluates network conditions and predicts potential threats or bottlenecks in the ownership transfer process. This model is trained on past transfers and security incidents to adapt and optimize future transfers in real-time.

Real-Time Threat Monitoring and Adaptation

In order to continuously monitor the network and cloud environment for security threats during secret sharing and ownership transfers, adapting the system to counteract potential risks. The process is based as inspiration from Intrusion Detection System (IDS) further inspired by the biological immune system, the IDS monitors for anomalies such as unusual access patterns, network traffic spikes, or unauthorized attempts to access data shares.

Adaptive Response Mechanism: In the event of a detected threat the system automatically re-encrypts high-sensitivity data or regenerates new shares to replace potentially compromised ones.

The algorithm redistributes shares to new nodes if certain nodes are deemed insecure.

Threat Feedback Loop: The system continuously learns from threats by feeding security event data into the neural network model for future threat prediction, allowing it to adapt and improve the optimization of future ownership transfers.

Algorithm Workflow

- Initialization:
- Data sensitivity is assessed.
- Secret is split into shares based on sensitivity and network resources.
- Shares are encrypted selectively based on sensitivity level.

Ownership Transfer Triggered: Swarm intelligence agents begin evaluating the network for the best nodes to handle the transfer. Predictive models assess potential risks, and nodes are ranked for security and availability.

Secret Sharing and Encryption

- Shares are migrated to new nodes while keeping k
- k shares available to ensure continuous access.
- Real-time monitoring ensures shares are not compromised during transfer.

Completion

After successful ownership transfer, the system verifies that all shares and encrypted data are correctly reassembled and accessible by the new owner.

Advantages of proposed model ASSASEO:

Efficiency: Selective encryption reduces computational overhead.

Security: Adaptive secret sharing ensures data is protected even during network or node failures.

Flexibility: Swarm intelligence allows dynamic reallocation of resources based on real-time network conditions.

Self-optimization: Neural network models continuously learn to improve the security and efficiency of future ownership transfers.

This above discussed algorithm ensures secure, optimized, and flexible handling of secret sharing and ownership transfers in cloud-based systems, particularly in cyber-physical environments where real-time responsiveness is essential.

CONCLUSION

Traditional blockchains' issues with scalability and performance may be effectively resolved with sharded blockchain architecture. The system maintains security through decentralised validation and coordination via the beacon chain, allowing it to accept more transactions, store more data, and grow effectively by dispersing the processing burden over numerous shards. Even with issues like security threats and cross-shard connectivity, sharding is still one of the most promising ways to enable the next wave of blockchain technology.

For cloud-based cyber-physical systems, proposed architecture offers improved security, scalability, and efficiency by combining sharded blockchain with secret sharing and selective encryption. While secret sharing makes sure that no single entity has access to all sensitive data, sharding makes it possible to handle massive amounts of data efficiently. By encrypting only the most important data, selective encryption improves speed even further. Smart contracts and consensus methods based on blockchain technology securely handle ownership transfers, guaranteeing an unalterable, transparent, and smooth procedure.

This concept works effectively in large-scale, dynamic contexts like Internet of Things (IoT), healthcare networks, financial services, and other cyber-physical systems where efficiency and security are equally important.

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A Deep Learning Based Approach for Chlorophyll Estimation in Citrus Leaves

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ABSTRACT

Chlorophyll is a critical indicator of plant health, playing an essential role in photosynthesis and reflecting the physiological state of leaves. Estimating chlorophyll content in citrus leaves can provide valuable insights into early crop leaf disease identification and help quantify the severity of crop diseases, thereby facilitating timely and effective intervention strategies. Traditional methods for chlorophyll estimation, such as chemical assays and spectrometry, are often labor-intensive, time-consuming, and require expensive equipment, limiting their applicability for large-scale field monitoring. In this study, deep learning models based on MobileNetV2 & EfficientNetB0 using Transfer Learning are proposed to accurately estimate chlorophyll values from images of citrus leaves and their performance using different optimizers is also compared. The models leverages a Convolutional Neural Network (CNN) architecture to learn complex patterns and features associated with chlorophyll content from leaf color and texture. Training of the model is done on a dataset of annotated leaf images, capturing a diverse range of chlorophyll levels. Experimental results demonstrate that EfficientNetB0 model achieves high accuracy in chlorophyll estimation, outperforming traditional methods. By providing a non-invasive, rapid, and scalable solution for chlorophyll estimation, our approach offers a valuable tool for early disease detection and severity quantification, supporting improved crop management and disease control practices in citrus farming. This research highlights the potential of deep learning in precision agriculture, contributing to the development of smarter, data-driven agricultural systems.

KEYWORDS *: CNN, Chlorophyll, Crop disease, Deep Learning, Transfer Learning etc.*

INTRODUCTION

Chlorophyll content is a crucial indicator of plant health and productivity, as it directly influences photosynthetic capacity and reflects the physiological state of leaves. In citrus cultivation, monitoring chlorophyll levels is vital for understanding plant nutrient status, assessing stress conditions, and predicting potential disease outbreaks [1]. Conventional methods for estimating chlorophyll, such as destructive chemical analysis and spectrophotometry, are precise but often require substantial labor, resources, and time, making them unsuitable for large-scale or continuous monitoring in agricultural settings [2]. To address these limitations, there is a growing interest in developing non-invasive, efficient, and scalable techniques for chlorophyll estimation using digital image analysis.

Convolutional neural networks (CNNs), in particular, have demonstrated exceptional promise in deep learning for plantphenotyping tasks such as leaf segmentation, species and disease classification, and disease detection etc. [3]. Large volumes of labeled data and computational resources are needed for training deep learning models from scratch, and these resources might not always be available. Transfer learning in such case is one of the best solution which utilizes pre-trained models to leverage knowledge from large-scale datasets, allowing for efficient learning on smaller, domain-specific datasets [4]. In this study, we explore the use of transfer learning to estimate chlorophyll content in citrus leaves, employing deep learning models such as MobileNetV2 and EfficientNetB0, known for their performance and computational efficiency in image analysis tasks.

MobileNetV2 and EfficientNetB0 are lightweight CNN architectures that are specifically designed for mobile and edge applications, providing a computational efficiency and accuracy balance. Since MobileNetV2 reduces the number of parameters by the use of depth-wise separable convolutions, it is a good choice for deployment in contexts of limited resources. EfficientNetB0 implements a new scaling strategy that proportionally adjusts depth, width, and resolution, delivering improved performance while using fewer parameters than conventional models. By fine-tuning these pre-trained models on a domain-specific dataset of citrus leaf images, we aim to achieve high-accuracy chlorophyll estimation with reduced computational overhead. In [5], a hybrid model is presented, to enhance short-term chlorophyll-a (Chl-a) prediction in the Lake basin. The model incorporates bidirectional gate recurrent unit (BiGRU) and Temporal Convolutional Network (TCN along with an attention mechanism (AM) to forecast Chl-a concentrations.[6] uses multiple machine learning models such as Support Vector Regression (SVR), Multiple Linear Regression (MLR), Artificial Neural Networks (ANN), and K-Nearest Neighbors (KNN) to predict the chlorophyll content in tea leaves under natural light conditions. [7] Explores the potential of combining hyperspectral data with transfer learning application in deep learning to improve chlorophyll content estimation, offering insights into advanced agricultural technology.[8] focuses on using deep neural networks for chlorophyll concentration estimation while addressing challenges like data imbalance.

In addition to utilizing advanced CNN architectures, we also investigate the effect of different optimizers—such as Adam, RMSprop, and AdamW—on model performance. Optimizers play a critical role in the convergence of deep learning models by adjusting the learning rate and minimizing the loss function during training. Selecting the right optimizer can significantly influence the model's accuracy and generalization ability. By comparing various optimizers in conjunction with MobileNetV2 and EfficientNetB0, this study aims to identify the optimal combination for chlorophyll estimation in citrus leaves.

This paper has threefold contributions in following manner: (1) the development of a transfer learning-based approach using MobileNetV2 and EfficientNetB0 for chlorophyll estimation, (2) a comprehensive evaluation of the impact of different optimizers on model performance, and (3) the demonstration of a scalable and efficient method for non-invasive chlorophyll monitoring in citrus agriculture. Our results suggest that transfer learning, coupled with appropriate optimization techniques, can offer a viable solution for rapid and accurate chlorophyll estimation, supporting the broader goals of precision agriculture and sustainable crop management.

MATERIALS AND METHODS

Dataset Preparation

The dataset used in this study consists of digital images of citrus leaves captured under controlled lighting conditions to minimize variations in color representation. The leaves were taken from Citrus trees of around 7 year old. Images are taken using Samsung A14 5G mobile camera having specifications of main camera as 50 MP, f/1.8, (wide), PDAF 2 MP, f/2.4, (macro) & 2 MP, f/2.4, (depth). Each image is paired with a corresponding chlorophyll content index (CCI) value, obtained using CCM-200 plus Chlorophyll content meter. The dataset includes approximately 1,000 images, representing a wide range of chlorophyll levels and leaf conditions. CCM-200 plus meter has absorption of light in two distinct wavelength bands: 653nm & 931nm. It's measurement area is 9.52 mm (3/8 inch) diameter circle (71 mm2). CCM-200 plus displays chlorophyll value in Chlorophyll Content Index (CCI). The CCI was taken twice for each leaf approximately at the center of the leaf and average of two values was noted as final CCI for that leaf. Leaf images were pre-processed as described in next section.

Leaf Image Preprocessing

Image Acquisition and Grayscale Conversion

Given a set of RGB leaf images $\{ I_i\}_{\{i=1\}}^{N}$, where each image $I_i \in R^{HXWX3}$ represents a matrix with height H, width W, and three color channels (Red, Green, Blue), we first convert each image to grayscale to facilitate segmentation.

The grayscale image $G_i \in R^{HXW}$ is computed using a weighted sum of the RGB channels:

$G_i(x,y) = 0.2989.I_i(x,y,R)+0.5870.I_i(x,y,G)+0.1140.I_i(x, y, B)$.

where $I_i(x,y,c)$ represents the intensity of color channel $c \in \{R,G,B\}$ at pixel location (x,y).

Binary Thresholding for Segmentation

To segment the leaf from the background, we apply binary thresholding to each grayscale image G_i. This process produces a binary mask $B_i \in \{0,255\}^{HXW}$, where each pixel is classified as either foreground (leaf) or background (non-leaf):

$$B_i(x,y) = \begin{cases} 255 & if\ G_i(x,y) > T \\ 0 & Otherwise \end{cases}$$

where T is a predefined threshold value, chosen to separate the leaf (non-zero pixel intensities) from the black background.

Contour Detection and Leaf Extraction

Contours are extracted from the binary mask B_i using a contour detection algorithm. Let $C=\{C_k\}_{k=1}^{K}$ denote the set of detected contours, where each contour C_K is a set of points forming a closed boundary around a connected component in B_i.

To identify the leaf, we assume that it corresponds to the largest contour in C_I, denoted as:

$$C_{leaf} = arg \max_{C_k \in C} Area(C_k)$$

where $Area(C_k)$ is the area enclosed by contour C_k, computed as the number of pixels inside the contour.

Bounding Box Calculation

A bounding box B= (x,y,w,h) is then computed around the largest contour C_{leaf}, where:

x & y represent the coordinates of the top-left corner of the bounding box.

w & h correspond to the width and height of the bounding box, respectively..

Mathematically, this is represented as:

$(x,y,w,h) = BoundingBox(C_{leaf})$

Cropping and Centering the Leaf

The bounding box B is used to crop the original RGB image I_i, yielding a cropped image

$$I_i^{crop} \in \mathbb{R}^{hxwx3}$$

$$I_i^{crop} = I_i\ [y: y + h, x: x + w]$$

Next, a new black background image

$I_i^{centered} \in \mathbb{R}^{HxWx3}$ is created, initialized to zero:

$$I_i^{centered}(x, y, c) = 0, \forall(x, y) \in \{1, \ldots, H\} \times \{1, \ldots, W\},\ \forall c \in \{R, G, B\}$$

To center the cropped image I_i^{crop} within $I_i^{centered}$, we compute the offsets (x_{offset}, y_{offset} as:

$$x_{offset} = \left\lfloor \frac{W-w}{2} \right\rfloor, \quad y_{offset} = \left\lfloor \frac{H-h}{2} \right\rfloor$$

The cropped image is then placed into the center of the black background image:

$$I_i^{centered}[y_{offset} : y_{offset} + h, x_{offset}: x_{offset} + w, :] = I_i^{crop}$$

Fig. 1 Cropped & Centered Leaf Image

Dynamic Programming for Maximum Inscribed Rectangle

The goal is to determine the largest rectangle that can be inscribed fully within the leaf contour C_{leaf}. This is achieved using a dynamic programming approach. We define a 2D array dp(i,j) such that:

dp(i,j)=side length of the largest square ending at pixel (i,j)

The recurrence relation for computing dp(i,j) is:

$$dp(i,j)=\begin{cases}1 & If\,M(i,j)=255 \text{ and } (i=0 \text{ or } j=0)\\ \min(dp(i-1,j), dp(i,j-1), dp(i-1,j-1)+1 & If\,M(i,j)=255 \text{ and } (i>0 \text{ and } j>0)\\ 0 & If\,M(i,j)=0\end{cases}$$

Here, the value of dp(i,j) depends on the minimum value of the three adjacent squares above, left, and top-left of (i,j) ensuring that the square remains within the leaf contour.

Identifying the Maximum Inscribed Rectangle

The maximum side length s of the inscribed square is:

$$S = \max_{(i,j)} dp(i,j)$$

The coordinates of the bottom-right corner of this maximum inscribed square are stored as (x,y) where dp(x,y) = s.

Extracting and Saving the Cropped Region

The final step is to extract the region corresponding to the largest inscribed rectangle from the original image:

$I_{cropped} = I[(y-s):y,(x-s):x]$

Finally, each image $I_{cropped}$ is saved to the specified output directory for further use in subsequent machine learning tasks.

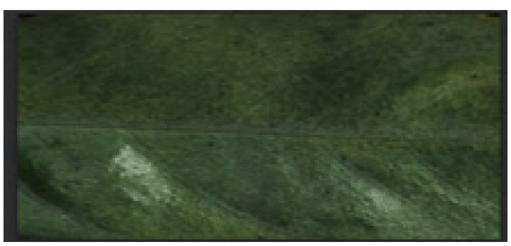

Fig. 2. Largest Inscribed Rectangle of Leaf. Dataset Consist of These Types of Images

This pre-processing pipeline effectively isolates the leaf from the background, standardizes its position by centering it within a fixed image size, and preserves its original color and texture properties. Then leaf regions are standardized by aligning them within the maximum possible inscribed rectangle. This uniformity is crucial for downstream machine learning tasks, such as regression models predicting chlorophyll content, as it mitigates the influence of varying leaf shapes , background etc. This also helps to improve accuracy as while measuring chlorophyll using CCM-200 plus meters values were taken from area near to center of the leaf. By mathematically defining the region of interest and optimizing its extraction, this method improves the model's potential to emphasize on the most relevant areas of the image, thereby boosting prediction accuracy.

Data Augmentation

In order to enhance the models' resilience, data augmentation methods were implemented on the training dataset. Augmentation methods included random rotations, horizontal and vertical flips, zoom and shifts. These techniques were used to simulate real-world variations in leaf appearance due to different angles, orientations, lighting conditions, and noise, thereby improving the model's capacity to generalize to fresh, untested data.

DEEP LEARNING MODELS AND TRANSFER LEARNING APPROACH

The primary reason to select Transfer Learning approach was size of Dataset. The dataset utilized for training as well as for validating of the model consist of 1000 images. Due to small Dataset size using pre-trained deep learning model was the inherent choice. This study employed two pre-trained deep learning models—MobileNetV2 and EfficientNetB0—for chlorophyll estimation through transfer learning. These models were chosen for their lightweight architectures and demonstrated efficiency in image recognition tasks.

The models are pre-trained on ImageNet, a large-scale dataset containing around 1.18 million labeled images across 1,000 classes. EfficientNetB0 has 237 layers & MobileNetV2 has 155 layers, all of which remain frozen in this configurations, maintaining the learned weights from the ImageNet dataset. Therefore, none of the EfficientNetB0 & MobileNetV2 layers will be updated during training; only the custom dense layers added on top will be trained. Both the Transfer Learning models includes three custom dense layers added on top of the frozen base. First custom dense layer with 256 Neurons followed by a dropout layer, second custom dense layer with 128 Neurons followed by another dropout layer and final output dense layer with single neuron which is designed for the regression task of predicting chlorophyll values.

MobileNetV2: MobileNetV2 is a convolutional neural network architecture developed for mobile and embedded vision tasks. It employs depth-wise separable convolutions and inverted residuals with linear bottlenecks to minimize the number of parameters and reduce complexity of the computation [10]. For this study, MobileNetV2 was initialized using weights that were pre-trained on the ImageNet dataset, and the top (fully connected) layers were replaced with a custom head tailored for regression tasks to estimate chlorophyll content.

EfficientNetB0: In order to attain excellent performance with fewer parameters, EfficientNetB0 is a scalable neural network architecture that strikes a trade-off between network depth, width, and resolution[11]. EfficientNetB0 was also initialized with ImageNet weights, and the final layers were customized for chlorophyll estimation. A fully connected dense layer with ReLU activation was placed after a global average pooling layer, followed by an output layer with a single neuron to predict the chlorophyll value.

Model Training and Optimization

The models were trained on the prepared dataset using different optimizers—Adam, AdamW and RMSprop—with the goal of identifying the most effective optimization technique for this regression task. The models were implemented using TensorFlow and Keras libraries.

- Adam Optimizer: The Adam optimizer (Adaptive Moment Estimation) is a method used for optimizing deep learning models, maintaining a per-parameter learning rate to improve convergence. It is particularly effective for large datasets and models with numerous parameters. [12]. An initial learning rate of 0.001 was used, with decay in learning rate applied to adjust dynamically during training.
- RMSprop Optimizer: The RMSprop optimizer adjusts the rate of learning based on a moving average of recent gradients, preventing rapid fluctuations and ensuring smoother convergence. An initial 0.001 learning rate was selected, with 0.9 decay rate.
- AdamW Optimizer: The AdamW optimizer is a variant of the Adam optimizer that introduces decoupled weight decay. It improves upon the original Adam optimizer by modifying how regularization (specifically, weight decay) is applied to the model parameters during optimization. AdamW updates the model weights iteratively based on the learning rate and momentum, with 0.001 initial learning rate and 0.9 momentum to speed up convergence and avoid local minima.

Training Procedure

Each model with corresponding optimizer undergone training for 50 epochs, with 32 batch size. An 80-20 train-validation data split was used to ensure sufficient data for both training and validation phases. In order to avoid overfitting, Early Stopping was implemented and validation loss was monitored with a patience parameter set to 10 epochs. Regression's loss function was the mean squared error (MSE), and the model's effectiveness was assessed by calculating the coefficient of determination (R2 score).

Evaluation Metrics

Metrics like Mean Squared Error (MSE) and Mean Absolute Error (MAE) were used to assess each model's performance. These metrics provided a comprehensive understanding of the models' performance in estimating chlorophyll values from leaf images. Additionally, the coefficient of determination (R^2 score) was computed to assess the proportion of variance explained by the model, giving insight into its predictive accuracy.

Table 1 Summary of Evaluation Metrics

Metric	Description	Purpose
Mean Absolute Error (MAE)	Average of absolute differences between predictions and actual values.	Measures prediction accuracy in terms of the original units (chlorophyll values).
R^2 Score	Proportion of the variance in the dependent variable that can be explained by the independent variables in the model.	Evaluates the goodness of fit of the model, with a value closer to 1 indicating better performance.

Mean Squared Error (MSE)	Average of squared differences between predicted & actual values.	Used as the loss function to optimize the model during training. Sensitive to large errors.

Experimental Setup

All experiments were conducted on Google Colab to accelerate model training. The Python programming language was used for model implementation, leveraging deep learning frameworks such as TensorFlow and Keras. Data preprocessing, augmentation, and model evaluations were performed using standard libraries such as NumPy, Panda, and Scikit-learn.

RESULT & DISCUSSION

The two models used were MobileNetV2 & EfficientNetB0. Initially MobileNetV2 model was run using Adam optimizer and parameters like initial learning rate was tweaked to get the maximum accuracy. The same model was then run with RMSprop & AdamW optimizers. The Same process was repeated for EfficientNetB0 model. The experimental results for MobileNetV2 with Adam optimizer only & EfficientNetB0 with RMSprop optimizer only are shown below.

MobileNetV2

Table 2 Comparative of Performance Metrics

Model	Optimizer	MSE	Loss	R^2 Score
MobileNetV2 (EPOCHS=50)	Adam	6.78	104.01	81.55
	AdamW	7.0741	102.35	81.43
	RMSprop	7.04	110.33	80.37
EfficientNetB0 (EPOCHS=50)	Adam	6.64	80.46	84.07
	AdamW	6.52	80.27	84.73
	RMSprop	6.33	72.51	85.86

Adam Optimizer

```
8/8 ━━━━━━━━━━━━━━━━━━━━ 21s 3s/step - loss: 104.0154 - mean_absolute_error: 7.0787
Validation MAE: 6.784100532531738
8/8 ━━━━━━━━━━━━━━━━━━━━ 17s 2s/step
R² Score: 0.81551325650032
```

