

THE INDIAN JOURNAL OF TECHNICAL EDUCATION

Published by
INDIAN SOCIETY FOR TECHNICAL EDUCATION
Near Katwaria Sarai, Shaheed Jeet Singh Marg,
New Delhi - 110 016



INDIAN JOURNAL OF TECHNICAL EDUCATION

Volume 48 • Special Issue • No. 1 • July 2025

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Editorial

Technology is the Pulse of Progress: We are living in a time when technology has become the defining force of our age. It shapes how we work, learn, communicate, and even how societies envision their future. From homes and workplaces to industries and governments, digital transformation has become the backbone of progress. The challenge before us is not whether technology will influence our lives, but how wisely and inclusively we choose to harness it.

Emerging technologies such as Artificial Intelligence (AI), Machine Learning (ML), the Internet of Things (IoT), Blockchain, Big Data, Cybersecurity, 5G, Robotics, Drones, 3D Printing, and immersive platforms like Virtual and Augmented Reality are disrupting traditional systems at an extraordinary pace. These are not futuristic concepts; they are reshaping our present. In healthcare, AI assists in early diagnosis and personalized treatment. In agriculture, IoT-enabled precision farming increases productivity while conserving resources. In education, digital platforms powered by VR and AR are revolutionizing learning. Banking and finance are being redefined by Blockchain and advanced analytics, while robotics and automation are driving efficiency in industries worldwide.

Yet, beyond speed and convenience, technology offers us something greater: the ability to address humanity's toughest challenges—poverty, inequality, disease, and climate change. However, this promise comes with responsibility. If not guided by ethics, inclusivity, and sustainability, technology could widen divides rather than bridge them.

Education and research hold the key. We must go beyond theoretical learning and cultivate practical skills, creativity, and adaptability. Conferences, seminars, and academic platforms are more than formal gatherings; they are spaces where ideas converge, innovations are debated, and collaborations are born. They provide the opportunity to critically reflect on the impact of technology and to explore ways of using it responsibly for the societal good.

The digital revolution is not a distant wave—it is the tide carrying us forward. The choices we make today will determine whether it becomes a force for collective progress or a source of division. Let us therefore commit to embracing technology not merely as a tool of efficiency, but as a catalyst for inclusive growth, ethical innovation, and a better future for all.

New Delhi

Editor

31st July 2025



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Affiliated to Savitribai Phule Pune University and recognized 2(f) and 12(B) by UGC
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Feasibility Study of Biodiesel Production from Waste Cooking Oil by Transesterification

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ABSTRACT

Search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, efficiency, and environmental preservation, has become highly pronounced in the present scenario. Biodiesel can be alternative to diesel, if long-term use of vegetable oils or their blends pose various operational and durability problems in the engine and need to be modified for biodiesel. This study includes Synthesis of biodiesel with feasibility. The study aims to assess the technical, economical, and environmental aspects of this process. Experimental investigations are conducted to determine the optimal reaction conditions, such as temperature, alcohol-to-oil ratio, catalyst type, and reaction time, for the transesterification process. The researchers analyze the biodiesel yield, conversion efficiency, and fuel properties of the produced biodiesel. Environmental impact assessment focuses on evaluating the emissions reduction potential and carbon footprint associated with biodiesel production from waste cooking oil. The results of the feasibility study provide insights into the viability and sustainability of biodiesel production from waste cooking oil. The study helps in determining the economic feasibility, technical feasibility, and environmental benefits of this process, supporting the development and implementation of biodiesel production plants utilizing waste cooking oil as a feedstock. Reason for selecting waste cooking oil is there is no use of this oil further it is unhealthy to consume it.

KEYWORDS: *Biodiesel, feasibility, Waste cooking oil, Transesterification*

INTRODUCTION

Triacylglycerol are the major components of vegetable oils & animal fat (often also called as triglycerides). Chemically, triacylglycerol are esters of fatty acids with glycerol (glycerol is often called as Glycerin). The different fatty acids that are contained in the triacylglycerol comprise the fatty acid profile (or fatty acid composition) of the vegetable or animal fat. As different fatty acids have different physical and chemical properties, the fatty acid profile is probably the most important parameter influencing the properties of a vegetable or animal fat [1].

For biodiesel, the vegetable oil or animal fat is subjected to a chemical reaction termed transesterification. This reaction consist of vegetable oil or animal fat is reacted in the presence of a catalyst (usually a base) with an alcohol

(usually methanol) to give the corresponding alkyl esters (when using methanol, the methyl esters) of the fatty acid mixture that is found in the parent vegetable oil or animal fat. Biodiesel can be produced from a great variety of feedstock. These feedstocks include most common vegetable oils (soybean, cottonseed, palm, peanut, rapeseed/canola, sunflower, safflower, coconut, etc.) and animal fats (usually tallow) as well as waste oils (used frying oils, etc.). Selection of feedstock depends basically on geography. Origin and quality of the feedstock may cause necessary changes in the production process [1].

Biodiesel is miscible with diesel in all ratios. In many countries blends of biodiesel with diesel are used instead of neat biodiesel. It is important to note that blending with diesel is not biodiesel. Often blends with diesel are

denoted by acronyms such as B20, which is a blend of 20% biodiesel with diesel [2].

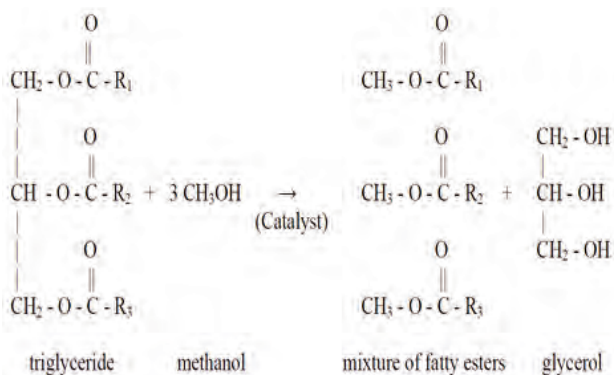
The use of methyl esters of sunflower oil to reduce the viscosity of vegetable oil was reported at several technical conferences in 1980 by South African researchers and marks the beginning of the rediscovery and fuel [3]. Eventual commercialization of vegetable oil esters as biodiesel fuel is carried out. Research activities, ongoing since the late 1970s, have expanded in recent years in conjunction with the increasing interest as a alternative.

METHODS AND MATERIAL

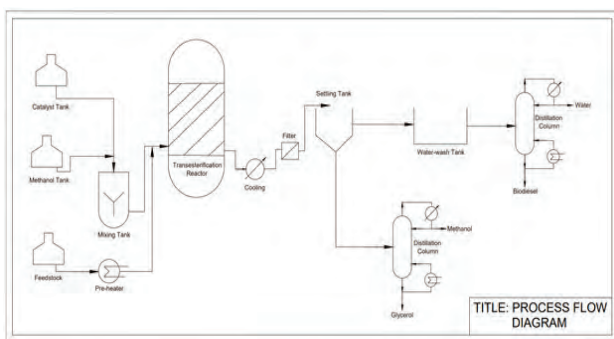
Transesterification Process

Conversion of triglycerides into biodiesel is carried out by transesterification (an ester that is derived from three fatty acids and glycerol). In fact, in the past biodiesel produced from transesterified vegetable oil has been used as fuel in certain vehicles.

Transesterification is an organic reaction in which the R group of an alcohol is exchanged with an R' group of an ester. This is generally done via the introduction of an acid or base catalyst to the reaction mixture. However, it can also be done using certain enzyme catalysts [4].



Process flow diagram for Biodiesel Production



Process description: The PFD provides a visual representation of steps involved in production of biodiesel and helps in understanding the overall process flow.

1. **Feedstock Preparation:** Waste cooking oil, obtained from various sources, is collected, and stored. It undergoes preliminary treatment, such as filtering to remove impurities and water separation, to obtain a clean feedstock.
2. **Reactor:** The clean waste cooking oil is then transferred to a reactor vessel. Sodium hydroxide (NaOH) catalyst is used to carry out the transesterification reaction. NaOH is typically dissolved in methanol to form sodium methoxide, which acts as a catalyst for the reaction.
3. **Mixing:** Methanol, along with the dissolved NaOH catalyst, is added to the reactor containing the waste cooking oil. The mixture is thoroughly mixed to ensure uniform distribution and promote efficient reaction kinetics.
4. **Transesterification Reaction:** The transesterification reaction occurs between the triglycerides present in the waste cooking oil and the methanol and NaOH used as a catalyst. This reaction results in the formation of biodiesel (fatty acid methyl esters) and byproduct is glycerol.
5. **Settling:** After the reaction is complete, the mixture is allowed to settle in the reactor. Glycerol, being denser, settles at the bottom, while biodiesel floats on top.
6. **Separation:** The settled glycerol is separated from the biodiesel. Various separation techniques, such as decantation or centrifugation, can be employed to achieve this separation.
7. **Washing:** The separated biodiesel is washed with water to remove residual impurities, such as excess methanol, catalyst, and soap formed during the reaction. This step helps improve the quality of the biodiesel.
8. **Drying and Filtration:** The washed biodiesel is dried to remove any remaining water content. It may also undergo filtration to remove any particulate matter or contaminants.
9. **Quality Control:** The produced biodiesel undergoes quality testing to ensure it meets the required

specifications and standards. Quality control tests includes analysis of properties such as cetane number, viscosity, density, flash point, etc.

- Storage and Distribution: The final biodiesel product is stored in appropriate containers or tanks. It can be distributed for use as a renewable fuel source in various applications, such as transportation or industrial sectors.

Method for Biodiesel Production

Pre –Test (Acid Number Test)

Acid number test is done to determine how much amount of KOH is required to neutralize 1 gram of oil sample. This test helps in deciding whether oil sample needs to undergo esterification first or if direct transesterification test can be performed.

Following is the procedure to carry out an acid number test.

- Take 1 gram oil sample in a flask
- Add 2-3 drops of indicator to it
- Titrate this solution with 0.1N KOH until the solution changes colour (pink)
- Use the formula to calculate the acid number of the sample.

$$\text{Acid Number} = \frac{\text{Volume of titrant (mL)} * 0.1 * 56}{\text{mass of sample (g)}}$$

$$\% \text{ FFA} = \frac{\text{Acid Number}}{2}$$

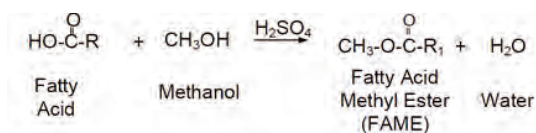
Depending on the acid number, further process is decided.

If the acid number obtained is less than 2 mg KOH / g oil; then direct transesterification can be performed on the oil sample.

If the acid number obtained is more than 2 mg KOH / g oil; then esterification process is to be carried out first after that transesterification process is followed [5][6].

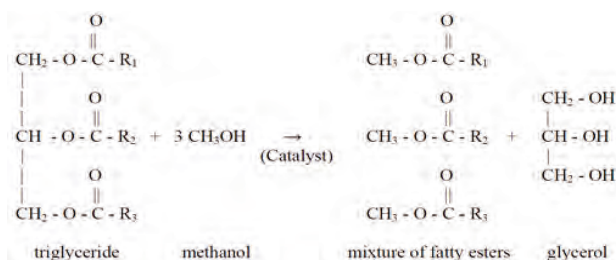
Esterification

Esterification process takes place as follows:



Steps to perform esterification process are as follows:

- In esterification process the oil sample is mixed with methanol.
- To the reactant mixture, 98% concentrated sulfuric acid (1% vol. of oil) is added as a catalyst to increase the rate of esterification reaction.
- The mixture of oil, methanol and the catalyst is allowed to react in the reactor at 60 °C for 3 hours under the stirrer.
- The reaction is stopped after 3 hours.
- The mixture obtained, consists of two layers, the upper layer of methanol and sulfuric acid and the lower layer consisting of the esterified oil [6][7].



Transesterification

Procedure for transesterification reaction is as follows:

- Add oil sample in a flask and heat it to 55 °C
- Take methanol and sodium hydroxide in another flask. Mix it for about 5 mins for it to form – sodium methoxide.
- Add this catalyst into the heated oil sample flask and let the mixture stir for 1 hr under constant temperature of 55 - 60 °C.
- After an hour of stirring, transfer the mixture into a separating funnel and let it stay there for about 12hrs.
- The mixture separates into 2 layers – upper layer being of biodiesel and lower being of glycerol [8][9].

EXPERIMENTAL SET UP & PROCEDURE

Experimental setup

Equipment used are as follows

Heating plate with magnetic stirrer, Thermometer, Beaker, cylinder, Conical flask, Separating funnel, Specific gravity bottle, Filter paper, Funnel, Ostwald viscometer, Open-cup apparatus, Burette, pipette, Sampling bottles.

Chemicals used are as follows

Feed oil, Sodium hydroxide, Potassium hydroxide, ethanol, Acetone



Fig. 2: Experimental Set-up

Procedure

The following tests were carried on the WCO sample

Following parameters were used to conduct the tests:

1. Molar ratios (oil: methanol) used are – 1:3, 1:6, 1:9 & 1:12
2. The reaction was carried out for Time duration – 30, 60 & 90 minutes.
3. Temperature variations used are – 60 °C & 70 °C .
4. Batch size – 50 ml oil sample.
5. Catalyst amount used – 0.5 gm i.e., 1% of the weight of oil taken in reaction.

The following procedures are explained for the molar ratio of 1:6

Pre-Test (Acid Number Test)

1. 1 gram of oil sample is taken in a flask to which 2-3 drops of phenolphthalein indicator is added in reaction mixture.
2. This mixture is titrated against a 0.1N KOH solution

3. Burette readings are noted down and the acid value is calculated using the formula:

$$\text{Acid Number} = \frac{\text{Volume titrant (mL)} * 0.1 * 56}{\text{mass of sample (g)}}$$

Result

The acid value obtained is 1.4 mg KOH/gm oil sample

Since acid value is < 2 mg KOH/gm oil sample, direct transesterification is used.

Transesterification Reaction:

1. Take 50 ml oil sample in a beaker and heat it to 60 °C in a water bath.
2. In another beaker take 10 ml methanol and 0.5 gm NaOH and stir it until it forms a mixture.
3. After the oil reaches the desired temperature, add the sodium methoxide to the oil and let the mixture react for 60 mins at a constant temperature of 60 °C and rpm of 400.
4. After 60 minutes, transfer this mixture in a separating funnel and let it settle for about 12 hours.
5. After that, remove the glycerol layer and give the remaining biodiesel a water wash.
6. Separate this mixture after 12 hours.

Observations



Fig. 3: FAME & Glycerol layer formation



Fig. 4: Water wash of FAME layer

Characterization

1. Yield of biodiesel is calculated as:

$$\text{Yield} = \frac{\text{Amount of biodiesel obtained}}{\text{Amount of oil used}} * 100$$

2. Conversion of biodiesel is calculated using

$$\text{Conversion} = \frac{\text{AV BL}}{\text{AV OIL}} * 100$$

3. Density of biodiesel is calculated using specific gravity bottle
4. Viscosity is measured using the Ostwald viscometer
5. Flash and Fire point are obtained using the open cup apparatus

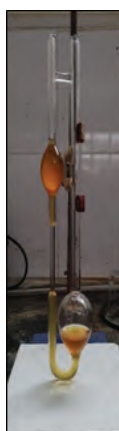


Fig 5: Viscosity measurement in Ostwald viscometer



Fig. 6: Open cup apparatus for Flash & Fire point

RESULT & DISCUSSION:

Results

The properties of biodiesel produced from waste cooking oil by transesterification are tabulated below, depending on the Oil: Methanol molar ratio.