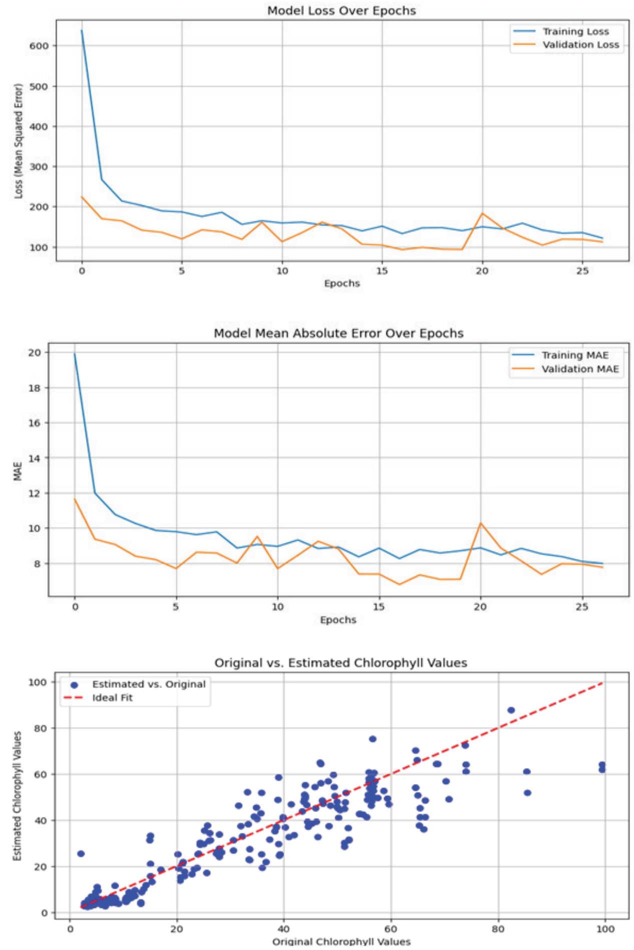

Fig 3. Mobilenetv2 with Adam Optimizer Performance Plots

EfficientNetB0

RMSprop

```
8/8 ━━━━━━━━━━━━━━━━━━━━ 4s 493ms/step - loss: 72.5188 - mean_absolute_error: 6.3379
Validation MAE: 6.207448056762695
8/8 ━━━━━━━━━━━━━━━━━━━━ 11s 923ms/step
R² Score: 0.858689369492326З
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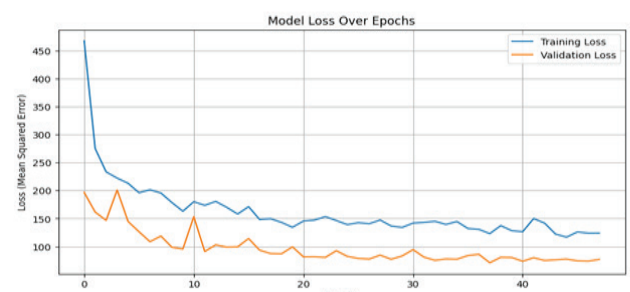

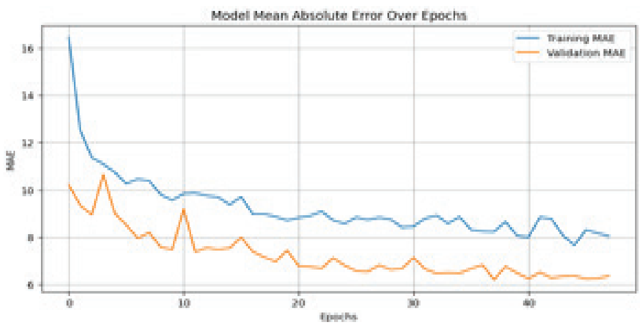

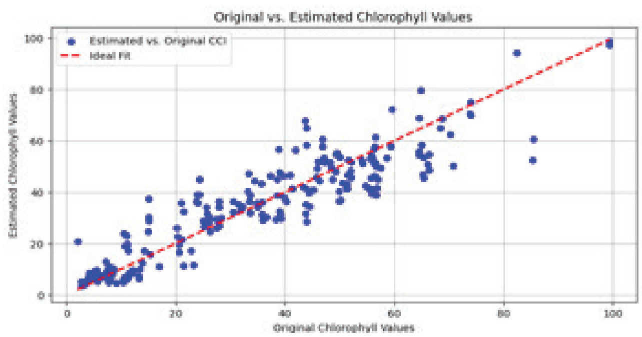

Fig. 4 FficientNetb0 with RMS Prop Optimizer Performance Plots

CONCLUSION

In this study, we developed and evaluated deep learning models, MobileNetV2 and EfficientNetB0, utilizing transfer learning to estimate chlorophyll content from citrus leaf images. Our approach offers a non-invasive, rapid, and scalable solution for chlorophyll estimation, significantly reducing the need for labor-intensive and expensive traditional methods like chemical assays and spectrometry. The experimental results demonstrate that EfficientNetB0 outperforms traditional techniques and provides high accuracy in predicting chlorophyll levels, which can be very helpful in early disease detection and quantification of disease severity in crops.

The challenges faced were uneven lightning conditions while taking leaf images. This can introduce the undesired color variation in leaf resulting in inaccurate estimation of CCI value. Also leaf samples of having different CCI values covering total range has to be there in dataset so that deep learning model can perform optimally.

This research highlights the potential of deep learning models in precision agriculture, particularly for crop health monitoring and management. By accurately estimating chlorophyll levels, these models contribute to smarter, data-driven agricultural practices, enabling timely interventions for disease control and optimizing resource use. Future work could explore expanding the model to different crop types and integrating additional environmental data to further enhance prediction accuracy and its applications in larger agricultural ecosystems.

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Performance Testing of Evaporator Using R1234yf for Different Inclination

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ABSTRACT

Refrigeration and air conditioning systems contribute greatly to greenhouse gas emissions. Equipment with working fluids having lower global warming potential and a higher level of performance is preferred. This work estimates heat transfer phenomena during the evaporation process of refrigerants within horizontal and inclined plain tubes. The study aims to achieve two primary objectives: first is to determine the heat transfer coefficient within horizontal plain tubes, and second is in inclined plain tubes. The refrigerant selected for the experimentation is R-1234yf, which is selected for its environmental friendliness. This experimentation involves designing and testing a VCR system. The setup developed allows testing of refrigerant performance characteristics at various inclinations of test evaporator. Key parameters such as temperature, pressure, and flow rates are closely monitored and recorded throughout the experiments. By varying system conditions and observing parameter changes, the study aims to analyse heat transfer characteristics and refrigerant performance. The outcome of the study reveals that heat transfer coefficient increases with angle of inclination and quality of vapour. The study helps designer to build compact design with improved performance. The research contributes to the development of efficient and environment friendly refrigeration technology.

KEYWORDS *: Dryness fraction, GWP, Heat transfer coefficient, R1234yf.*

INTRODUCTION

The greenhouse effect and global warming have made it clear that, when handled improperly, science and technology can be a curse rather than an instrument for progress and peace. Since 1945, there has been a massive industrial revolution in the energy, power, and processing sectors. Initially, the scientific community participated in a race to consume natural energy resources for industrial growth. However, over the past 30 years, the negative impacts of excessive energy use on the environment and human life, such as global warming, ozone depletion, and ecosystem imbalances, have become apparent. To report these issues, optimizing energy use in all energy, power, and processing sectors is crucial. Heat transfer enhancement techniques are vital for efficient energy utilization in heat-transforming devices. These techniques also play a significant role in the miniaturization of modern heat-transforming technology. Due to the harmful effects of chlorine-containing refrigerants on the ozone layer, HCFCs and CFCs have been banned and replaced with new refrigerants. However, these replacements require thorough investigations into their flow boiling performance and heat transfer efficiency under various conditions, as each refrigerant behaves differently.

Growing interest in thermal energy recovery in the process industry has driven the development of heat exchanger technology by means of heat transfer enhancement techniques at lower pressure penalties. Boilers, evaporators, and condensers are the major heat exchanger in industry. If heat transfer enhancement occurs effectively, it increases the performance of heat exchanger and result in enhanced effectiveness of equipment.

The study involves designing and testing a VCR system. The setup allows for comprehensive examination of heat transfer characteristics and refrigerant performance at various inclination angles for the Test Evaporator. Key parameters such as temperature, pressure, and flow rates are closely monitored and recorded throughout the experiments. By varying system conditions and observing parameter changes, the study aims to analyze heat transfer characteristics and refrigerant performance. The novelty of the study is variations in angle of inclinations for test evaporators with low global warming potential refrigerant R1234yf.

The expected outcomes include a comprehensive phenomenon of heat transfer during the evaporation process of refrigerants in both horizontal and inclined plain tubes. Specifically, the study aims to determine the heat transfer coefficient in various configurations, providing valuable insights into the performance of the refrigeration system under different operating conditions. Ultimately, this research contributes in the development of more efficient and environmentally friendly refrigeration technologies.

M. D. Hambarde et. al. (2019) experimentally investigated heat transfer characteristics during flow boiling of R-407C in a smooth horizontal tube of 13.39 mm inner diameter and 2m length. The effect of heat flux, mass flux, vapor quality, and temperature glide on heat transfer coefficient, during evaporation of R407C are scrutinized.

Arun Autee et al. (2019) experimentally studied two-phase pressure drop in small diameter tubes orientated horizontally, vertically and at two other downward inclinations of ϴ = 30o and ϴ = 60o . Correlation is developed by modification of Chisholm parameter C by incorporating different parameters. It was found that the proposed correlation predicted two-phase pressure drop at satisfactory level.

Arijit Kundu et al. (2014) presented the results of experimental investigations carried out with refrigerant R407C during flow boiling inside a smooth tube of inside diameter 7.0 mm at different tube inclinations. The heat transfer coefficients predicted by some available models and correlations in the open literature are compared with the present data. An empirical correlation has also been developed to predict the heat transfer coefficient of R407C during flow boiling inside an inclined plain tube By using the experimental data.

A.H. Dhumal et al. (2017) investigated heat exchanger theoretically. The effect of Reynolds number on the heat transfer performance and flow behaviour of the fluid has been theoretically determined.

Cheol-Hwan Kim et al. (2021) experimentally studied four R404A alternative refrigerants – two interim refrigerants (R448A, R449A) and two long term refrigerants (R455A, R454C) The pressure drops of the alternative refrigerants were larger than those of R404A. Finally, the data are compared with the predictions by existing correlations.

METHODOLOGY

Heat transfer enhancement in flow boiling of environmental friendly refrigerants for horizontal and inclined plain tube is estimated by experimental setup. It is revealed that most of cases are considered with refrigerant with high GWP and ODP. For protecting ozone layer and solution for global warming research is concentrated on environmental friendly refrigerants. Providing reliable data with plain horizontal and inclined tube for environmental friendly refrigerants with acceptable error band is the main hypothesis of the study.

Experimental setup is a vapor compression refrigeration system, design for the investigation of heat transfer enhancement during evaporation. Design and fabrication procedure of experimental setup involved:

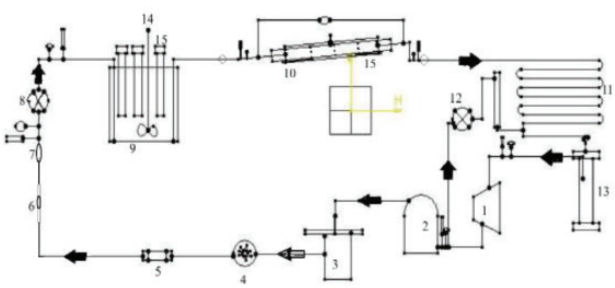
1. Design calculation for selection of mass flow meter, heating element and compressor as per operating parameter range and specifications of test section.
2. Fabrication of system components.

Experimental facility is designed and fabricated to determine the heat transfer rate inside horizontal / inclined tube during flow boiling of refrigerants under different operating parameters e.g. heat flux, mass flux, boiling temperature Test facility is calibrated through calibration of instruments used. In-situ calibration is also made.

Experimental data is reduced to draw graphs between heat transfer coefficient and vapor quality under different operating conditions. Heat transfer enhancement ratio variation with vapor quality for different operating parameters will be studied.

Experimental setup with Horizontal and inclined tube

Figure 1 depicts the design and fabrication of a vapor compression refrigeration system using horizontal plain tube for experimental investigations in accordance with the research objectives including all necessary accessories. For performing the investigation on heat transfer enhancement in evaporation with new environmental friendly refrigerant three major components are required in the vapor compression refrigeration system. These are: 1. Pre- evaporator, 2. Test section 3. After- evaporator.



1. Compressor 2. Condenser 3. Refrigerant flow meter 4. Dryer 5. Filter 6. Slide glass 7. Oval gear flow meter 8. Pre-evaporator 9. Test evaporator 10. After evaporator 11. Differential pressure gauge 12. Accumulator 13. Shut off valve 14. Heater rod 15. Submersible pump/stirrer

Fig. 1 Experimental Setup

Specifications of Test Section-

1) Test section- ½" soft copper tube, K type with outer diameter, do = 12.60 mm and inner diameter, di = 10.80 mm

2) Total length of test section- 1m

REFRIGERANT SELECTION

Environmental friendly and safe refrigerants are under scrutiny since 1987 due to issue of global warming and ozone depletion. Further pool down period is to be reduced for modern system. There are various criteria to select environmentally safe refrigerant. Based upon industrial need, pollution control needs and concept of zero discharge system refrigerant will be selected. Central to our exploration is the choice of refrigerant. While the industry has predominantly relied on refrigerant R-134a, its adverse environmental impacts are well-documented. As such, our project emphasizes evaluating alternatives, with a particular focus on the utilization of refrigerant R-1234yf, renowned for its significantly lower global warming potential (GWP) and ozone depletion potential (ODP).

By prioritizing environmental considerations in refrigerant selection, we align with regulatory mandates and sustainability objectives, thus contributing to the global endeavor towards climate resilience and environmental stewardship. Environmental friendly and safe refrigerants are under scrutiny since 1987 due to issue of global warming and ozone depletion. Further pool down period is to be reduced for modern system. There are various criteria to select environmentally safe refrigerant. Based upon industrial need, pollution control needs and concept of zero discharge system refrigerant will be selected.

The analysis results revealed that the R1234yf system C.O.P. and cooling capacity were lower by 4.8% to 7% and 7.7 to 10.6% than that of R134a system under all three conditions (idle, city and high speed), respectively. R1234yf system cooling capacity could increase by 72.8% with compressor volumetric efficiency (ηvol) from 0.55 to 0.95. If the other compressor efficiency and state points were fixed. On the other hand, compressor isentropic efficiency improvement could reduce the power consumption dramatically which resulted in system COP increasing. It was concluded that adding an internal heat exchanger and improving compressor efficiency would be better options in the future R1234yf MAC system enhancement.

SELECTION OF COMPONENT

Compressor

Specification :- MTZ64-4 , 1.5 TR Quantity:- 1

Make:- Dansfoss, Hermetically sealed reciprocating compressor, capacity 1.5 TR . It eliminates refrigerant leaks, enhancing system reliability and safety. Its compact design saves space, making it suitable for smaller installations. Hermetic sealing prevents moisture and contaminants from entering the system, ensuring long-term performance. It simplifies installation and maintenance, reducing labor costs and downtime. Hermetic compressors operate quietly, minimizing noise pollution in residential or commercial settings. Their sealed construction eliminates the need for additional components like shaft seals, reducing the risk of mechanical failures.

Condenser

When selecting a condenser for the HVAC system, several

factors come into play to determine its suitability and performance

1. Total condenser area calculation (5.5 sq. ft. per ton):

• This calculation serves as a rule of thumb to estimate the required surface area of the condenser coils based on the cooling capacity of the system.

2. Adjustment with overall Size:

• The overall size of the condenser needs to be adjusted to fit within the available space for installation.

3. Number of Rows:

• The number of rows of condenser coils directly impacts the surface area available for heat exchange.

4. Length (L) and Width (W):

• Determining the length and width of the condenser coils is crucial for optimizing the surface area-to-volume ratio.

Thermostatic Expansion Valve

Specification:- Expansion Valve Ten 2-5 & Orifice 5”. TXVs regulate refrigerant flow based on system conditions, ensuring precise control of evaporator temperature and superheat, which optimizes system performance and efficiency.

TXVs prevent liquid refrigerant from entering the compressor by maintaining proper superheat at the evaporator outlet, preventing compressor damage and improving system reliability.

Receiver

Specification:- LRRV-3482-3S Liquid Refrigerant Receiver Vertical Length:-482mm Diameter:- 3 inch Connection type solder

The receiver serves several essential functions in the system:

The receiver acts as a reservoir for excess liquid refrigerant during periods of low load or when the system is not operating at full capacity. This storage capability ensures a continuous and stable supply of refrigerant to the system, preventing issues such as liquid refrigerant starvation and compressor damage.

The receiver helps separate liquid refrigerant from any vapor present in the system. This separation ensures that only liquid refrigerant is supplied to the expansion device, preventing inefficient operation and ensuring optimal performance.

The receiver allows for sub-cooling of the liquid refrigerant before it enters the expansion device. Sub-cooling improves system efficiency by ensuring that the refrigerant is in its liquid state and at its lowest possible temperature, maximizing the cooling capacity of the system.

Test Evaporator

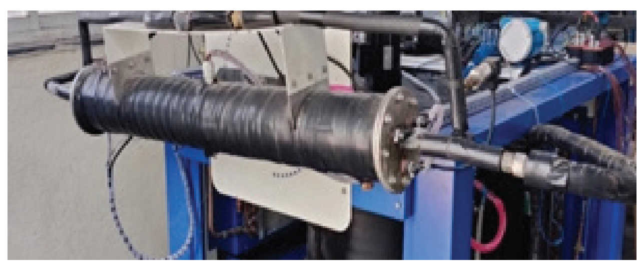


Fig. 2 Test Evaporator

Test evaporator is a tube in pipe type of arrangement. Test section copper tube is inserted in to the stainless steel pipe of 1 m length. An opening is provided to pour the water-glycol mixture in the steel pipe. The two ends of horizontal pipe of test-evaporator are closed by flanges, having an arrangements to pass the test section copper tube and heating rods.

To estimate average outer surface temperature of test section copper tube, total 16 thermocouples are brazed on four equally spaced locations. Four thermocouples are brazed in a group with each thermocouple separated by 900 from each other as shown in figure 3.

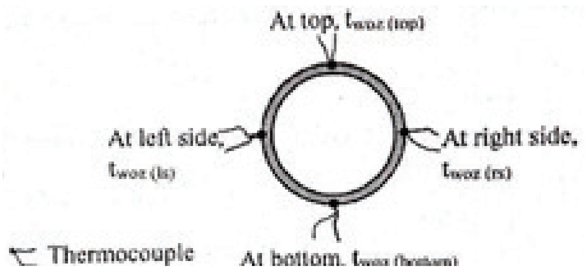


Fig. 3 Schematic of Test section

Pre-Evaporator

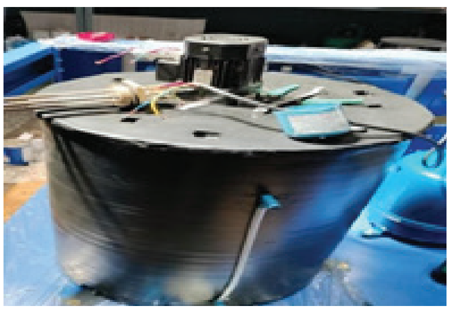


Fig. 4 Pre-Evaporator

Pre-evaporator is fabricated as a stainless steel drum with a copper tube inside the drum in the form coil. The Pre-evaporator is filled with a water-glycol solution with 20% glycol and 80% water. Three electrical heaters in the form of rods are dipped into the solution to apply heat on the copper tube coil through which the refrigerant is flowing. The heating capacity of each heating rod is 3 kW. The electric stirrer is inserted into the pre-evaporator at the centre.

Post-Evaporator

Specification:- Fin & Tube ½ Ton Capacity To ensure liquid does not go ahead when evaporating not happening properly during the experiment, this evaporator is used. The post-evaporator follows the pre-evaporation stage to further concentrate the solution, It's designed to achieve the desired final concentration.

Pressure Sensor

The experimental setup utilizes Gems 3500 Series compact low-pressure transducers to measure refrigerant pressure across expansion valve and evaporator in test section.

The silicon pieces are bonded using silicon fusion bonding. Temperature compensation is performed directly on the chip, with laser-trimmed resistors in parallel with the bridge arms to meet specific requirements after sensor testing.

T –Type Thermocouples

T type thermocouples are used for temperature measurement with accuracy 0.5OC. All thermocouples are calibrated and after placing them at the set-up, in-situ calibration is made.

Mechanical pressure gauge

Bourdon pressure gauges are placed at suction and discharge tube of compressor with 30 psi to 300psi range, 5% accuracy and + 2% repeatability.

Fig. 5. Photographic view Experimental setup

Data Reduction

Using Newton's law of cooling, experimental heat transfer coefficient during evaporation of R-404a in test-section tube is calculated by equation 1.

$$h = \frac{q_{ts}}{t_{wi} - t_{sat}} \qquad (1)$$

where,

qts is the heat flux (kw/m2) applied on the test section tube and is calculated as following.

The inner side wall temperature of test section tube, twt is calculated by using equation 2,

$$t_{wi} = t_{wo} - \frac{q_{ts}}{2\pi L_{ts} k} \ln \frac{do}{di} \qquad (2)$$

Average outside wall temperature of test-section tube, two is calculated from equation 3,

$$t_{wo} = \frac{t_A + t_B + t_C + t_D}{4} \quad (3)$$

Where, tA, tB, tC, tD are the average outside wall temperatures of test-section tube, measured at four locations A, B, C, D, on the copper tube and each is calculated as equation 4.

$$t_{woA} = \frac{t_{woA(top)} + t_{woA(bottom)} + t_{woA(ls)} + t_{woA(rs)}}{4} \quad (4)$$

Vapor quality is considered as an average vapor quality in the test-section tube and is calculated by equation 5.

$$x_{avg} = \frac{x_{in} + x_{out}}{2} \quad (5)$$

Where, x_{in} and x_{out} are vapor qualities at entry and exit of test section and are calculated by equations 6 and 7.

$$x_{in} = \frac{e_{in} + e_{f(in)}}{e_{fg(in)}} \quad (6)$$

$$x_{out} = \frac{e_{out} + e_{f(out)}}{e_{fg(out)}} \quad (7)$$

RESULTS

The results are observed for the flow rates of 60, 68 and 76 kg per hour with vapour quality between 0.15 to 0.9. It is found that with increase in refrigerant flow rate and vapour quality, the heat transfer coefficient increases. It is also observed from h-x plot figure 6 to 8 that increase with angle of inclination and improvises the rate of heat transfer. The turbulent dispersion plays an important role in increasing the heat transfer. The present study shows that value of h increases with increase in inclination angle Theoretically, there are four forces related to two-phase flow in channels: gravitational, inertia, viscous, and surface-tension. The relative significances of all these forces are considered for heat transfer phenomenon, which is in turn, depends upon size and orientation of test section.

In the present study as dryness fraction increases, heat transfer coefficient increases [1]. As effect of gravitational force and ultimately Froude number with the combination of turbulence dispersion increase in heat transfer coefficient is observed [2].

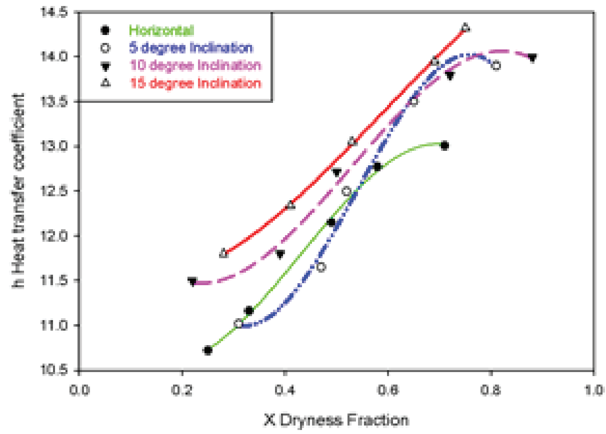


Fig. 6 Heat transfer coefficient versus dryness fraction for G = 60 kg/hr

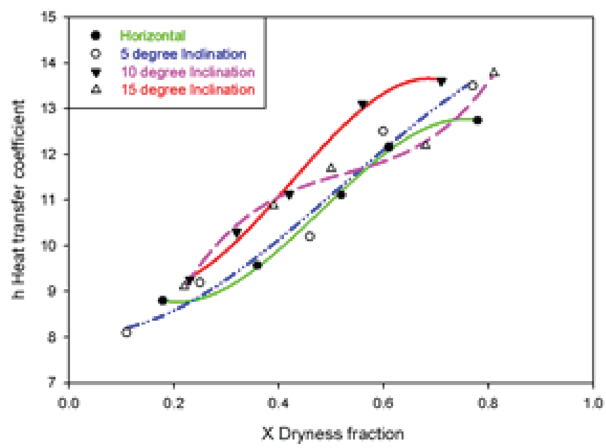


Fig. 7 Heat transfer coefficient versus dryness fraction for G = 68 kg/hr

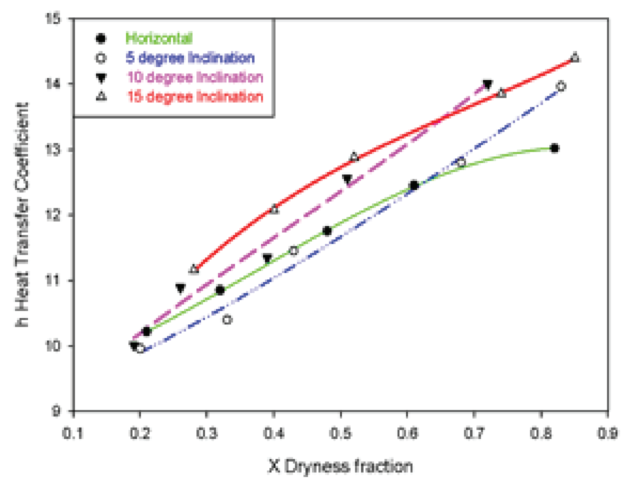


Fig. 8 Heat transfer coefficient versus dryness fraction for G = 76 kg/hr

The effect of tube inclination angle is prominent at high mass velocities for all inclinations of the tube.

CONCLUSION

In conclusion, this work has successfully addressed the objectives outlined to investigate heat transfer phenomena during the evaporation process of R-1234yf refrigerant within horizontal and inclined plain tubes with different flow rate. Through the meticulous design, assembly, testing, and calibration of a Vapour compression refrigeration (VCR) system, comprehensive data was gathered to analyze heat transfer characteristics.

The study concludes,

The experiments conducted allowed for the determination of heat transfer coefficients within both horizontal and inclined plain tubes under varying conditions. By closely monitoring temperature, pressure, and flow rates, valuable insights were gained into the performance of the refrigeration system across different inclination angles.

The findings of the study contribute significantly to the understanding of heat transfer during the evaporation process of refrigerants, particularly in the context of plain tube configurations.

The plotted graphs depicting the variation of heat transfer coefficient with respect to vapour quality provide a visual representation of the observed phenomena.

Overall, this research contributes to the development of more efficient and environmental friendly refrigeration technologies.

The insights gained from this study can potentially inform future design considerations and optimizations in refrigeration engineering, paving the way for sustainable advancements in the field.

ACKNOWLEDGMENT

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A Survey on Different Methods of Machine Learning Models used to Predict the Price of Gold

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ABSTRACT

A Price of gold plays a crucial role in budgetary and financial systems. Prediction and forecasting the upcoming tendency of gold prices and other valuable metals will be helpful for investors and money managers to avoid choosing when to supply this article of trade. Central banks throughout the globe carry gold reserves to assure the currency holders, the money of their shareholders, and foreign-debt creditors. They also utilize the gold treasury to manage inflation and indurate their country's economic standing. During this procedure, the prediction of the gold rate has become a major issue these days. So, various methods, mostly intelligent techniques, have played a vital role in predicting gold prices. Moreover, a comparative investigation on the impact of machine learning (ML) algorithms such as support vector machine (SVM), random forest (RF), linear regression (LR), decision tree (DT), and other hybrid methods for gold price forecasting has been formed. Some significant research directions for additional research on gold price prediction are highlighted, which may assist the researchers in widening specialized intelligent techniques for the prediction of gold rate.

Recent advancements in data analytics and the availability of real-time data have further enhanced the accuracy of gold price forecasting. By integrating economic indicators, global events, and market sentiment analysis, predictive models can now offer more refined insights. This not only helps investors make informed decisions but also enables governments and financial institutions to develop strategies that mitigate risks associated with volatile gold prices. Consequently, continuous exploration of innovative algorithms and hybrid approaches will likely shape the future of gold price prediction, aligning with the needs of an increasingly complex global economy.

By leveraging these sophisticated techniques, predictive accuracy has reached new heights, fostering more resilient financial strategies. Future research could focus on combining these advanced models with alternative data sources, such as social media sentiment and geopolitical events, to create even more robust forecasting frameworks.

KEYWORDS *: Prediction, Gold price, Machine Learning, Currency and gold reserves, Inflation and gold prices.*

INTRODUCTION

Gold has long been regarded as a stable store of value, especially during periods of economic uncertainty. Its historical role as a hedge against inflation and market volatility has made it a significant asset for investors. However, gold prices are subject to various economic, political, and market factors, making accurate prediction a challenging yet valuable endeavor.

In recent years, advancements in data analytics, machine learning, and statistical modeling have opened new avenues for predicting asset prices, including gold. These approaches enable researchers and financial analysts to uncover complex patterns and relationships that traditional models may overlook. By leveraging both macroeconomic indicators, such as inflation rates, currency fluctuations, and geopolitical risks, alongside technical market data, gold price prediction can potentially offer more precise insights for investors, central banks, and policymakers.

This research paper aims to explore various methodologies for predicting gold prices, comparing traditional econometric models with modern machine learning techniques. The objective is to identify the most effective tools for forecasting future price trends, while also analyzing the impact of key global factors on gold's value. Through this study ,we seek to contribute to the growing body of literature on financial forecasting and offer practical insights for stakeholders in the financial markets.

LITERATURE ANALYSIS

Gold price forecasting has been a significant area of research, with studies focusing on understanding the impact of various macroeconomic factors and employing different modeling techniques. Research has consistently identified factors such as stock market performance, crude oil prices, exchange rates, inflation, and interest rates as key influencers of gold prices. For instance, studies have shown that these factors often exhibit strong correlations with gold price movements during certain economic phases, such as periods of rising or stable trends.

Traditional econometric models like linear regression have been widely used to capture these relationships, but they often struggle with the complex, non-linear patterns inherent in financial data. To overcome these limitations, recent studies have turned to machine learning algorithms like random forest and gradient boosting, which offer more flexible modeling capabilities.

Table 1 summarizes the contributions, categorized by their impact on stock rates, key milestones, and major developments. It highlights the significant influences each contribution has had on market trends, outlining critical advancements and progress in the field.

Table 1. Literature Work

References	Basic Concepts	Keywords	Claim by Authors
Weichen Gong [3] [2023]	Gold price forecasting using LSTM and Linear Regression models. The LSTM model achieved 50.67% accuracy, while Linear Regression slightly outperformed with 53.02%. The findings offer valuable insights for investors in the gold market.	LSTM, Linear Regression, Prediction accuracy, gold market	LSTM model is recommended for predicting long-term trends due to its ability to capture temporal dependencies and complex patterns, while the Linear Regression model is more suitable for short-term price fluctuations due to its simplicity and interpretability.
Manjula K A and Karthikeyan P [6] [2019]	Gold prices correlate strongly with economic factors in a rising trend (2000-2011) but less so during a horizontal trend (2011-2018). Random forest had the best overall prediction accuracy, while gradient boosting excelled in each period individually.	Gradient boosting, Stock market, Crude oil prices, Exchange rates, Inflation	Machine learning algorithms are effective for analyzing gold price trends, with random forest showing the best overall accuracy and gradient boosting performing better in specific periods.
Yiqi Xin [7] [2023]	ARIMA, Decision Tree, and Multi-Linear Regression models for predicting gold (AU99.99) prices. It finds ARIMA (2,1,2) ineffective, while Multi-Linear Regression excels in forecasting next day's prices, aiding investors in optimizing trade yields.	ARIMA, Multi-Linear Regression (MLR), Financial Forecasting, Moving Average	The study evaluates ARIMA, MA, and Multi-Linear Regression (MLR) models for predicting gold prices, ARIMA inadequate and MLR most effective. Despite its strengths, MLR shows lag issues due to the moving average algorithm.

Dinesh Kumar Kushwaha, Dhananjay, Kumar Sharma, Snehal Sing Khullar, Satyam Shukla, Tarun Kumar Pandey, Surendra Pal [1] [2023]	An optimized ensemble method for gold price prediction by combining Random Forest and XGBoost with a meta-model, enhancing predictive performance. Evaluation with various metrics shows this approach outperforms individual models, offering significant improvements for financial decision-making and risk management in gold investments.	XGBoost, MAE, R squared, Financial Decision-Making, Random Forest	An advanced ensemble machine learning model for gold price prediction, combining Random Forest and XGBoost with a meta-model, showing superior accuracy and precision. This approach enhances financial decision-making and investment strategies, with future research aiming to refine the model and explore other precious metals.
Reni Pushpita, Hendra Cipta, Rima Aprili [9] [2024]	This research uses Support Vector Regression with Grid Search to predict gold prices, achieving a 5.43% MAPE. The linear kernel proved most effective for forecasting, indicating gold prices will rise until March 2024 before declining.	Grid Search Algorithm, Kernels, Support Vector Regression	Support Vector Regression with a linear kernel provides the most accurate gold price predictions, achieving a MAPE of 5.43%. Predictions indicate a rise in gold prices above IDR 1,000,000 until March 2024, followed by a decline below IDR 1,000,000 starting in March 2024.
Dr. Pradip S. Thombare, Dr. Rakesh Bhati [8] [2024]	Analysis of the monthly data from Jan 2004 to Oct 2023, finding no short-term causality between gold prices and Nifty stock prices but confirming a long-term equilibrium relationship. Foreign investors in India should use portfolio strategies based on this integration, though short-term opportunities are limited.	Indian Stock Market, Economic Indicators	The short- and long-term relationships between gold prices and the Indian stock market, using Granger causality, ADF, and Johansen Co-integration tests. No short-term correlation but confirms a long-term relationship, suggesting that while gold and stock prices are stable.
Baixi Jiao [5] [2024]	While XGBoost and linear regression models accurately predicted gold prices from 2012-2018, integrating Random Forests, MLR, SVM, and ANN offers a more advanced approach. Geopolitical and economic factors also play a significant role in gold price fluctuations.	Gold Price Forecasting, Financial Forecasting	Combining linear regression and XGBoost models provides strong accuracy in gold price forecasting, though each has limitations such as linearity constraints and overfitting.

PREREQUISITE OF PREDICTION

The prerequisites for accurate price prediction

1. Quality Data Collection: Historical Price, Data Economic Indicators, Geopolitical Data, Sentiment Data.
2. Data Preprocessing: Cleaning Data, Normalization/ Scaling, Time-Series Processing.
3. Domain Knowledge and Feature Selection
4. Model: Machine Learning Models, Traditional Statistical Models, Hybrid/Ensemble Models.
5. Evaluate Metrics: Model Performance Evaluation.
6. Training and Validation: Training the Mode, Validation & Testing.
7. Visualization Tools and External Shocks and Uncertainty Management

Meeting these prerequisites ensures the accuracy, reliability, and generalizability of price prediction models, facilitating better forecasting and decision-making.

ALGORITHMS IN MACHINE LEARNING

When evaluating models such as Random Forest, XGBoost, Gradient Boosting, Decision Tree, and Logistic Regression, researchers consider several key performance metrics. For regression tasks, metrics like Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and R-squared are used to assess the accuracy of predictions. For classification tasks, common metrics include accuracy, precision, recall, F1 score, and AUC-ROC. These metrics help in comparing the models based on their prediction accuracy and ability to handle complex patterns or linear relationships. Generally, advanced models like Random Forest and XGBoost tend to perform better in terms of accuracy, while simpler models like Decision Trees and Logistic Regression may offer easier interpretability but with potentially lower performance.

Random Forest and XGBoost are often preferred for their ability to handle non-linear relationships and complex data patterns, providing higher accuracy in most scenarios. However, they can be computationally intensive and harder to interpret. Gradient Boosting offers strong predictive performance, especially after hyper-parameter tuning, but is typically slower than XGBoost. On the other hand, Decision Trees, while easy to interpret and computationally efficient, are prone to over-fitting and generally have lower accuracy.

Table 2 Evaluation of Models[1]

MODEL	RND	XGB	GB	LR	DT	ADA	ENB
MAE	10.65	8.47	8.38	63.30	13.54	23.91	7.56
MSE	226.3	158	14.2	6528	413.2	936.1	140.8
RMSE	15.04	12.57	11.92	80.79	20.32	30.59	11.86
R*R	0.99	0.99	0.99	0.99	0.99	0.99	0.99
MAPE	0.74	0.57	0.57	4.22	0.94	1.66	136.3
MAX AE	84.35	80.50	53.25	250	144.2	136.3	79.59

Table 2 visually compares the performance of the ensemble, Random Forest, and XGBoost models by plotting the differences between predicted and actual gold prices. The ensemble model consistently outperforms the individual models on test data, demonstrating its superior accuracy. These results offer valuable insights for improving financial decision-making with more accurate gold price predictions.

Comprehensive analysis of the factors influencing gold prices and presents a robust ensemble-based machine learning model for accurate price prediction. Through evaluation metrics like MAE, MSE, RMSE, R-squared, MAPE, and Max AE, we demonstrate the superior performance of the ensemble model compared to individual Random Forest and XGBoost models, with lower errors and greater precision. The addition of a meta-model using Linear Regression further enhances accuracy. This research has significant implications for financial decision-making in the precious metals market, providing investors with valuable insights and predictions to optimize strategies. Future work will focus on refining the model, expanding input variables, and extending the approach to other precious metals, advancing the field of price prediction.

CONCLUSION

This study provides a comprehensive overview of current research on gold price forecasting using various machine learning (ML) techniques. It highlights the significance of gold and the impact of ML methods in enhancing prediction accuracy. A critical survey of past studies on gold price prediction and the performance of different ML approaches is presented, emphasizing the growing interest among researchers in ML for its effectiveness. Key findings from previous research are discussed, and a systematic review is provided to help expand more accurate models for gold price prediction.

The predictive performance of Linear Regression and LSTM models for gold price forecasting, highlighting the strengths and limitations of each. The LSTM model is recommended for predicting long-term trends due to its ability to capture temporal dependencies, while the Linear Regression model is more suited for short-term fluctuations and offers greater interpretability. Future research should focus on improving these models, especially LSTM, by enhancing their architecture to handle longer-term forecasting and incorporating more comprehensive factors for accurate gold price predictions. The MLR model, combined with a moving average, improves gold price prediction, it still faces lag issues. Future work suggests using ANN for more accurate financial forecasting, especially during uncertain times like the pandemic.

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Analyzing NCC Cadet Experiences and Aspirations: A Data-Driven Study for Proposed Effective Management through Machine Learning

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ABSTRACT

This research paper explores the experiences of National Cadet Corps (NCC) cadets who attended various camps in India. The NCC plays a vital role in shaping the character, discipline, and leadership qualities of youth. Through qualitative analysis of interviews, surveys, and literature, this paper aims to understand the cadets' experiences, challenges, and benefits gained from attending NCC camps. The findings suggest that participation in these camps significantly contributes to personal and social development, fostering a sense of patriotism, responsibility, and physical fitness among cadets, the demographic profiling of candidates, family support for NCC participation, motivation and aspirations, sprit from social and cultural bonds with the spirit of patriotism and National pride. Sentimental analysis, cluster analysis and correlation analysis has been caried out through machine learning.

KEYWORDS *: National Cadet Corps, Aspirations, Machine Learning, Camps, Leadership, Discipline, Personal development, Patriotism, Physical fitness, Family support.*

INTRODUCTION

The National Cadet Corps (NCC) is a youth organization in India that works under the Ministry of Defence, aiming to instill values such as discipline, leadership, and a sense of duty in young men and women. Established in 1948, the NCC provides military-based training to students from schools and colleges across the country. A significant part of the NCC experience includes participating in various camps such as the Annual Training Camp (ATC), National Integration Camp (NIC), and Republic Day Camp (RDC). These camps are designed to foster leadership, teamwork, and patriotism among the cadets.

This research paper focuses on the personal and collective experiences of NCC cadets during these camps. By exploring the benefits, challenges, and skills acquired through participation, we aim to highlight the impact of these camps on the cadets' development. The research employs qualitative methods, drawing from primary interviews with cadets and secondary literature to analyse their lived experiences. & through a structured questionnaire.

LITERATURE REVIEW

Several studies have examined the role of NCC in developing leadership and discipline among students. According to Reddy (2010), NCC cadets display higher levels of patriotism and physical fitness than their non-NCC peers. Pandey (2015) highlights that NCC training emphasizes personal responsibility, which helps students manage academic and extracurricular commitments. These findings suggest that participation in NCC camps contributes to holistic development. However, while the broader role of NCC has been studied, there is limited research focused on the specific experiences of cadets attending camps. This paper attempts to fill this gap by exploring the emotional, psychological, and physical impact of camps on cadets.

Previous research has primarily focused on the qualitative aspects of NCC training. Studies such as Reddy (2010) and Pandey (2015) have highlighted the role of NCC in fostering leadership, discipline, and a sense of national pride among cadets. These studies have typically relied on interviews and surveys for data collection and analysis. While they provide valuable insights, they lack the depth and scalability offered by data-driven techniques.

Machine learning has been increasingly used in educational and psychological research to analyze large datasets and uncover hidden patterns. Sentiment analysis, for example, has been widely employed in customer feedback studies to gauge emotional responses (Liu, 2015). Clustering algorithms like K-means and hierarchical clustering have been used in educational research to categorize students based on their learning behaviors (Aggarwal, 2018).

RESEARCH DESIGN AND METHODOLOGY

This research follows a qualitative approach to explore the experiences of NCC cadets who attended camps. Data was collected through:

1. Interviews: In-depth interviews were conducted with 200 current and former NCC cadets who have attended various camps. These interviews focused on their personal experiences, challenges faced, and the benefits they gained.
2. Surveys: A questionnaire was administered to 355 cadets from different schools and colleges, gathering information on their perceptions of the camp experience. The survey contained both quantitative questions (e.g., satisfaction ratings, frequency of camp activities) and qualitative questions (e.g., open-ended responses about camp experiences) & machine learning techniques.
3. Secondary Data: Articles, books, and NCC training manuals were reviewed to provide a contextual understanding of NCC activities and camps.

SIGNIFICANCE OF THE STUDY

1. It provides a comprehensive analysis of cadet experiences after camps, which are key to NCC training.
2. The study offers valuable insights for camp organizers to improve the quality of facilities and training programs.
3. It highlights the importance of family support in cadet participation and the role of NCC in shaping cadet futures, particularly in developing leadership and discipline.
4. The findings can be used by NCC units to enhance future training camps and make them more beneficial for cadets.

LIMITATIONS OF THE STUDY

1. The data is limited to cadets who attended camp, which may not be representative of all NCC camps across regions.
2. The study relies on self-reported data from cadets, which may be subject to bias or inaccuracies.
3. The sample size may be limited, which could affect the generalizability of the findings to all NCC cadets.
4. The study does not include longitudinal data, meaning it cannot assess long-term impacts of NCC participation on cadet development.

RESEARCH DESIGN

The research employs a descriptive design to analyze the experiences and aspirations of cadets after attending camp. The study is structured to gather both quantitative and qualitative data from participants, focusing on their camp experiences, family support, and future goals. The design allows for a thorough examination of the factors influencing cadet satisfaction and participation in NCC activities.

SAMPLING RELATED TO TOPIC

The study uses purposive sampling to target cadets after attending the camp. Participants were selected based on their involvement in the NCC training program during the camp. The sample includes cadets from various districts and NCC units of Amravati zone ensuring a diverse representation of backgrounds and experiences. The final sample size consists of cadets who completed the survey distributed through a structured Google Form.

Data Collection Related to Topic

Data was collected through an online Google Form distributed to cadets. The form included a range of questions designed to gather both quantitative (e.g., ratings of camp facilities, satisfaction with training) and qualitative (e.g., open-ended responses about experiences and future goals) data. The form was structured to ensure clarity and completeness, covering key topics such as personal information, family support, camp experience, and career aspirations.

Requirement Of Tools

1. Google Forms: For data collection through structured questionnaires distributed to cadets.
2. Excel/Statistical Software: For data analysis, including descriptive statistics and qualitative feedback analysis.
3. Charts and Graphs: For visual representation of key data points, helping to communicate trends and findings more effectively.

Ethical Considerations

1. Informed Consent: Cadets were informed about the purpose of the study and their voluntary participation. They were assured that their responses would be confidential and used only for research purposes.
2. Confidentiality: All personal information collected was kept confidential, with data being anonymized during analysis to protect participant identities.
3. Non-coercion: Participation was voluntary, and cadets had the option to withdraw from the study at any time without any negative consequences.
4. Data Security: The data collected was securely stored, and access was restricted to the research team to maintain confidentiality and integrity.

The data collected from cadets who have attending different camps has been analyzed to assess their experiences, satisfaction with camp facilities, and future aspirations. The key findings are based on both quantitative data (e.g., ratings on different aspects of the camp) and qualitative feedback (e.g., personal experiences and future goals).

FINDINGS AND DISCUSSION

The data collection of the male cadets are (71.8%) & female cadets are (28.2%). Out of 355 cadets, the different category represented consisting of General cadets (09%), OBC cadets (52.4%), SC cadets (24.5%), ST cadets (3.9%), VJNT cadets (8.7%) & SBC cadets (1.4%). The profession of cadets is student (94.4%) 335 and 18 (5.1%) cadets work part time. The (58.3%) cadets' fathers are farmer, (23.1%) fathers are Laborers', (8.5%) fathers are government employee and (10.1%) fathers are businessmen. The family income per annum of (88.7%) cadets is less than Rs.1 lakhs, (6.8%) cadets is between Rs. 1 lakh to Rs. 3 lakhs, (3.1%) cadets are between Rs. 3 lakh to Rs. 5 lakh and (1.4%) cadets are more than Rs. 5 lakhs. The (65.6%) cadets join the NCC to achieve the goal, (28.5%) cadets join the NCC to learn the discipline & (02%) join by inspiring their friends. This study aims at creating a Machine Learning based approach that would consider all the NCC cadets of any state or of complete India and create a system that provides best possible NCC experience to the cadets.

Demographic Profile of Cadets

- Age Distribution: The majority of cadets were between 16 and 18 years of age, representing typical NCC participants who are in high school or early college.
- Educational Background: Cadets attended various schools and colleges, with representation from different districts and states, indicating a diverse sample.

Family Support for NCC Participation

- Parental Encouragement: A significant number of cadets reported that their families, particularly their fathers, were supportive of their involvement in NCC. This support played a key role in motivating cadets to participate and excel in the program.
- Distance from NCC Units: Many cadets traveled considerable distances to attend NCC activities,

which was not seen as a major obstacle due to family encouragement.

Camp Experience

- Medical Facilities: Approximately 60% of cadets rated the medical facilities at the camp as Excellent, while others found them Satisfactory. However, a small percentage suggested the need for more accessible or enhanced medical services.
- Food and Accommodation: While 70% of cadets appreciated the variety and quality of food provided, a minority expressed a desire for more meal options and flexibility in the menu.
- Sports and Physical Training (PT): Cadets were highly satisfied with the PT classes, with over 80% rating them as Excellent. Physical activities were one of the highlights of the camp, and cadets valued the fitness and discipline instilled by these sessions.
- Yoga and Meditation: The introduction of yoga and meditation was positively received, with 70% of cadets expressing interest in continuing these practices even after the camp. They felt that these activities contributed to both mental and physical well-being.

Motivations and Aspirations

- Future Career in Armed Forces: A considerable percentage of cadets (around 60%) expressed aspirations to join the Indian Armed Forces, citing NCC as a significant influence in shaping their career goals. The leadership and discipline gained from NCC were frequently mentioned as critical factors in this decision.
- Leadership and Personal Development: Many cadets believed that NCC had helped them develop leadership qualities, discipline, and confidence, which would benefit them in their future endeavors, whether in the defense forces or other careers.

Key Aspects

1. Satisfaction with Camp Facilities: Most cadets reported high levels of satisfaction with the camp's medical facilities, accommodation, food, and physical training sessions.
2. Family Support: Parental encouragement, especially from fathers, was crucial in sustaining cadet participation in NCC activities, even when the NCC units were far from home.
3. Impact of Yoga & Meditation: The inclusion of yoga and meditation in the camp curriculum had a lasting impact, with cadets planning to continue these practices post-camp.
4. Career Aspirations: NCC was viewed as a significant contributor to future career choices, especially for those aspiring to join the armed forces or develop leadership skills.

Camps as a Platform for Leadership and Teamwork

One of the most significant experiences shared by cadets was the development of leadership skills. In camps like the Annual Training Camp (ATC) and National Integration Camp (NIC), cadets are assigned roles that require them to take charge of activities, lead teams, and coordinate with their peers.

For instance, Cadet Bhushan Dabhade from Khamgaon reflected, "Being a section leader at the ATC taught me the importance of responsibility. I had to manage a group of cadets and ensure they were motivated and focused during the training sessions." This sense of responsibility was echoed by many cadets, who mentioned that leading teams under challenging conditions enhanced their confidence and decision-making abilities.

In addition, teamwork was a core value reinforced through group activities such as obstacle courses, marching drills, and campfire events. Cadet Shruti Sasane from Khamgaon noted, "Working as part of a team in the camp helped me understand the importance of trust and collaboration. You realize that success comes from everyone doing their part."

Physical and Mental Challenges

NCC camps are physically demanding, with activities ranging from military drills to adventure sports like trekking, rock climbing, and shooting practice. The physical endurance required for these tasks is intense, often pushing cadets beyond their limits. Cadet Kartik Chopade from Malkapur stated, "The camps are grueling, especially the early morning PT (Physical Training) sessions. But it's rewarding because you see yourself getting fitter and more resilient."

Apart from physical challenges, the camps also test mental strength. Cadets are often put in high-stress situations, such as mock drills or survival camps, where they need to think quickly and act decisively. Cadet Aniket Bhopade from Amravati shared, "During one of the survival drills, we were given minimal resources and had to set up camp in the forest. It was both mentally and physically exhausting, but it taught me valuable lessons about resilience and problem-solving."

Cultural Exchange and Social Bonds

Camps like the National Integration Camp (NIC) bring together cadets from diverse cultural and regional backgrounds. The shared experience of living and working together fosters a sense of national unity and mutual respect. Cadet Bhushan Wankhade from Nandura explained, "Meeting cadets from different states and learning about their cultures was one of the best parts of the camp. We exchanged ideas, songs, and stories, and it made me feel more connected to the country as a whole. These interactions often lead to lifelong friendships, with cadets building strong social bonds that extend beyond the camp experience. Many cadets emphasized the camaraderie that develops in the camps as one of the most rewarding aspects of their participation.

Patriotism and National Pride

For many cadets, attending NCC camps reinforced a sense of patriotism and national pride. Camps such as the Republic Day Camp (RDC) and Independence Day celebrations are particularly designed to instil these values. Cadet Abhishek Bhusari from Buldana recalled her experience participating in the RDC, "Marching in the Republic Day parade was a dream come true. The feeling of representing my state and the NCC in front of national leaders was overwhelming. It made me proud to be an Indian." Such experiences often inspire cadets to pursue careers in the armed forces or other services dedicated to the nation. Cadet Vijay Khadae from Daryapur mentioned, "After attending the RDC, I became more determined to join the Indian Army. The training, discipline, and pride we felt during the camp made me realize the importance of serving the country."

Personal Growth and Development

Many cadets reported that attending NCC camps led to significant personal growth. The challenges they faced, both physical and mental, helped them build resilience, discipline, and self-confidence. Cadet Roshan Johre from Jalgaon Nadu shared, "Before joining the NCC, I was shy and unsure of myself. But after attending several camps, I became more confident in my abilities. The discipline instilled by the NCC has stayed with me in all aspects of life."

The camps also emphasize values such as punctuality, respect for authority, and responsibility. These values often translate into improved academic performance and better time management for cadets. Surveys indicated that 80% of cadets felt more organized and disciplined after attending the camps.

Sentiment Analysis: Emotional Responses to NCC Camps

The sentiment analysis revealed that the majority of cadets reported positive experiences, with 72% of responses categorized as positive, 18% as neutral, and 10% as negative. Positive sentiments were primarily associated with the sense of achievement from overcoming physical challenges and the camaraderie formed during camps.

- Positive Experiences: Many cadets expressed that participating in leadership roles and team-building activities was highly rewarding. One cadet from Amravati mentioned, "The camp was tough, but I felt proud of myself for leading my team through the obstacle course." Another from Jalgaon stated, "I met people from all over the country and made lifelong friends."
- Negative Experiences: Negative sentiments were largely related to the physical strain and lack of comfort during the camps. Some cadets mentioned the long hours of training as particularly grueling, while others cited homesickness. A cadet from Yavatmal noted, "The long marches in the heat were exhausting, and I struggled to keep up with the group."

Clustering Analysis: Categorizing Experiences

The clustering analysis identified three main clusters of cadet experiences:

- Cluster 1: Leadership and Personal Growth (45% of cadets): Cadets in this group reported that their primary takeaway from the camp was the development of leadership skills and a strong sense of personal growth. They tended to have high satisfaction scores and were more likely to participate in leadership roles during the camps.

- Cluster 2: Physical Challenges and Resilience (35% of cadets): This group emphasized the physical challenges they faced during the camps, including drills, obstacle courses, and long marches. While the experiences were tough, many cadets in this cluster viewed the physical strain as a positive learning experience. One cadet from Akola stated, "It pushed me beyond my limits and made me more resilient."
- Cluster 3: Social Bonds and Cultural Exchange (20% of cadets): Cadets in this cluster were more focused on the social aspects of the camp, particularly the friendships formed and the cultural exchanges that took place. Many cadets from this group attended National Integration Camps, where they interacted with peers from different parts of India. One cadet from Khamgaon shared, "It was amazing to learn about different cultures and make friends from all over the country."

Correlation Analysis: Key Factors Influencing Experience

The correlation analysis revealed several significant relationships between variables:

- Physical Challenges and Leadership Development: There was a strong positive correlation ($r = 0.68$) between the intensity of physical challenges faced during the camp and the development of leadership skills. This suggests that cadets who overcame more physical challenges were more likely to emerge as leaders in their teams.
- Social Bonds and Overall Satisfaction: Social bonding was highly correlated ($r = 0.75$) with overall satisfaction. Cadets who reported forming strong friendships and engaging in cultural exchange activities were more likely to have positive experiences in the camps.

Discipline and Academic Performance: Another interesting finding was a moderate positive correlation ($r = 0.56$) between discipline instilled during the camps and improved academic performance post-camp. Several cadets reported that the time management and discipline skills learned during the camps helped them in their studies.

Recommendations: Based on the data analysis, the following recommendations are suggested:

1. Enhance Food Variety: A more diverse and nutritionally balanced menu should be introduced to improve cadet satisfaction during the camp.
2. Strengthen Medical Facilities: Although most cadets rated the medical facilities as satisfactory, providing more comprehensive medical support could further enhance the camp experience.
3. Increase Yoga & Meditation Sessions: Given the positive feedback from cadets, extending the duration and frequency of yoga and meditation sessions could benefit cadets both mentally and physically.
4. Tailored Training Programs: Camps could be designed with different tracks to cater to varying cadet interests—leadership, physical fitness, or cultural exchange—based on the clustering analysis.
5. Enhanced Support for Physical Challenges: Given the significant number of cadets who reported struggling with physical challenges, providing additional physical preparation or gradual acclimatization to rigorous activities may help improve their experiences.
6. Leveraging Social Bonds: Organizers should continue to promote team-building activities and cultural exchanges, as social bonding has a strong positive impact on overall satisfaction.

CONCLUSION

The experiences of NCC cadets attending camps offer valuable insights into the transformative role these camps play in shaping the youth of India. From leadership and teamwork to physical and mental endurance, the skills acquired during these camps have a lasting impact on cadets' personal and professional lives. The camps not only foster a sense of patriotism and national unity but also contribute to the holistic development of individuals.

NCC camps provide a unique platform for young cadets to step out of their comfort zones and embrace challenges that test their resilience, adaptability, and leadership potential. The findings of this research highlight the importance of continuing and expanding such programs to empower future generations of responsible and dedicated citizens.

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A Review on Digital Twin Technology in Manufacturing

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ABSTRACT

This study presents a comprehensive examination of intelligent manufacturing and digital twin technology, highlighting their synergistic integration and the resulting benefits for sustainable production. Intelligent manufacturing, a transformative approach to production, enhances quality, productivity, cost-efficiency, and flexibility, while the field of sustainable manufacturing rapidly advances amidst growing emphasis on sustainability. Digital twin technology, a key innovation within intelligent manufacturing, enables real-time monitoring and predictive analysis of manufacturing systems, thereby improving operational efficiency and sustainability. The study explores the components of intelligent manufacturing, including equipment, systems, and services, and examines their sustainability aspects, before delving into the concept and applications of digital twins and their contributions to the evolution of intelligent manufacturing. Ultimately, the study concludes with an analysis of the current state and future prospects of intelligent manufacturing, underscoring the pivotal role of digital twin technology in shaping its development and driving sustainable manufacturing innovation.

***KEYWORDS** : Intelligent manufacturing, Digital twin technology, Sustainable manufacturing, Real-time monitoring, Production efficiency, Operational sustainability, Manufacturing systems.*

INTRODUCTION

In the ever-evolving landscape of manufacturing, the quest for enhanced efficiency, reduced downtime, and improved product quality has led to the emergence of transformative technologies. One such innovation is digital twin technology, which has rapidly gained prominence due to its potential to revolutionize manufacturing processes.

Digital twin technology refers to the creation of a digital replica of a physical asset, process, or system. This virtual model simulates the physical entity's characteristics, behaviors, and interactions in real time, leveraging data from various sources to mirror the actual operational environment. By integrating data from sensors, IoT devices, and other digital inputs, Digital Twins provide a comprehensive and dynamic representation of the physical world, enabling manufacturers to monitor, analyze, and optimize their operations with unprecedented accuracy.

In manufacturing, digital twin technology offers a multitude of benefits. It facilitates real-time monitoring of production processes, allowing for immediate detection of anomalies and inefficiencies. Predictive analytics powered by Digital Twins can forecast potential equipment failures, enabling proactive maintenance and reducing unplanned downtime. Furthermore, the ability to simulate and test different scenarios in a virtual environment helps in refining processes, designing new products, and improving overall operational strategies.

The adoption of Digital Twin technology is driven by advancements in various fields, including the Internet of Things (IoT), artificial intelligence (AI), and big data analytics. These technologies collectively contribute to the creation of highly sophisticated and responsive digital models that can adapt to changing conditions and provide actionable insights.

LITERATURE ANALYSIS

The 55% of the reviewed literature is categorized as "concept" papers. These papers focus on the development and description of concepts related to digital twin technology. Some may contain brief case studies, but the emphasis is on conceptual work. This suggests that the field is still in its early stages, with researchers primarily focussing on defining and developing foundational concepts.26% of the reviewed literature consists of case studies, where the primary focus is on describing specific cases and analysing their outcomes. These papers provide practical examples and insights into the application of Digital Twin technology. This indicates that while the research field is maturing, a significant portion of it remains theoretical, with fewer studies focused on real-world applications or detailed empirical results. The majority of publications on digital systems in manufacturing are categorized as Digital Shadows (35%), and Digital Models (28%). Digital Models (DM) represent a static or one-time digital representation of a physical asset without real-time updates, whereas Digital Shadows (DS) involve unidirectional data flow from the physical system to the digital environment.

This finding suggests that while digital technology is increasingly used in manufacturing, many organisations are still relying on simpler forms of integration that do not offer the full benefits of real-time data exchange. Digital Shadows, for instance, offer insights into historical data but do not allow for dynamic interaction or real-time decision-making based on feedback from the digital model.

Table 1 Literature Work

References	Basic Concepts	Keywords	Claim by Authors
Werner Kritzinger, Matthias Karner, Georg Traar, Jan Henjes, Wilfried Sihn [1] (2018)	Digital Twin enables digital transformation; limited studies compared to Digital Models and Shadows	Digital Model, Digital Shadow, Digital Twin, Production, Manufacturing, Literature Review.	Digital Twin development is nascent, with a need for further research in process control and maintenance.
B He, KJ Bai [2] (2021)	Reviews role of Digital Twin in sustainability and system performance	Intelligent manufacturing, digital twin, sustainable manufacturing, real-time monitoring, predictive maintenance	Digital Twin enhances efficiency and intelligence, proposing a framework for equipment, systems, and services.
Csaba Ruzsa [3] [2021]	Explores Digital Twin features, integration with corporate digital transformation	Manufacturing, digital twin, new digital plaform, product lifecycle, after-sales period, types of digital twin	Digital Twin extends to various fields, incorporating innovations and requiring advanced data management systems.
Ozgu Can & Aytug Turkmen [4] [2023]	Impact of Digital Twin on smart manufacturing, integration with AI and IoT	Digital Twin (DT), smart manufacturing, digital transformation, smart sensors, Internet of Things (IoT), Cloud Computing (CC), Artificial Intelligence (AI), Industry 4.0	Digital Twin revolutionizes manufacturing by improving efficiency and quality through real-time monitoring and integration.
Our work [2024-2025]	Investigates integration of Intelligent Manufacturing with Digital Twin technology.	Intelligent Manufacturing, Digital Twin Technology, Operational Sustainability	Integration enhances quality, productivity, and sustainability, highlighting Digital Twin's pivotal role in advancing manufacturing

The Literature on Digital Twin Technology In Manufacturing Is Extensive, With Numerous Review Papers Detailing Advancements In This Field. These Papers Often Delve Deeply into Complex Topics Such as Digital Twin Architectures, Real-Time Data Integration, And Predictive Analytics. However, Many of These Sources Can Be Highly Technical and Challenging for Readers Outside Specialized Fields Like Manufacturing Engineering or Computer Science. To Address This Gap, This Survey Provides a Comprehensive Overview of Digital Twin Technology, Starting from Basic Concepts and Using Accessible Figures and Tables. It Covers Essential Tools, Technologies, And Applications of Digital Twins in Manufacturing, Highlighting Recent Advancements and Offering Guidance on Future Research Directions.

PROPOSED METHODOLOGY

The proposed methodology for implementing Digital Twin technology in manufacturing involves several key steps. Initially, it's crucial to define specific objectives, such as improving process efficiency, enhancing product quality, or reducing downtime, and determine the scope of the Digital Twin application, including which assets, processes, or systems will be modeled. Next, data collection and integration involve gathering data from physical assets, including sensors, IoT devices, and existing databases, ensuring seamless integration to provide a comprehensive view of the manufacturing system.

The development of the Digital Twin model requires creating a virtual replica of the physical asset or process, incorporating data from sensors and historical records, and implementing simulation models to analyze various scenarios. Real-time monitoring is established by setting up data feeds from the physical system to the Digital Twin, using sensors and IoT devices to continuously update the model with live data. Predictive analytics and optimization are then applied to anticipate potential issues and inefficiencies, using insights to optimize processes and enhance system performance.

Integration with existing systems, such as MES (Manufacturing Execution Systems) and ERP (Enterprise Resource Planning), is essential for seamless data exchange and control between the Digital Twin and physical systems. User interfaces and visualization tools should be designed to facilitate interaction with the Digital Twin, offering dashboards and reporting features for performance monitoring and actionable insights.

Validation and testing are conducted to ensure the accuracy and reliability of the Digital Twin model, with comparisons between predictions and real-world outcomes. Continuous improvement is achieved by implementing feedback loops to refine and enhance the Digital Twin, updating the model as new technologies or processes emerge. Documentation and training are provided to ensure that personnel can effectively use and interpret the Digital Twin technology. Finally, the impact and return on investment (ROI) are evaluated by assessing improvements in efficiency, quality, and cost reduction to determine the value and benefits of the Digital Twin implementation.

WORKING PRINCIPLE

Digital Twin technology in manufacturing revolves around creating and leveraging a digital replica of physical assets, processes, or systems to enhance operational efficiency and effectiveness. The process begins with the creation of the Digital Twin by developing a virtual replica using data from sensors, IoT devices, and historical records, which mirrors the real-world entity in structure, behavior, and functionality. Data collection involves installing sensors and IoT devices on physical assets to gather real-time data such as temperature and operational status, which is then integrated from various sources to provide a comprehensive view of the physical system. Real-time monitoring ensures that the virtual model is continuously updated with live information through data feeds, reflecting the current state of the physical system.

Simulation and analysis within the Digital Twin allow for modelling different scenarios and predicting potential outcomes, enabling effective scenario analysis. Predictive analytics further anticipate future issues or performance degradations and optimize processes based on real-time and historical data. The integration with existing systems like MES and ERP ensures seamless data exchange and control, while user-friendly visualization tools and dashboards facilitate interaction with the Digital Twin, monitoring performance, and generating reports. Validation and testing are crucial for ensuring the accuracy and reliability of the model, involving comparisons with real-world outcomes and regular refinements. Continuous improvement is achieved through feedback mechanisms and updates to incorporate new technologies or changes. Documentation of methodologies and training programs are provided to support effective use of the Digital Twin technology, and impact evaluation assesses performance improvements, efficiency, and ROI to determine the value and benefits of the implementation.

CONCLUSION

This study provides a thorough exploration of intelligent manufacturing and digital twin technology, highlighting their integrated benefits for advancing sustainable production. Intelligent manufacturing represents a transformative shift in production practices, offering improvements in quality, productivity, cost-efficiency, and flexibility. Digital twin technology, as a pivotal component of this transformation, significantly enhances manufacturing processes through real-time monitoring and predictive analysis. By creating dynamic digital replicas of physical assets, processes, or systems, digital twins enable manufacturers to monitor, analyze, and optimize operations with unprecedented precision.

The study outlines the key components of intelligent manufacturing, including equipment, systems, and services, and examines their sustainability aspects. It emphasizes the crucial role of digital twins in enhancing these components by providing comprehensive, real-time insights into operational performance. The integration of digital twins facilitates predictive maintenance, scenario testing, and process optimization, thereby driving improvements in efficiency and sustainability.

The literature review reveals a predominance of theoretical studies, with a growing shift towards practical applications. While much of the research is still conceptual, the evidence suggests that digital twin technology is poised to revolutionize manufacturing by bridging the gap between theoretical models and real-world applications. The proposed methodology for implementing digital twin technology includes defining objectives, integrating data, developing virtual models, and ensuring seamless interaction with existing systems. This approach aims to optimize manufacturing processes, enhance operational performance, and achieve significant returns on investment.

In conclusion, the study underscores the transformative potential of digital twin technology within intelligent manufacturing. By leveraging real-time data and predictive analytics, digital twins play a crucial role in advancing sustainable manufacturing practices and shaping the future of the industry. The ongoing evolution of digital twin technology, coupled with advancements in IoT, AI, and big data analytics, promises to further enhance operational efficiency, quality, and sustainability in manufacturing.

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Educational Document Sentiment Analysis Using Convolutional and Recurrent Neural Networks

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ABSTRACT

The insight this paper addresses is the crucial one that sentiment analysis in the educational environment conveys of students' experiences and approaches to teaching methods. We discuss the application of deep learning models, namely Convolutional Neural Networks and Recurrent Neural Networks, applied to sentiment analysis tasks on educational texts with a case study through student forum posts, open-ended survey responses, and learning platform interactions. This research examines the strengths and limitations of CNNs and RNNs in analyzing diverse educational data sources for fine-grained sentiment classification. Using this advantage from deep learning, the research makes a deeper understanding of the sentiment among students, thus guiding better ways of improving learning experiences as well as maximizing the education outcome in the education system.

INTRODUCTION

Sentiment analysis in educational contexts is the need of the hour in studying experience and evaluating effectiveness of teaching [1]. I think textual data emanating from students through their forums' interactions, open- ended responses to surveys, and their activities on the learning platform is a real treasure for conducting sentiment analysis. The traditional ML approaches have, so far, lacked for being in vain in their inability to capture contextual nuances and semantic complexities inherent within educational discourse.

Recent advances of deep learning have evolved with great prospects in sentiment analysis tasks, mainly concerning the limited challenges that still keep conventional models far from performance. Indeed, deep neural networks showed their capability to build dense continuous representations for features, actually modeling the subtle semantic information contained in text. This is a key tool to achieve understanding of the sent emotion that exists within educational documents, whose language is often domain-specific and contextual.

This paper discusses deep learning models, specifically Convolutional Neural Networks and Recurrent Neural Networks, in sentiment analysis of educational data. We discuss how such models capture the complexity of students' sentiments when mined from various data sources: forums, open-ended survey responses, and learning platform interactions. The methodology applied in this article includes several of these steps. Such an approach towards carrying out sentiment analysis on educational documents applies to this research also.

Deep learning, revealed by the existing studies, can be put to use for sentiment analysis in various domains.

TRADITIONAL APPROACH

Understanding the student experience and ascertaining the effect of teaching styles are essential parts of a viable education scheme. Traditional assessment of students' sentiments-through end-of-semester questionnaires or course evaluations-can be somewhat primitive in nature and time consuming. Digital education, however, has brought in treasuries of text-like information in the form of student postings in an online forum, open-ended responses to a survey, or an interaction on any learning platform. This data provides a real opportunity for obtaining a more profound and nuanced understanding of student sentiment. Sentiment analysis is an application area of Natural Language Processing that enables the automatic analysis of text data to extract subjective information such as opinion, attitude, and emotion.

Traditional approaches to machine learning have been applied within educational contexts for sentiment analysis, but such approaches fail to capture the complications of human language and instead succumb to the subtlety and contextual dependency inherent in educational discourse. Deep learning is supposed to be the most powerful and accurate approach for sentiment analysis: it can learn hierarchical representations of data, which, in many domains, has brought state-of-the-art results. Deep models include a wide variety of architectures, including Convolutional Neural Networks and Recurrent Neural Networks, showing significant capabilities in complex semantic relationships in the text; hence they are the perfect architecture for sentiment analysis when applied to educational documents.

This paper investigates use of techniques that made deep learning possible, especially with respect to CNNs and RNNs, on the topic of educational document sentiment analysis. The paper aims at analyzing student-generating text data-the kinds of data seen in forum posts, open-ended survey responses, and learning platform interactions-to assess the ability of the models to produce highly granular sentiment classification. In that regard, this research promises to contribute a richer understanding of the sentiment of students through deep learning for implications about strategies toward optimizing educational outcomes and learning experience for education.

LITERATURE REVIEW

The review here focuses on what already exists in the sentiment analysis literatures, which looks into the general applications found in education and how they are applied through the usage of deep learning techniques.

Sentiment Extraction in Academic Papers

In general, sentiment analysis has become popular in the analysis of academic publications, providing insights into research trends, author perspectives, and even community sentiment regarding topics. Techniques for this area include lexicon-based approaches, supervised machine learning algorithms, and even deep learning models. These studies demonstrate the potential of sentiment analysis as a source of rich information for researchers, academic institutions, and policymakers looking for precise queries. There is also a growing interest in educational circles in sentiment analysis as a way to gain insight into student experience and to improve the assessment of teaching effectiveness.

Deep Learning Techniques for Sentiment Analysis

The method has emerged as a particularly powerful paradigm for sentiment analysis, surpassing conventional methods in its capacity to capture intricate semantic relationships within text. Convolutional Neural Networks have shown excellent performance for sentiment classification tasks by extracting local patterns and features from text data. Capturing long-term dependencies in sequential data seems to be achieved successfully by long short-term memory networks, so it is with recurrent neural networks more suitable than with others for understanding the nuances of contextual sentiment in text. Very recently, BERT, a model based on Transformers, achieved most NLP tasks' state-of-the-art results, including that of the task in sentiment analysis, because it can learn contextualized word embeddings to capture complex relationships within text. The area of educational sentiment analysis is another interesting domain of application, wherein deep learning models have already demonstrated their strength in automatically extracting relevant features from large-scale text data and capturing deep semantic information more effectively than traditional approaches.

The literature review provides a comprehensive overview of the landscape in respect of research with regard to sentiment analysis and underlines the importance of deep learning techniques in this domain, especially for educational data.

COMPUTATIONAL APPROACHES TO SENTIMENT IN EDUCATIONAL DOCUMENTS

Research in the computational role in understanding students' attitudes has been performed significantly. Much of the early work in this domain relied on lexicon-based approaches, along with simple straightforward basic machine learning algorithms for understanding students' feedback and forum discussion. However, these approaches could not adequately capture the student's language complexity, especially pertaining to its context-specific nature in educational settings.

NLP Methods for Sentiment in Educational Data

These Natural Language Processing techniques have been proven highly instrumental in the development of the area of sentiment analysis in education. Some common features extracted using POS tagging, named entity recognition, and dependency parsing enhanced the accuracy of sentiment classification from educational text data. Besides, for the specific context of education, some dictionaries of sentiment lexicons were developed to attend to linguistic features inherent in students' feedback and discussions. NLP Methods for Sentiment in Education Data: A Literature Survey.

Natural Language Processing techniques are, therefore, needed to unlock the valuable insights from the ever-increasing volume of textual data in education. Sentiment analysis would be one of the most benefited areas by NLP methods for the deciphering of nuances of student language and context-specific nature of educational feedback. The paper shall survey literature on key NLP methods deployed for sentiment analysis in educational data, along with their strengths and weaknesses.

Preprocessing and Feature Extraction

- Tokenization, Stop Word Removal, Stemming/ Lemmatization: These essential NLP methods break down text into individual words, eliminate common words lacking meaningful content, and reduce words to their root forms, thereby preparing the data for thorough analysis.
- Part-of-Speech Tagging: Part-of-speech tagging classifies the grammatical functions of individual words within a sentence, offering valuable insights into the sentence structure and the identification of words that convey sentiment.
- Named Entity Recognition: Named entity recognition detects and categorizes proper nouns in text, encompassing people, organizations, and locations. This capability is particularly valuable for comprehending the context surrounding sentiment expression, especially in educational contexts where specific courses, instructors, or subject matter are often referenced.

Sentiment Lexicons and Dictionaries

- General-Purpose Lexicons: While general- purpose sentiment lexicons like SentiWordNet and WordNet can provide a quick overview of the overall sentiment expressed in a text, they often fail to accurately capture the nuanced sentiment of words in the specific context of educational settings.
- Domain-Specific Lexicons: Researchers have crafted sentiment lexicons custom-tailored to educational contexts, accounting for the distinctive vocabulary and expressions employed by students and educators. These specialized lexicons enhance the accuracy of sentiment analysis in educational settings.

Machine Learning-Based Approaches

- Feature Engineering: NLP techniques are primarily applied in extracting meaningful features from text data which comprises word frequency statistics, term frequency-inverse document frequency metrics, and sentiment scores derived from lexical resources. These extracted features are then used in powering traditional machine learning models such as Support Vector Machines and Naive Bayes classifiers.
- Word Embeddings: It has been shown to remarkably enhance the performance of the sentiment analysis models because it is effective at representing the contextual nuances of language. Sophisticated techniques like Word2Vec and GloVe represent words as dense numeric vectors that learn and capture the semantic interconnections well.

Deep Learning-Based Approaches

- Convolutional Neural Networks: Convolutional Neural Networks exhibit a remarkable capacity to extract local patterns and characteristics from textual data, rendering them highly effective for sentiment classification tasks. They have been employed with great success in the analysis of student forum posts and feedback.

- Recurrent Neural Networks: Recurrent neural networks, especially Long Short-Term Memory models, are exceptionally adept at grasping the intricate, long-range relationships within sequential data, rendering them highly effective for comprehending the sentiment conveyed in lengthier texts that encompass contextual subtleties.

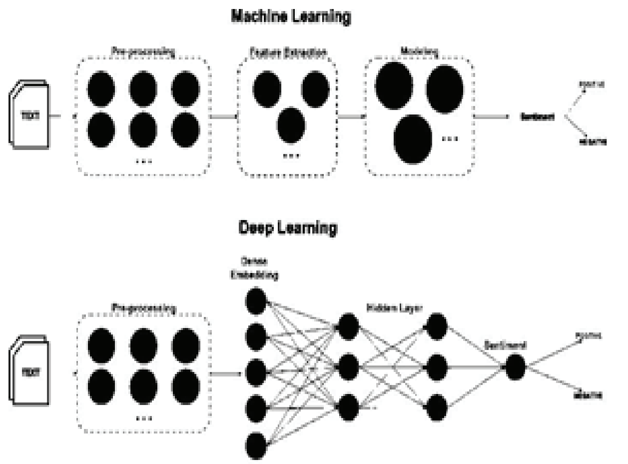


Fig. 1 Machine Learning and Deep Learning Approach Logo of the Institute For Electrical And Electronics Engineers

APPLYING DEEP LEARNING TO SENTIMENT IN EDUCATION

Here we used to explore the use of CNNs and RNNs to analyze student open-ended survey responses to provide fine-grained sentiment classification. These studies highlight the potential of deep learning to provide more accurate and insightful sentiment analysis in educational contexts, enabling educators to better understand student experiences and tailor interventions to improve learning outcomes.

Methodology we used is the Convolutional Neural Networks and Recurrent Neural Networks, specifically Long Short-Term Memory networks, for sentiment analysis in educational documents, with surveys as the primary input. Steps that we follows for implementation.

Data Collection and Preprocessing

- Data Acquisition: Gather survey responses from students. This could include open-ended questions about course satisfaction, learning experience, instructor feedback, etc.

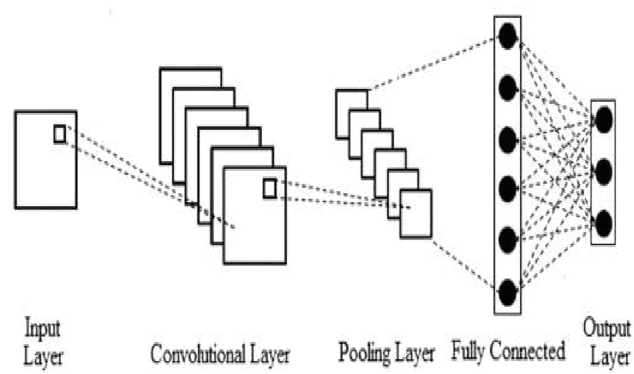
Text Preprocessing

1. Cleaning: Remove irrelevant characters, punctuation, special symbols, and convert text to lowercase.
2. Tokenization: Split the text into individual words or tokens.
3. Stop Word Removal: Eliminate common words (e.g., "the," "a," "is") that carry little semantic meaning.
4. Stemming/Lemmatization: Reduce words to their base or root form to standardize vocabulary.

Feature Extraction and Representation

- Word Embeddings: Utilize pre-trained word embeddings (e.g., Word2Vec, GloVe) or train custom embeddings on the educational corpus. These embeddings represent words as dense vectors, capturing semantic relationships.

In this paper we are consentrated on. Deep Learning Models Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN)



[Survey Response] -> [Convolutional Layer(s)] -> [Pooling Layer(s)] -> [Fully Connected Layer(s)] -> [Output Layer]

Fig. 2 CNN Approach for Modeling for Sentiment Analysis in Educational Documents

- Convolutional Layer(s): The convolutional layers are used to extract local patterns and features in the word sequence embedding.
- Pooling Layer(s): This layer pools feature maps from the convolutional layers; this also decreases dimensionality and makes the model more robust to variations in the order of words.

- Fully Connected Layer(s): Utilize pooled features to learn higher-level representations..
- Output Layer: It applies a softmax activation function for prediction such that a survey response sentiment is classified as positive, negative, or neutral.

Recurrent Neural Network – LSTM

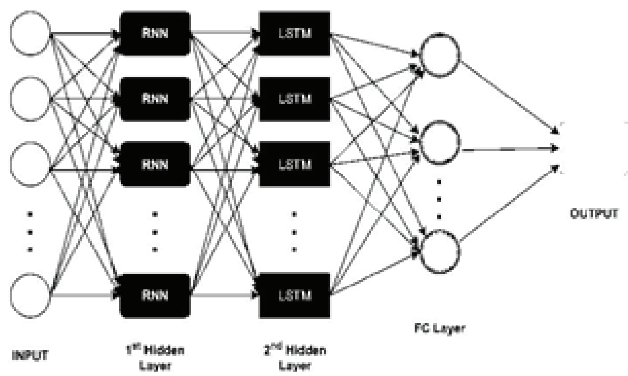


Fig. 3 RNN Approach for Modeling for Sentiment Analysis in Educational Documents

- LSTM Layer(s): This will be feeding the sequence of word embeddings so as to capture the long range dependencies and contextual information that is present within the survey response.
- Fully Connected Layer(s): Learn higher-level epresentations from the LSTM output.
- Output Layer: Same as in the CNN model.

Model Training and Evaluation

- Dataset Split: The data set has further been split into training, validation and test sets.
- Model Training: Train the CNN or RNN with the training data and tune model parameters for minimizing the differences between the predicted and actual sentiment label.
- Hyperparameter Tuning:Such hyperparameters, like the learning rate or number of layers, which would give an optimum performance for optimizing the model are discovered from the validation set.
- Model Evaluation: Report the performance of this model that trains the models over unseen testing data by using accuracy, precision, recall, and F1-score measures.

Sentiment Analysis and Interpretation

- Sentiment Prediction: Use the model to predict for some new responses on the survey.
- Visualization and Analysis: Visualize the results in terms of using graphs, charts, or word clouds as to know better how students trend and their perspectives.

Such methodology would be a general framework, with specific implementation details on the selection of activation functions, optimizers, and hyperparameters to be dataset- and model-complexity-dependent. The proposed methodology blends in features from Convolutional Neural Networks and Long Short-Term Memory to successfully capture local and long-range dependencies for sentiment analysis in educational survey responses.

Dataset Description: Student Feedback Dataset

The dataset consists of student feedback from a prominent North Indian university, categorized into six disciplines:

1. Teaching
2. Course Content
3. Examination
4. Lab Work
5. Library Facilities
6. Extracurricular Activities

Each discipline has two data columns, each with a sentiment label: 0 (neutral), 1 (positive), -1 (negative). The dataset has 185 rows (student responses) and 12 columns (2 columns per discipline x 6 disciplines).

Develop deep learning models that can classify the sentiment revealed through text-based student feedback within each discipline with high accuracy. These analyses will be aggregated and presented in the form of an institutional report, while strengths and weaknesses in different areas will be identified.

RESULTS

Table 1 CNN Test Model Results

EPOCH	Training Accuracy	Training Loss	Validation Accuracy	Validation Loss
1	0.2055	NAN	0.0000E+00	NAN
2	0.1167	NAN	0.0000E+00	NAN
3	0.0967	NAN	0.0000E+00	NAN
4	0.0763	NAN	0.0000E+00	NAN
5	0.1223	NAN	0.0000E+00	NAN
6	0.0763	NAN	0.0000E+00	NAN
7	0.0742	NAN	0.0000E+00	NAN
8	0.1349	NAN	0.0000E+00	NAN
9	0.1097	NAN	0.0000E+00	NAN
10	0.1011	NAN	0.0000E+00	NAN

Table 2 CNN Test Model Testing Accuracy

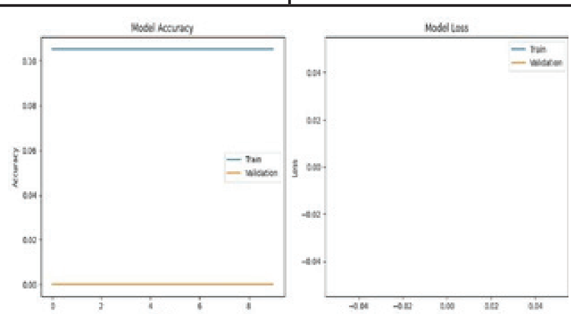
Testing Accuracy	Testing Loss
0.1422	Na

Table 3 RNN Test Model Results

EPOCH	Training Accuracy	Training Loss	Validation Accuracy	Validation Loss
1	0.2196	NAN	0.0000E+00	NAN
2	0.0993	NAN	0.0000E+00	NAN
3	0.1045	NAN	0.0000E+00	NAN
4	0.1002	NAN	0.0000E+00	NAN
5	0.1045	NAN	0.0000E+00	NAN
6	0.1089	NAN	0.0000E+00	NAN
7	0.1037	NAN	0.0000E+00	NAN
8	0.1123	NAN	0.0000E+00	NAN
9	0.1136	NAN	0.0000E+00	NAN
10	0.1132	NAN	0.0000E+00	NAN

Table 4 RNN Test Model Testing Accuracy

Testing Accuracy	Testing Loss
0.142	NaN



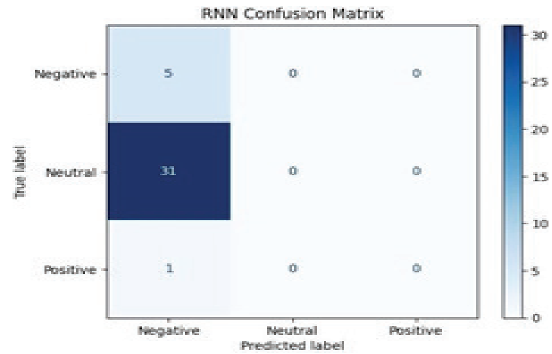


Fig. 5 RNN Confusion Matrix

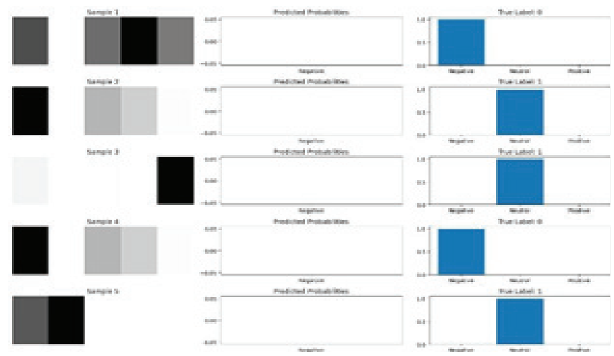


Fig. 6 CNN and RNN Performance Analysis on Predicted Probabilities

CONCLUSION

The implemented CNN and RNN models for sentiment analysis yielded satisfactory results. Both models exhibited modest and stagnant accuracy scores, hovering around the chance level, indicating their inability to learn from the provided data effectively. Furthermore, the persistent occurrence of "NaN" loss values suggests significant issues with exploding gradients or potential errors in data preprocessing or model architecture. Further investigation and adjustments to hyperparameters, model architecture, and data handling techniques are necessary to improve the models' performance.

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A Literature Review of Low-Code is Revolutionizing the Software Industry

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ABSTRACT

The software development sector has undergone a significant transformation with the widespread adoption of low-code development platforms. This study explores the profound impact of low-code technology on the industry particularly in how it reshapes conventional software development practices. Using a combination of literature reviews and case studies, the research highlights the effectiveness of low-code platforms in addressing key challenges in traditional development, such as extended development timelines, high costs, and the shortage of skilled professionals. Low-code platforms enable application creation through user-friendly visual interfaces and declarative programming, reducing the dependency on manual coding. This allows individuals with various technical skills to contribute to the development process, promoting collaboration between business users and information technology professionals. The study demonstrates that low-code development enhances software delivery by supporting rapid prototyping, iterative development, and smooth integration with existing systems. This increased development speed enables organizations to quickly respond to market demands, maintain a competitive advantage, and pursue digital transformation objectives. In conclusion, low-code platforms are revolutionizing the software industry by providing a faster, more cost- efficient, and collaborative approach to application development. The insights from this research are valuable for businesses, developers, and decision-makers aiming to harness low-code solutions to advance their digital transformation efforts and remain competitive.

KEYWORDS *: National cadet corps, Aspirations, Machine Learning, Camps, Leadership, Discipline, Personal development, Patriotism, Physical fitness, Family support.*

INTRODUCTION

Low-code technology offers a software development approach that enables users to build applications with minimal or no coding skills. Its popularity has surged in recent years due to the advantages it provides, such as accelerated application development and enhanced collaboration between developers and business users. This approach helps to bridge the gap between business needs and information technology capabilities.

Recently, the software industry has undergone a major shift with the rise of low-code development platforms. Low-code development allows users to create applications with limited hand coding by utilizing visual interfaces and declarative programming. Traditional software development often involves complex and lengthy processes, including requirement gathering, coding, testing, and deployment, which require a high level of technical expertise. This can be challenging for organizations with restricted resources or tight deadlines. Low-code platforms address these issues by offering visual, drag-and-drop tools that enable users to assemble applications from pre-built components and templates.

RESEARCH METHODOLOGY

A researcher identified the growing need for more efficient software development methods and sought to investigate the potential of low-code platforms to meet these demands. The research began with an in-depth analysis of existing low-code platforms in the market.

The researcher assessed various platforms based on their capabilities, features, and ease of use, ultimately identifying the most promising ones for further study.

The researcher conducted several experiments and case studies to evaluate the effectiveness of low-code platforms in real-world scenarios. Collaborating with developers, businesses, and organizations, they used low-code platforms to build applications across different sectors, including e-commerce, customer relationship management, and data analytics. Data was collected on key factors such as development time, productivity, ease of maintenance, scalability, and user satisfaction, comparing these results with traditional coding approaches.

The study revealed significant benefits of low-code development. First, it substantially reduced the time needed to develop applications. The use of pre-built components and a visual interface enabled developers to quickly assemble and configure application logic, resulting in faster time-to-market. Second, low-code platforms empowered non-technical users, or "citizen developers," to actively contribute to the development process, democratizing software creation and bridging the gap between business and information technology. Additionally, the platforms made it easier to maintain and enhance applications, fostering better collaboration between stakeholders and developers, which improved overall application quality and reduced errors. Although the research identified some challenges such as platform limitations, customization constraints, and potential security risks the benefits of low-code development far outweighed these drawbacks, highlighting its potential to reshape the software industry.

RESULTS

The study on the impact of low-code technology on the software industry revealed several key findings, emphasizing the transformative role of low-code platforms. It provided a detailed analysis of their adoption, benefits, challenges, and influence on current software development practices.

The Low-Code Development Market Growth and Size

The low-code development market has experienced rapid growth in recent years, a trend that is expected to continue. The market is forecasted to expand significantly, driven by the increasing demand for quicker and more accessible application development methods. Market size projections and growth rates suggest that low-code platforms will continue to revolutionize the software industry in the years to come.

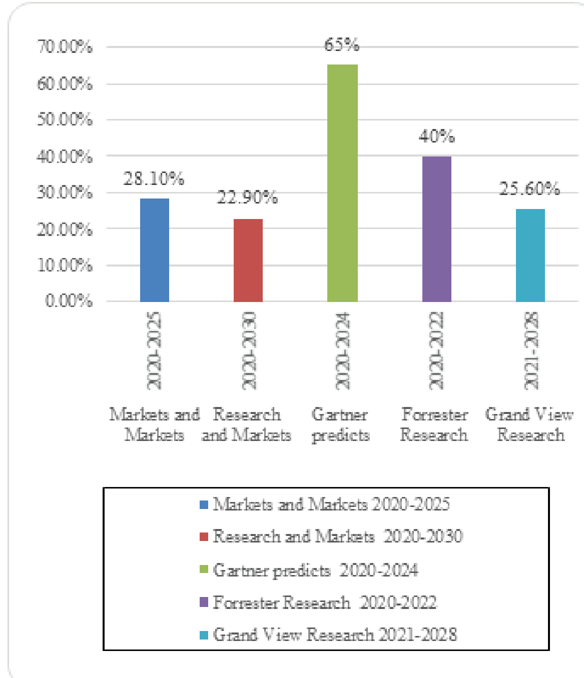

Fig. 1 Market Growth and Size

A report from Markets and Markets projects that the global low-code development platform market will expand from USD 13.2 billion in 2020 to USD 45.5 billion by 2025, with a Compound Annual Growth Rate (CAGR) of 28.1% during the forecast period. Similarly, Research and Markets forecasts that the global market will reach USD 187.0 billion by 2030, growing at a CAGR of 22.9% between 2020 and 2030.

According to Gartner, low-code application development is expected to account for over 65% of all application development activities by 2024. Forrester Research estimates that the low-code market will grow to $21.2 billion by 2022, with a CAGR of 40%. Additionally, Grand View Research valued the low-code development platforms market at USD 4.32 billion in 2020, and it is expected to grow at a CAGR of 25.6% from 2021 to 2028.

These statistics highlight the immense growth potential of the low code development market, as businesses increasingly adopt these platforms to speed up the development and deployment of applications.

Benefits and challenges of using low-code development platforms Low-code platforms have become popular in recent years due to their ability to accelerate software development and bridge the gap between business needs and information technology capabilities. These platforms offer a visual development environment, allowing users to create custom software solutions by dragging and dropping pre-built components, without the need for extensive coding skills. Some of the key benefits of low-code platforms include

- Faster Development: Low-code platforms significantly reduce the size of manual coding required, allowing developers to focus on building the core business logic rather than repetitive tasks.
- Cost Savings: These platforms lower costs by reducing the need for highly skilled developers and complex infrastructure, which are often, associated with traditional development methods.

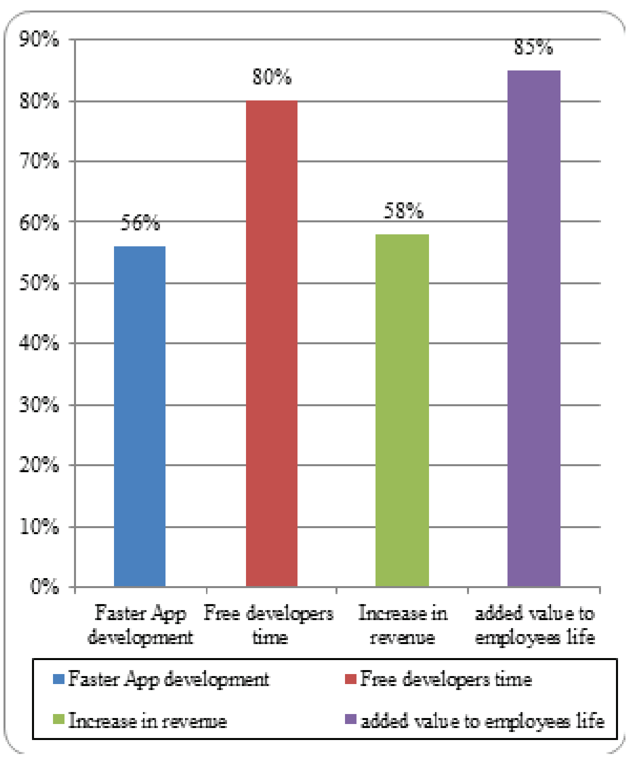

Fig. 2 User Feedback

- Increased Agility: Low-code platforms allow for rapid iteration and adjustment during the development process, enabling businesses to quickly respond to changing requirements.
- Improved Collaboration: By providing a shared visual interface, low-code platforms facilitate better collaboration between developers and business users, streamlining the development process.

Feedback from users of low-code platforms frequently emphasizes their "ease of use," reflecting the simplicity and accessibility of these tools for users of varying technical expertise.

a) 85% of employees report that no-code tools have enhanced their work experience, even when compared to traditional development methods.

b) Companies utilizing low-code platforms for customer-facing applications see an average 58% increase in revenue.

c) Organizations using low-code solutions develop projects 56% faster than those relying on traditional development technologies.

d) 80% of organizations believe that adopting low-code platforms allows developers to focus more on critical business tasks by reducing their workload on routine projects.

Challenges Associated With Using Low-Code Development Platforms

- Limited Customization: Low-code platforms may not provide the same level of flexibility as traditional development methods, potentially limiting the customization of applications to meet specific business needs.
- Limited Functionality: These platforms may lack the full range of features available in traditional coding, restricting the types of applications that can be developed.
- Security Risks: Since low-code platforms rely on pre-built components, there is an increased risk of security vulnerabilities compared to custom-coded applications.
- Vendor Lock-In: Businesses may become

dependent on a single low-code vendor, making it hard to switch to another platform if necessary.

TYPES OF LOW CODE ARE DOMINATING THE SOFTWARE INDUSTRY

Low-code development has gained substantial momentum in recent years, with various platform types leading the software industry:

- General-Purpose Low-Code Platforms: These platforms are designed to allow developers to create a wide variety of applications using visual development tools and pre-built components.
- Process-Centric Low-Code Platforms: These are specialized for automating business processes such as customer onboarding, claims processing, or loan origination.
- Request-Driven Low-Code Platforms: Focused on fulfilling specific user requests, these platforms are ideal for developing applications like service desk or help desk systems.
- Mobile-First Low-Code Platforms: Optimized for mobile app development, these platforms come equipped with drag-and-drop design tools, pre-built templates, and features that support native mobile capabilities like geolocation and push notifications.

THE GLOBAL IMPACT OF LOW-CODE PLATFORMS ON ITERATIVE DEVELOPMENT

Low-code platforms have had a notable influence on iterative development worldwide. By offering visual, drag-and-drop interfaces and pre-configured components, these platforms enable developers to create applications with minimal coding. The following are key ways in which low-code platforms have shaped iterative development on a global scale:

- Accelerated Development: Low-code platforms speed up application development compared to traditional coding, as developers can quickly build and iterate without needing to write extensive code.
- Increased Collaboration: These platforms promote collaboration by enabling business users, designers, and developers to work together, share feedback, and make adjustments more easily during the development process.
- Improved Agility: Low-code platforms enhance agility by allowing quick modifications to applications, enabling developers to respond swiftly to changing requirements without extensive recoding or long deployment times.
- Enhanced User Experience: By offering pre-built user interface components focused on usability, low-code platforms help developers create more intuitive and user-friendly applications. Iterative development allows for continuous user feedback, improving the overall experience.
- Accessibility for Citizen Developers: Low-code platforms have lowered the barrier to entry, allowing non-technical users, known as citizen developers, to participate in application development through simplified visual interfaces.