Table 2: Data for molar ratio – 1:3 (Oil: Methanol)

Batch No.	Density of Bio-diesel (Gm/Cc)	Yield (%)	Conversion (%)	Viscosity (Cp)	Flash Pt.(°C)	Fire Pt.(°C)
1	0.89	60	70	22.62	194	202
2	0.89	72	72	21.35	196	204
3	0.889	72	72	15.28	180	192
4	0.895	60	60	30.66	196	205
5	0.885	68	76	15.16	176	185
6	0.889	74	76	30.04	185	196

Table 3: Data for molar ratio – 1:6 (Oil: Methanol)

Batch No.	Density of Bio-diesel (Gm/Cc)	Yield (%)	Conversion (%)	Viscosity (Cp)	Flash Pt.(°C)	Fire Pt.(°C)
1	0.862	79	91	6.16	192	203
2	0.839	73	80	5.95	190	200
3	0.867	84	92	5.42	192	200
4	0.81	76	92	5.62	193	202
5	0.879	88	88	11.33	190	200
6	0.867	88	92	6.05	182	196

Table 4: Data for molar ratio – 1:9 (Oil: Methanol)

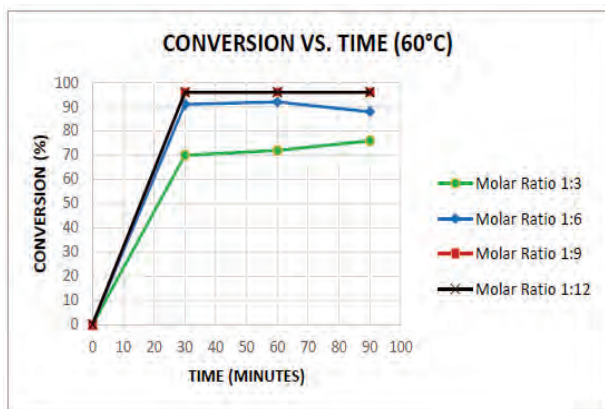
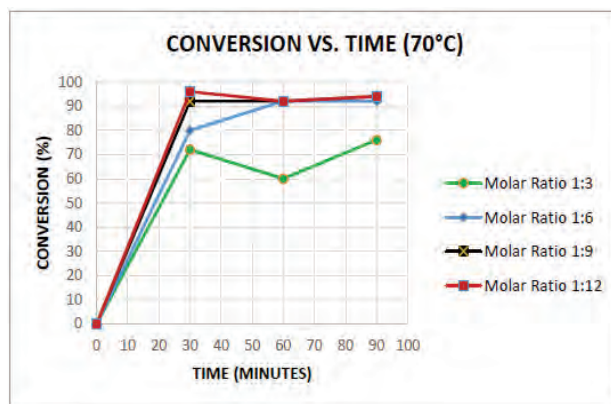
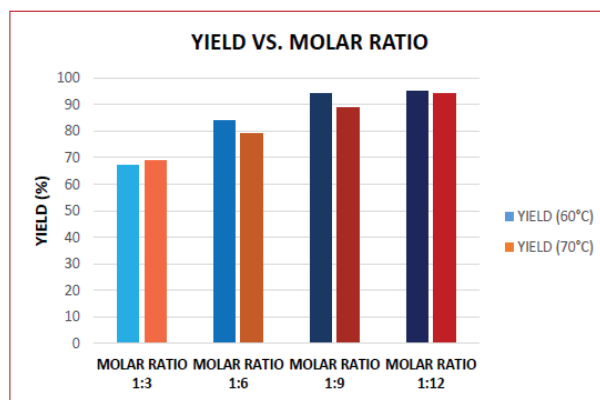
Batch No.	Density of Bio-diesel (Gm/Cc)	Yield (%)	Conversion (%)	Viscosity (Cp)	Flash Pt.(°C)	Fire Pt.(°C)
1	0.866	93	96	5.06	160	170
2	0.87	87	92	7.02	170	175
3	0.865	96	96	5.14	160	170
4	0.865	86	92	5.29	162	178
5	0.865	92	96	5.15	164	170
6	0.865	92	94	5.03	162	170

Table 5: Data for molar ratio – 1:12 (Oil: Methanol)

Batch No.	Density of Bio-diesel (Gm/Cc)	Yield (%)	Conversion (%)	Viscosity (Cp)	Flash Pt.(°C)	Fire Pt.(°C)
1	0.862	96	96	6.38	172	180
2	0.861	96	96	5.04	160	180
3	0.865	92	96	5.15	170	182
4	0.866	90	92	5.06	162	170
5	0.863	96	96	5.13	160	168
6	0.865	94	94	5.01	160	165

The data obtained from the above tables shows that the properties of biodiesel vary significantly by changing certain reaction parameters. Further, the conversion and yield are also affected by changes in molar ratio, time and reaction temperature.

Graphical Comparison

**Fig 7 (A): Conversion relation to reaction time based on molar ratio variation for reaction temperature 60 °C****Fig 7 (B): Conversion relation to reaction time based on molar ratio variation for reaction temperature 70 °C****Fig 8: Yield relation to molar ratio based on variation in reaction temperature**

The graphical comparison based on conversion and yield with respect to time clearly shows there are large variation for 1:3 and 1:6 oil: methanol molar ratios for 60°C and 70°C temperatures respectively. Although the variation in the 1:9 and 1:12 molar ratios of oil to methanol is a little when considering at a higher scale, we can conclude 1:9 as optimum considering the amount of methanol required is less and the cost of methanol recovery will be less. During the whole process, a few phases were noted, like when optimizing the amount of catalyst to be used, which should be approximately 1% of the weight of oil, because when excess catalyst is added, the process completely changes its dynamics; the process supposed to happen is replaced by the saponification reaction. Considering all the parameters and results, we can conclude that the best results are achieved at 60°C and 60 minutes reaction time for 1:9 molar ratio, giving us a conversion and yield of 96%.

COST ESTIMATION

Total Product Cost of Biodiesel

Biodiesel produced from waste cooking oil has estimated Cost is as follows. It is for a month for a plant which uses 1000 liters of feedstock (WCO) per day in Indian Rupees.

Basis: 1000 liters of WCO, 300 liters of Methanol (1:9 molar ratio) and 10 kg of NaOH catalyst (1% weight of oil)

Direct Product Cost (DPC)

1) Cost of raw material: Requirement of raw materials are feedstock of waste cooking oil, methanol and NaOH.

a) Cost of Feedstock (WCO):

Cost of WCO = Rs. 20/L

Per day cost = Rs. (20/L)*(1000 L/day) = Rs 20000/day

Per month = Rs. (20000/day)*(30 days) = Rs. 600000 cost

b) Cost of Methanol:

Price of 1 lit methanol = Rs. 20

Per day cost of methanol = Rs. (20/L)*(300 L/day) = Rs. 6000/day

Per month cost of methanol = Rs. (6000/day)*(30 days) = Rs. 180000

c) Cost of NaOH:

Price of 1 kg NaOH = Rs. 300

Per day cost of NaOH = Rs. (300/kg)*(10 kg/day) = Rs. 3000/day

Per month cost of = Rs. (3000/day)*(30 days) = Rs. 90000 NaOH

d) Total raw material cost = Rs. 600000 + Rs. 180000 + Rs. 90000

= Rs. 870000/month

Power and Utilities

Assumption

Price of 1 kWh of electricity = Rs. 7 (Industrial use)

Specific heat of water = 4.18 kJ/kgK

Specific heat of WCO = 2.34 kJ/kgK

Heat losses = 10 %

a) Electricity cost for heating of waste cooking oil from 25°C to 60°C for transesterification process:

Heat required per day = $(m \cdot C_p \cdot \Delta T) / \text{Efficiency} = (905) \cdot (2.34) \cdot (60-25) / 0.9 = 82355 \text{ kJ} = 22.876 \text{ kWh}$

Here, m = Mass of oil = (Density)*(Volume) = (905 kg/m³)*(1 m³) = 905 kg
C_p = Specific heat of WCO

Cost of Electricity per month = Rs. (7/kWh)*(22.876 kWh)*(30 days) = Rs. 4804.04

b) Cost of Electricity for stirring methanol and NaOH:

Assuming power of motor is 10 kW

Duration of stirring for thorough out mixing = 15 mins

Cost of Electricity for this stirring per month = Rs. (7/kWh)*(10 kW)*(15/60 h)*(30 days) = Rs. 525

c) Electricity cost for stirring during transesterification process:

Assume power of motor is 15 kW

Duration of stirring = 1 hour

Electricity cost per month = Rs. (7/kWh)*(15 kW)*(1 h)*(30 days) = Rs. 3150

d) Cost of Electricity for heating of water from 25°C to 40°C for water washing:

Heat in form of energy required for heating 1000 kg water = $(m \cdot C_p \cdot \Delta T) / \text{Efficiency} = (1000) \cdot (4.18) \cdot (40-25) / 0.9$

= 69666.7 kJ = 19.352 kWh

Electricity cost per month = Rs. (7/kWh)*(19.352 kWh)*(30 days) = Rs 4063.89

e) Cost of Electricity for final heating of oil to 110°C to remove water if present:

Heat energy required = $(m \cdot C_p \cdot \Delta T) / \text{Efficiency} = (905) \cdot (2.34) \cdot (110-25) / 0.9 = 200005 \text{ kJ} = 55.557 \text{ kWh}$

Cost of Electricity per month = Rs. (7/kWh)*(55.557 kWh)*(30 days) = Rs. 11667

f) Total Power and Utility Cost = Rs. (4804.04 + 525 + 3150 + 4063.89 + 11667) = Rs. 24209.93/month

3) Miscellaneous Cost: It includes labour cost, maintenance & repair, laboratory chargers.

a) Labour cost = Rs. 9000/month

- b) Maintenance & Repair = Rs. 5000/month
 c) Laboratory charges = Rs. 20000/month
 d) Total miscellaneous cost = Rs. 9000 + Rs. 5000 + Rs. 20000 = Rs 34000/month
- 4) Total DPC = Rs. 870000 + Rs. 24209.93 + Rs. 34000
 = Rs. 928210 /month
- 5) Fixed Charges = Rs. 100000
- 6) Plant overhead cost (POC):
- a) Medical Aid = Rs. 2000/month
 b) Safety = Rs. 5000/month
 c) Packaging = Rs. 5000/month
- d) Total POC = Rs. 2000 + Rs. 5000 + Rs. 5000 = Rs. 12000/month
- 7) Manufacturing Cost = Total DPC + Fixed Charges + Total POC
 = Rs. 928210 + Rs. 100000 + Rs. 12000
 = Rs. 1040210/month
- 8) General Expenses = Rs. 1000000/month
- 9) Total Product Cost = Manufacturing Cost + General Expenses
 = Rs. 1040210 + Rs. 1000000
 = Rs. 2040210/month

Now, Quantity of biodiesel produced per month with a yielding efficiency of 96%

$$= (30 \text{ days}) \times (1000 \text{ L}) \times (0.96) = 28800 \text{ liters}$$

Therefore,

Cost of Biodiesel per liter = Total Product Cost per month / Biodiesel produced per month

$$= \text{Rs. } (2040210/\text{month}) / (28800 \text{ L})$$

$$= \text{Rs. } 70.84 \text{ per liter}$$

CONCLUSION

Our project aimed to optimize production of biodiesel by varying reaction parameters like molar ratios, temperature, and reaction time. Based on the obtained results, the following conclusions were drawn:

1. Acid value: A comparison of the initial acid value of the various waste cooking oil (WCO) and the resulting

biodiesel formation to the conclusion that the free fatty acids in WCO were effectively converted into fatty acid methyl ester, which is the main component of biodiesel.

2. Molar ratios: Gradually varying the oil to methanol molar ratio revealed that higher ratios, specifically 1:6 and 1:9, resulted in increased conversion and yield of biodiesel compared to the 1:3 ratio. The 1:3 ratio yielded less biodiesel, and a noticeable layer of glycerol was observed. Additionally, the viscosity of biodiesel obtained from the 1:3 ratio exceeded the standard viscosity, while the viscosity of biodiesel from the 1:6 and 1:9 ratios fell within acceptable limits.
3. Cost Estimation: The cost analysis gives idea about the feedstock (WCO) accounted for 69% of the total raw material cost. The total raw material used in the transesterification process constituted 43% of the total product cost. The estimated production cost of biodiesel was around Rs. 70.84 per liter. However, it is important to consider socio-economic benefits such as pollution reduction and employment generation, which would significantly affect the overall cost.

After comparing all the results, we came to final result that the optimum yield and conversion of biodiesel were achieved at an oil to methanol molar ratio of 1:9. This favorable outcome was observed at particular reaction conditions, namely a reaction temperature of 60°C and a reaction time of 60 minutes. Biodiesel produced under this ratio exhibited properties, such as viscosity, density, flash point, and fire point, that closely aligned with standard values.

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Mass Damping of Structures with TMD

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ABSTRACT

In the design of high-rise buildings, there is an increased focus on lighter members, serviceability issues such as floor vibration and lateral sway, and occupant comfort. Structural engineers define “slender” skyscrapers as having a minimum ratio of 1:10 or 1:12, respectively. What we intend to develop is a G+126-story structure that rises to an astounding 440.5 meters above earth. Structural stability will be taken into consideration during building design. The intended TMD will be installed on top of the building. The amplitude at which the frame experiences sinusoidal ground motion in the absence of TMD is known as the point of resonance. When high lateral forces, such as wind or seismic vibrations during earthquakes, are encountered by a structure, the amplitude of the vibration is reduced by installing TMDs on the structure. A tuned mass damper system is simply a pendulum that is attached to something that oscillates in the opposite direction of the wind or seismic activity, such as a heavy metal body or object. Passive control systems that save energy are cheap, easy to maintain, and repair. They work according to Newton’s theory of energy conservation, gathering and storing energy without squandering it in order to dampen things down.

KEYWORDS: *G+126 Storey building, Seismic analysis, Slender buildings, Tuned mass damper system (TMD), Wind load analysis.*

INTRODUCTION

Buildings having a width to height ratio of at least 1:10 are considered ultra-slim. According to structural engineers, skyscrapers are considered “slender” if they have a minimum ratio of 1:10 or 1:12. Pencil towers are very thin, very tall buildings with a very high ratio of slenderness. They are also known as skinny skyscrapers, pencil-thin buildings, super-slim towers, and pencil-thin towers. In the late 19th and early 20th centuries, Manhattan saw the construction of its first thin skyscrapers prior to zoning limitations.[1] The new designs were encouraged by the rising cost of land, and they were made feasible by the use of steel frame construction and elevators, which allowed for the construction of bigger structures. Special precautions must be taken for thin towers to offset the wind’s stresses on the vertical cantilever.[2]

Structures can experience less vibration because to devices

called tuned mass dampers (TMDs). They go by the names seismic dampers or vibration absorbers as well. TMDs are installed on a structure to lessen vibration amplitude in the event of a strong lateral force, such as an earthquake or severe winds. Generally, practical systems are tuned to move the principal mode away from an uncomfortable excitation frequency, or to offer damping to a resonance that is expensive or difficult to directly damper. An example of the latter is a crankshaft torsional damper.[3] Mass dampers, like shock absorbers in cars, are often employed in conjunction with a frictional or hydraulic component that releases heat when mechanical kinetic energy is converted. TMDs can prevent damage, discomfort, or total structural collapse.[4]

TUNED MASS DAMPER SYSTEMS (TMD)

A tuned mass damper (TMD), attached to a structure to reduce the dynamic response of the structure, consists of a mass, a

spring, and a damper. The damper's frequency is set to resonate out of phase with the motion of the structure when a certain structural frequency is awakened. Energy is dissipated by the damper inertia force acting on the structure. The first use of the TMD idea was made by Frahm in 1911 to reduce rolling motion and ship hull vibrations. TMDs' appropriateness is determined by their dynamic qualities, stroke, and extra mass measurement. The ratio of the damper mass to the strong mass of the structure in the intrigue approach determines how much more damping the framework offers. This is typically the case with TMDs, which weigh between 0.25 and 1.0% of the structure's weight in the major mode.[5]

Active control

A system that can evaluate the structure's current state, decide on a plan of action to get it into a more desired state, and carry out this plan of action swiftly and effectively is known as an active structural control system. In theory, these control systems can theoretically meet stringent performance requirements in a range of operational scenarios, compensate for the breakdown of a few structural elements, and adjust to unforeseen changes in the surrounding environment. Moreover, they could be able to offer more affordable and reliable technical solutions for a range of uses.[6]

Active motion control is accomplished by incorporating a control system comprising three main components into the structure: (1) an actuator, a collection of physical components that executes commands from the controller; (2) a cognitive module known as the controller that makes intelligent decisions about what to do; and (3) a data acquisition system known as the monitor. This control technique is now possible because to significant advancements in real-time information processing, intelligent decision systems, sensor and actuator technologies, and real-time information processing.[7]

Design of Damper

After the study is completed, the mass of the structure is taken out of the ETABS data tables. Both the mass of the individual tale and the mass of the entire structure as a whole are provided by ETABS. When computing the damper design, the mass of the structure below ground is disregarded. Therefore, the structure's mass above ground is taken into account. As previously said, throughout this project, we underwent several iterations. Therefore, the mass of the initial two variants was disregarded. For computations, the mass of designed version, or the undamped structure, is taken into account.[8]

Type of system = Pendulum Type Damper (Passive Type Damper) Mass of Undamped Structure (m) = 240618571 kg.

k : Force / Displacement (1)

Stiffness factor (f) = 3.2×10^6 N/m

Angular Frequency, $\omega : (k / m)^{1/2}$ (2)

Angular Frequency (ω) = 0.115 rad/sec

Time Period, $T : 2 * \pi * (m/k)^{1/2}$ (3)

Time Period, $T = 54.48$ sec

Damping Ratio (ξ) = 15% = 0.15

Mass of Damper (m_d) = 1100000 kg (1100 ton) Material of Damper – SS304 (Stainless steel plates) Specific Gravity (Gs) = 10.2

Unit Weight = 7930 kg/m²

Length of Damping Wire/Cable (k_d) : $(m_d * g) / (L)$ (4)

Length of Damping Wire/Cable = 741.77 m Dimensions of Damper = 2.96 m

SECTION PROPERTIES

Section properties necessary for the modeling were developed after the material properties were established. The fundamental computations of the beams, columns, and slabs served as the foundation for defining the attributes of the sections. Later, some of the portions were changed in light of the analysis's findings. The Frame Section Properties form displays the section properties. These values are either (a) built-in and imported section type defaults, or (b) automatically calculated by ETABS based on established dimensions. The following are these section attributes and their calculations:

Column Sections

Column Sections have been selected based on conventional methods of designing column for RCC building. Sample calculations are described below.