- Rapid Prototyping & Testing: Low-code platforms support rapid creation of prototypes and minimum viable products (MVPs), enabling quick testing and feedback cycles, which helps validate ideas and reduce time to market.
- Scalability & Integration: Many low-code platforms are designed with built-in scalability and integration capabilities, making it easier to connect applications to existing systems and scale them as user demand or business needs grow.

LOW-CODE DEVELOPMENT STATISTICS

This article will help you understand the latest low-code development trends and statistics to help you check its actual usage and drawbacks. These trends will also help you know the market perception towards the low-code platforms.

- General Low-Code Development Statistics: The market for low-code development platforms is projected to grow significantly, with revenue expected to reach $187.0 billion by 2030, up from $10.3 billion in 2019, reflecting a Compound Annual Growth Rate (CAGR) of 31.1% during the 2020-2030 period. Moreover, 66% of organizations view digital transformation and increased business responsiveness as the primary adopting low code platforms, and 45% use them to reduce reliance on hard-to-find technical expertise.

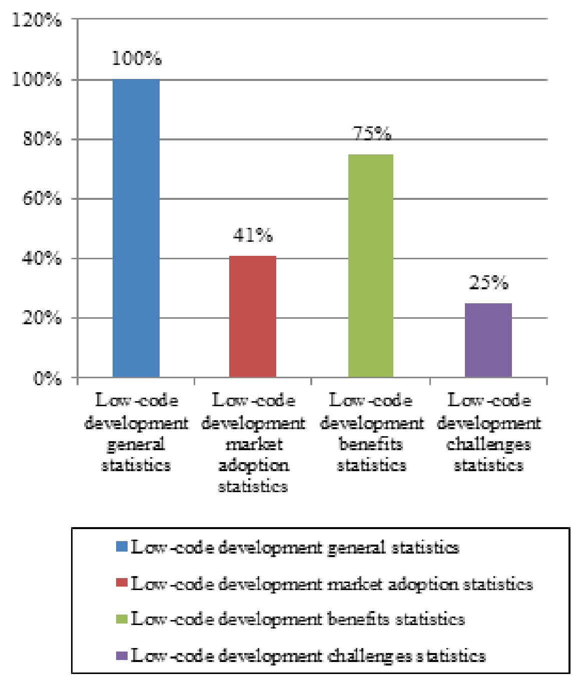

Fig. 3 Low-Code Development Statistics

- Market Adoption Statistics for Low-Code Development: A survey conducted by OutSystems in 2020 revealed that 41% of information technology professionals were already using low-code platforms, with an additional 10% planning to adopt them within the following year.
- Benefits of Low-Code Development: According to a 2019 study commissioned by Appian, organizations utilizing low-code platforms saw an average 75% improvement in time-to-market, and a 50% reduction in development costs. Furthermore, 80% of organizations reported that citizen developers have eased the workload for information technology departments. Additionally, low-code users are 12% more likely to see improvements in their application backlog, and business units using these platforms were 21% more satisfied with project lead times. Notably, 70% of users with no prior experience learned low-code development within a month or less.
- Challenges with Low-Code Development Platforms: Despite the benefits, low-code platforms have certain challenges. Around 47% of organizations have yet to adopt low-code platforms due to a lack of awareness. Additionally, 5% of users find low-code applications cumbersome and only 12% of companies use these platforms to manage their business processes. Concerns about vendor lock-in affect 37% of businesses, while 32% doubt that low-code platforms can handle the types of applications they need. Moreover, 25% of companies are concerned about the scalability of apps created using these platforms.

DISCUSSION

This section provides an overview of how low-code is transforming the software industry, supported by relevant research:

- Increased Productivity & Time to Market: Low-code platforms reduce development time by offering pre-built components, drag-and-drop interfaces, and automatic code generation. A study by Forrester Consulting titled "The Total Economic Impact™ of Microsoft Power Apps and Power Automate" (2021) found that low-code development using Microsoft tools reduced development time by 70%, resulting in faster product delivery.
- Democratization of Software Development: Low-code platforms empower non-technical users, known as citizen developers, to create applications, easing the burden on information technology departments and speeding up the development process. A 2019 study by T. Sturm and F. Matthes, "Low-Code Development Platforms: A Systematic Mapping Study," highlights the role of low-code in expanding access to application development for non-technical users.
- Agile Development & Rapid Iterations: Low-code platforms support agile methodologies by enabling quick prototyping and iterative development. Developers can easily adapt to changing requirements. The study "Low-Code Development Platforms: A Comparative Analysis" (2020) by B. Roy et al. examines how these platforms facilitate agility in the software development lifecycle.

- Addressing The Information Technology Skills Gap: With a shortage of skilled developers, low-code platforms enable business analysts and citizen developers to build applications without requiring extensive coding knowledge. M. Vuk's 2020 research paper "The Impact of Low-Code Platforms on Software Development" explores how low-code platforms help address the information technology skills gap.
- Integration & Modernization of Legacy Systems: Low-code platforms offer tools for integration and modernization of legacy systems, making it easier for organizations to update and adapt older applications. S. Bala's 2021 study "Low-Code Development Platforms for Legacy System Modernization" discusses the role of these platforms in modernizing legacy software.
- Collaboration & Citizen Development Ecosystems: Low-code platforms often feature collaborative tools that allow various stakeholders to participate in the development process.

The research paper "Low-Code Development Platforms: The Decentralization of Software Development" by J. Mantyla and C. Lassenius (2021) examines how citizen development ecosystems have evolved around low-code platforms and the challenges they pose.

These studies provide a foundation for exploring how low code platforms are revolutionizing the software industry, offering both benefits and challenges those businesses must consider.

LIMITATIONS OF THE STUDY

The findings of this study are based on one specific low-code platform, which was already integrated into the organization's existing information technology systems, potentially influencing the results. While low-code platforms share similar features, the authors acknowledge that different platforms could produce varying outcomes. This limitation presents an opportunity for future research, where various platforms can be compared for their suitability within different segments of the software industry.

CONCLUSION

Low-code platforms have had a significant global impact on iterative development, enabling faster development cycles, fostering collaboration, enhancing agility, improving user experiences, empowering citizen developers, and facilitating rapid prototyping and testing. Additionally, these platforms provide scalability and integration capabilities, reshaping how applications are developed and making the process more accessible to a broader range of individuals and organizations.

The study concludes by recommending that businesses carefully evaluate low-code platforms to ensure they meet their specific needs. Through rigorous analysis and real-world application, the research demonstrates how low-code platforms offer efficiency, speed, and user-friendliness, heralding a new era of software development.

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Iris Recognition for Forensic Application

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ABSTRACT

Recent developments have now made Iris Recognition possible for postmortem applications. Postmortem Iris Recognition is viable 21 days after death. The most important condition for such Iris Recognition is that the body should be kept at a stable temperature of 6° Celsius. The difficulties that arise in Iris Recognition for postmortem are that there are limited datasets for training, and the postmortem iris images often suffer from dehydration and decay, making it difficult to segment. These difficulties can be reduced using a Generative Adversarial Network (GAN) and the Recognition method. Human- driven binarised Image features (HDBIF) are one of the most efficient techniques for Iris Recognition, which combines human expertise with computational algorithms, making Iris biometrics more robust.

KEYWORDS : *Generative Adversarial Network (GAN), Human-driven Binarised Image features (HDBIF).*

INTRODUCTION

Iris Recognition, typically used to identify individuals during their lifetime, can now be used for postmortem application because of the recent developments in the respective field. Initial studies showed iris recognition was impossible or difficult after death[1]. However, recent studies show that postmortem iris recognition is possible approximately 5-6 hours after death, and sometimes accurate results can be obtained 21 days after death. The iris structure remains well visible if the pupils stay in the ideal position, meaning there is no excessive pupil enlargement or there is a presence of constriction. One of the important parameters in postmortem iris recognition is that the body should be kept in controlled mortuary conditions at a stable temperature of 6° Celsius (42.8°F)[1].

Iris Recognition has emerged as one of the most reliable biometric identification methods due to its unique and stable characteristics. This paper explores advancements in postmortem iris recognition, addressing the critical need for effective identification in forensic applications. Traditional iris recognition relies on high- quality images captured from living subjects; however, postmortem conditions present significant challenges, including degradation of ocular tissues and variations in lighting. We examine innovative techniques and algorithms designed to enhance the accuracy and reliability of iris recognition in these scenarios.

DIFFICULTIES IN DETECTING POST-MORTEM IRIS

Post-mortem iris images often suffer from biological decay processes resulting in excessive cornea drying and wrinkles on the iris texture, partial ocular Hypotony, and additional light reflections associated with these changes[2]. Also, the postmortem iris image contains metal retractors used to open eyelids wide. This makes traditional iris segmentation methods, which were invented by Dr Daugman, inaccurate. Hence cannot be used in forensic applications.

One of the important factors in determining iris recognition effectiveness is segmentation. The major challenge during segmentation is the iris decomposition process, which initiates after death. Dehydration of the eye tissues results in a reduction in their size. The traditional Iris Recognition method cannot handle such processes[1]. The data-driven solution can learn specific deformations in post-mortem samples missing from living irises [2].

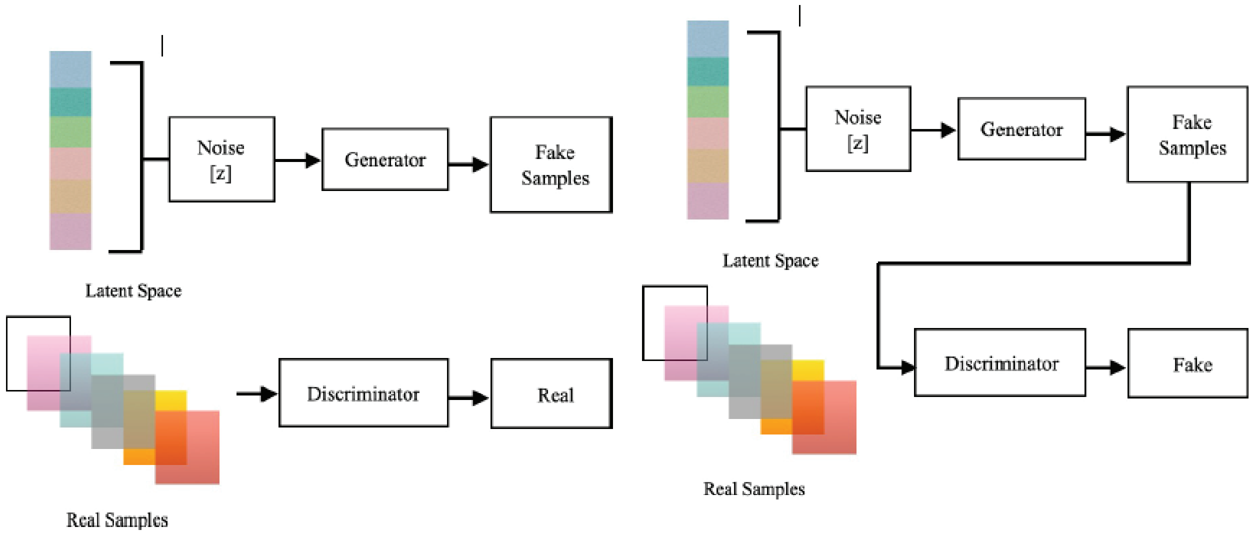

Fig.1 Generator and Discriminator as GAN building blocks

GENERATIVE ADVERSARIAL NETWORKS (GAN) FOR IRIS RECOGNITION

GAN is a machine learning model that generates new data samples similar to a given real data set. GAN consists of two neural networks:

1. Generator: This network creates new data samples. Its objective is to generate data that is a replica of real data.
2. Discriminator: This network evaluates the data produced by the generator and determines whether it is real (from the training dataset) or fake (generated by the generator).

During training, the generator tries to improve its ability to create realistic data, while the discriminator tries to better distinguish real from fake data. This creates a competitive process where both networks are improving continuously. The ultimate goal is for the generator to produce data so convincingly that the discriminator can no longer reliably tell the difference between real and generated data.

Out of the various types of GAN, StyleGAN controls the style and features of generated images. It employs progressive growing. Initially, low-resolution images are used to train both the generator and discriminator. Later, higher-resolution layers are added so that more detailed and complex images can be generated.

Variants of StyleGAN

1. StyleGAN2: It enhances image quality and training stability.
2. StyleGAN3: It handles temporal consistency for animations and improves image fidelity and diversity.

Using StyleGAN, diverse and high- quality synthetic iris images can be generated, resulting in more effective and secure iris recognition technology.

LITERATURE SURVEY

In [1], four independent iris recognition methods, which are VeriEye, IriCore, Merlin and OSIRIS, were employed by Trokielewicz et al. for a comprehensive analysis of postmortem iris recognition. OSIRIS is an open-source solution and the other three are commercially available products. In this paper, OSIRIS and IriCore offered the best performance. The authors observed that the NIR and R images provide better information about post-mortem iris texture than the original VIS samples.

In [2], DCNN semantic segmentation is used. As per the paper, Data-driven solution can learn specific deformations present in post-mortem samples, which are missing from alive Irises. Conventional iris segmentation algorithms can deliver correct matches for samples acquired even 17 days after death when bodies are kept in mortuary condition. SegNet architecture was used for segmentation, which is the most successful DCNN architecture for semantic segmentation. For the encoder stage, the author used the VGG-16 model.

In [3], an Open source-based semantic segmentation model trained with SGDM optimiser was used. The normalisation stage includes a Circular Hough Transform to differentiate inner and outer iris boundaries. Gabor wavelets and post-mortem iris-specific kernels were combined for feature extraction. The author compared the model with OSIRIS implementation to check for its supremacy. The ERR was decreased by almost a third.

In [4], the author proposed a ResNet-50-based iris feature extractor fine-tuned to provide appropriate network embedding. The author detected abnormal regions caused by eye decomposition processes, such as pale lines around the iris or reflected light that is generally present on the dry cornea. The segmentation model was based on mask R-CNN, which detected the iris texture in NIR images using images and labels from a combination of live and post-mortem iris images and then fine-tuned the model to perform instant detection and segmentation using data with newly described wrinkles. The proposed segmentation detected the iris annulus, dryness of the cornea and cornea/ tissue wrinkles. The Recognition was done by implementing VGGFace 2 on the Keras framework, which uses the ResNet-50 as the backbone.

In [5], the author used a conditional StyleGAN-based iris synthesis model. The author generated the largest dataset of post- mortem iris samples that were acquired from more than 350 subjects. Full-resolution iris samples of 640*480 pixels were generated for a given interval (up to 1674 hrs). Comparison scores were calculated by employing an open- source academic solution specially designed for postmortem iris recognition and based on human-driven binarised image features[HDBIF]. This model generated samples including all minute details like post- mortem deformed iris tissues and cornea, metal retractors, eyelid shape because of using such retractors and deformed specular high light caused by drying of the cornea.

SUMMARY OF LITERATURE SURVEY: METHODOLOGY

Open-source solutions based on human- driven binarised image features can be used for Iris Recognition. It involves the extraction and analysis of distinct patterns in the iris, which are then encoded in a binary format. Open source solutions and libraries useful for HDBIF are OpenCV, Dlib, Scikit-Image, Biometric SDKs, Iris Lib and Tensorflow/keras. By using a combination of these libraries for different stages (e.g. OpenCV for preprocessing and Scikit-Image for feature extraction), a robust system for iris recognition can be implemented. StyleGAN can be used to generate synthetic iris images to increase the diversity and volume of the training data[7]. As there is a limited dataset for postmortem iris recognition, GAN thus helps models to generalise better. Also, the discriminator can improve the feature extraction process, making the recognition process more robust. In the last stage, Hamming distance can be used to calculate comparison scores between codes representing non-occluded iris portions. The Hamming distance measures statistical independence between the two iris templates under comparison and gives us a decision on whether to accept or reject the iris template.

Datasets

There are three publicly available datasets, which are as follows:

1. Warsaw BioBase PostMortem iris v2.0
2. Warsaw BioBase PostMortem iris v3.0 and 3. NIJ-2018-DU-BX-0215

These datasets can be used to train the Recognition System.

Table 1: Summary of Literature Survey

AUTHOR	METHOD	CONTRIBUTION
Mateusz Trokielewicz et. al	VeriEye, IriCore, MIRLIN and OSIRIS	OSIRIS and IriCore offered the best performance.
Mateusz Trokielewicz et. al	DCNN semantic segmentation [SegNet Architecture], VGG-16 for encoding	DCNN-based method outperformed conventional iris segmentation algorithm by a wide margin: Intersection over Union (IoU)=83%.
Mateusz Trokielewicz et. al	CNN-based segmentation model trained with SGDM optimiser and hybrid filter bank comprising a combination of Gabor wavelets and postmortem iris-specific kernel.	EER was decreased by almost a third.
Andrey Kuehlkamp et. al.,	Fine-tuned Mask RCNN segmentation and feature extraction was done using VGG Face2 with ResNet-50 backbone.	Detected abnormal region caused by eye decomposition
Rasel Ahmed Bhuiyan et al.,	HDBIF with StyleGAN	1. Enhancement of the existing datasets. 2. Generated variants of the same forensic sample to expose the experts to never-before-seen deformations of iris tissues.

SUMMARY

In this research, we reviewed various Postmortem Iris Recognition methods. One of these methods included using DCNN for segmentation while VGG-16 model for encoding. Also, in one paper, four independent Iris Recognition methods were used and compared to which OSIRIS and Iricore offered the best performance. In another paper, a based semantic segmentation model trained with SGDM optimiser was used, which reduced ERR by almost a third. One of the papers used a ResNet-50-based iris feature extractor. The segmentation model was based on mask R- CNN. Their method detected abnormal regions caused by eye decomposition like pale lines that curve around the iris and light reflections. A new approach was seen in one of the papers, which used a conditional StyleGAN-based iris synthesis model along with an iris recognition method. Comparing all these methods, we finalised a methodology that included the Human-driven Binarised Image Feature Recognition technique. Also, StyleGAN will be used before segmentation to reduce the challenges that usually occur during segmenting postmortem iris images. This study aims to contribute to biometrics and improve identification processes in postmortem investigation by bridging the gap between theoretical research and practical forensic applications. We hope this system will become one of the most efficient and robust Iris Recognition Systems.

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A Comprehensive Review of Sarcasm Detection Techniques in Natural Language Processing

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ABSTRACT

Sarcasm is a prevalent form of communication characterized by a discrepancy between literal meaning and intended meaning. Detecting sarcasm presents a unique challenge, especially in the realm of Natural Language Processing (NLP) and speech analysis, due to the nuanced, context-dependent, and often ambiguous nature of sarcastic expressions. Sarcasm detection is unfolding area under sentiment analysis and text mining. It is preliminary need of all conversation Agent to detect sarcasm and create response based on natural language understanding. There are many developments since sentiment analysis is being attempted by many researchers. This paper addresses many of the attempts made for identification of Sarcasm detection for text and speech i.e., rule-based approach, Machine learning Approach and hybrid approach. Paper ends with various conclusions and areas where researchers can contribute in this area.

KEYWORDS *: Natural Language Processing (NLP), Sarcasm detection, Support Vector Machine (SVM), Whisper, Speech recognition, Text classification, Machine learning, Prosody.*

INTRODUCTION

Sarcasm is an advanced form of verbal communication often used to convey contempt, mockery, or humour. The speaker's intended meaning is often the opposite of what is said, which makes detecting sarcasm particularly challenging for both humans and machines. With the rapid growth of social media and digital communication, sarcasm detection has become critical for several NLP applications, including sentiment analysis, dialogue systems, and content moderation.[1]

Some of the examples are:

- This product is good to give 5 stars! LoL!
- Staying up late up to 2.30 is really great thing!
- It's so early to have medicines of morning at 7pm, isn't it?

Identification of presence of sarcasm in any text or speech (unstructured) data, which is inclusive of instructions, blogging sites, views about person situation, or reviews about product or services, is known as sarcasm detection [3]. Sarcasm detection is unfolding area under sentiment analysis and text mining. It is preliminary need of all conversation Agent to detect sarcasm and create response based on natural language understanding. [2]. There are many challenges available in detecting sarcasm. These challenges increase complexity to detect sarcasm present in available piece of data. Following are the prominent challenges.

i. Wide Range of Emotions: Wide range of emotions are there like happiness, angry, sad, fear, disgust etc. There is fine line between irony, sarcasm and satire, these real time difficulties make sarcasm detection even more complex.

ii. Multilingualism: There are 7K languages spoken by people around the world. Such huge multilingualism makes analysis more difficult. Creation of grammar rules for every language makes it complex process and hence make this detection process restricted to English Language. As many people uses English and much data is available to train the model.

iii. Implicit knowledge: how one methodology applied to other domain can be applied to detecting sarcasm is implicit knowledge.

iv. Domain Specification: Context of sentence may differ with domain. Statement which stands sarcastic for sports domain may not be true for movie reviews. So, it is necessary to select domain on which you will apply technique and train your model.

v. Nature of Text: As already mentioned above, enormous data is flooding over internet. Most of that data id unstructured and available in variety. If I consider only textual data, there are short forms used by individual user, use of slang words, missing data values, way of writing, irrelevant punctuation marks, etc are the major challenges while detecting sarcasm. Most of these challenges are taken care during pre-processing of data to get accurate results.

According to other studies, multiple brain regions other than the right sagittal stratum are involved in comprehending sarcasm. French researchers group gave cynical and literal speech to 21 healthy adults.

The individuals discussed whether each picture was sarcastic or literal while having their brain activity analysed using functional magnetic resonance imaging, a kind of MRI. The activation in many brain areas, including activation of the left and right-side inferior frontal gyrus, was linked to recognising sarcasm, according to the researchers which is shown in the Fig 1. Sarcasm is understood by regions on the left side of the brain involved in reading language in general, as well as areas on the right side of the brain involved in comprehending other people's emotional states and knowing when something is humorous.

In speech, sarcasm is often signaled through prosodic cues such as intonation, pitch variation, emphasis, and pauses, which are difficult for traditional text-based models to capture. Existing systems for sarcasm detection in speech either rely solely on acoustic features or are limited to detecting sarcasm in text.

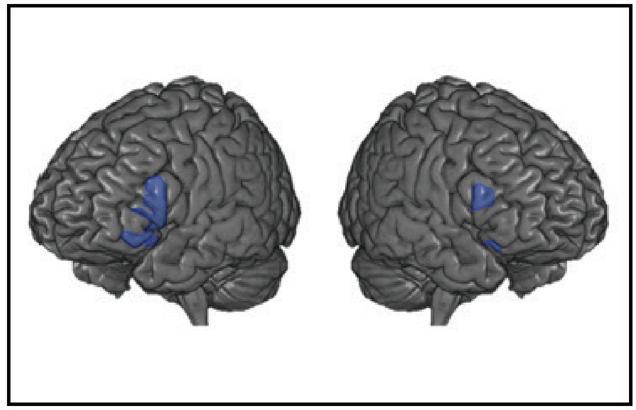

Fig. 1. Recognition of sarcasm by the brain system

Does chatbots are able to detect it and answer it as human do? So, for experiment some screen shots are given below for famous chatbots Natasha and Julie.

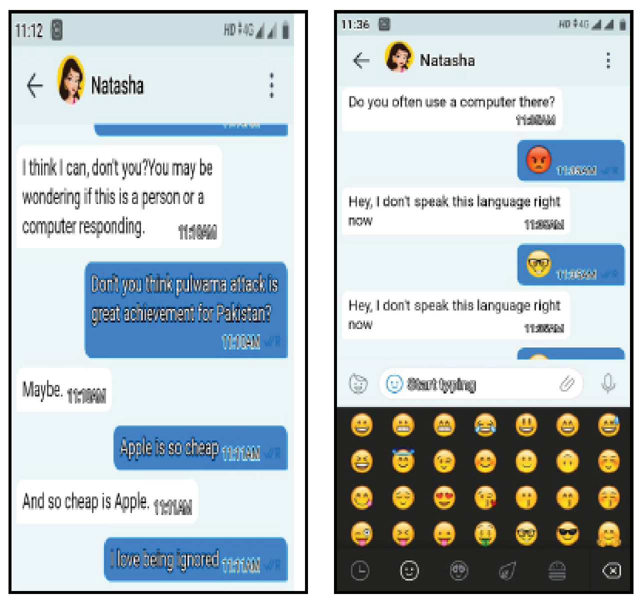

Fig. 2. Screen shots of chat with Natasha Bot

With this, it is clear that, Chatbots are not yet so intelligent that can handle critical sentiment like sarcasm. So, this can be a motivation for doing research on various sarcasm detection techniques which can solve such issues and make conversational agent able to understand natural languages.

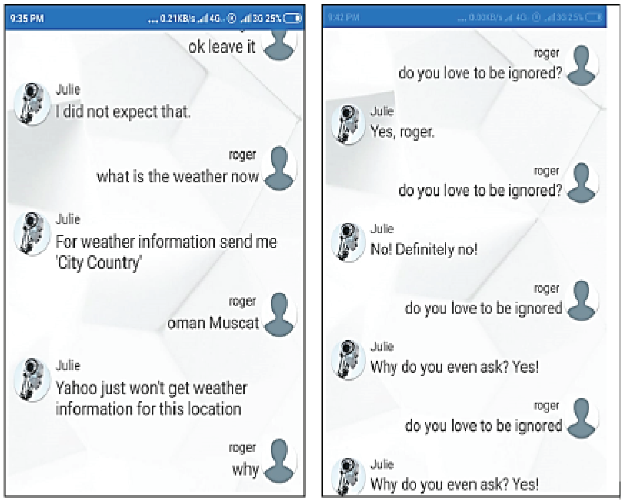

Fig. 3. Screen shots of chat with Julie Bot

LITERATURE REVIEW

The goal of many academics was to accurately represent the sentiment found in the data. Many tried to identify irony in evaluations or data that was provided. According to thorough study, typical machine learning algorithms, processes, rule-based approaches, and deep learning techniques are utilized to recognize sarcasm. A hybrid technique, often known as a combination of syntactic and semantic approaches, is utilized to get superior results. The following is a description of these endeavours, including the approach and concept:

The emphasis of a lot of research on sarcasm detection is emotion detection; implicit and explicit techniques, including rule-based, classical learning models, and even deep learning models, are examined. This chapter covers the literature that has been researched, all of the research approaches that have been employed, and the findings that have been attained.[6]

Rule Based Approach

Occurrence of numbers initially considered as mistake or error in identifying sarcasm in given piece of text[10]. They checked the possible causes for problem. They further investigated current approaches used such as Deep learning, Rule based and machine learning in numerical portions of data. They came out with observation that their Deep Learning approach performs excellent over previous functions for detecting sarcasm and Rule based and ML methodologies on a Tweeter dataset. They got a 0.93 as the F1-score. This gives attention on having numbers will improve sarcasm detection efficiency. For this purpose, authors applied various approaches. They applied two rule-based approaches. First Approach is exact matching of noun phrase, In this, they created two repositories, as sarcastic and non-sarcastic which uses trained dataset. In every repository item of format like:(Index No., List of Noun Phrase, Number unit mean, Number Unit Std Dev, Number Unit). The repositories were built as below. Here most datasets are labelled as sarcastic or non-sarcastic.

- Step-1: Parser Extracts noun phrases in the tweeter dataset
- Step-2: Selection of number unit which follow CD POS tag.

  Numbers used for date, minutes, seconds, years, etc.
- Step-3: Each entry will be added to created repository with label.

Second Approach is to get cosine matching of noun phrase, First approach was constrained towards the phrase matching. As a result, by comparing the words in the test tweet and the repository using cosine similarity, this problem is solved.

This method also resulted in the creation of two repositories, one for sarcastic material and the other for non-sarcastic material, as follows:

- Step-1: Vector representation of noun phrase is done.
- Step-2: Summation of 200 embeddings present in noun phrase and then dividing by its count.
- Step-3:Repositories are created with (Tweet Index No., Vector representation of Noun phrase list, Mean of Number unit, Std Dev of Number unit, Number Unit).

Machine learning approach

In this approach, authors used K-NN, SVM and random Forest classifiers for this they extracted various features like sentiments, emoticons, punctuation, number units, embedding of tweets. This paper gave the different approaches to detect sarcasm that appears due to the appearance numerical portions present in the tweets. Special sarcastic case is having numerical sarcasm where some incongruity is between context of text and numbers. They presented Rule based, Deep Learning and Machine learning approaches for detection of numerical sarcasm and obtained extraordinary score of 0.93 from CNN-FF model. Here they tried to build approach to detect numeric sarcasm. Their work improved performance compared to previous work by different authors. In another approach authors used context between dialogues of two participants[12]. Traditional scholars have split the problem of comprehending and distinguishing sarcasm into two parts: an examination of a sarcastic appearance in text and the ironic condition that surrounds it, and an analysis of a sarcastic appearance in text and the ironic condition that surrounds it. The problem with such technique is that it is quite limited, and it is unable to exploit the context between two critical actors, namely, humans and machines. The listener and the speaker. It weakens the necessary context needed to understand a sarcastic exclamation.

This study proposes a distinctive approach towards getting sarcasm using existing knowledge structure between the speaker and listener, which creates the basis of the context shared by both agents. This helps to capture difference between speaker and audience over social media like tweeter.[4][5] Model is applied on this collected data to get efficient results, and which show light on context or subjectivity of data. In this researcher worked on Lexical, Pragmatic and Contextual features to find common knowledge between speaker and listener. In lexical approach, they used unigrams and bigrams to form grouping of words. Brown cluster unigrams are formed, and part of speech are used in lexical approach. In Pragmatic approach, focus was given on Capital letters, repeated characters and emojis and in Contextual approach, they used Belief contradiction method to get context. They achieved accuracy 71.2%, 75.8% and 78 % respectively for proposed approaches. With the results, it is found that when sarcasm is identified with contextual approach it gives good accuracy. Some researchers pointed out that context incongruity in sarcasm detection plays very important role. The authors reviewed past work which were based on hashtag detection, natural language Processing rule-based sarcasm detection, unigram and pragmatic features, positive emphasized verb followed by contradictory situation, etc. Here they mentioned how previous work is not sufficient to detect sarcasm correctly and after addition of context incongruity, they got exceptional results and improvements in past result. Proposed model work for two types of incongruity implicit and explicit. Model can handle short tweets to long discussion forums. This model performed better compared to previous work like Rilof model, this model used context incongruity theory, which used linguistic approaches. For detection of sarcasm authors used four types of features set namely implicit and explicit incongruity, lexical and pragmatic features. For finding explicit incongruity author used following four ways. First, they found out how many times positive word followed by negative and negative word or sentences followed by positive sentences. Second, they tracked longest subsequence of positive or negative words. Third count of negative and positive words. Lastly but most important is getting polarity of words by using lexical approach. Polarity helps to get intensity of positive and negative words which helps to predict sarcasm accurately. For implicit detection, extraction of negative nouns with positive verbs are done. Some phrases, which were ignored in previous research, is considered in this work. Some rules are employed to check this. Here proposed system by authors gave better results than Rilof and Green Wood. The author concluded with the results which is 77% precision. Authors also provide some condition where they have not tested system such as incongruity which is present outside of text. They have considered number incongruity while dealing with context incongruity. Consideration of subjective context is underline thing while detecting sarcasm as statement varies with domain and may or may not be true in other case. If any statement is uttered with ultimate polarity, then detection of sarcasm becomes very complex. Inter sentential incongruity is proposed future work for sarcasm detection.

Hybrid Approach

Recent research work used hybrid approach for detecting sentiment and context of data. Authors used combinational approach which incorporates rule-based, machine learning and deep learning approaches together. Transformer-based approach to detect sarcasm is mentioned[9]. They said, Figurative language (FL) appears everywhere in every social media platforms & chat, this increased challenges to identify exact sentiment behind said data. All attempt for Identification of such symbolic language in short and crisp data still an unsettled issue. In field of NLP, this is most metaphorical content. Mostly data with figurative language possess irony, sarcasm, or metaphor. In mentioned study authors employed deep learning methodology to solve this issue of figurative language. In this approach, they put detailed study of neural network architecture, which was built on transformer learning based network methodology. This is further improvised with the application and design of a RCNN. Here they kept data pre-processing minimum. Performance of this architecture was tested with four distinct and benchmarked datasets available. This methodology outperforms with four datasets. The main notion behind their mentioned RCNN-RoBERTa methodology is based below observation: Pretrained networks are always useful for many posterior tasks. Output of these networks can be further improvised by other networks in use. They created an end-to-end approach using pretrained RoBERTa weights coupled with RCNN based on this notion. This aids in the collecting of conceptual data. The RoBERTa network design is used to effectively verify words on a combined space. To improve RoBERTa's performance and find FL in text, the dependencies in RoBERTa's pre-trained model must be obtained. This task efficiently handled using RNN layer. This is used to get worldly relatable information.

Sarcasm as implicit sentiment and strategy to detect it.[11]. Sarcasm portrays the contrast sentence what exactly person wants to convey with motive of insult but generally choose humorous way of expression. Most of social media posts are best example of sarcasm presence mostly contains sarcastic shades. Most studies just focused on detecting sarcasm, but this article gives different forms of sarcasm with detection of sarcasm. Author says motivation to identify varieties of sarcasm is to identify extent of hurt exact meaning behind sarcastic sentences. Authors improved previous work by separating sarcasm into different categories. Major application of their work is to find correct state of emotion of person dependent on the extent of harshness used. With the type of sarcasm, he/she displayed can provide focus on emotional behaviour of person. Optimal feature selection played key role in classifying tweet into different sarcasm types. First based on ensembled features tweets are classified as sarcastic and non-sarcastic tweets. After this first level of classification, done tweets are then classified into further types by applying multi rule-based approach. With primary efforts, they are classified into four main categories namely deadpan, raging, rude and polite. Efficiency and performance of their approach has been analysed experimentally; mood change of person for each type of sarcasm is modelled. In this system authors used almost twenty distinct features to identify sarcasm like verb and noun count, intensity of positive words, intensity of negative words, unigram, trigram, bigram, skip gram, sentiment expressed through emojis, score after sentiment count, punctuators, interjections, exclamations, uppercase, repeat words count, question mark, polarity flip, parts of speech tagging positive word and negative word frequency. Author defined polite sarcasm where sentence appear more positive, rude sarcasm is when people express negative inclination in their words, more negative form of rude sarcasm is raging. Deadpan is the most implicit form of sarcasm where it's difficult to judge sentence as positive or negative where ensembled features play their role. Here fuzzy sets are used to form clusters of sarcasm to classify them further. Accuracy for detection of sarcasm is about 92.7% & proposed multi-rule approach for sarcastic types of detection gives an accuracy of 95.98%, 96.20%, 99.79%, and 86.61% for raging, rude, polite, and deadpan types of sarcasm, respectively.

Various studies performed on emotion detection and their detailed analysis is shown with strength and limitations[8]. This is one of most rigorous and well-structured work for explicit and implicit methods for emotion recognition present in given text. Here authors represented different approaches in vivid literatures with their advantages and disadvantages. This study shown hybrid methodology is proven best with word distribution and set benchmark. This work gives importance on performing basic NLP tasks such as part of speech tagging, parsing techniques which plays outstanding role in getting more accurate results.

To detect explicit emotion keyword-based approaches are used but they can't not give satisfying outcomes to detect implicit emotions present in given text and it is due to scarcity of linguistic information. To detect implicit emotion most followed approach is rule based approach and classical machine learning approach too. Nowadays deep learning approach is used for it. However, it is observed that hybrid approach is proven best because it gives advantages inherited from all approaches. Rule based approaches can determine only those implicit emotions that are already defined in their rules set. Classical learning can train classifier which is already trained on similar types of emotions. This do not require large amount of training dataset hence learning sometimes gives unexpected outcomes. In addition, accuracy remained questionable. Amongst all deep learning approach gives outstanding performance compared to other approaches when provided with large no of datasets. Hybrid approach is best one to choose as it can inherit advantages of all rules and models to detect implicit emotions present in given text. Sentiment analysis or more specifically identifying exact emotion like sarcasm is need of time as nowadays most of businesses are using conversational agents like chatbots. Alexander et al. [7]discussed on effect of intelligent chatbots on user compliance. Here in this article, they discussed about how human chat services are replaced by conversational agents or chatbots, which uses natural language processing along with artificial intelligence, which can give accurate sentiment detection, which helps conversational agents/chatbots to reply like human. Focus is on social presence that interface the effect of anthropomorphic design prompt over compliance of users. Here authors elaborated about how chatbots or agents failed at some time to detect correct emotion and created scepticism and resistance for technology. Study is based on anthropomorphic design prompts and various ways to increase its sustainability. This part of research needs prior knowledge of customer service sector and conversational agents.

EVALUATION METRICS AND DATASETS

Various evaluation parameters Standard datasets for sarcasm detection include:

- Twitter Sarcasm Corpus: an extensively used dataset for identifying sarcasm in tweets. Generally, tweets within this corpus are classified as either non-sarcastic or sarcastic. Sarcasmic tweets can be easily recognized by using certain hashtags like "#sarcasm," "#irony," or by having scholars manually annotate them. Thousands of tweets make up the majority of the corpus, while the quantity can vary based on the source or version.
- Reddit Sarcasm Dataset: Offers a more conversational and contextual variety of sarcasm. The dataset is taken from Reddit comments, which are arranged into many communities (subreddits) cantered around particular subjects. This helps with sarcasm detection jobs because these conversations frequently contain more background and context than tweets.
- SARC (Sarcasm Corpus): a bigger dataset containing Reddit news and discussions. Millions of comments make up the "SARC 2.0 Main" edition of the massive dataset SARC, which offers an abundance of data for sarcasm detection model training. The dataset is offered in two versions: balanced and unbalanced. The unbalanced version captures the sarcasm that naturally occurs in Reddit comments, while the balanced version has an equal mix of sarcastic and non-sarcastic comments.

Evaluation will be done through the metrics: Accuracy, Precision, Recall, F1-score.

CONCLUSION

This paper provides a thorough summary of the numerous studies that have been conducted in the areas of sentiment analysis and sarcasm detection. The primary focus of this chapter is to outline three different research approaches for sarcasm detection. At first, sarcasm was identified using a rule-based method. creating rules and determining where they appear in the provided data. This is a sophisticated method of sarcasm detection, and its precision is based on the individual's level of linguistic and sarcastic expertise. The next strategy involves classifying provided data as sardonic or non-sarcastic using machine learning methods. This method was highly well-liked, and numerous researchers employed it in their investigations. The most common usage of machine learning algorithms for sarcasm detection is logical regression and support vector machines (SVM). The third and most efficient method for sarcasm detection is the hybrid approach, which combines the application of deep learning or machine learning algorithms with the development of specific criteria. More accurate and satisfying outcomes are obtained with this strategy, as mentioned in Table-I. Throughout the entire literature analysis, it becomes clear that the key to obtaining correct results is feature extraction.

Table 1. Comparison Analysis of Various Approaches for Sarcasm Detection

Characteristics	Ruled Based Approach	Machine Learning Approach	Hybrid Approach
Data Req.	Small	Large	Very large
Accurate results	Good	Better	Best
Time	Short	Long	Long
Debugging	Very Easy	Easy	Difficult

Table 1 depict that data requirement for rule-based approach is small but in case of machine learning approach it is large but for hybrid approach is very high. In terms of accuracy, hybrid approach works best. In terms of time requirement, hybrid approach takes more time and for identification of errors/bug this approach requires more efforts. So, in general depending upon data and requirement one can apply any approach but hybrid approach works perfectly in most of the scenarios. Though new pretrained models are available for training the datasets, hybrid model works economically in all scenarios. Apart from this any language input (Marathi, Hindi, and their dialects) can also to be taken into account. This work can be applied to find out sarcasm present in Codemix language, which is most popular language of youth. Further research can also be carried out in autodetection of sarcasm present in images like those that memes can be called as image discourse. So, there is vast scope of research work in this field of sarcasm detection.

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AI-Driven Mental Health Support using Deep Learning Approach

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ABSTRACT

The prevalence of mental health issues is a growing concern, with approximately 1 in 4 people struggled with mental health issues at some time in their lives. While mental health support is available, many individuals face barriers to accessing traditional forms of treatment, such as long wait times, stigma, and financial constraints. As a result, there is a need for innovative solutions that can provide effective and accessible support to individuals experiencing mental health challenges. The research work proposes the development of an automated assistance system for mental health that leverages natural language processing and machine learning techniques to provide personalized and responsive support to individuals in need. The system will be designed to be interactive and conversational, using chatbot technology to engage with users in a natural and empathetic manner. To ensure the effectiveness and reliability of the system, this research work will adopt a user-cantered approach that involves extensive user testing and feedback. This approach will allow the system to be tailored to the needs and preferences of different users, including factors such as cultural background, language proficiency, and individual coping styles. The ultimate goal of this work is to create an automated assistance system that can serve as a reliable and accessible tool for individuals experiencing mental health issues. The system has the potential to help users better manage their mental health, access support when they need it, and improve their overall quality of life. Additionally, the system could serve as a complement to traditional mental health treatment, providing ongoing support and guidance to individuals even after they have completed formal treatment programs.

KEYWORDS *: Intent, Patterns, Response, NLP, Chatbot.*

INTRODUCTION

Automated Assistance for Mental Health' concept helps us to get primary aid for the mental illness. Mental illness is a type of illness that an individual hesitates to have discussion upon. Therefore, having a chatbot that deals with mental illness opens up an individual to have healthy discussion about it and get suggestions to get out of that mental state.

The problem statement for this research work is the lack of accessibility and convenience in mental health care. Mental health issues are a growing problem worldwide, with approximately one in four people being affected by mental or neurological disorders at some point in their lives. However, many individuals do not have access to the care they need due to various barriers such as stigma, cost, and lack of resources.

The old approaches of mental health care, such as in-person treatment or counselling, can be inconvenient and inaccessible for many individuals. This is particularly true for those who live in country or distant areas, who may not have access to mental health professionals in their local area. The cost of mental health care can be excessive for some individuals, especially those without insurance coverage.

To address these issues, this research work aims to design a chatbot for mental health. Computer programs called chatbots are made to mimic human-user dialogue. They are programmable to offer a range of functions, from customer support to mental health counselling. By developing a chatbot for mental health, we aim to provide a convenient and accessible way for individuals to access mental health resources and support.

The chatbot will be designed to provide guidance on managing stress and anxiety, access helpful resources, and provide encouragement and motivation. The chatbot will be developed using Python for backend, HTML CSS for frontend, and Flask for integration. In order to enhance the chatbot's comprehension and responsiveness to user input, natural language processing (NLP) methods may be included using Python, a popular programming language for many recent applications. The chatbot's UI will be made visually beautiful and user-friendly using HTML and CSS, and its frontend and backend will be integrated using Flask.

The definition and motivation behind the development of a chatbot for mental health involves using technology to provide accessible and convenient mental health support to individuals in need. A chatbot is a computer program that can simulate human conversation and respond to user input. In the context of mental health, a chatbot can provide support and guidance for managing stress and anxiety, accessing resources, and offering encouragement and motivation.[1]

The goal of creating a chatbot for mental health is to overcome the obstacles that keep a lot of people from getting the proper mental health care. These barriers may include stigma, cost, and lack of resources or accessibility. By providing a chatbot that can be accessed anytime, anywhere, individuals can receive support and guidance on their mental health journey without the need to travel or wait for an appointment with a mental health professional. This can be particularly beneficial for those living in remote or rural areas or for those who are hesitant to seek traditional mental health care.[5].

Furthermore, a chatbot for mental health can help to reduce the stigma associated with mental health issues by providing a confidential and non-judgmental space for individuals to seek support. The use of a chatbot can also be cost-effective compared to traditional mental health care, making mental health support more affordable for people who might not be able to afford regular medical care.[2]

All things considered, the creation of a chatbot specifically designed for mental health purposes is a viable way to meet the increasing need for easily accessible mental health services. By leveraging technology, we can reach a wider audience and provide support to those who may not have had access to it before.

Need of Mental Health Assistance

The proposed research work, an automated assistance system for mental health, is aimed at addressing the growing need for accessible and effective mental health support. [3]. There are several reasons why such a research work is necessary:

1. Prevalence of mental health issues: As stated before, 1 in 4 people will at some time in their life encounter mental health issues, and this percentage is rising. In addition to making mental health issues worse, the COVID-19 epidemic has brought attention to the need of having easy access to quality treatment.
2. Barriers to traditional mental health support: Many patients face barriers to receiving routine mental health services, including long wait times, stigma, and financial constraints. An automated assistance system for mental health can provide a more accessible and cost-effective solution to support these individuals.
3. Complement to traditional mental health treatment: While traditional forms of mental health treatment, such as therapy and counselling, are effective, they may not always provide ongoing support. An automated assistance system can provide users with ongoing support and guidance, complementing traditional treatment and promoting long-term mental health and well-being.
4. Personalized support: The proposed system

leverages natural language processing and machine learning techniques to provide personalized support to users. This level of personalization can help users feel heard and understood, promoting engagement and ultimately improving outcomes.

Overall, an automated assistance system for mental health can help to address the growing need for accessible and effective mental health support. It has the potential to provide users with ongoing support, complement traditional mental health treatment, and improve overall mental health and well-being.[6]

PROPOSED METHODOLOGY

Our proposed solution consists of creating a machine learning model and building a user interface which will process the user input and after analyzing returns proper assistance to the user accordingly. For this, we tried to solve the problem in 2 ways, one could be Retrieval based model and another is Generative based model. Methodologies are explained below in detail.

Retrieval based model

In this methodology, we discussed about Retrieval based model. This type of chatbot generally uses pre-defined responses to generate an appropriate response to a user's query. It works by retrieving the most appropriate response from a pre-defined set of responses based on the user's query. Retrieval-based models are generally simpler and less resource-intensive than other types of chatbots, such as generative models, and are particularly useful in scenarios where there is a limited range of user queries, such as customer service or technical support, they can be very effective at providing quick and accurate responses to user queries.[4]

Steps to create this model is discussed below.

- Collect data: Collect a dataset of conversations between humans on the topic of interest. This data will be used to train the model.
- Pre-process the data: Clean and pre-process the data to remove any unnecessary information, such as timestamps and usernames. Convert the text into a format that can be used by the model, such as tokenization, lemmatization, or stemming.
- Define intents: Define the intents that the chatbot will handle, such as "greetings," "information request," "complaint," etc. Group similar user queries under the same intent.

```
"tag": "anxious",
{"patterns: I feel so anxious,
  I am anxious because of..}
{"responses": "Don't be too hard with yourself",
"What is the reason behind this"}},
```

Fig 1. Example of Intent

- Create training data: Create training data by associating user queries with their corresponding responses. This will be used to train the model.
- Defining model Architecture: Our proposed model has 4 layers.

A. Embedding Layer: This layer takes in the vocab_ size (the corpus's unique word count), embedding _dim (the embedding space's dimensionality), It creates a dense embedding layer, where each word in the input sequence is mapped to a dense vector in the embedding space.

B. GlobalAveragePooling1D layer: This layer calculates the average value for each feature across the entire sequence of embedding generated by the Embedding layer. This reduces the dimensionality of the output to a fixed size, which is important when passing the output to the next layer.

C. Dense layer: This is a fully connected layer with 16 units and the Rectified Linear Unit (ReLU) activation function.

D. Dense layer with softmax activation: This is the output layer of the model. It has num classes units, where each unit represents a possible class that the input can be classified into. The softmax activation function is used to convert the output values into probabilities.

- Training and Testing Model: Training and testing is done with separate dataset which is evaluated by human. Accuracy of such model is generally done by humans as their feedback can be valuable in improving the accuracy of proposed model.
- Implementing chat function: This feature will make

it easier to interact with the real user. Every time the chatbot receives a new message from a user, it calculates the degree of similarity between the freshly entered text sequence and the training data. Based on the confidence scores acquired for each category, the user message is assigned to the intent with the highest confidence score.

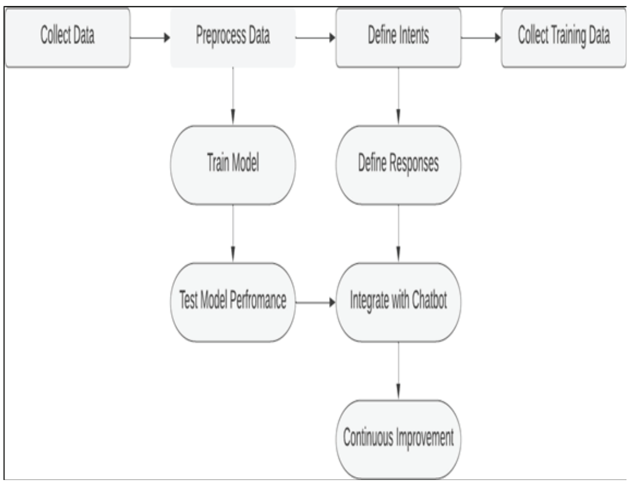

Fig. 2. Workflow Diagram

IMPLEMENTATION

Implementation included creating machine learning model and user interface where real user can interact with the system. A chat function is also implemented using python so that user can run the machine learning model in real quick time.

Collecting Data & Creating Intents

1. Collecting correct data about mental healthiness is very crucial and the difficult task as people are not free to talk about their problems. For this research work, we collected data from different websites, articles and online forums for creating intents.
2. For creating intents, we have identified important keywords/concerns regarding mental health domains to create tags.
3. After which, create a list of patterns and their appropriate responses for each tag. Compiling all this as one JSON format file.
4. This JSON file will further be used as dataset for training our automated assistance for mental health system.

Preprocessing datasets