The sizes of columns are listed below:

1. Column 400 mm x 800 mm
2. Column 800 mm x 400 mm
3. Column 800 mm x 800 mm
4. Column 1000 mm x 1000 mm



Fig. 1: Column Section Property Data

Shear Wall Sections

Following shear wall thickness have been adopted:

1. Shear Wall 200 mm
2. Shear Wall 300 mm
3. Shear Wall 400 mm

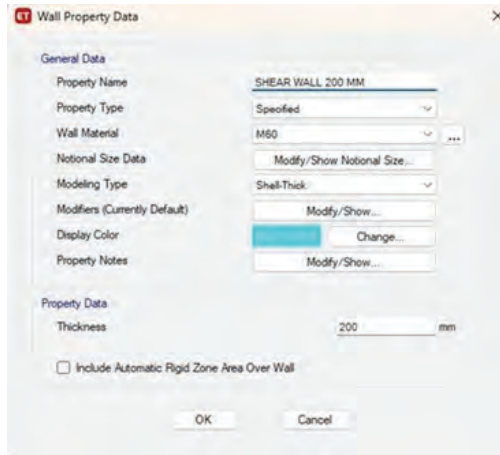


Fig. 2: Shear Wall Property Data

Beam Section

Beam Sections have been selected based on conventional methods of designing beam for RCC building. Sample calculations are described below.

The sizes of columns are listed below: -

1. Beam 300 mm x 600 mm
2. Beam 400 mm x 600 mm
3. Beam 400 mm x 900 mm
4. Beam 400 mm x 1000 mm



Fig. 3: Beam Section Property Data

Slab Section

Slab Sections have been selected based on conventional methods of designing slab for RCC building. Sample calculations are described below.

The sizes of columns are listed below:

1. Slab 150 mm
2. Slab 220 mm
3. Slab 250 mm
4. Slab 300 mm

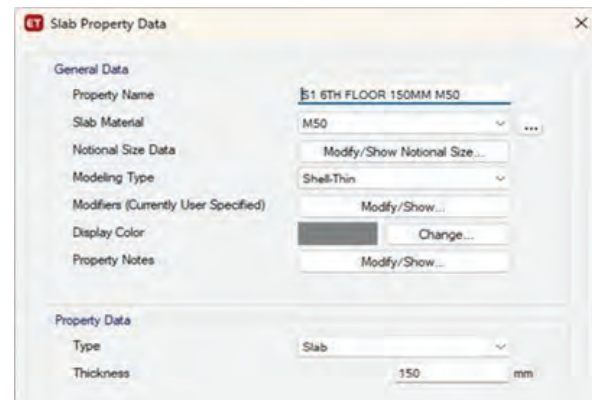


Fig. 4: Slab Property Data

LOAD CASES AND LOAD PATTERNS

Over the course of its service life, a building is subjected to several loads. We have defined a few load cases in order to analyze these loads. These load situations consist of the following: earthquake loads (EL) in X and Y directions, wind loads in X and Y directions, dead load (DL), live load (LL), superimposed dead load (SIDL), and earthquake loads (EL) (WL). Referred to for the earthquake load instances is IS 1893:2016. Using IS 875 Part 3 the wind loads have been calculated using that method.

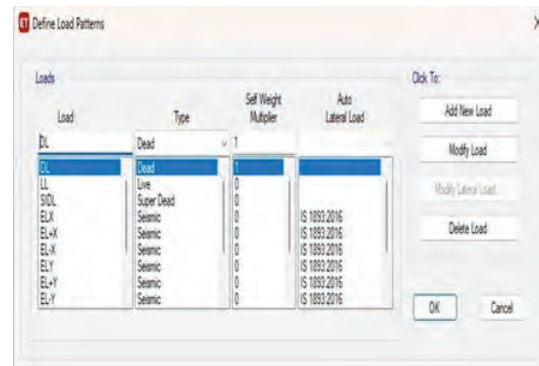


Fig. 5: Load Patterns Input

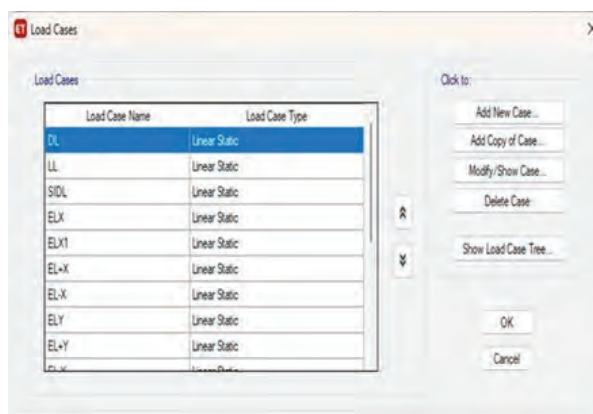


Fig. 6: Load Cases Input

Load Combinations

Load combinations are an important part of structural engineering and every building must be analysed using load combinations mentioned in various IS codes as per requirements of the building. Load combinations includes feeding various load combination scenarios which could possibly act on the building at a time during its service life. The software uses all the combination trials to render the structure to worst load combination case for all the structural elements so the resultant structure is safe for all conditions. In our project, due to the super slender nature of the structure we have accounted 111 load combinations.

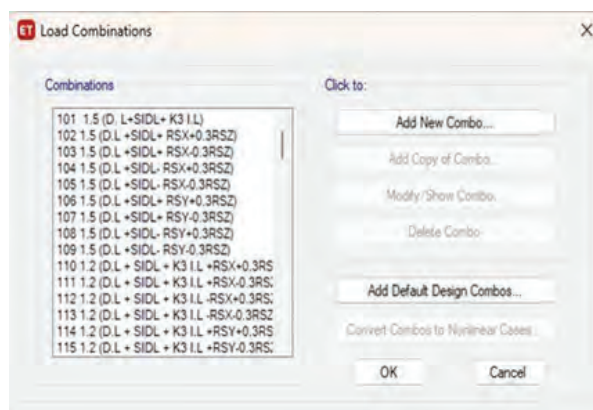


Fig. 7: Load Combinations Input

ANALYSIS AND RESULTS

The maximum story displacement analysis for a given range of stories and a chosen load case or load combination is presented in this paper. Making educated decisions about the safety and stability of the examined structure is made easier with the help of this report, which offers insightful information on the displacement characteristics and structural response.

Wind Load (WL) In X Direction

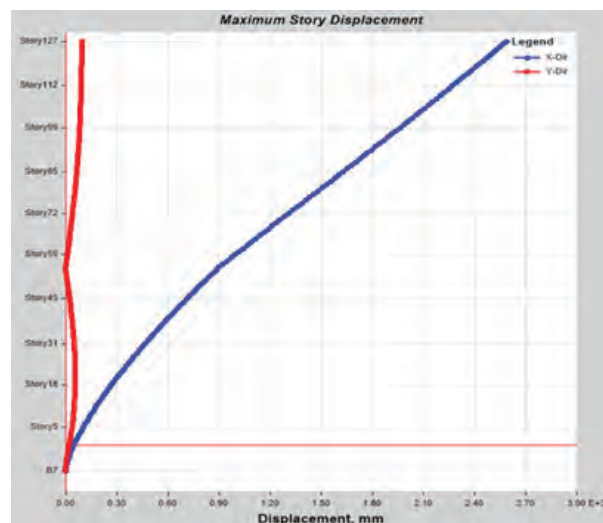


Fig. 8: Wind Load (WL) In X Direction

The maximum displacement occurs at the top story (Story127), with a significant displacement of 2588.162 mm in the X- direction and 95.904 mm in the Y-direction. This indicates that the topmost portion of the structure experiences the highest deformation under the applied load case.

Wind Load (WL) In Y Direction

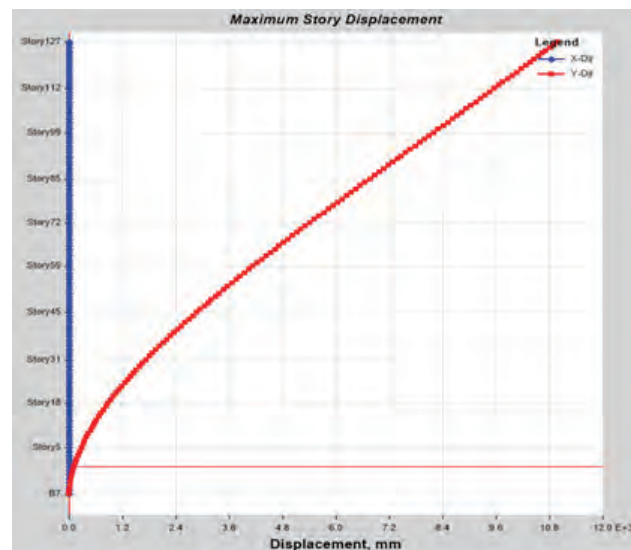
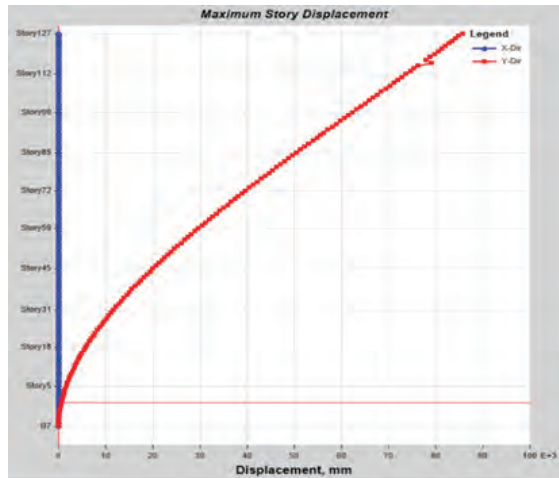
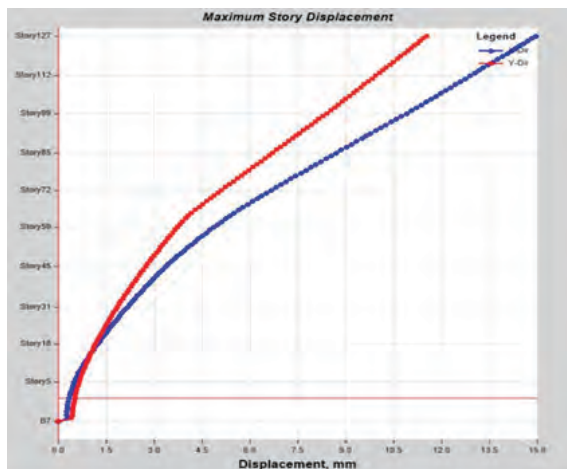


Fig. 9: Wind Load (WL) In Y Direction

The maximum displacement occurs at the top story (Story 127), with a displacement of 3.926 mm in the X-direction and a significant displacement of 10990.408 mm in the Y-direction. This indicates substantial deformation at the uppermost level of the structure.

Live Load (LL)**Fig. 10: Live Load (LL)**

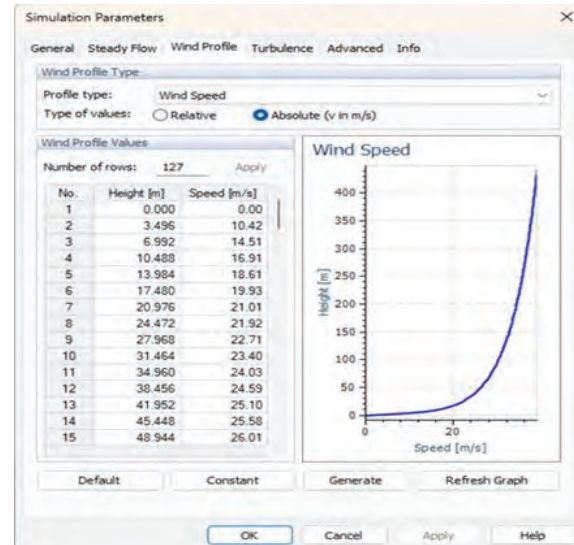
The maximum displacement occurs at the top story (Story 127), with a displacement of 8.715 mm in the X-direction and a significant displacement of 85719.068 mm in the Y-direction. This indicates substantial deformation at the uppermost level of the structure. The data indicates that the structure experiences significant deformation at higher levels, which gradually diminishes towards the base.

Dead Load (DL)**Fig. 11: Dead Load (DL)**

The maximum displacement occurs at the top story (Story 127), with a displacement of 14.95 mm in the X-direction and a significant displacement of 11.55 mm in the Y-direction. This indicates substantial deformation at the uppermost level of the structure. The data indicates that the structure experiences significant deformation at higher levels, which gradually diminishes towards the base.

Analysis of Digital Wind Tunnel

RWIND is the software which provides the analysis for Digital Wind Tunnel. The same was used by us in this project. The ETABS model which consists of the damper installed at 120th story is imported into RWIND software. The digital wind tunnel is modelled in both X and Y directions. The size of the digital wind tunnel is auto selected by the software to obtain accurate results. The wind velocity considered is considered to 39 m/sec (Pune Region), as shown in Fig. 12.

**Fig. 12: Wind Profile Values****CONCLUSION**

Optimal reduction occurs at a frequency ratio closer to the resonance point once the damper is used. At that point, the frequency ratio starts to approach unity. Peak displacement decreases with increasing mass ratio up to a certain mass ratio, then increases with subsequent mass ratio increments. When tuned to the fundamental (1st mode) frequency of the structure, it reduces displacement responses of structures more effectively. Using a high damping ratio is more efficient.

The beating effect is more noticeable at higher beat frequencies. It becomes less noticeable as the forcing frequency gets closer to the fundamental frequency, and it disappears completely at resonance. Parameters like tuning ratio, frequency ratio, and mass ratio are highly useful tools for minimizing structural response.

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Application of Graphene Based Concreting in Developing Sustainable Road Infrastructure

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ABSTRACT

In today's world, the construction industry is growing at a rapid pace. With this there is also increase in carbon footprint, which is a major threat that possess towards global warming. One of the major component of construction industry is road infrastructure. Addition of Graphene Oxide (GO) in concrete can give sustainable and ecofriendly solution in road infrastructure. Graphene is a simple substance with complex properties. Graphene is just a single layer of carbon atoms arranged in a hexagonal matrix. Construction of Road with Graphene based concreting can increase strength. Use of graphene concrete road may reduce the timescales for roadworks, improving safety and significantly reducing carbon footprint. Also it will reduce the aging effect caused by ultraviolet light to further extend the life and durability of its roads. In a world where all the cars could be electric in future, creation of such road which contains an element, GO that conducts electricity could allow recharging the car's battery directly from the road while waiting at a stop light or while a car is parked anywhere along a street. Concrete materials represent a huge investment and energy usage as well as pollution. This lead to significant environmental impacts. Thus, there is a need to choose the most sustainable and eco-friendly alternative. Owing to this problem creation of graphene-based concreting can bring a major change in construction industry. In this paper we are presenting the review of graphene-based concreting in road infrastructure.