```python
words=[]
classes = []
documents = []
ignore_words = ['?', '!']
data_file = open('intents.json').read()
intents = json.loads(data_file)
for intent in intents['intents']:
    for pattern in intent['patterns']:
        w = nltk.word_tokenize(pattern)
        words.extend(w)
        documents.append((w, intent['tag']))
        if intent['tag'] not in classes:
            classes.append(intent['tag'])
words = [lemmatizer.lemmatize(w.lower()) for w in words if w not in ignore_words]
words = sorted(list(set(words)))
classes = sorted(list(set(classes)))
print (len(documents), "documents")
print (len(classes), "classes", classes)
print (len(words), "unique lemmatized words", words)
pickle.dump(words,open('texts.pkl','wb'))
pickle.dump(classes,open('labels.pkl','wb'))
training = []
output_empty = [0] * len(classes)
```

Fig. 3. Preprocessing Dataset

- Initialize empty lists for words, classes, and documents, and set ignore words to a list of question marks and exclamation marks.
- Loop through each intent in the intents dictionary and extract the patterns and tag information. Tokenize each pattern into individual words using the NLTK library, and append each word-tag pair as a tuple to the documents list. If the tag for the intent is not already in the classes list, append it.
- Lemmatize each word in the words list to reduce them to their base form, convert them to lowercase, and remove any words in the ignore_words list.
- Sort the resulting list of words alphabetically and remove any duplicates. Sort the classes list alphabetically as well.

Model Architecture

- Create a Sequential model object using model = Sequential ().
- Add an Embedding layer to the model with model. add(Embedding(vocab_size, embedding_dim, input_length=max_len)). This layer learns to map each word in the input sequence to a dense vector representation of embedding_dim dimensions.
- Add a GlobalAveragePooling1D layer to the model

with model.add(GlobalAveragePooling1D()). This layer averages the embeddings of all words in the input sequence, resulting in a fixed-length vector representation of the sequence.

```
[ ] model = Sequential()
    model.add(Embedding(vocab_size, embedding_dim, input_length=max_len))
    model.add(GlobalAveragePooling1D())
    model.add(Dense(16, activation='relu'))
    model.add(Dense(16, activation='relu'))
    model.add(Dense(num_classes, activation='softmax'))

    model.compile(loss='sparse_categorical_crossentropy',
                  optimizer='adam', metrics=['accuracy'])

    model.summary()
```

Fig. 4. Model Architecture

- Add 2 Dense layer with 16 neurons and ReLU activation function to the model with model. add(Dense(16, activation='relu')).
- Add a final Dense layer with num_classes neurons and softmax activation function.
- Compile the model with model.compile.
- Use model.summary() to print an overview of the model architecture.

Chat Function

```
def clean_up_sentence(sentence):
    # tokenize the pattern - split words into array
    sentence_words = nltk.word_tokenize(sentence)
    # stem each word - create short form for word
    sentence_words = [lemmatizer.lemmatize(word.lower()) for word in sentence_words]
    return sentence_words
```

Fig. 5. Clean_up Function

- This function tokenizes the query given by the user into array of words after which stemming is done on each word to reduce the word into its root form.
- This function returns bag of words array: 0 or 1 for each word in the bag that exists in the sentence.

```
def bow(sentence, words, show_details=True):
    # tokenize the pattern
    sentence_words = clean_up_sentence(sentence)
    # bag of words - matrix of N words, vocabulary matrix
    bag = [0]*len(words)
    for s in sentence_words:
        for i,w in enumerate(words):
            if w == s:
                # assign 1 if current word is in the vocabulary position
                bag[i] = 1
                if show_details:
                    print ("found in bag: %s" % w)
    return(np.array(bag))
```

Fig. 6. Bow function

- This function takes in a sentence (user input) and a list of words as input arguments.
- The clean_up_sentence() function is called with the sentence as an argument to tokenize the sentence by breaking it down into individual words and removing any unwanted characters or words.
- For each word in the sentence_words list, the function loops through the words list and checks if the word is present in it. If the word is found in the words list, the corresponding index in the bag list is set to 1, indicating that the word is present in the sentence.
- The function returns a numpy array of the bag list, which represents the bag of words representation of the input sentence.

```
def predict_class(sentence, model):
    # filter out predictions below a threshold
    p = bow(sentence, words,show_details=False)
    res = model.predict(np.array([p]))[0]
    ERROR_THRESHOLD = 0.25
    results = [[i,r] for i,r in enumerate(res) if r>ERROR_THRESHOLD]
    # sort by strength of probability
    results.sort(key=lambda x: x[1], reverse=True)
    return_list = []
    for r in results:
        return_list.append({"intent": classes[r[0]], "probability": str(r[1])})
    return return_list
```

Fig. 7. Predict class function

- The function first applies the bow function on the input sentence to convert it into a bag- of-words representation. The bag-of-words representation of the sentence is then fed into the trained model to obtain the predicted probabilities for all intents.

- A threshold value is set to filter out predictions that have probabilities below the threshold. The predicted probabilities are then sorted in descending order.
- For each predicted intent with probability above the threshold, a dictionary containing the intent and its probability is appended to the return list.
- The final output is a list of predicted intents and their probabilities, sorted in descending order of probability.

```
def getResponse(ints, intents_json):
    tag = ints[0]['intent']
    list_of_intents = intents_json['intents']
    for i in list_of_intents:
        if(i['tag']== tag):
            result = random.choice(i['responses'])
            break
    return result
```

Fig. 8. Get Response function

- The function takes in two arguments - ints, which is a list of predicted intents returned by the predict_class function, and intents_json, which is a JSON object containing all the intents and their associated data.
- The tag variable is assigned the value of the first predicted intent from the ints list.
- The list_of_intents variable is assigned the value of the intents array from the intents_json object.
- The function then loops through the list_of_intents array to find the intent that matches the predicted tag.
- Once the matching intent is found, the function selects a random response from the responses array of that intent.
- The selected response is then returned by the function as the output.

RESULTS

After implementing the proposed solution, we have obtained following results. After collecting data from different sources, intents are creating by choosing various mental health concerns and each are represented by tags. Whole tags are saved in JSON file. This particular file contains tags, patterns and responses which will be furthered served as dataset for training the model.

Model Summary

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 embedding (Embedding)       (None, 20, 16)            16000

 global_average_pooling1d (G  (None, 16)               0
 lobalAveragePooling1D)

 dense (Dense)               (None, 16)                272

 dense_1 (Dense)             (None, 16)                272

 dense_2 (Dense)             (None, 80)                1360

=================================================================
Total params: 17,904
Trainable params: 17,904
Non-trainable params: 0
```

Fig. 9. Model Summary

- The model is a linear stack of layers since it is a sequential model.
- The first layer is an Embedding layer, which takes in a vocabulary size of 1000, an embedding dimension of 16, and an input length of 20. This layer is responsible for converting input text into dense vectors of fixed size.
- The second layer is a GlobalAveragePooling1D layer, which averages the embedding across the sequence dimension and outputs a fixed-length vector for each input example.
- The third and fourth layers are Dense layers, each with 16 units and a ReLU activation function.
- Additional Dense layer with 80 units and a softmax activation function makes up the fifth and final

layer. It generates a probability distribution across the 80 potential classes.

- The model has a total of 17,904 trainable parameters.

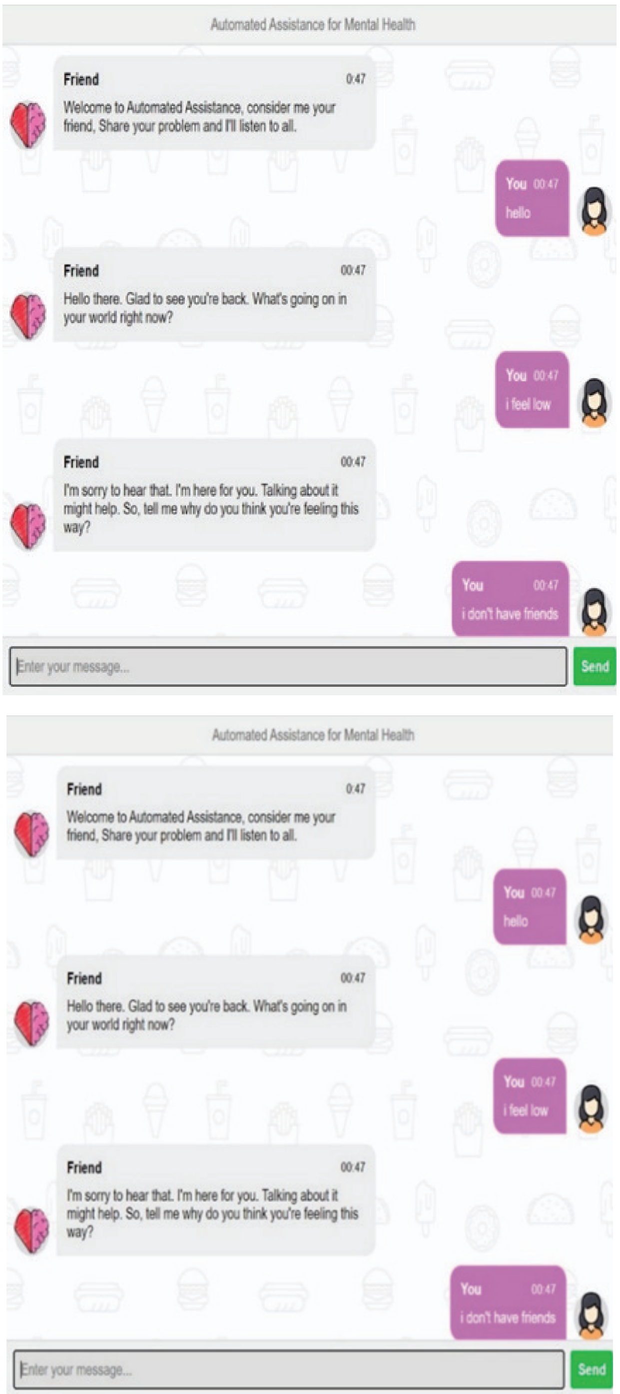

Fig. 10.1, 10.2 Screenshot of UI

CONCLUSION

In conclusion, there is an increasing need for easily available mental health help, and the study work on developing an automated mental health aid using a chatbot has considerable potential to satisfy this need. The chatbot uses artificial intelligence (AI) and natural language processing to deliver prompt, individualized help to anyone looking for mental health resources and support. The chatbot can interpret user inputs and produce relevant responses by utilizing a retrieval-based or generative-based model. The model can be trained using a combination of predefined intents and responses, along with a large and diverse dataset of mental health-related conversations. While the research work has immense value, there are areas for improvement, such as expanding the dataset, incorporating advanced NLP techniques, implementing dialog management, and enhancing personalization features. Additionally, deploying the chatbot on various platforms can enhance its accessibility and impact.

Overall, an automated assistance for mental health holds the potential to support individuals, provide valuable resources, and promote mental well-being on a larger scale. Continued development and improvement in this research work along with Indian languages can contribute to addressing mental health challenges and making mental health support more accessible and inclusive.

There are several potential areas for improvement in this research work:

- Data collection and augmentation: Gathering a larger and more diverse dataset of intents and responses can improve the accuracy and robustness of the chatbot.
- Dialog Management: Incorporating a dialog manager to maintain the context of the conversation can improve the chatbot's ability to respond appropriately to user inputs.
- Personalization: Adding personalization features such as user profiles and preferences can enhance the user experience and make the chatbot feel more engaging and natural.
- Deployment: Deploying the chatbot on a cloud

platform and integrating it with messaging services such as Facebook Messenger, Slack, or Telegram can make it more accessible to users and increase its reach.

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Data Security and Multifaceted Platform Enabled Digital Expense Tracker for Individuals and Businesses

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ABSTRACT

The digital expense tracker paper is a major step towards solving expense tracking and financial management problems. The program tracks and analyses expenses for financial management. The tracker should help people and corporations manage their finances and ensure long-term stability. The article develops using Python, SQL Server, and frontend technologies. To ensure dependability and scalability, the Expense Tracker system uses cutting-edge technology and programming languages, data protection, customization, and a multi-platform approach. Users could track and categorise expenses simpler with the Expense Tracker, which identified spending tendencies and financial trends. Intended for both new and experienced users, its interface emphasises simplicity. Real-time financial data and analytical insights helped users make better financial decisions, increasing their financial outcomes. Over 30 corporate entities tried the digital tracker tool last year, and over 100 people used it for various purposes. Corporate house and individual satisfaction ratios are good. Tool detail analysis is encouraging for all six parameters appraised and surveyed. With around 96% and 91% robustness and stability, data security and multifarious platforms are the most significant factors.

***KEYWORDS** : Expense tracking tool, Financial management, Data security, Real-time financial data, User-friendly interface, Multifaceted platforms.*

OVERVIEW

Today's fast-paced world makes spending management difficult for people and organisations. A flexible, user-friendly spending monitoring solution for personal finance management, corporate budgeting, and educational institutions is needed. This system should make recording, analysing, and controlling spending easy and customisable for different financial demands.

In the digital age, Expense Tracker is crucial. It simplifies financial record-keeping and provides financial clarity. It improves financial behaviour, reduces overspending, and helps people and organisations reach their financial goals. The comprehensive Expense Tracker solution helps customers improve money management and savings.

Individuals and organisations need efficient financial management. Expense Tracker solves disorganised and ineffective expense tracking. It provides a complete financial management solution to improve control and expenditure insights. This article examines the command-line tool Expense Tracker, which helps users budget, manage expenses, and analyse spending trends. Users can create accounts, log in, and make financial activities.

This tool helps firms make educated decisions, optimise budget allocation, and simplify financial analysis by automating operations, improving accuracy, and providing important financial insights. The Expense Tracker helps modern organisations manage their finances with its simple interface, powerful data storage, and wide range of features. These components must be created by the formatter using the following criteria.

RELATED WORK

Expense tracking solutions have gained popularity due to the increasing need for better financial management by individuals and businesses. Research shows that expense tracking enhances financial awareness and promotes smart spending [1]-[2]. Traditional methods like manual record-keeping and spreadsheets are inefficient, leading to the rise of mobile and web-based digital expense tracking systems [3]-[4]. Transitioning from CLI programs to GUI and web-based interfaces has improved user interaction and satisfaction [5], with UI/UX design playing a critical role in making these tools more intuitive and appealing [6]-[7].

Expense tracker applications rely on SQL databases for secure data storage and management due to their stability and scalability [8]. Software engineering practices like iterative development help continuously refine these systems based on user feedback [9], ensuring they meet user needs while improving performance. However, challenges like data security, privacy, and integration with financial ecosystems persist. Addressing these requires understanding user demands, technology, and regulatory frameworks [10].

Despite their success, expense trackers are criticized for relying on manual keyboard input, which is time-consuming, suggesting a need for automated solutions to ease the input process [11]-[14]. Current desktop-only systems limit real-time updates and portability, which can be addressed by improving mobile access [15]. Features like social media-based sign-ups [16]-[17], smart categorization based on previous entries [18]-[19], and mobile-focused development can enhance usability. Microservices also enable scalability and efficiency in financial decision-making [20], with automated tracking reducing manual effort [21]-[22].

Effective expense tracking systems include cost categorization and synchronization with bank accounts to provide a holistic view of personal finances [23]-[24]. New technologies like blockchain offer secure and transparent expense tracking for businesses [27], while mobile apps enable users to track expenses on the go [28]. Predictive methods and data engineering models further improve expense control strategies for both individuals and corporations [29].

This paper aims to address the challenges in existing systems by proposing a more automated and user-friendly solution. Trust and privacy significantly influence online information disclosure, impacting how willing people are to share data [30]. The integration of expert systems and effective UI/UX design also plays a crucial role in the adoption of financial management applications [31]-[32]. Additionally, studies on financial literacy help shape tools that better meet user needs by considering their financial knowledge and learning preferences [33]-[34].

METHODOLOGY

Proposed System

The proposed expense tracking system meets varied user needs. Register, create profiles, and easily record costs by date, category, amount, and description. The technology lets customers set category budget restrictions to better manage expenditure. It also offers comprehensive data analysis capabilities to help consumers understand their finances and make smart choices.

Software Development Lifecycle

Login/signup, expenditure, and analysis report ideas were initially gathered for our prototype. We set goals, but as we built the prototype, we realized it's an iterative process that requires constant revisions based on user input, examiner comments, and industry viewpoints. Therefore, we used agile for continual learning and efficient results.

Stages of SDLC: The Agile Method

1. Gathered and specified paper goals, user needs, and system features.
2. Development: Implemented features incrementally to meet changing needs.
3. Testing: Thoroughly tested functionality, usability, and reliability.
4. Regularly update software to meet user needs and introduce enhancements.
5. Continuously gather and integrate user feedback to improve system performance.

Product Development

Our MVP for a cost tracker helps people and organizations track and analyze their expenses. We are always getting input and improving our paper, including adding new tools and technologies to our model.

Tools and Technologies: Python: The Expense Tracker's backend logic was developed using Python as the core programming language. Budget tracking, expense management, and user identification were easier to manage, process, and implement. Python's versatile libraries, including CSV and JSON for data management, helped build the paper.

Integrating SQL Server into the paper to improve scalability and data management. This relational database management solution organises user profiles, spending, and budgets better than CSV and JSON files. SQL Server improved query, data integrity, and structure.

Figma was used to construct the expense tracker's UI/UX design, then HTML, CSS, and JavaScript were utilised to build the front end. HTML structured the web interface, CSS styled and layoutd it, and JavaScript added dynamic behaviour. By making the software more interactive, this frontend design increased usability [6]. Data visualisation was crucial to the Expense Tracker report. Financial analysis can be done with Power BI, Python, and JavaScript. These visualisations let consumers comprehend and assess their spending habits, financial condition, and other data on the web dashboard.Project Stages

Stage 1: Python and Python Libraries

Stage 2: CSV, Excel, JSON Files

Stage 3: GUI Toolkit

Stage 4: UI/UX Design using Figma

Stage 5: ER Diagram and Tables

Stage 6: Frontend Development - HTML, CSS, Javascript

Stage 7: SQL Server Integration

Stage 8: Backend-Frontend Integration

Stage 9: Data Visualization Integration

Stage 10: Testing

System Advantage

The system prioritises user data security, safeguarding the privacy and confidentiality of critical financial information. Moreover, users possess the ability to modify the program to meet their own financial needs, yielding a customised spending monitoring experience. The multi-platform support ensures accessibility, while the system includes reporting features, user documentation, and quality assurance to uphold reliability. The system is dedicated to continuous improvement and upgrades to ensure its relevance and effectiveness for users in various financial management contexts.

Data processing and management are conducted in Python utilising CSV and JSON utilities in the Expense Tracker document. Code development is executed proficiently with VSCode. Creating user-friendly functionalities such as budget tracking and expenditure analysis necessitates financial expertise.

We employ comprehensive unit and integration testing to ensure system reliability. The document retains data in CSV and JSON formats; however, more intricate expenditure trackers may require databases. The paper underscores the need of user authentication for securing access to financial data, rendering it a comprehensive tool for spending management and analysis.

IMPLEMENTATION

The program begins with a login menu where users can log in, register, or quit. After logging in, the primary menu offers cost monitoring and analysis options. Menus allow users to navigate the program's features. Figure 1 shows a financial navigator and efficient expense tracker. Enter a username, password, usage type, organisation name, and designation to create an account.

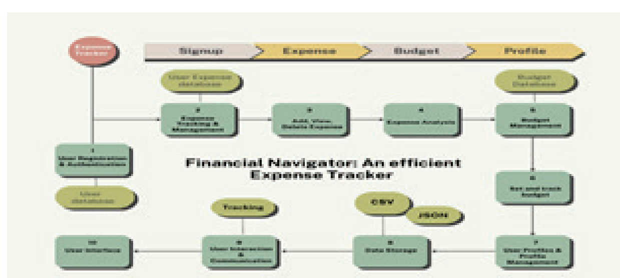

Fig. 1 System Diagram For Financial Navigator

A CSV file saves user data. Users can log in with their username and password. Successful login opens the main menu. After logging in, a menu appears with options like, Users can input expenses with dates, categories, amounts, and descriptions. Users can see their expenses. You can analyse expenses by category or date. You can eliminate a cost. Users can limit category budgets. Users can compare spending to budgets. View profile information. Update your profile (use, organisation, and designation). Users can erase their profile and data. Account holders can log out. The application stores budgets in JSON and expenses in user-named CSV files. These files help users track costs and budgets. The program allows users to log in or register and validates their credentials. User profiles, spending, and budgets are stored in CSV and JSON files, accordingly. You can analyse expenses by category or date. Users can

track category budgets and compare costs against restrictions. Users can update or delete profiles.

The above details pertain to the existing command line interface and graphical user interface, equipped with proper signup options and a suitable, unique database system. Currently, we have developed a frontend website, which will provide users with an advantage in managing expenses more efficiently and handling budgets with ease.

We have created the UI/UX design, and once it's complete, we have developed the website with specific situational changes. The product design encompasses a signup page, profile update functionality, expense features, budget management, and expense analysis. We will make further adjustments based on user responses, following an agile methodology and a user-centric approach. Our website's UI/UX designs are listed below.

When the user opens the website, they can login/signup and are redirected to their account with security authentication. The dashboard, also referred to as the homepage, greets the user after they log in as shown in figure II This dashboard functions similarly to the menu system in a Command Line Interface (CLI) application. The dashboard includes monthly balance spending, category-wise spending, budget status, and crucially, month-by-month spending data categorized by a bar graph.

Table 1 For the End-User, Budgets Efficiently and Secure Platform

Functionality		Description
User Management	User registration	Users can create accounts by providing a username and other details
	User login	Registered users can log in with their credentials.
Expense Tracking	Add Expense	Users can add expenses, providing details such as date, category, amount, and description.
	View Expense History	Users can view their expense history and delete specific expenses.
Expense Analysis	Analysis	Users can analyze their expenses by category or date, providing insights into their spending patterns
	Total	Expense analysis displays the total expenses in a specific category or on a particular date.
Budget Management	Set Budgets	Users can set budgets for different expense categories, defining spending limits.
	Budget Status Display	The application tracks and displays the budget status for each category, including the budget limit, total expenses, and remaining budget.

User Profile Management	View and update profile	Users can view and update their user profiles, modifying information such as usage type, organization name, and designation
	Delete Profile	Users have the option to delete their profiles.
Logout	Users can log out of their accounts, ensuring account security	

RESULTS & DISCUSSION

We have outcome into two parts: Software structure and real time output and testing validation.

Software Structure

The Expense Tracker's output window, via a Command Line Interface (CLI), allows users to engage with their personal databases, facilitating login, expense entry, viewing, management, budget setting, and financial data analysis. This degree of customisation guarantees data confidentiality, scalability, and an improved user experience. Furthermore, the CLI offers a direct and effective method for users to engage with the system, rendering it accessible and user-centric. Each user may possess an individual database to safely keep their financial information. This database system enables customers to own individualised storage for costs, budgets, and other financial data. Figures II and III depict the UI/UX Interface: Command Line Interface and Graphical User Interface.

In the output window of the Expense Tracker, via a Command Line Interface (CLI), users can engage with their personal databases, allowing them to log in, add, examine, and manage spending, establish budgets, and analyse financial data. This degree of customisation guarantees data privacy, scalability, and an improved user experience. Furthermore, the CLI offers a direct and effective method for users to engage with the system, rendering it accessible and user-centric. Each user may possess an individual database for the secure storage of their financial information. This database system provides customers with individualised storage for costs, budgets, and other financial data. Figures II and III depict the User Interface/User Experience: Command Line Interface and Graphical User Interface.

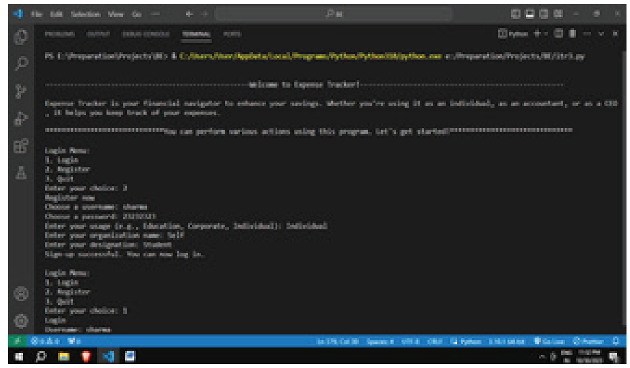

Fig. 2 User Interface (Command Line Interface)

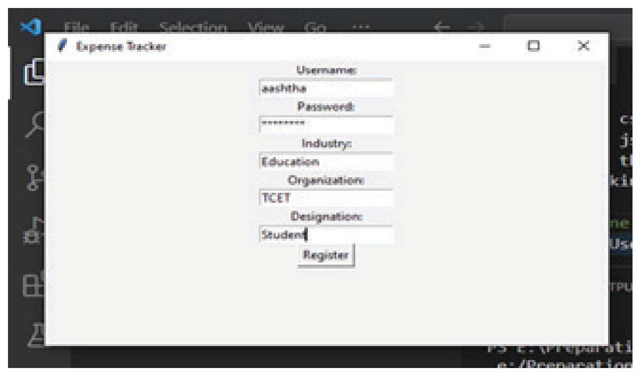

Fig 3. User Interface (Graphical User Interface)

VALIDATION AND TESTING

The survey and validation were done during operation and filed training of tool. As digital tracker is deployed under two main categories:

1. Business /Corporate Validation and testing and Individual usage. The Corporate houses are our convenience we have divided as Small Size (with employee number less than 30) Medium Size (less than 50) and Big Size (more than 50 but less than 100).
2. Individual entity: The individual who want to keep track of amount and already accustomed to such tool.

As a testing and validation part, we have conducted survey of more than 30 corporate houses and around

100 Individuals after deployment tool. We have validated performance on the basis of 6 parameters: User-friendly, Versatile, Finance management, Setting-up Goal, Data Security and Multifaceted platforms. The paper for shows performance of tool with respect to data security and multifaceted platforms.

CORPORATE VALIDATION AND TESTING PHASE

The Figure IV shows satisfaction level of SMALL Size corporate over various parameters and with respect to Data Security aspect shown as linear dotted line. As duration is increased there is more acceptance with respect to and data security. The satisfaction level is measured with scale of (0-5).

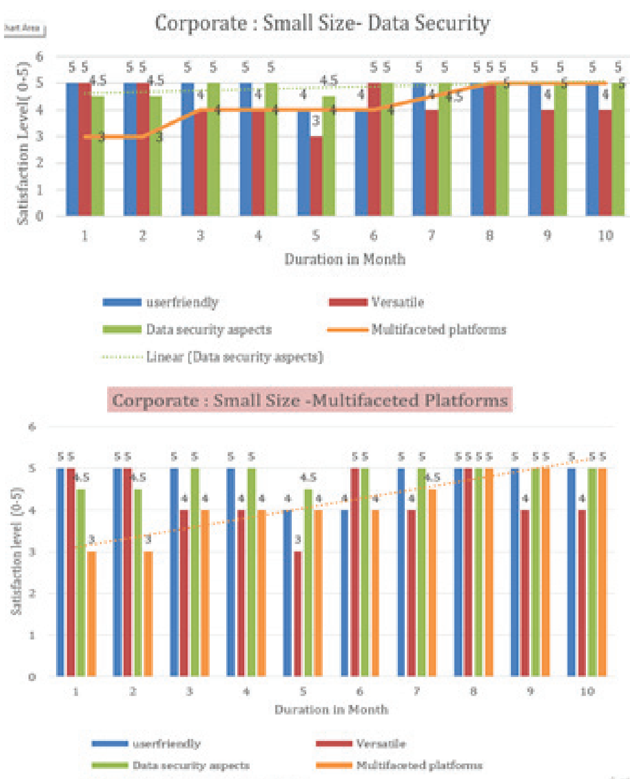

Fig. 4 Satisfaction Level of Small Size Corporate

Figure V shows comparison of results with respect to multifaceted platforms. As it is clear that employees of small size corporate are highly satisfied with tools even for longer duration of period. Figure VI. shows corporate house responses to Data Security and Multifaceted platforms. The response is encouraging across small, medium and big corporate for two important parameters. The effectiveness of tool for Data security is 94% and for multifaceted platforms 88%.

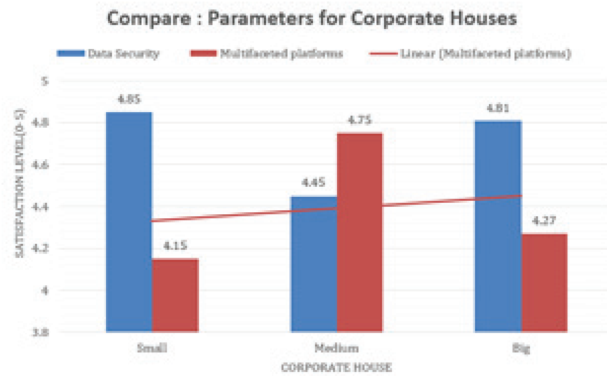

Fig. 5 Corporate House: Multifaceted Platforms

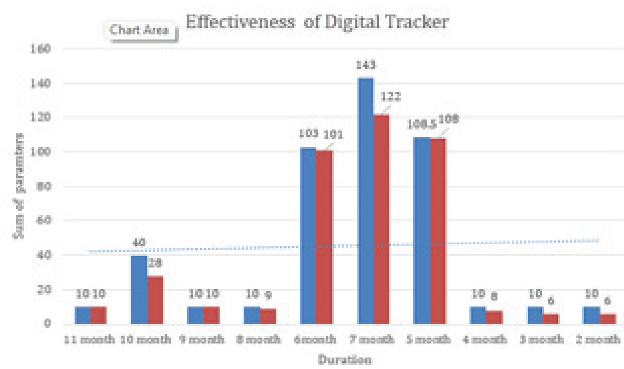

Fig. 6. Individual Multifaceted Platforms

Figure VI shows effectiveness of digital tracker for individuals and validated for two important parameters. A figure shows that for maximum sum is accumulated for 7 month and data security is has been highest priority of individuals over other parameters. Also, after calculation effectiveness is around 98% for data security and for multifaceted platform parameter it is around 94%. Also, found that Individuals are more concerned on data security when it comes to financial transaction and rated better over other parameter as shown in figure VII.

The Table I discussed about the outcomes user point of view and below are few developers point of view paper outcomes.

- Create an account with username, password, etc., store information in a CSV file.
- Program offers options to log in or register, validating user credentials for security.

- Main Menu (dashboard)- Provides options to Add Expense, View Expenses, Analyze Expenses, Delete Expense, Set Budget, Track Budget, View Profile, Update Profile, Delete Profile, and Logout.
- Expense Tracking - Maintains user expenses in CSV files and budgets in JSON files, enabling users to track expenses and budgets effectively.
- Data Storage- User profiles stored in CSV files; expenses and budgets stored in CSV and JSON files, respectively.
- Expense Analysis - Users can analyze expenses by category or date, gaining insights into spending patterns.
- Budget Tracking- Allows users to track budgets for different categories and compare expenses against budget limits.