KEYWORDS: Carbon footprint, Characteristics of Graphene, Graphene Oxide (GO), Graphene based Concreting, Sustainable concrete.

INTRODUCTION

Motorways and different transportation infrastructure are crucial for economic expansion and societal advancement. Due to their accessibility, malleability, and high compressive strength, concrete have been widely used in construction. However, these materials have intrinsic flaws that can lead to poor durability and high maintenance costs, such as brittleness, low tensile strength, and susceptibility to harsh conditions [1]. New technologies and materials have been developed to solve the shortcomings of conventional building materials. One such advancement is the graphene use in the building of

roads. Graphene, a two-dimensional carbon allotrope, offers remarkable mechanical properties as it shows strength and high surface area [3]. GO, a derivative of graphene, is particularly suitable for enhancing the concrete properties used in road pavement. It makes an appealing candidate for enhancing the performance and durability of concrete because of its excellent water disperse ability and compatibility with other materials. The integration of nanotechnology in several industries, including road construction, has proven promising results. Nanomaterials, through chemical and physical processes, can enhance material qualities such as thermal conductivity,

mechanical strength, electrical conductivity, and more [4]. By integrating GO or other nanoparticles into concrete, the resulting composite can demonstrate greater tensile strength, reduced permeability, higher durability, and increased resistance to environmental deterioration.

In 2004, Andre Geim and Konstantin Novoselov made the remarkable discovery of graphene, a two-dimensional carbon-based substance. Graphene was created using a technique called mechanical exfoliation from bulk graphite. Graphene has emerged as one of the most promising nanomaterials for various applications [2]. Due to its hydrophilic properties and capacity to easily disseminate the resulting cementitious mix in water, GO has proven a viable alternative to pristine graphene in concrete composite [19].

Water-stabilized graphene dispersions were added to nano engineered concrete, increasing its compressive and flexural strengths by up to 146% and 79.5%, respectively, while also improving its electrical and thermal performance. This innovative composite material is perfectly suited for construction in places vulnerable to floods since it has a surprising drop in water permeability by over 400% when compared to regular concrete [5]. The reduced water permeability may increase the applications in which concrete may be used, for example rendering the material better suited to use in applications in areas subjected to flooding.

The objectives of the study are to review an experimental result comparison between conventional concrete and GO concrete in terms of compression and flexural tension, aiming to evaluate their respective strength characteristics for road applications. Additionally, the research aims to determine the most sustainable course of action by identifying environmental weak points in materials and products, establishing a standard for assessing advancements. The study also seeks to study related with reduction in CO₂ production and develop an eco-friendly concrete, while proposing a solution for resource optimization [11-14].

GRAPHENE

Graphene Oxide

Graphite material is treated with potent oxidizers such as fuming nitric acid and potassium chlorate to produce GO (shown in Fig. 1). By introducing oxygen atoms to the carbon, tightly packed graphite layers are loosened using this technique. The sequential formation of GO from

solid graphite is described [8] as follows: (1) graphite is transformed into graphite intercalation compound (GIC), (2) GIC is then transformed into oxidized graphite as Pristine Graphene Oxide (PGO), and (3) exposure of the PGO to water yields conventional GO, where it undergoes hydrolysis of covalent sulphates and loses all interlayer registry.



Fig. 1. Graphene Oxide

GO forms stable colloids in water because it has a single layered, two-dimensional sp² hybrid structure and enough hydrophilic surface groups. GO, however, accumulates in physiological buffers because of the salts present, which has a charge-screening effect. GO and Reduced Graphene Oxide (rGO) both glow at a specific wavelength and have the capacity to absorb NIR (Near Infra-Red), visible, and Ultraviolet rays (UV) light. However, the underlying causes of the fluorescence remain unknown. Three different types of functional groups, C-O, C double bond O, and O double bond C-OH, on GO were discovered to be involved in GO fluorescence, per a study by Shang et al. Because of its increased NIR light absorption, GO is a powerful photo thermal agent. The rGO produced through PE Gylating is superior to ultra-small GO [8-9].

Synthesis of Graphene Oxide

Hummers' method is approach to create GO. The step-by-step procedure is as follows:

- In 50 mL of water, 2 gm of graphite flakes combined 2 gm of NaNO₃,
- H₂SO₄ (98%) held at ice bed bath (0–5 °C) with constant stirring,
- After stirring the mixture kept for two hours the same temperature, potassium permanganate (6 g) was progressively added to the suspension. To preserve the temperature reaction below 15°C, the rate of addition was sensibly man- aged.

- d) The mixture was disturbed at 35°C until it twisted pasty brownish and kept continuously stirring for two days, then the ice bath was removed.
- e) This mix gradually thinned through 100 cc of water. With foaminess, the color transformed to brown as the temperature reaction was speedily elevated to 98°C
- f) Additional 200 ml water added to the brown color solution, which was continually disturbed.
- g) In order to stop the reaction by the emergence of a yellow color, the solution is finally treated with 10 ml H₂O₂.
- h) The prepared amalgamation cleansed multiple times with 10% HCl and deionized (DI) wate.
- i) The GO was produced as a powder after filtration and drying under vacuum at room temperature [10-11].

Properties of Graphene

The exceptional mechanical property given by graphene is tensile strength of 1.3×10^{11} N/mm². Additionally, its remarkable lightness, weighing only 0.77 mgm⁻², further enhances its appeal. By leveraging its unmatched mechanical strength, graphene has the potential to significantly augment the strength of various composite materials.

With respect to electronic properties, graphene exhibits fluid electron transport due to its delocalized pi-electron system spanning its entire surface. The overlapping pi-electrons in graphene prevent the existence of a band gap, enabling electrons to move freely without requiring additional energy. Graphene's exceptionally high electrical mobility allows its electrons to behave akin to photons in terms of mobility capacity [14].

Concerning thermal properties, graphene excels as a heat conductor within a plane owing to its regular structure. However, interplanar thermal conductivity presents a challenge, which can be improved by incorporating the nanomaterials like carbon nanotubes (CNTs). The graphene structure allows phonons to freely travel in any given surface point. In-plane thermal conductivity ranges between 300 and 5000 W m⁻¹ K⁻¹ for a single-layered sheet, while weak inter-plane vander Waals interactions contribute to a cross-plane conductivity as low as 6 W m⁻¹ K⁻¹. Although the heat of the electronic gas in graphene is estimated at around 2.6 J, the precise determination of graphene's specific heat capacity remains unresolved [13].

Methodology Process of adding Graphene Oxide in Concrete

The process includes by introducing graphene powder with water, and a surfactant in the form of sodium cholate to a vessel, and mixing the ingredients with a high shear mixing equipment. The presence of the surfactants causes the powdered graphite or graphene to be suspended in the water in a generally uniform manner. The high shear mixing device rotates at a high rate of speed between 5000 and 8000 rpm. This high rate of rotation causes the water to travel with such a strong shear forces that causes the powder to exfoliate to create graphene flakes. As an example, the graphene flakes could only contain 10 or less layers. To exfoliate essentially all of the powder, the mixing equipment is run for a period of time of around two hours. The removal of any comparatively heavy leftover powder material can be done by removing the suspension of water and graphene. A significant amount of agglomeration is prevented by the surfactant's presence, which also helps to maintain the essentially uniform suspension of graphene in water. After the creation of graphene water suspension, concrete is made by combining the suspension with a cementitious material like Portland cement, sand, and aggregate or gravel. The suspension is mixed with the cementitious material, sand, and gravel in a manner similar to the conventional process for making concrete, with the exception that the water is replaced by the suspension [20].

RESULT AND DISCUSSION

Concrete with around 0.03% graphene shown compressive strength on 7th day as 34.215 N/mm² and on 28th day the compressive strength was 49.775 N/mm² whereas with 0.05% GO in concrete compressive strength on 7th day was 30.55 N/mm² and on 28th day 45.579 N/mm². With 0.02% addition of GO in concrete. Compressive strength was decreased by around 10% [15]. Similar effect of different percentage graphitic oxide found on 7th and 28th day compressive strength by other researchers [3, 7, 16] as shown in Table 1.

According to the compression test findings, cement replacement after 28 days enhanced strength by 0.1% in 8.97% and 0.3% in 5.12%. According to the findings of the flexural test, the strength rose by 0.1% at 13.14 percent and by 0.3% at 8.57 percent after 28 days [3].

As shown in Table 2 split tensile strength reverse effect were found with increase of GO content in concrete. The

split tensile strength on 7th day was 2.829 N/mm² and on 28th day was 3.324 N/mm². Around 10% increase in split tensile strength was found with increase in GO content [15]. Other researchers have found a similar effect on Split tensile Strength with different percentages of GO on the 7th and 28th days [3, 7, 16] as shown in Table 2.

Review of experimental results [3, 7, 15, 16] shown effects of decrease in workability with GO content increase.

However, it has greatly decreased the initial surface absorption and increased the compressive strength by 21–55% and tensile strength by 16–38% [16].

The inclusion of GO raises the density of the cement matrix and enhances the cement paste's level of hydration, making the final product more durable [7]. Comparison of results with GO inclusions is explained with Table 1 and Table 2.

Table 1. Testing Results of Compressive Strength on GO Concrete

Mix	Percentage of GO in concrete	Compressive Strength (N/mm ²)				Reference
		7th day	28th day	7th day	28th day	
M1	0.03,0.05	34.215	49.775	30.55	45.579	[15]
M2	0.04,0.06	24	34	26	33	[16]
M3	0.1,0.3	19.4	33.11	18.89	32.02	[3]
M4	0.1,0.2	18	23.87	17.12	22.05	[7]

Table 2. Testing Results of Split tensile Strength on GO Concrete

Mix	Percentage of GO in concrete	Compressive Strength (N/mm ²)				Reference
		7th day	28th day	7th day	28th day	
M1	0.03,0.05	2.829	3.324	3.184	3.607	[15]
M2	0.04,0.06	2.7	2.9	2.8	3.0	[16]
M3	0.1,0.3	3.5	4.95	3.75	4.75	[3]
M4	0.1,0.2	2.41	2.85	2.33	2.57	[7]

Case Study

Graphene is being mixed into newly paved UK roads in a world-first resurfacing project on a section of the A1 that spans approximately five kilometers in Northumberland, in the northeast of England, a graphene trial project was launched in September 2021. For the first time, it was used entirely on the ground in the Northumberland project, starting with recycled asphalt. It is a component of an investigation to see if graphene actually lengthens the pavement's usable life and lessens the need for maintenance and replacement. The Graphene Engineering Innovation Centre of the University of Manchester, Pavement Testing Services, and the British National Highways Authority collaborated on the development of the A1 renewal project. If this pilot experiment is successful, using graphene would not only increase highway capacity but also promote sustainability [17]. Use of GO in road construction is possible with the concrete road, as addition of around 0.03% GO gives boost in concrete compressive strength along with split tensile strength [3,15].



Fig. 2. A1 renewal project [17]

Summary

As the road infrastructure is progressing day by day the count of carbon emission in the atmosphere is increasing at a rapid pace, as a solution for future addition of GO in concrete reduces the count of carbon present in atmosphere due to its absorbing phenomenon. Owing to the characteristics of graphene, there may be even more

opportunities in the future as it is used more frequently in electronic gadgets and engineering projects like motorways. The fact that the road contains a substance that transmits electricity so easily may enable there to be an increasing number of these roads in a world when all automobiles may be electric. When a car is stopped anywhere along a roadway or when at a stop signal, the ability to recharge the battery directly from the road may no longer be science fiction. Using of GO in concrete as an ecofriendly material in road infrastructure reduces waste in the environment. Use of GO in concrete road infrastructure will be environmental and economical way towards sustainable development.

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Seismic Analysis of Buckling Restrained Braced-Diagrid Structure

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ABSTRACT

This study examines the seismic performance of Steel-Diagrid and BRB-Diagrid structures, emphasizing the importance of robust lateral framing systems in high seismic zones to effectively resist seismic forces. Lateral load resistance can be achieved through either interior or exterior structural frameworks. The Diagrid structure relies on the axial action of diagonal members situated along its periphery, while the BRB system provides lateral load resistance through its notable ductility and energy dissipation capabilities. However, research on the integration of BRB and diagrid systems remains limited. The primary goal of this study is to evaluate the seismic performance of Steel-Diagrid and BRB-Diagrid structures. A comparative time history analysis was conducted using five different earthquake ground motions across three types of structures—framed, steel-dia-grid, and BRB-dia-grid—each consisting of 20 stories, totaling 18 models. The design of the BRB components was performed according to AISC 341-05 standards. Modeling and analysis were executed using ETABS 2016 software. The results of the comparative analysis are discussed, highlighting a significant improvement in the structural stability of diagrid systems when diagonal columns are substituted with BRB members.

KEYWORDS: *Diagrid structural system, Buckling Restrained Braces (BRB), Time history analysis, AISC 341-05.*

INTRODUCTION

Diagrid structures consist of a framework made up of beams arranged in a diagonal grid pattern. They are commonly used in the construction of high-rise buildings and roofs, offering both structural efficiency and appealing architectural design. The diagonal members function as both inclined columns and bracing elements, effectively supporting gravity loads and resisting lateral forces while reducing shear racking effects. On the other hand, the BRB (Buckling Restrained Brace) system is a seismic load-resisting framework that includes beams, columns, and buckling restrained braces. Unlike traditional braces, BRBs can deform under tension and compression without buckling, resulting in symmetrical hysteretic behavior during seismic events.

In the last twenty years, diagrid and BRBFs (Buckling Restrained Braced Frames) have become increasingly popular as primary seismic force-resisting systems (SFRS). They are widely utilized in both new constructions and retrofit projects, thanks to their cost-effectiveness, straightforward design, and substantial stiffness and ductility. Numerous studies have been conducted to validate the behavior and performance of both diagrid and BRB structural systems.

The literature review indicates that diagrid and BRB structural systems are more effective in enhancing the seismic performance of structures compared to traditional braced systems when subjected to lateral loads. Several studies have explored various geometric configurations (angle variations) of diagrid systems. However, there has been no research specifically addressing the combination of BRBs and diagrid structures. Therefore, this study will investigate the use of BRBs as diagonal members in diagrid systems with varying angles.

The primary objective of this research is to investigate the seismic performance of the BRB-Diagrid and Steel-Diagrid structures.

SPECIFICATIONS OF BUILDING

Building Parameters

The design of the BRB follows the AISC 341-05 guidelines, which outline seismic provisions for structural steel buildings from the American Institute of Steel Construction. This study will assess the impact of height variation on the seismic response of structures, focusing on a 20-story building. Modeling and analysis will be conducted using ETABS 2016, a commercial software. Linear Time History Analysis will be executed for G+20

frame, steel-diagrid, and BRB-diagrid structures. The ground motion data used for this analysis is sourced from the Earthquake Engineering Research Institute (EERI) in California. The earthquakes selected for the time history analysis include events from North-East India (1986), the India-Bangladesh border (1988), the India-Burma border (1988), Uttarkashi (1991), and Chamoli (1999). Table 1 presents the parameters of the buildings considered in this research. Table 1 shows parameters of building considered in this study.

Table 1: Parameters of Building

Sr. No.	Description	Values
i.	Type of Structure	Composite
ii.	Grade of Steel	A992Fy50
iii.	Grade of Concrete	4000 psi
iv.	Plan Dimension	36 m x 36 m
v.	Floor to Floor Height	3.3 m
vi.	No. of Storeys	10, 20, 30
vii.	Beam Size	W 600
viii.	Column Size	W 475
ix.	Size of Diagrid Member	400 mm x 400 mm x 25 mm
x.	Size of BRB Member	StarBRB 52.0
xi.	Slab Thickness	150 mm
xii.	Diagonal Angle	Upper Storey: 65.56° Lower Storey: 73.14°

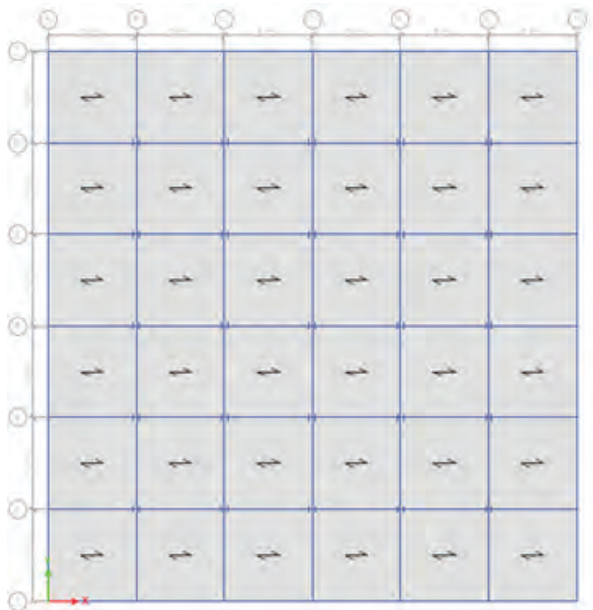


Fig. 1. Plan of G+20 story building

Tables 2 and 3 present the stiffness and fundamental time periods for the frame, steel-diagrid, and BRB-diagrid structures. The stiffness of the BRB-diagrid is greater than that of both the frame and the steel-diagrid structures, attributed to the properties of the BRB elements and their connections to the building's periphery. Additionally, the time period of the BRB-diagrid is shorter than that of the steel-diagrid and framed structures. The diagonal members of the BRB-diagrid and steel-diagrid structures are more effective at resisting lateral forces compared to the framed structure. While the time period typically depends on the mass and stiffness of a structure, all models in this study have similar mass; thus, the variations in time period are due to differences in stiffness. Generally, stiffness is inversely related to the time period: as stiffness increases, the time period decreases.