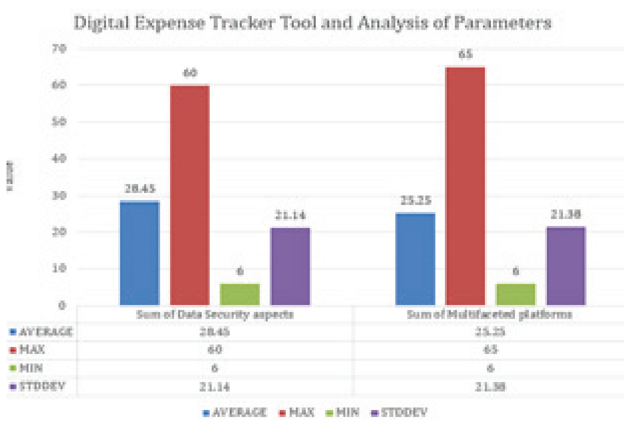

Fig. 7: Corporate House Multifaceted Platforms

FUTURE SCOPE

Our initial step involves completing the website by integrating the frontend with the backend and ensuring a responsive database. On a broader scale, our vision is to transform it into an everyday essential for individuals and businesses, facilitating expense tracking. We plan to extend the paper into a mobile application, enhancing portability and integrating it with various APIs from mobile applications. This integration will enable users to track payment history across different platforms such as food delivery apps, online shopping apps, or ticket booking platforms. In the near future, we envision our expense tracker becoming a global necessity for individuals.

CONCLUSION

The Expense Tracker Tool is a Python-based application that functions as a comprehensive financial management instrument, intended to aid users in efficiently overseeing their expenditures. This command-line utility enables users to establish accounts, authenticate, and execute certain fundamental financial transactions. The application offers user-friendly features, like expense monitoring, budget management, and expense analysis, allowing individuals and organisations to monitor their spending patterns closely. Few highlights of tools after detailed real time testing and validation are as follows:

1. Its real time tool with fast and easy interface.
2. Data Security and Multifaceted features are successfully validated and test with more than 90% satisfaction level.
3. Individuals and business houses need is taken care with AI enabled facility
4. Training of it is simple and its installation and uninstallation won't be affecting operating system.

The Expense Tracker provides a multifaceted money management solution for individuals, enterprises, and organisations. The primary objectives encompass facilitating user registration and personalisation, efficient expense monitoring and tracking, budget management, automating expense tracking processes, ensuring data accuracy, providing valuable financial insights, optimising budget allocation, simplifying financial analysis, ensuring data security, offering a user-friendly interface, delivering a diverse array of features, and ultimately aiding users in navigating the intricate financial landscape.

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Tribological Behavior of Low Carbon Steel, Grade AISI1018 Overlayed with Nickel based MMC + WC using Plasma Transfer arc Welding

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ABSTRACT

Coefficient of friction (CoF), Rate of specific wear (SWR) of low carbon steel of grade AISI 1018 overlayed with nickel-based MMC plus WC using laser cladding were investigated in this tribological study. Specimens were pressed up on to a rotating steel disc (EN31), experiments were conducted on AISI 1018 grade low carbon steel and AISI 1018 grade low carbon steel overlayed with nickel-based MMC plus WC using PTA cladding method on a pin-on-disc DUCOM machine. A set of samples were used in the experiments, which lasted 20 minutes and involved loading conditions of 10N to 50N with sliding distances ranging from 1000 m to 3000 m. The findings demonstrate how different loads and sliding distances affect the SWR and CoF. Generally, CoF rises during the rubbing phase and then stays steady for the duration of the test. The obtained results indicate that, for cladded material, the CoF and SWR increase with increasing load applied and distance of sliding.

SWR and CoF of prepared specimen found to be decreased. When compared to low carbon steel, the SWR of cladded specimen decreased to 39.68%. CoF of prepared specimen is found to be 18.79% lower. To investigate the worn surfaces of the base metal, a Scanning Electron Microscope (SEM) was used, which is low carbon steel (AISI 1018) and low carbon steel layered with nickel-based MMC plus WC using PTA cladding. Two types of samples had worn surfaces with shallow and fine grooves at low loads, and large quantities of cracks at high loads, which raised weight loss.

KEYWORDS *: Low carbon steel overlayed with Nickel based MMC plus WC; PTA cladding, Coefficient of friction, Rate of specific wear, Dry sliding wear, Scanning Electron Microscope (SEM).*

INTRODUCTION

As cobalt-based alloys have a superior corrosion, errosion resistance and higher resistance to wear under sliding conditions, they have long been used as hardfacing materials for components of nuclear power plants, including valves, bushes, and sleeves. According to Ohiner et al., the low stacking fault energy (SFE) and strain-induced martensitic transformation of the cobalt-based alloys from a metastable face-centered cubic structure to a hexagonal close-packed structure could be the cause of their high wear resistance [1]. Cobalt-free hardfacing alloys are becoming more and more popular, despite the fact that cobalt alloys have long provided good service. Specific surface qualities, such as hardness, wear resistance, and corrosion resistance, are needed for some industrial applications. The most efficient and cost-effective material-processing technique yet created results in a metallic surface cladding with the following benefits: (1) good fusion bonding between the material and substrate; (2) ease of use; and (3) yielding a work piece with improved surface properties [2-4]. As a result of frequent use in harsh environments, impact loading, erosion, wear, corrosion, etc., metallic machine parts eventually degrade and are eventually discarded due to poor performance. By precisely depositing powder of metal over the deteriorated component, plasma transfer arc welding (PTAW) is one of the repair techniques being used to extend the span of service life of machine components across a variety of industries. PTAW process is being used to repair critical components such as gas turbine blade wear areas restored, propeller shafts repaired, helicopter engine nozzle set cracks, etc. [5-7]. The following requirements must be met by alloys to replace cobalt-based varieties: they must be comparable in terms of strength, hardness, toughness, coefficient of friction, wear resistance, and corrosion resistance to the alloys based on Cobalt currently in use. The low SFE of the matrix is the basis for the resistance to wear of hardfacing alloys based on iron, according to Ohriner et al. Generally speaking, though, the SFE rises with temperature, which leads to a decrease in the distance between neighbouring partial dislocations and an ease of recombination of the partial dislocations required for cross slip [1]. As a result, wear resistance may decrease at higher temperatures. Furthermore, according to Presson et al., strain-induced austenite to martensite transformation in the iron-based alloy takes place below 180 uC, which means that wear performance declines at higher temperatures [8]..

Combining structural, surface, and cost properties—factors that frequently interact—while designing parts to function under harsh tribological conditions is one of the biggest challenges engineers faces. A well-known and frequently used technique for creating parts that are competitive is hard facing. It entails choosing an alloy to preserve the structural qualities provided by the substrate alloy while tailoring properties of surface for a specific usage. Controlling the relationship between surface behavior and microstructure is crucial to maximizing the benefits of the banked high-performance alloy. NiCrSiBC superalloy coatings can provide protection for steel components that are subjected to elevated temperatures. Colmonoy-6® alloy, one of the many super-alloys available for this use, has seen extensive use because of its superior performance in high-temperature, abrasion, and corrosion environments. Developed initially for thermal spray coatings, Colmonoy-6® alloy offers superior properties at a lower cost than Co-based superalloys. Due to these properties, laser cladding, gas tungsten arc (GTAW), and plasma-transferred arc (PTA) were used in hardfacing applications [9]. Weld overlays are surface treatments that add a surface layer or coating to improve resistance to wear, corrosion, erosion and allow for restoration of dimension [10]. A variety of heat sources, including lasers, electric arcs, and plasma, can be utilized to melt base and additive materials and produce various types of deposits as a result.

The Plasma-Transferred Arc (PTA) process uses plasma as a heat source. Weld overlays made with this technique can be fairly thick, usually 4 to 6 mm in a single pass. If the right welding parameters are chosen, low penetration and low dilution levels can be achieved. Since PTA welding is typically automated, it is more productive than manual welding and yields consistent overlays [11-12]. Pulsed PTA welding can produce a smaller melting pool and lower penetration. The microstructure and hardness of the deposited material, in addition to penetration, are influenced by pulsation parameters [13-14]. Another useful technique for additive manufacturing is the PTAW process [15]. PTAW-based additive manufacturing technology has the potential to be competitive when compared to laser-based technologies. [16]. The PTAW process poses a number of benefits over other welding methods, including a large range of deposition, minimal loss of coating material, less distortion of base material, low dilution, and lower manufacturing costs. It also benefits from the large range of powders that are available and the versatility of their mixing for different applications. Because the PTAW process uses powder materials, any kind of powder can be freely mixed to achieve the desired composition, making it far more flexible than other welding processes.

Although Ni-based alloys are known to confer much better wear resistance at higher temperatures, there have been relatively few reports about systematic high temperature tests with nickel-based hardfacing alloys. When examining wear against increasing temperature, Sttott et al. (working with nickel-based superalloys) discovered a distinct temperature above which wear and friction are notably reduced. PTA overlaying is among the most favourable of these processes due to its broad applicability and high deposition rate. The widest variety of materials are covered by the PTA process. Ferroelectric, nickel, and cobalt-based alloys, as well as borides and carbides borides, are commercially accessible and frequently utilized primary materials in the PTA process. Wear rate is significantly impacted by each tested variable. The wear rate stays constant as the sliding distance increases, but it falls as the normal load and counter-body sliding speed increase. As the contact area increases and the contact pressure decreases, the wear rate under typical load decreases [16-18]. More information about how microstructure influences coating performance can be found in the topography of wear scars, which is data organized based on wear performance. Dirty grooves are the wear mechanism for the most part. A number of tiny, parallel grooves form on the sample surface as a result of a significant percentage of the abrasive particles sliding rather than rolling in the sample/counter-body interface, according to micro-abrasion tests. A plasma arc is created in the PTAW process between an electrode and the metallic substrate that will be the target for material deposition. The metal powders are pneumatically delivered to the substrate via the plasma arc pathway. Depending on their size and the amount of current applied, the powder particles heat up and might even melt as they migrate from the hot plasma arc onto the substrate.

High-speed steels (HSS) are complex iron-base alloys that contain tungsten, vanadium, chromium, molybdenum, or their combinations; in some cases, significant amounts of cobalt are also present. The alloy's balanced carbon and alloy contents provide excellent toughness, which makes it suitable for industrial cutting operations. It also has a high attainable hardening response, high resistance to wear, and great resistance to the softening effect of heat. HSS parts can be fabricated using a variety of methods, such as laser cladding, thermal spraying, metallurgy, and more. Few research, nevertheless, have examined PTA deposition of HSS. It has been found that when metal powder is deposited using the PTAW process on different steel substrates, the deposition width increases with an increase in arc current at constant speed and the overlay thickness increases with a decrease in scanning speed at constant current. Raising the current can thicken the coating layer without causing pores or fissures in the interface or layer; however, this also increases the dilution, which reduces the resistance to wear and hardness of the layer [34–35]. In the PTAW process, the dilution can be as low as 0% at low deposition rates, and it typically ranges from 5% to 20% at high deposition rates.

However, from going through the review of literature it is learned that quantum of work done on surface modifications using PTAW cladding for improving surface properties like strength, toughness, corrosion and erosion resistance is very large and study of wear resistance has been given the less focus. Wear is very common mechanical issue causing the corrosion and fatigue failure of components of assemblies. Valve, valve seat, seal, cams, follower, gears, driving wheels, brakes, impellers, blower fans, nuts, bolts, bearings, bushes, chain and sprocket etc,. are the tribological parts that are used in machines. Different overlaying methods are most widely implemented for industrial sectors like automotive, aerospace etc. In this tribological study, the friction's coefficient (CoF) and rate specific wear (SWR) of Low Carbon Steel of grade AISI 1018 overlayed with Nickel based MMC plus WC using PTAW Cladding, were examined. Tests for wear were conducted on pin-on-disc wear test set up on Low Carbon Steel and Low Carbon Steel overlayed with Nickel based MMC plus WC using PTAW Cladding. Specimens were pressed on to a rotating steel disc (EN31).

EXPERIMENTATION

Materials

In this research work Low carbon steel Grade AISI 1018 and Nickel based MMC + WC materials were used. PTAW cladding was carried out at SVNIT, Surat. Pin on Disc,wear testing method was chosen for wear testing. The details of compositions of overlaying material as Nickel based MMC + WC are mentioned in Table 1.

AISI 1018 grade low carbon steel substrate material is cladded by using a mixture of Ni-based alloy powder (Cr-3.14%, Si-1.24%, B-0.64%, Fe-1.16%, C-2.54%, W-Balance) as a cladding material. Ni based MMC powder with particle size was -125 + 45 micrometer (μm) and WC particles are of irregular or angular shapes. The substrate selected for cladding was the AISI1018 steel (100 mm × 100 mm × 10 mm). The Nickel based alloy powder (45–125 μm) was used as the cladding metal matrix. The powder form was fed through closed-loop powder feed unit in a laser molten pool over a polished low carbon steel substrate.

Table 1. Chemical Composition of Overlayed Alloying Element

C	B	Cr	Fe	Si	Ni	W	Others
2.54	0.64	3.14	1.16	1.24	33.6	bal	<0.3

Fig. 1. PTAW Cladding Machine

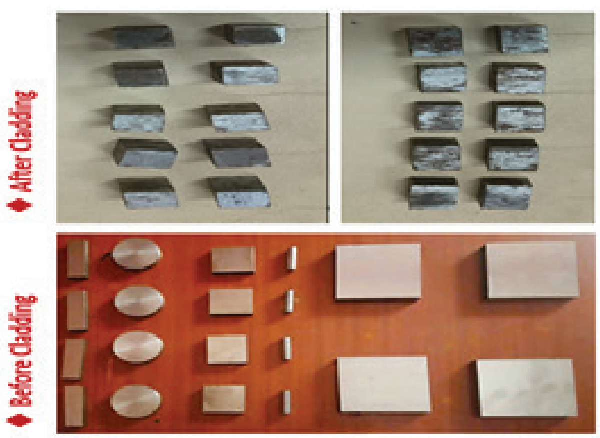

Fig. 2. Image of Raw Pin Prepared for Wear Testing

The PTAW cladding machine depicted in Figure 1 was used to create the 2 mm layer through the overlap of individual clad passes with an optimized overlap ratio of 35%.. Specimen samples were prepared in 10 x 10 x 12 mm size as shown in figure 2. Pin on disc type of wear testing method was used to investigate specimen's tribological behavior at S. G. G. S. Nanded.

Plan of Experiments

This study examined the effects of overlaying low carbon steel of AISI 1018 grade with nickel-based alloy powder (Cr-3.14%, Si-1.24%, B-0.64%, Fe-1.16%, C-2.54%, W-Balance) using a PTA cladding process. The applied load and sliding distance were taken into account. The tribological process parameters are displayed in table 2. All potential combinations of the chosen parameters are used in a total of 25 experiments (three replicates). Table 2 displays the specific parameters that were chosen for the tests.

Table 2. Parameters and Levels for the Specimen Wear Test

Parameters	Levels
Load (N)	10, 20, 30, 40, 50
Sliding distance (m)	1000,1500,2000,2500, 3000
Test pin length (mm)	30
Test pin diameter (mm)	10
EN 31 steel disc diameter (mm)	165
EN 31-disc hardness (HRC)	58-62

Cladded and uncladded specimens were subjected to tribological testing using a pin-on-disc machine setup (Model TR-20 LE-PHM 400 - CHM -400) from DUCOM, Bangalore. The computer and machine configuration are integrated by the WINDUCOM 2010 software [10]. The experiments were conducted in a dry sliding environment. Every experiment was conducted in a laboratory where in the temperature was 24 degree C and relative humidity of 46%. The specimens of 10 mm x 10 mm × 12 mm dimension in square pin (Figure 1) were adhered to 10 mm steel pin holders. Pin's surface slides against EN31 disc surface which is rotating having 58–62 HRc hardness. The EN31 disc had a harder surface than the material of specimen that was being used. Before testing, the specimen was polished with emery sheets ranging in grade from 500 to 2000 to ensure correct contact with the counterpart (disc). After that, the polished test specimens were placed up against a rotating steel disc with an 80 mm track diameter. Figures 3 show the experimental test setup. The parameters of the investigation are sliding distance and applied load, with each run lasting 20 minutes.

For calculating the sliding distance, the used equation is 1.

$$\text{Sliding distance } (S_d) = \frac{\pi DNT}{60000} \quad (1)$$

where

N - is disc speed, revolution per minute, D - is track diameter, mm,

T - is time duration, minute, Sd - is sliding distance, m.

A precision digital electronic weighing machine with a least count of 0.001 g was used to weigh the specimen after it had been taken out of the wear testing apparatus. Weight loss is calculated as the difference between the initial and final weights.

For determining SWR used equation is 2.

$$\text{Specific wear rate (SWR)} = \frac{\Delta m}{q L S_d} \quad (2)$$

Where

q is density of cladded specimen in g/mm^3,

Δm is weight loss, g, L is normal load, N, S_d is sliding distance, m

specific wear rate (SWR) is given in 10^{-6} g/Nm

Fig 3. Pin on Disc Experimental Setup for Wear Testing

RESULT AND DISCUSSION

Many industrial applications use a PTA cladding process to overlay low carbon steel of AISI 1018 grade with nickel-based alloy powder (Cr-3.14%, Si-1.24%, B-0.64%, Fe-1.16%, C-2.54%, W-Balance). To replace the current material, a wear study of these overlayed laminates is required. Their strength and wear characteristics are improved by the addition of alloy powder based on nickel to the AISI 1018 substrate. Table 3 displays the experimental results of average Friction's coefficient (CoF) and rate of specific wear (SWR) of cladded specimen at the different factor groupings.

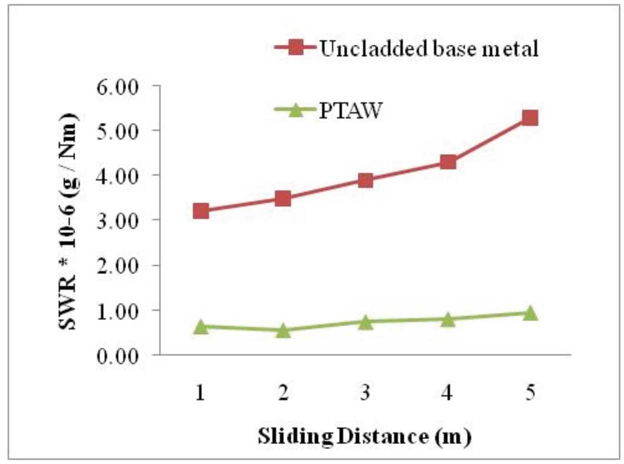

Fig. 4. Effect of Sliding Distance on SWR at Different Load.

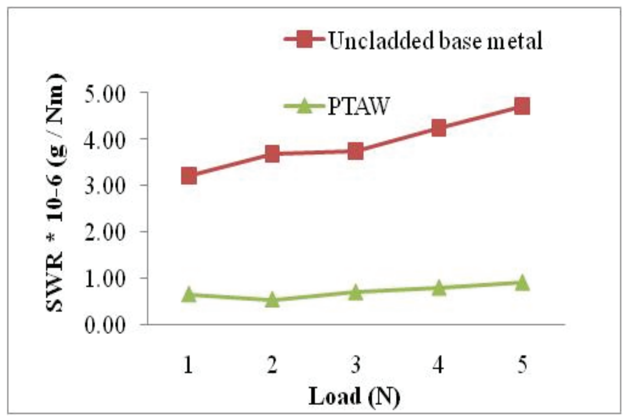

Fig. 5. Effect of Load Over SWR at Various Sliding Distance

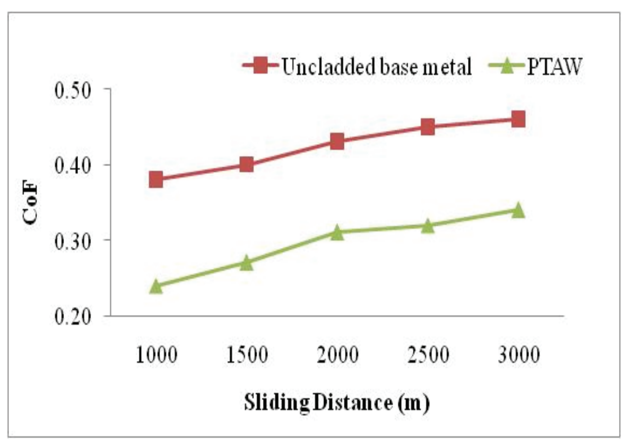

Fig. 6. Sliding Distance Over CoF at Different Load.

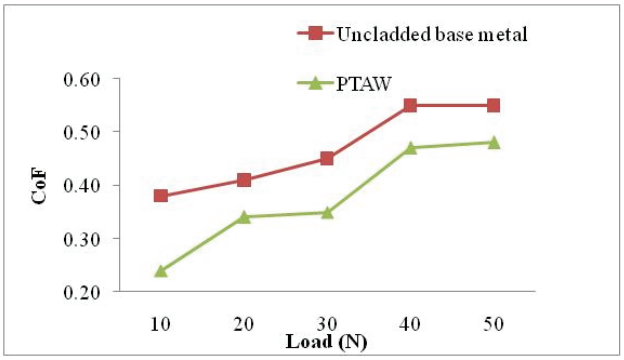

Fig 7. Load Over CoF at Different Sliding Distance

Variation of SWR with control parameters

When nickel-based alloy powder is cladded on the AISI 1018 substrate, the effects of sliding distance and applied load on tribological behavior are depicted in Figure 4 and Figure 5. Longer sliding distances are known to increase resistance to worn discs and decrease SWR. It was discovered that applied loads and sliding distances had a greater impact on SWR. Other researchers have also noticed these kinds of differences in the SWR of cladded surfaces [27–29].

The Effect of control parameters on CoF

Wear tests are conducted on nickel-based alloys operating at 10, 20, 30, 40, and 50 N under typical load conditions at 1000, 1500, 2000, 2500, and 3000 m sliding distances. Variations in average CoF were examined at different sliding distances and applied loads. Figure 6 and Figure 7 show the behavior of applied load and sliding on the average CoF on the low carbon steel AISI 1018 as well as the nickel-based alloy cladded using laser cladding. According to the study, the average CoF rises with increasing applied load and sliding distance. Moreover, the CoF drops in cladding as compared to base material for longer sliding distances. Higher frictional heating, which causes localized adhesion and composite surface softening, can be used to explain this. Additionally, it was noted that the applied load had a greater impact than the sliding distance. The cladding is causing an increase in surface roughness, and the average coefficient of friction is believed to be increasing as the load increases due to the introduction of a substantial amount of debris. Researchers from other fields have also noted this type of variation in the CoF of cladded surface [29].

Analysis of worn surface

Worn surfaces are examined to determine the kind of wear and how it affects the wear pattern. A JEOL JSM 6380 analytical scanning electron microscope (SEM) is used to analyze two different types of specimens: one type has PTAW cladding, while the other type does not.

The wear test is conducted at 30 N and sliding distances of 2000 m for both specimen types. Figure 8a and Figure 8b display SEM micrographs. The oxidative and abrasive wear mechanisms can sometimes be seen in micrographs of all wear surfaces. In certain areas, micrographs show the development of an oxide layer and tiny, continuous grooves. The cladded specimen exhibits the least amount of grove depth, indicating that the addition of nickel-based alloy has increased wear resistance. The wear rate is lowered by the nickel-based alloy's ability to obstruct the counterpart's (the disc's) cutting action. The figure showed that the fiber pull-out was less than that of the specimen that was not cladded. Additionally, it is noted that shallow grooves were only found in a few places, while fine grooves were present throughout the sliding direction. This may occur due to the presence of an alloy based on nickel, which serves as a load-bearing element and keeps the disc and pin from making contact.

Table 3. Response of Experimental Design I. E. Average SWR and Average CoF

Et. No.	Load (N)	Sliding Distance (m)	SWR	Avg CoF	Et. No.	Load (N)	Sliding Distance (m)	SWR	Avg CoF
Uncladded (Base Material)					Cladded (PTAW)				
1	10	1000	3.20	0.38	1	10	1000	0.65	0.24
2	20	1000	3.68	0.41	2	20	1000	0.54	0.34
3	30	1000	3.74	0.45	3	30	1000	0.69	0.35
4	40	1000	4.25	0.55	4	40	1000	0.79	0.47
5	50	1000	4.72	0.55	5	50	1000	0.91	0.48
6	10	1500	3.49	0.40	6	10	1500	0.57	0.27
7	20	1500	3.98	0.41	7	20	1500	0.76	0.38
8	30	1500	4.22	0.45	8	30	1500	0.90	0.41
9	40	1500	4.45	0.56	9	40	1500	1.05	0.51
10	50	1500	5.11	0.58	10	50	1500	1.34	0.51
11	10	2000	3.89	0.43	11	10	2000	0.75	0.31
12	20	2000	3.98	0.46	12	20	2000	0.95	0.41
13	30	2000	4.15	0.48	13	30	2000	1.03	0.43
14	40	2000	4.84	0.58	14	40	2000	1.18	0.50
15	50	2000	5.24	0.62	15	50	2000	1.41	0.53
16	10	2500	4.30	0.45	16	10	2500	0.81	0.32
17	20	2500	4.80	0.47	17	20	2500	0.95	0.42
18	30	2500	4.98	0.53	18	30	2500	1.01	0.48
19	40	2500	5.28	0.61	19	40	2500	1.09	0.52
20	50	2500	5.60	0.63	20	50	2500	1.43	0.57
21	10	3000	5.29	0.46	21	10	3000	0.95	0.34
22	20	3000	5.58	0.49	22	20	3000	1.28	0.44
23	30	3000	5.84	0.54	23	30	3000	1.33	0.50
24	40	3000	6.14	0.63	24	40	3000	1.41	0.55
25	50	3000	6.29	0.66	25	50	3000	1.48	0.57

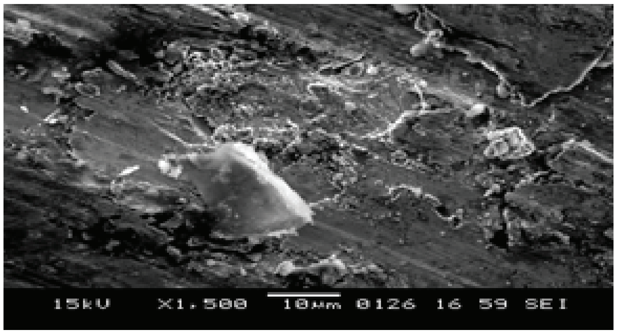

Fig. 8. SEM Image of Worn Surface of A) Base Material

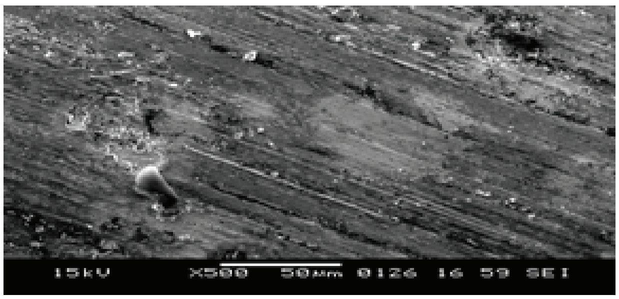

Fig. 9. Sem Image of Worn Surface of B) Cladded Surface

In comparison to an uncladded substrate specimen, the presence of an alloy based on nickel on the substrate material would carry the load and prevent the load from shifting, resulting in a reduced SWR that is advantageous for wear applications.

CONCLUSIONS

The current study examines and compares wear and friction behavior of AISI 1018 steel plain substrate specimens and substrate material overlayed with nickel-based alloys using laser cladding. Following conclusion can be drawn from the current study.

1. Results show that SWR is dependent on scrubbing length and rises with increasing applied load and sliding distance. Applying a nickel base to the alloy reduces SWR. The SWR of the laser-cladded material made of nickel-based alloy decreased by 39.68%.
2. For the material under test, CoF increases as the sliding distance and applied load increase. The CoF of the cladded material is observed 18.79 % lower.
3. At low loads, the worn surfaces of the uncladded and cladded material developed shallow and fine grooves, and at high loads, a large number of cracks were discovered, which increased weight loss.

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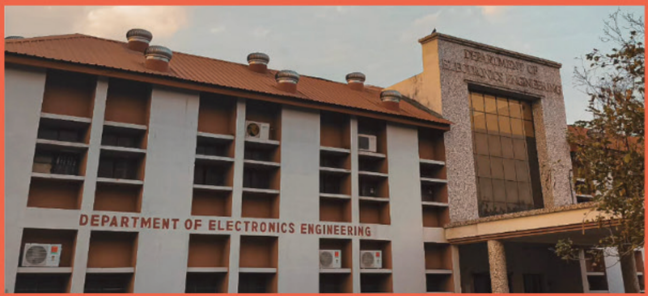

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