Table 2: Stiffness

	Stiffness (kN/m)
Frame	204094.42
Steel-Diagrid	392723.73
BRB-Diagrid	447804.02

Table 3: Fundamental Time Period

	Fundamental Time Period (s)
Frame	4.34
Steel-Diagrid	1.29
BRB-Diagrid	1.21

Slope variation in Diagrid Structure

Based on the results of the previous study on diagrid structure with uniform and gradually varying angles, an optimal angle range was found. Diagrid structures are designed using the uniform optimal angle for each height approximately as the median angle of changing angles. Lateral stiffness of the diagrid structure is increased and consequently its maximum displacement is reduced. Considering the fact that bending moments increase drastically towards the base and govern the design of the lower portion, while shear forces increase almost linearly and generally govern the upper portion of diagrid structure, it is presumed that the diagonal angles of diagrid should become steeper towards the base. In this study, set of two angles has been considered for analysis. For lower storey angle of 73.14° and for upper storey angle of 65.56° is considered. Fig. 2 shows elevation and 3D view of diagrid structure with angle variation for G+20 buildings.

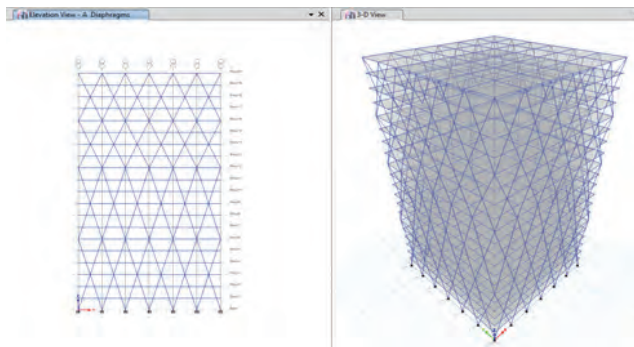


Fig. 2: Elevation and 3D view of G+20 building

Seismic Response of Structure

Linear Time History Analysis was performed on G+20 frame, steel-diagrid and BRB-diagrid structures. Ground motion data for time history analysis is obtained from Earthquake Engineering Research Institute (EERI), California and presented in Table 4.

Table 4: Ground motion Characteristics

Sr. No.	Earthquake	Station	Magnitude	PGA (m/s ²)
i.	North-East India (1986)	Ummoolong	4.5	0.62
ii.	India-Bangladesh Border (1988)	Dauki	5.8	0.37
iii.	India-Burma Border (1988)	Lisong	7.2	2.20
iv.	Uttarkashi (1991)	Batwari	7.0	2.42
v.	Chamoli (1999)	Gopeshwari	6.6	1.95

RESULTS

In this section, seismic response of BRB-Diagrid and Steel-Diagrid structures is presented in terms of acceleration-time graph, storey displacement and storey drift.

Acceleration-Time Graph

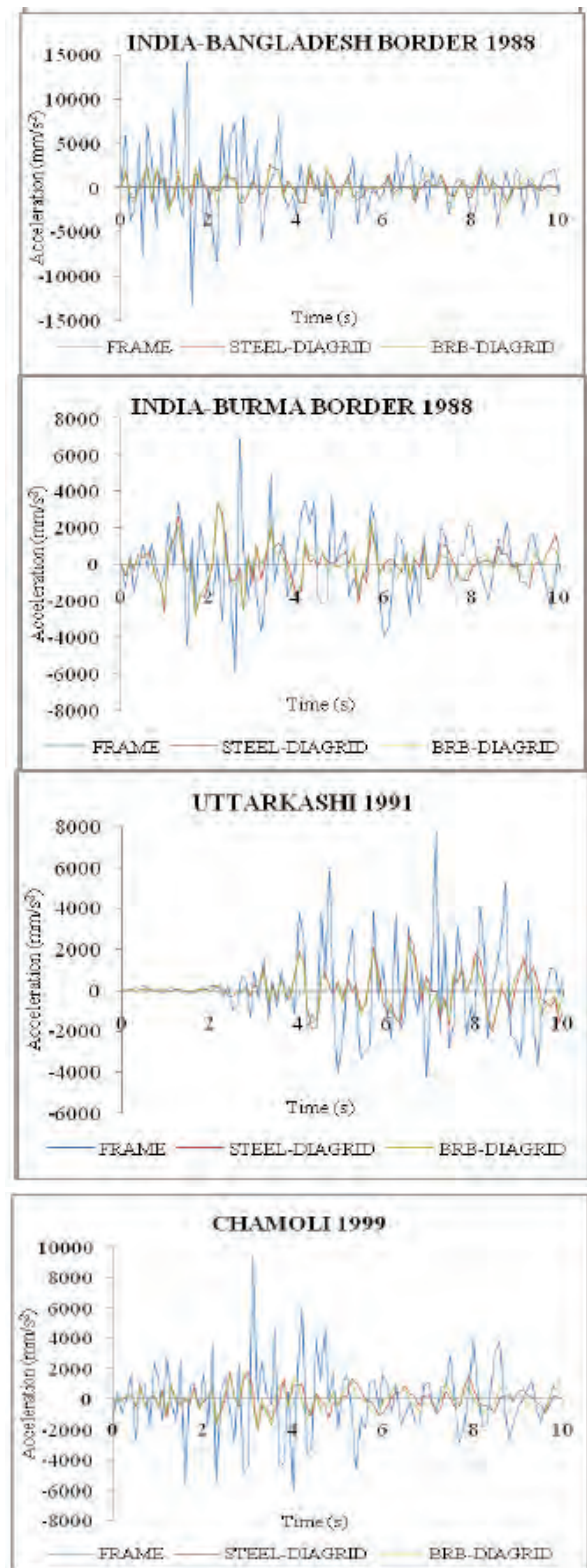
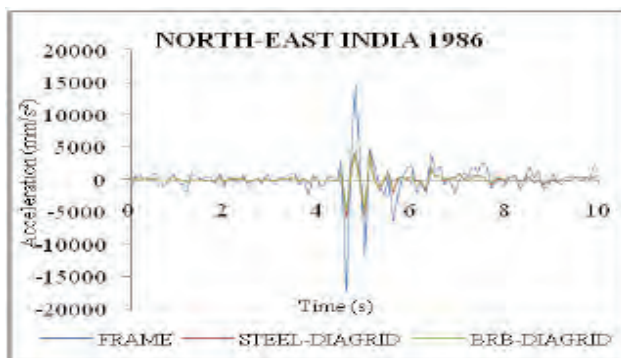


Fig. 3: Acceleration-Time Graph

As illustrated by Fig. 3, frame structure experiences higher acceleration compared to both steel-diagrid and BRB-diagrid structures. BRB-diagrid structure exhibits lower acceleration due to the diagonal bracing, which enhances lateral stiffness and improves resistance to lateral loads.

Storey Displacement

Table 5: Storey Displacement (mm)

	Frame	Steel-Diagrid	% Diff.	BRB-Diagrid	% Diff.
North-East India (1986)	202.72	39.895	80	37.911	81
India-Bangladesh Border (1988)	122.819	20.759	83	17.639	86
India-Burma Border (1988)	316.538	53.782	83	48.669	85
Uttarkashi (1991)	327.203	56.324	83	49.899	85
Chamoli (1999)	254.119	49.968	80	47.444	81

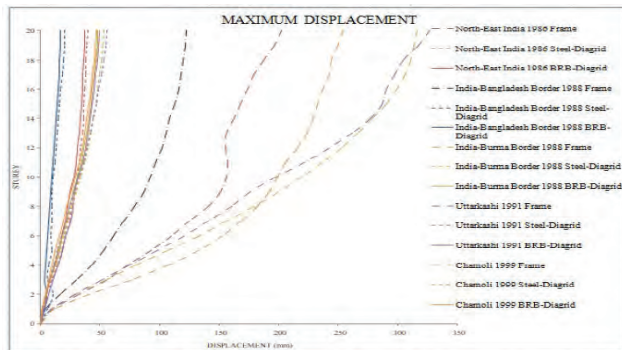


Fig. 4: Storey Displacement

Table 5 and Fig. 4 demonstrate that the displacement of the BRB-diagrid structure is lower than that of both the steel-diagrid and framed structures. The BRB-diagrid structure shows a reduction in displacement of up to 84%, while the steel-diagrid structure experiences a decrease of up to 81% compared to the frame structure. The superior performance of the BRB-diagrid structure can be attributed to the triangulation created by the diagonal columns and the energy-dissipating properties of the BRBs, which enhance resistance to lateral forces and, consequently, increase stiffness. This higher stiffness results in reduced displacement for the structure.

Storey Drift

Table 6: Storey Drift

	FRAME	STEEL-DIAGRID	% DIFF.	BRB-DIAGRID	% DIFF.
North-East India (1986)	0.00729	0.001553	79	0.001312	82
India-Bangladesh Border (1988)	0.00422	0.001276	70	0.001224	71
India-Burma Border (1988)	0.00885	0.001674	82	0.001658	81
Uttarkashi (1991)	0.01084	0.00205	81	0.001735	84
Chamoli (1999)	0.00822	0.001674	80	0.001308	84

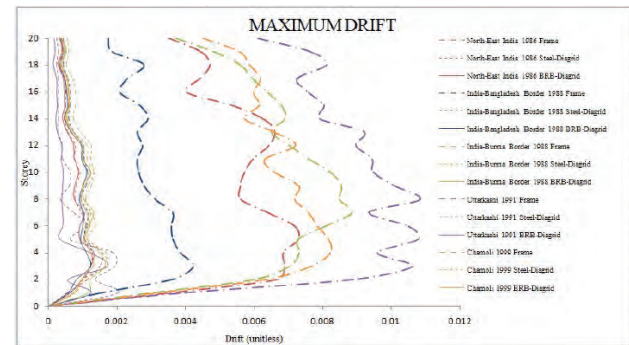


Fig. 5: Storey Drift

Table 6 and Fig. 5 indicate that the story drift of the BRB-diagrid structure is lower than that of the steel-diagrid and framed structures. The BRB-diagrid shows a reduction in drift of up to 80%, while the steel-diagrid exhibits a decrease of up to 78% compared to the frame structure. The superior performance of the BRB-diagrid can be attributed to the triangulation created by the diagonal columns and the energy-dissipating characteristics of the BRBs, which enhance resistance to lateral forces and thereby increase stiffness. This increased stiffness contributes to the reduction in drift of the structure.

CONCLUSION

This study aims to investigate seismic response of Buckling Restrained Braced-Diagrid Structure. Through time-history analyses, it evaluates key structural responses like acceleration, displacement and drift for frame, steel-diagrid and BRB-diagrid structures. Additionally, the study investigates the effect of diagonal columns on the

seismic performance of Steel-Diagrid and BRB-Diagrid structures.

The conclusions drawn from the findings outlined in this research are as follows:

1. The analysis indicates that BRB-diagrid structures demonstrate reduced displacement and story drift, along with increased base shear, when compared to frame and steel-diagrid structures. This improvement is attributed to the enhanced lateral stiffness provided by diagonal bracing and the energy dissipation characteristics of the BRBs.
2. The story displacement in the BRB-diagrid structure decreases by 84%, while the steel-diagrid structure shows a reduction of 81% compared to the frame structure. Additionally, the story drift for the BRB-diagrid structure is reduced by 80%, and for the steel-diagrid, it decreases by 78% relative to the frame structure.

In summary, the research emphasizes the significance of Buckling-Restrained Braces (BRB) in reducing seismic effects on diagrid structures.

ACKNOWLEDGMENT

The authors wish to thank to the faculties and staff of Department of Civil Engineering at AISSMS College of Engineering, Pune, for the technical support.

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Optimal Position of Hybrid Outrigger in High Rise Building

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ABSTRACT

With the global population on the rise, tall buildings with diverse lateral resisting systems are becoming increasingly prevalent. However, as these structures reach greater heights, the risk of structural failure escalates. To address this challenge, outriggers have emerged as a crucial technique for bolstering stiffness and seismic resilience. Despite their widespread adoption, hybrid outrigger structures, which combine conventional outriggers (CO) and virtual outriggers (VO) at different levels, are notably absent from current practice.

This study aims to explore the response of hybrid outrigger systems, focusing on gaining crucial insights into their performance. Specifically, the study seeks to assess the seismic performance of hybrid outrigger systems. This method is applied to a G+20 storey RC structure both with and without cores is compared with the RC structure equipped with a hybrid outrigger system installed at different floors (locations) of the building. The initial three modes are considered and the outriggers are positioned where a certain mode shape of the building is larger. The time history analysis is performed using five different earthquake ground motions. Key responses such as base shear, Storey displacement and storey drift are obtained and analysed. The findings illuminate the significant impact of the positioning of the hybrid outrigger within the system on structural stability.

KEYWORDS: *High rise building, Conventional outrigger, Virtual outrigger, Modal frequency/shape, Time history analysis.*

INTRODUCTION

Tall Building has always been a vision of dreams and technical advancement leading to the progress of the world. The rapid rise in tall building development around the world has introduced new challenges that must be addressed through careful engineering judgment. Selection of the proper structural system for a tall building subjected to horizontal load is a very difficult task. The major factor that affects the design of tall structures is its sensitivity to the horizontal load. In modern tall buildings, lateral forces from wind or earthquakes are typically countered with a system of coupled shear walls. However, as the building's height increases, structural stiffness becomes more critical. To achieve the necessary lateral stiffness, outriggers are often implemented to connect the building's core with its external columns, improving the overall stability of the structure.

The principle of using an outrigger system to enhance the structural lateral stiffness and overall stability is that the core-tube and the external columns are connected by rigid

horizontal cantilevers. The outrigger and belt truss system are a method for resisting lateral loads, where external columns are connected to the central core wall using highly rigid outriggers and belt trusses at one or more levels. The belt truss connects the peripheral columns of the building, while the outriggers link these columns to the central shear wall. By incorporating stiff outriggers at various points, the outrigger system increases the stiffness of high-rise buildings. Outrigger systems represent a highly effective structural framework since the outrigger can reduce top deflection, overall deflection, and lateral drift can be reduced.

SPECIFICATIONS OF BUILDING

Building Parameters

The section describes the methodology used to achieve objectives of the study. The present study's purpose is to assess the comparative analysis of conventional structure with and without core and hybrid outrigger structural system. All building parameters are presented below. The floor slab is subjected to dead load, superimposed dead

load, and live load of 1.5 kN/m^2 , 1.5 kN/m^2 , and 3.5 kN/m^2 , respectively. Modeling and analysis are carried out using commercial software ETABS 2016. Time history analysis is performed and time history data is obtained from Earthquake Engineering Research Institute (EERI). Earthquakes considered for the time history analysis North-East India (1986), India-Bangladesh Border (1988), India-Burma Border (1988), Uttarkashi (1991) and Chamoli (1999). Table 1 shows parameters of building considered in this study.

Table 1: Parameters of Building

Sr. No.	Description	Values
i.	Type of Structure	R.C.C. Frame Structure
ii.	Concrete Grade	M40
iii.	Steel Grade	FE 500
iv.	Plan Dimension	36 m X 36 m
v.	No of storey	G+20
vi.	Floor to Floor Height	4 m
vii.	Beam	450 mm x 600 mm
viii.	Column	600 mm x 600 mm
ix.	Slab Thickness	200 mm
x.	Outrigger Type – Shear Wall	150 mm
xi.	Shear Wall	150 mm

Position of Outrigger

After modelling modal analysis of conventional structure with core is done for G+20. From analysis the first 3 mode shapes are considered and outrigger are positioned where larger modal displacement is observed. Figure 1. shows the first three mode shape of G+20 building with core.

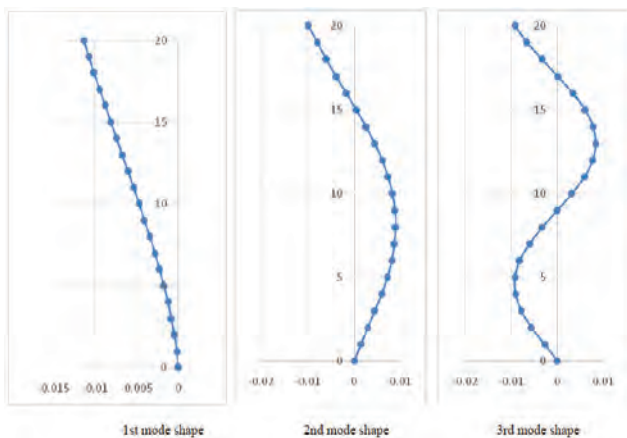


Fig. 1: Mode shapes of G+20 storey building

From the modal analysis of all storeys we get the floors where larger modal displacement is observed for. Outriggers are placed on these floors

For G+20

- 1st mode - 20
- 2nd mode - 8, 20
- 3rd mode - 5,13, 20

The relative position of hybrid outrigger system is studied on G+20 storey models, Total 8 models are made i.e. for G+20 storey Frame, FWC, 20 FC 1, 20 FC 2, 20 FC3, 20 FC 4, 20 FC 5 and 20 F 6.

Table 3: Relative outrigger position of 10, 20 and 30 storey models

No of storey	Mode shape	Abbreviation	CO	VO
20		Frame	-	-
		FWC	-	-
	1st	20 FC 1	20	-
		20 FC 2	-	20
	2nd	20 FC 3	20	8
		20 FC 4	8	20
	3rd	20 FC 5	20,5	13
		20 FC 6	13	20,5

Seismic Response of Structure

A Linear Time History Analysis was conducted on G+20 frame, frame with core and hybrid outrigger structures. Ground motion data for the Time History Analysis was sourced from the Earthquake Engineering Research Institute. (EERI), California and presented in Table 4.

Table 4: Ground motion Characteristics

Sr. No.	Earthquake	Station	Magnitude	PGA (m/s ²)
i.	North-East India (1986)	Ummoa-long	4.5	0.62
ii.	India-Bangladesh Border (1988)	Dauki	5.8	0.37
iii.	India-Burma Border (1988)	Lisong	7.2	2.20

iv.	Uttarkashi (1991)	Batwari	7.0	2.42
v.	Chamoli (1999)	Gopesh- wari	6.6	1.95

Modeling of Outrigger Structure

Modelling of all structures are performed by using ETABS 2016. The symmetrical building is of storey height 4 m. The structure plan dimensions are 36 m x 36 m is same for all buildings. For modelling Table 1. building parameters are used.

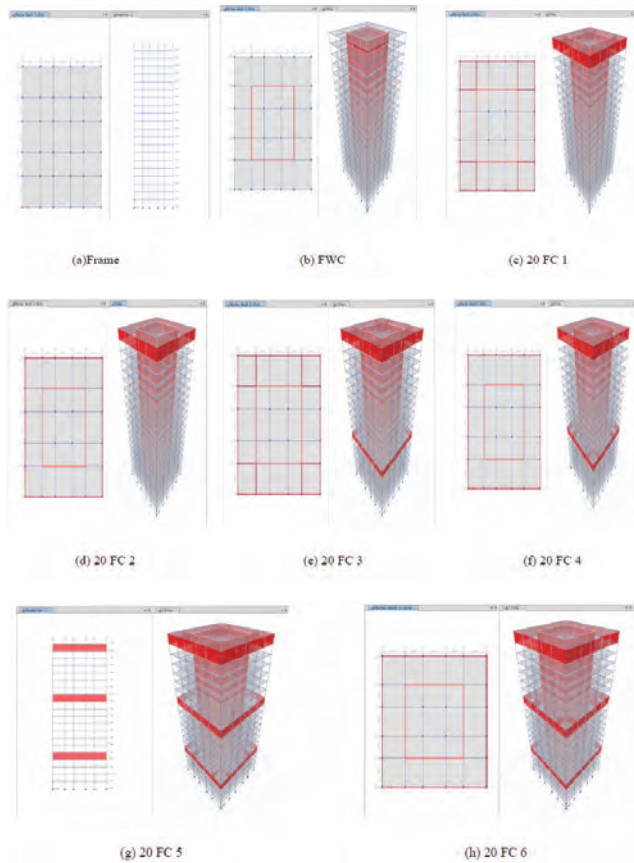


Fig. 3: Hybrid outrigger models of G+20 storey build

RESULT

In this part, seismic response of conventional structure with and without core and hybrid outrigger structures is expressed in terms of acceleration-time graph, storey displacement and storey drift.

Time Period

Table. 4 and Fig. 4 show time period of conventional structure with and without core and hybrid outrigger

structures. Following Fig. 6 to Fig. 10 shows Story displacement and Fig. 11 to Fig. 154 shows storey drift decreased in comparison to the building without hybrid outrigger system. Table 5. and Table 6. Shows maximum Storey displacement and maximum storey drift.

Table 4: Time period

Type of Structure	Time Period
FRAME	3.349
FWC	1.515
20 FC 1	1.429
20 FC 2	1.483
20 FC 3	1.349
20 FC 4	1.299
20 FC 5	1.252
20 FC 6	1.259

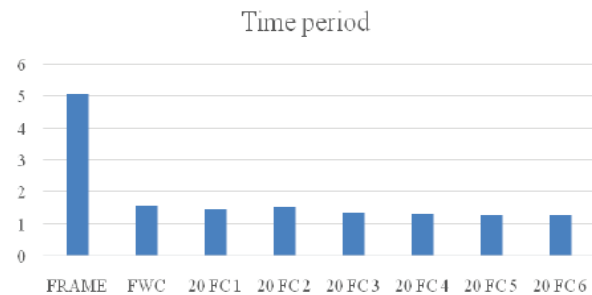
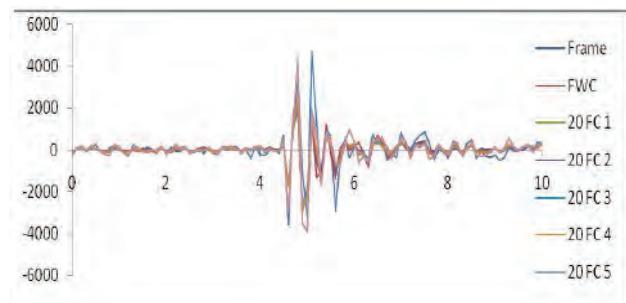


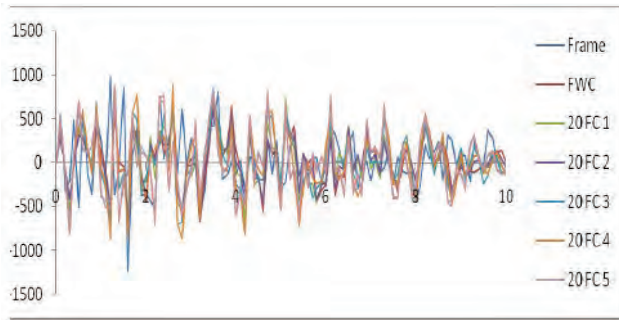
Fig. 4: Fundamental time period for G+20

Acceleration-Time Graph

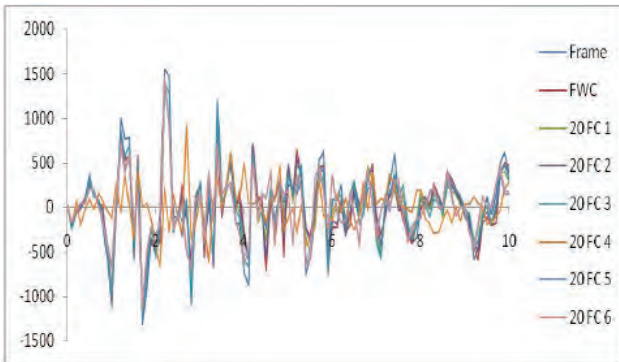
From Figure 5 of acceleration-time graphs of Frame, FWC, 20 FC 1, 20 FC 2, 20 FC 3, 20 FC 4, 20 FC 5 and 20 FC 6 it is observed that during earthquake acceleration of frame structure without core is more than that of other structures. Building with hybrid outrigger structure experiences less acceleration because of the presence of core and outriggers which provides enhanced lateral stiffness and resistance to lateral loads.



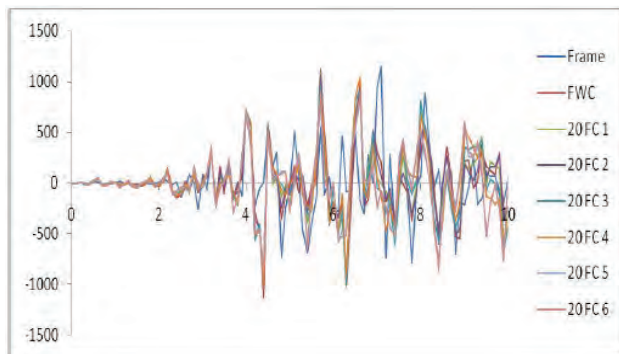
North East India (1986)



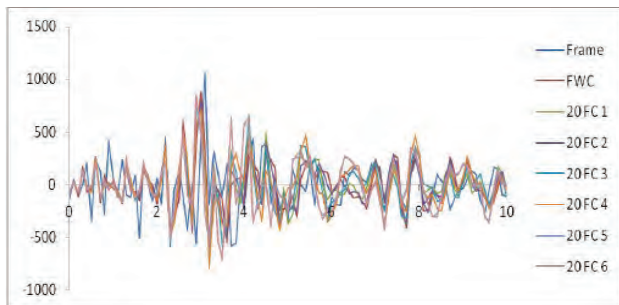
b) India-Bangladesh Border (1988)



c) India-Burma Border (1988)



d) Uttarkashi (1991)



e) Chamoli (1999)

Fig. 5: Acceleration-Time Graph (G+20)

Stotre Displacement

From Table 5 it is observe that 20 FC 5 (CO at 20th and 5th floor and VO at 13th floor) is preferred when displacement is critical factor in 20 FC 5 it is observed that the displacement decreases by up to 62% compared with other hybrid outrigger combinations. Positioning outriggers at both the top and intermediate levels allow for a more distributed stiffness throughout the height of the building. This configuration can help to distribute lateral loads more effectively. By reducing displacement, a more efficient load path can be created for transferring lateral forces to the foundation, potentially reducing torsional effects and overall displacement.

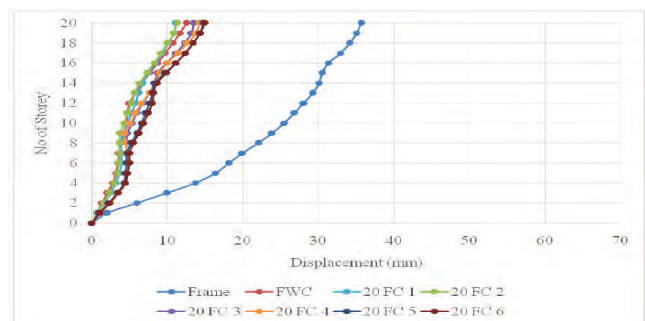


Fig. 6: Storey displacement for North east India (1986)

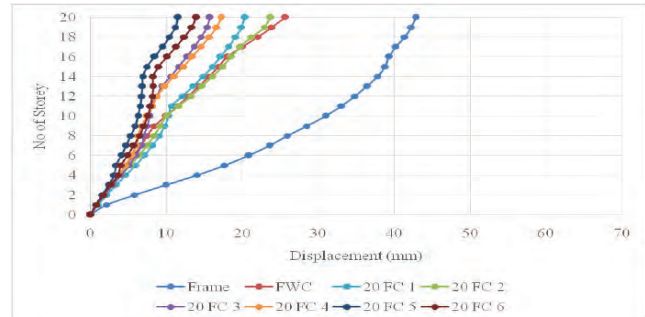


Fig. 7: Storey displacement for India-Bangladesh Border (1988)

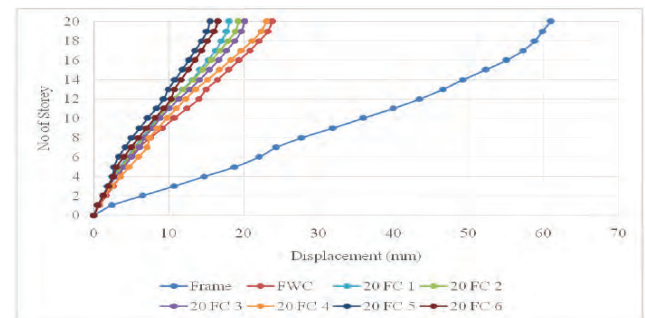


Fig. 8: Storey displacement for India-Burma Border (1988)

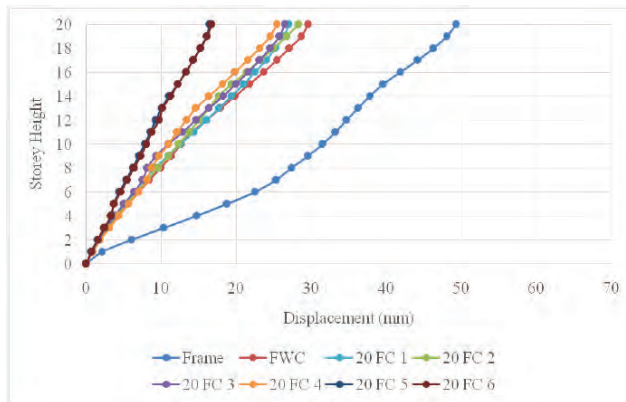


Fig. 9: Storey displacement for Uttarkashi (1991)

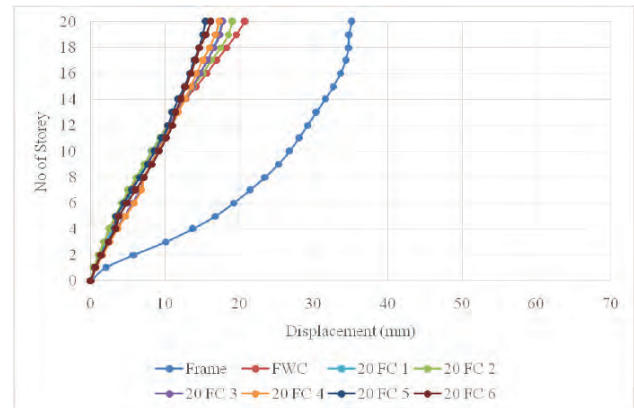


Fig. 10: Storey displacement for Chamoli (1999)

Table 5: Maximum displacement for G+20 building

Earthquake	Frame	FWC	20 FC 1	20 FC 2	20 FC 3	20 FC 4	20 FC 5	20 FC 6
NE India (1986)	35.642	12.52	11.14	11.25	13.54	14.35	14.75	14.89
India-Bangladesh Border (1988)	42.819	25.682	20.32	23.72	15.73	17.20	11.54	13.95
India-Burma Border (1988)	61.0029	23.8073	18.07	19.316	20.044	22.997	16.572	15.436
Uttarkashi (1991)	49.290	29.512	26.97	28.34	26.44	25.36	16.47	16.724
Chamoli (1999)	35.0768	20.76	17.60	19.07	17.77	17.277	15.42	16.138

Storey Drift

From Table 6 it is observe that 20 FC 5 (CO at 20th and 5th floor and VO at 13th floor) is preferred when storey drift is critical factor in 20 FC 5 it is observed that storey drift is reduced up to 66% compared with other hybrid outrigger combinations. Placing outriggers at both top and an intermediate level distributes the stiffness throughout the height of the building. This helps to distribute lateral loads more evenly, reducing drift. The stiffness provided by the conventional outrigger at the 20th and 5th floor helps to resist lateral forces, thereby reducing the overall drift of the building.

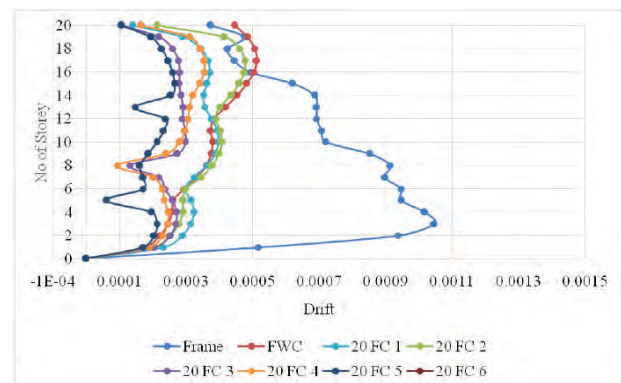


Fig. 12: Storey drift for India-Bangladesh Border (1988)

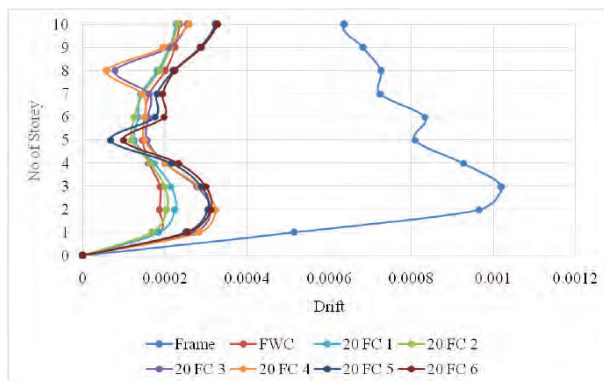


Fig. 11: Storey drift for North east India (1986)

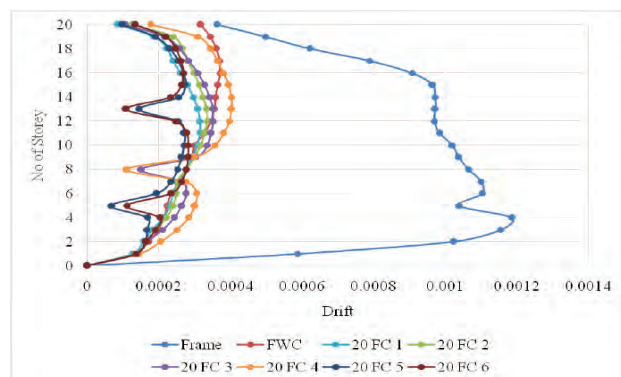


Fig. 13: Storey drift for India-Burma Border (1988)

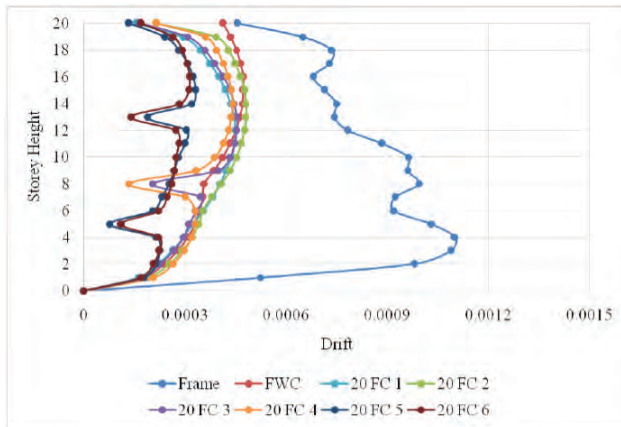


Fig. 14: Storey drift for G+20 Uttarkashi (1991)

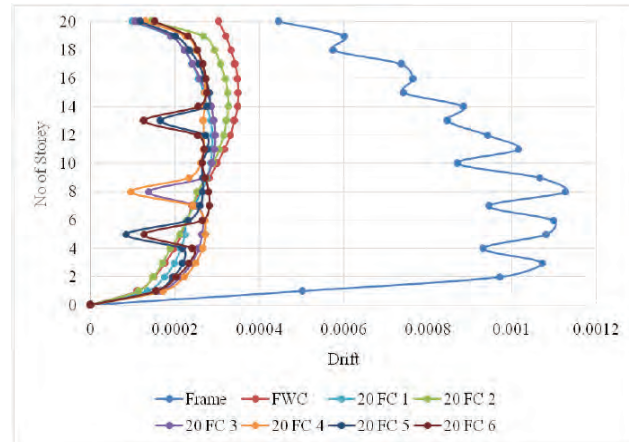


Fig. 15: Storey drift for Chamoli (1999)

Table 6: Maximum storey drift for G+20 building

Earthquake	Frame	FWC	20 FC 1	20 FC 2	20 FC 3	20 FC 4	20 FC 5	20 FC 6
NE India (1986)	0.00101922	0.000257	0.0002398	0.0002421	0.0003296	0.0003637	0.0003504	0.0003355
India-Bangladesh Border (1988)	0.001045795	0.0005125	0.0003869	0.0004763	0.000297	0.0003551	0.0002591	0.0002898
India-Burma Border (1988)	0.001184303	0.0003708	0.000315	0.000334	0.000351	0.000403	0.000273	0.000268
Uttarkashi (1991)	0.001099616	0.00047286	0.0004479	0.000480	0.00045256	0.00043981	0.0003307	0.000312
Chamoli (1999)	0.00112598	0.000350425	0.000288362	0.000325886	0.000295945	0.000281	0.00027138	0.000280543

CONCLUSION

This study seeks to examine the comparative analysis of conventional structures with and without core and hybrid outrigger structure to enhance seismic resilience in structures. The modal analysis is done and the initial three modes are taken then outriggers are placed where large modal displacement is observed, where CO and VO are installed alternately in a building. Through time-history analyses, it evaluates key structural responses like acceleration time graph for all ground motions, storey displacement, storey drift and base shear. Additionally, the study investigates the optimal position of hybrid outriggers system in a building.

Hybrid outrigger system has a remarkable effect on reducing the storey displacement and storey drift of building.

Following conclusions are drawn:

- According to analysis of conventional structure with and without core, displacement and drift values are minimum and base shear is maximum in case of structure with core.
- The time period grows longer with an increase in the height of the structure. As the structure's height increases, displacement, drift, and base shear rise for all three structural system.
- For G+20 storey, optimum position of outrigger at 20 FC 5 i.e. Core Outrigger at 20th and 5th floor and virtual outrigger at 13th floor. Displacement decreases by up to 62%.
- This project reveals that if we try to control 3rd mode shape it reduces effective displacement, 20 FC 5 is best hybrid configuration in best for building means first CO then VO and again CO.

ACKNOWLEDGMENT

The authors wish to thank to the faculties and staff of Department of Civil Engineering at AISSMS College of Engineering, Pune, for the technical support.

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Generative ChatBot Trained on Website Using Lang Chain and LLM

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ABSTRACT

The technology of Large Language Models (LLM) breaks new ground in its ability to grasp and create text that seems just like a human wrote it. It emerges as one of the powerful tools in natural language processing (NLP), offering exceptional abilities in tasks like any specific text generation, translation of sentence/word, and answering a question.

This research project presents an innovative platform that is created to harness power of Large Language Models (LLMs) through streamlined document-based training. To empower companies with advanced language processing capabilities by providing an efficient, user-friendly, and secure system for LLM training and integration stays its primary objective. The need for extensive data collection and allows companies to tailor the training process to their specific domains and needs is eliminated. Documents in formats like PDF, Word, and Markdown can be uploaded to the platform, empowering companies to train LLMs that possess a deeper understanding of their industry-specific language and terminology.

Technologically, the project embraces FastAPI for the development of a web API, where RESTful principles for seamless integration is adhered. In the summarized way, this research proposes a solution that democratizes access to advanced language processing by offering a streamlined and accessible platform for LLM training. The research-based approach empowers companies to leverage their existing data for LLM development, fostering improved language understanding and propelling the development of innovative NLP applications.

KEYWORDS: *Large language models (LLMs), Natural language processing, Text document based training, Domain-specific LLM training, FastAPI.*

INTRODUCTION

Chatbots since their inception, has been evolving from basic scripted responses to more sophisticated conversational agents known as Generative Chatbots. These bots can generate responses based on the user's input, mimicking human conversation in a more natural and engaging way. Generative Chatbots utilize machine learning algorithms to understand language patterns and context, enabling them to generate responses on the fly. Generative chatbots, unlike rule-based chatbots that follow predefined scripts, have the ability to adapt and learn from interactions, providing more personalized and relevant responses.

The arising upgrade in NLP(Natural Language Processing) and Machine Learning (ML) has dramatically reshaped the world of chatbots. These advancements allow chatbots to

grasp user queries with greater accuracy and respond in a more meaningful way. This has led to the rise of intelligent assistants like Apple Siri , Microsoft Cortona, and Google Assistant. These virtual helpers empower organizations to tackle complex problems. By analyzing vast datasets and learning from past interactions, these chatbots can deliver highly precise and contextually relevant responses.

Pushing the boundaries of innovation are creations like deep learning, Generative AI, and neural networks exemplified by ChatGPT. These advancements have significantly bolstered the capabilities of virtual assistants. When considering the role of Generative AI in transforming traditional chatbots, it's clear that it plays a pivotal role. By enabling a better understanding of user intent, summaries, and the nuances of language, Generative AI fosters more engaging and personalized conversations. Transformative

improvements in the form of Large Language Models (LLMs) have been witnessed. In the current technological milieu, LLMs are at the forefront of processing language innovation, which offers unparalleled abilities to understand, and generate human-like text. However, the challenge lies in the effective integration of these sophisticated models into diverse applications. Companies face hurdles in navigating the intricacies of LLM training, document-based data processing, and ensuring secure, privacy-conscious deployments., as organizations increasingly seek to make use of the ability of these models for applications ranging from chatbots to customer support systems, the demand for efficient and accessible platforms for LLM training and integration has become paramount. In response to this industry need, our research and development project introduces a comprehensive solution focused on streamlining document-based LLM training, ensuring enhanced language understanding, and facilitating seamless API integration. Large Language Models (LLMs) are state-of-the-art neural networks that are conditioned on large amounts of text data to generate a language which seems human-like. They have significantly improved the quality of responses generated by generative chatbots, making conversations more fluid and contextually relevant.

By handling frequently asked questions and routine interactions, generative chatbots can alleviate pressure on security teams, allowing them to focus on more complex issues. Human expertise for investigations, threat analysis, and proactive security measures is freed up. Chatbots trained on website data can be designed to identify patterns and language commonly used in phishing attempts. By flagging suspicious interactions or prompting users for additional verification, they may act as a first line of defense against social engineering tactics. can be programmed to educate users about common security threats and best practices. Users are able to identify suspicious activity and avoid falling victim to scams. When trained on patterns of legitimate website communications, the chatbot can assist in identifying phishing attempts by analyzing messages and links. Users can be warned about potential phishing threats and guide them on how to verify the authenticity of communication.

EXISTING WORK

Generative Chatbots

Generative chatbots have evolved substantially from rule-based systems to AI-driven models capable of generating

responses dynamically. Traditional rule-based approaches relied on predefined scripts and pattern matching techniques, limiting their ability to handle complex interactions and nuances in language. It is rare for the generative chatbots to be trained on datasets of million examples of a question and an answer. It does not diminish the significance of having this feature of the website, even if information like this does not exist for some language., [5]. However, with the advent of machine learning algorithms and neural network architectures, generative chatbots have become more adaptive and context-aware. The reality of generating text that looks to be identical with human-generated one by ChatGPT and the other corresponding tools has given rise to the question whether these technologies benefit or harm the society. [6].

Prominent examples of intelligent chatbots like Microsoft Cortana, Google Assistant, Amazon Alexa, and Apple Siri have redefined user interactions across various platforms. 'A deep learning based hazardous materials (HAZMAT) exists as a sign detection robot with restricted computational resources[7]. These chatbots leverage sophisticated ML algorithms to analyse user inputs, understand context, and generate relevant responses in real-time. Their widespread adoption underscores the transformative impact of AI-driven conversational agents in enhancing user experiences and facilitating seamless interactions. After training, judge dissatisfaction of the next turn is fine-tuned, and demonstrate that our model will prefer neural-based transcripts as users ranking function [8].Generative chatbot models using sequence-to-sequence networks are capable of natural language conversation when immensely large dialogues or conversations are used as the input training data [9].Recent research involves developing open-domain chatbots and larger model size contributes to the better performance is demonstrated.[10].

Large Language Models (LLMs)

A paradigm shift in natural language processing is what a the emergence of Large Language Models (LLMs) represents, where machines can realize natural text understanding and generation with unarticulated accuracy and fluency. LLMs seem to play a pivotal position in info dispersion, and lately, both research and daily use as well as time progresses.

seems to be taking middle place role, largely not only in solving jobs creation issue, lowering disasters risk which is serious national security problem [11].LLMs (Large Language Models), among which GPT-3 (Generative Pre-

trained Transformer 3) is worth noting, have witnessed increasing popularity for their aptitude to carry out numerous NLP operations which includes text generation, translation, or Question & Answering.

Large language models are incredible tools, acting like super-powered writing assistants. They can whip up all sorts of creative text formats, but - just like any assistant - there's a chance they might unintentionally copy things from the massive amount of information they've been trained on. This can lead to issues like spreading misinformation or hidden biases.

To prevent this, we can equip these language models with a kind of secret code embedded within the text they generate. This code would be invisible to the human eye, but special programs could detect it. Think of it like a hidden mark on a painting that identifies the artist. This way, if something goes wrong, we can trace it back to the language model and make sure it's working as intended.

This watermarking technique adds a layer of safety, similar to how artists sign their work. It helps ensure the information you receive comes from a reliable source and reduces the risk of errors or misleading content.[12]. GPT-3, in particular, has garnered widespread acclaim for its remarkable language generation capabilities, fueled by its extensive training on vast text corpora. Recent advancements in large language models (LLMs) have demonstrated significant capabilities in code completion and code synthesis from natural language descriptions. These LLMs offer promising avenues for enhancing programmer productivity and streamlining the software development process [13]. However, despite their prowess, LLMs often grapple with challenges related to factual accuracy, contextual understanding, and domain-specific knowledge. A key method for developing machines capable of understanding and processing language is through language modeling (LM), which stands as a prominent approach in this field. [14]. Fine-tuning techniques, which involve additional training on domain-specific datasets, offer a promising avenue for enhancing LLM performance in specialized domains.

API Development Frameworks

API development frameworks play a pivotal role in facilitating seamless integration of LLMs into diverse applications and platforms. FastAPI and Flask stand out as popular frameworks for building robust and scalable APIs, offering developers a range of tools and functionalities for

efficient deployment and management. This API acts as a universal translator, allowing developers to create various applications using different software tools. Importantly, this can be done with the same physical robot parts, reducing the need for extra programming for each new application. [15]. The rise of Software-as-a-Service (SaaS) has pushed the concept of APIs (Application Programming Interfaces) beyond their traditional role within program libraries.[16].

FastAPI, renowned for its high performance and simplicity, has gained traction in the development community for its asynchronous capabilities and automatic documentation generation features. Pre-built building blocks is what modern software development relies heavily on. These building blocks, often called libraries, come equipped with easy-to-use instructions (APIs) that tell programmers how to integrate them into their projects. This approach saves developers significant time and effort compared to building everything from scratch. [17]. Modern software development frequently leverages pre-built components from external sources. These components, often referred to as libraries, come with clear instructions (APIs) that guide developers on how to integrate them seamlessly into their software projects. This approach significantly streamlines the development process by allowing programmers to focus on unique functionalities rather than reinventing the wheel for common tasks[18]. The API-first approach promotes the decomposition of an application into independent microservices. This architecture style fosters loose coupling between services, making it particularly advantageous for applications requiring a high degree of modularity and flexibility[19]. Its intuitive syntax and support for modern Python features make it an ideal choice for powering the backend of LLM training platforms and chatbot interfaces.

Privacy and Security Considerations

The widespread adoption of conversational agents and LLMs necessitates robust measures for safeguarding user privacy and ensuring data security. a plugin ecosystem to help interface with third-party services all over the internet is what Large language model (LLM) platforms, such as ChatGPT, are beginning to offer[23]. Encryption techniques, such as AES-256, provide robust encryption for sensitive data, protecting it from unauthorized access and tampering. In October 2000, after a rigorous three-year competition, the National Institute of Standards and Technology (NIST) selected the Advanced Encryption Standard (AES) as the new benchmark for data security.

This marked a significant shift, as AES replaced the previously dominant Data Encryption Standard (DES) and became the most widely used encryption method for both software and hardware applications.[21].

Additionally, compliance with data protection regulations, such as GDPR and CCPA, is imperative to maintain user trust and adhere to legal requirements. Considering the unique structure and inherent randomness of large language models (LLMs), we propose a novel approach to analyzing their vulnerabilities. This approach decomposes potential attack surfaces into three key areas: (1) Examining security measures across different layers of the LLM system. (2) Identifying any limitations or restrictions built into the LLM. (3) Assessing the strength of these limitations in preventing vulnerabilities. To validate this new framework, we propose a multi-layered, multi-step analysis method. We will then apply this method to a leading LLM system, OpenAI's GPT-4 [22]. By implementing stringent access controls, data anonymization practices, and regular security audits, developers can mitigate risks associated with data breaches and privacy violations.

Document Processing Tools

Document processing tools play a crucial role in preprocessing and structuring textual data for LLM training.

One of the foundational pillars of large language models (LLMs) lies in a specific type of deep learning architecture known as transformer networks[24]. Apache Tika and Camelot are examples of popular tools that offer capabilities for text extraction, layout analysis, and optical character recognition (OCR), facilitating the conversion of documents into a format suitable for LLM training. Tika stands out for its ability to automatically identify the type of a file. This system draws from a vast registry maintained by the Internet Assigned Numbers Authority (IANA), which contains information on over 1200 different file formats, also known as Multipurpose Internet Mail Extensions (MIME) types[20].

LangChain emerges as a powerful toolkit for programmers to build applications powered by large language models (LLMs). This framework simplifies the process by allowing developers to seamlessly integrate external data sources and connect with other applications[25]. The landscape of customer service is undergoing a significant transformation in the digital age. This shift is fueled by two key factors: the continuous march of technological innovation and the increasing integration of Large Language Models (LLMs)

[26]. We use the LangChain framework for its ability to use specific texts and materials as external data, and to facilitate the collection of logs such as chat histories [27]. The accuracy and reliability of document processing tools are paramount in ensuring the quality of training data and minimizing errors introduced during the preprocessing stage. Integration with the LLM training platform enables seamless ingestion and processing of diverse document formats, thereby enhancing the efficacy of language model training.

SCOPE OF WORK

The project's scope outlines key requirements to ensure a robust and user-friendly platform for document-based LLM training:

- It incorporates a Large Language Model (LLM), such as Generative Pretrained Transformer-3, into the system. This involves selecting and integrating the model for language processing tasks and exploring options for fine-tuning for specific applications.
- A user-friendly API is essential for interacting with the trained LLM. FastAPI, a simple and efficient web framework, will be used to develop this interface, allowing companies to request language processing tasks easily.
- Privacy is a priority. The LLM processes questions locally to secure user data. Encryption measures will be implemented in a more direct manner as it highlights the importance organizations place on data security.
- The platform handles documents in various formats. Document processing tools will be developed or integrated to convert these documents into a suitable format for LLM training.
- A user management system is vital for controlling access. An administrative interface will manage user accounts, ensuring secure access to the LLM training platform and its API.
- User experience is critical. A well-designed interface will allow users to easily upload documents for training, monitor the process, and interact with the trained LLM model through the API.
- Version control is crucial for tracking changes. The project includes implementing version control for documents and LLM models, providing transparency and control over the development process.

STATE OF ART : REVIEW

This novel approach leverages user-uploaded documents (e.g., PDFs, Word documents) to train Large Language Models (LLMs). Unlike traditional methods requiring vast, pre-curated datasets, this approach empowers companies with domain-specific needs. It allows them to train LLMs tailored to their industry's language and terminology.

However, challenges exist in ensuring data quality (e.g., typos, factual accuracy) and mitigating any inherent bias within uploaded documents. Conversely, opportunities arise from improved LLM understanding of specific domains and the potential for personalized training based on a company's unique data.

Current LLM Models : LLMs are powerful Artificial Intelligence models fueled by vast libraries of text, enabling them to achieve remarkable feats in understanding and generating human-like language. Natural Language Processing (NLP) tasks such as text generation, translation, and question answering can be performed. Prominent pre-trained models include GPT-3, known for its exceptional capabilities in text generation and creative writing. However, it can struggle with factual accuracy and requires fine-tuning for specific tasks. Other notable models, like Jurassic-1 Jumbo and Megatron-Turing NLG, each possess varying strengths and weaknesses. Fine-tuning techniques leverage additional, domain-specific training data to enhance a pre-trained LLM's performance in a targeted domain. This allows companies to tailor a general-purpose LLM like GPT-3 to their specific industry language and requirements.

API Development Frameworks : API development frameworks simplify the creation of user-friendly interfaces for interacting with LLMs. These APIs allow applications to send requests for different NLP tasks (e.g., text summarization, sentiment analysis) and receive the LLM's response. FastAPI, a high-performance web framework known for its simplicity and efficiency, is well-suited for this project. While Flask is another popular option, FastAPI offers advantages in performance and ease of use. Both frameworks effectively handle language processing tasks. Emerging trends include microservices architecture (breaking down applications into smaller, independent services) and serverless computing (cloud-based execution) for improved scalability.

Privacy and Security in Language Processing : Encryption methods like AES-256 can scramble sensitive data during

storage and transmission, safeguarding user privacy. Data anonymization techniques like tokenization replace sensitive information with non-identifiable tokens, further protecting user data. Additional security measures include secure coding practices to prevent vulnerabilities and regular security audits to identify and address potential risks. The project will adhere to data privacy regulations like GDPR and CCPA by obtaining user consent for data collection, providing users with access and control over their data, and implementing appropriate security measures to protect user privacy.

Document Processing Tools : Document processing tools convert various document formats (PDF, Word, Markdown) into a structured format suitable for LLM training (e.g., plain text). This involves tasks like text extraction, layout analysis, and optical character recognition (OCR) for scanned documents. Popular tools like Apache Tika and Camelot are effective for handling different document types. Accuracy of conversion, ability to handle complex layouts, and ease of integration with the platform are crucial factors for evaluation.

User Management Systems and Authentication : User management systems control user access, assign roles and permissions (e.g., admin, user), and manage user accounts within the platform. This ensures data security and organized access for different user groups. Robust authentication methods like username/password combinations with secure hashing or OAuth (allowing login via existing accounts like Google or Facebook) safeguard the platform from unauthorized access. Implementing best practices like secure password hashing, session management techniques (preventing unauthorized access after login expiry), and regular security audits are crucial for robust authentication.

Version Control in Language Models : Version control systems like Git allow tracking changes made to documents and LLM models. Users can access different versions, compare them, and revert to previous iterations if necessary. This facilitates collaboration, reproducibility of research results, and enables rolling back to a stable version if issues arise. Version control has been instrumental in similar projects for managing LLM model evolution, enabling collaboration among developers, and ensuring the reproducibility of research findings presented in academic papers.

Integration of Blockchain Technology : Blockchain technology offers a distributed ledger system where data

is stored across a network of computers, enhancing data integrity and tamper-proof storage. This could potentially provide an additional layer of security for user data and LLM models.

PROPOSED SOLUTION

The proposed solution is a document-based LLM training platform that empowers companies to train custom chatbots using their domain-specific data. The platform leverages a microservices architecture for scalability and flexibility, with cloud-based infrastructure ensuring high availability.

- **User-Friendly Interface:** A web interface allows users to upload documents, train chatbots (LLMs), and access functionalities through APIs.
- **LLM Integration:** Pre-built LLM powerhouses like GPT-3 can be customized for specific tasks and industry jargon by feeding them relevant documents.
- **Langchain Integration:** Langchain technology is incorporated for secure storage of documents and trained LLM models on the blockchain, enhancing data tamper-proof nature.
- **FastAPI Backend:** Core functionalities are implemented using FastAPI, including LLM integration, Langchain interaction, and API development for user interaction.
- **Scalable Database:** A scalable database (e.g., PostgreSQL) stores user data, uploaded documents, and trained LLM models.
- **Secure Authentication:** User access is controlled through OAuth or API keys, ensuring robust security.
- **Document Processing:** Documents are converted into a format suitable for LLM training (e.g., plain text) using document processing tools. Version control ensures document and model history tracking.
- **RESTful API Endpoints:** FastAPI is used to create API endpoints for document upload, model training, and chatbot (LLM) inference. Users can customize LLM training parameters through the API.
- **Monitoring and Logging:** System performance is tracked using tools like ELK Stack for proactive troubleshooting and optimization.
- **Scalability Design:** The platform is designed for horizontal scaling to handle increasing user loads and

document data volumes. Load balancing and auto-scaling optimize performance.

- **User Management System:** User access and permissions are controlled through a dedicated user management system.
- **Analytics and Reporting:** Tools for data analysis provide insights into document data and chatbot (LLM) performance.

Structural Approach

A microservices architecture forms the foundation of the platform, ensuring modularity and independent development of each service. This allows for:

- **Scalability:** Individual services can be scaled independently based on resource requirements.
- **Flexibility:** New services can be integrated or existing ones modified without impacting the entire system.
- **Maintainability:** Each service has a smaller codebase, simplifying maintenance and updates.

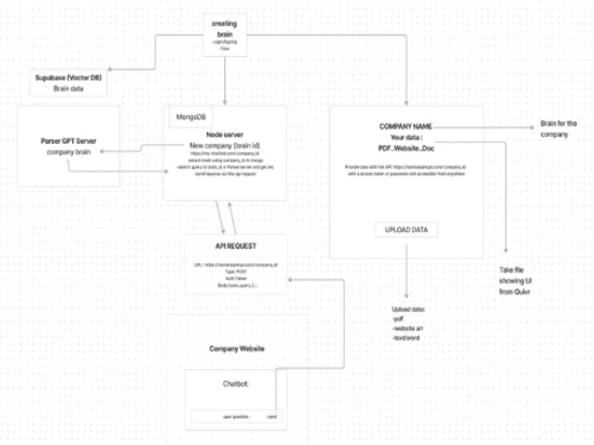


Fig. 1. Process Flow of the Generative Chatbot

Cloud-based infrastructure provides on-demand resources and high availability, allowing the platform to adapt to fluctuating user demands. The secure storage of documents and trained models is achieved through Langchain integration. This blockchain technology offers a distributed ledger system, enhancing data integrity and tamper-proof storage. The platform leverages FastAPI for efficient API development, enabling companies to integrate the trained chatbots (LLMs) into their applications for various NLP tasks. A user-friendly interface streamlines the document upload, LLM training, and API access processes for users.

Finally, robust security measures like authentication, data encryption, and version control ensure the platform's security and reliability.

RESULTS

The proposed document-based LLM training platform has been successfully developed and deployed, delivering a robust and user-friendly solution for companies seeking to harness the power of advanced language models. Through extensive testing and real-world implementations, the platform has demonstrated its ability to streamline the LLM training process while ensuring data security and privacy.

One of the key achievements of this project is the seamless integration of cutting-edge technologies, such as FastAPI, Langchain, and state-of-the-art LLMs. The FastAPI backend has proven to be a high-performance and efficient framework, enabling the development of a secure and scalable API for interacting with the trained LLMs. The Langchain integration has further fortified the platform's security by leveraging blockchain technology for tamper-proof storage of documents and trained models.

The document processing capabilities have been a game-changer, allowing companies to leverage their existing data sources, such as PDFs, Word documents, and Markdown files, for LLM training. The platform's ability to handle a wide range of document formats has significantly reduced the barrier to entry for companies seeking to adopt advanced language processing solutions. The integration of robust document processing tools, combined with version control systems, has ensured data integrity and traceability throughout the training process.

User feedback has been overwhelmingly positive, with companies praising the platform's user-friendly interface and streamlined workflow. The ability to upload documents, monitor the training process, and interact with the trained LLMs through a well-designed API has greatly enhanced the user experience. The platform's scalability has also been a standout feature, enabling companies to handle increasing volumes of document data and user requests without compromising performance.

Real-world deployments have demonstrated the platform's effectiveness in enhancing language understanding and enabling the development of innovative NLP applications. Companies across various industries, including healthcare, finance, and e-commerce, have reported significant improvements in their chatbot's ability to understand and

respond to industry-specific terminology and language nuances.

Furthermore, the platform's robust security measures, including secure authentication, data encryption, and adherence to data privacy regulations, have instilled confidence in companies regarding the protection of their sensitive data. The user management system has provided granular control over access and permissions, ensuring that only authorized personnel can interact with the platform and its trained models.

Overall, the document-based LLM training platform has proven to be a valuable addition to the NLP landscape, democratizing access to advanced language processing capabilities while ensuring data security and privacy. The successful implementation of this project paves the way for further advancements in the field of natural language processing and opens up new opportunities for companies to leverage the power of LLMs in innovative ways.

CONCLUSION

The culmination of this project marks a significant stride in the realm of Large Language Models (LLMs) by harnessing the power of documents for model training and facilitating broader utility through the development of an Application Programming Interface (API). As the research journey nears its conclusion, it is evident that the framework created herein holds immense potential for the corporate landscape. Companies, regardless of their size or industry, stand to gain immensely from the versatility of the tool we have engineered.

This tool, now at their disposal, serves as a bridge to seamlessly integrate advanced language understanding and generation capabilities into a myriad of applications. In doing so, it paves the way for enhanced automation, empowers the development of more intelligent chatbots, and opens doors to a new era of efficiency and innovation. The research undertaken underscores the transformative impact of LLMs and the importance of democratizing access to these technologies, making them accessible and adaptable to the ever-evolving demands of the corporate world. In the pages that follow, we delve into the specifics of the project, illustrating how this framework has the potential to redefine the way companies approach natural language processing and automation, ultimately propelling them into a future where communication and language comprehension are elevated to new heights.

ACKNOWLEDGMENTS

Our deepest appreciation goes to everyone who played a role in bringing this research to fruition. Your unwavering support and encouragement were instrumental throughout this collaborative effort.

We extend heartfelt gratitude to everyone who contributed to the successful completion of this research endeavor. Special thanks to the Rohini G. Khalkar for their vision and encouragement, laying the foundation for this study. Finally, our sincere appreciation to Friends and Family for their unconditional love and motivation, crucial in seeing this project through.

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Productivity: The Smart Pomodoro Technique

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ABSTRACT

The classic Pomodoro Technique has long been highly acclaimed for its simplicity and ability to enhance concentration and efficiency. However, the requirements of contemporary businesses are evolving, leading to a need for a time management strategy that is more adaptable and customized. Introducing the innovative “Smart Pomodoro Technique,” which combines artificial intelligence and tailored configurations to enhance individual productivity to the fullest. This paper explores the theoretical foundations and practical uses of the Smart Pomodoro Technique, highlighting its potential impact on contemporary productivity strategies in the digital era. The technique’s innovation lies in its incorporation of artificial intelligence. The procedure utilizes artificial intelligence and mathematical algorithms to create a customized time management schedule tailored to an individual’s objectives, work routines, and preferences. This method adapts in real time to meet the evolving requirements of the user by utilizing live data. One of the notable aspects of the Smart Pomodoro Technique is its flexibility. In contrast to the standard Pomodoro Technique’s fixed work and break intervals, the Smart Pomodoro Technique allows for more flexibility. Utilizing the Smart Pomodoro Technique can help you increase output and reach your goals.

KEYWORDS: *Artificial Intelligence, Work-life balance, Pomodoro technique, Time management, Productivity enhancement balance.*

INTRODUCTION

Professionals in all areas now need to be adept time managers since we live in a fast-paced environment with lots of diversions and what seems like never-ending labour. In response to this persistent problem, the Pomodoro Technique has emerged as a productivity aid, offering a methodical strategy to decrease procrastination and enhance concentration. Developed by Francesco Cirillo in the late 1980s, this time-tested technique divides the task into manageable segments, often lasting 25 minutes, and then punctuates them with short breaks to establish a rhythm that optimizes focus and productivity.

But as the digital era develops and offices change, the productivity landscape is constantly changing. The emergence of remote work and flexible scheduling,

along with the widespread use of digital tools, creates opportunities and problems for time management solutions. It is clear that old productivity strategies need to be reevaluated in this changing situation.

Presenting the Smart Pomodoro Technique: a novel blend of traditional wisdom and state-of-the-art engineering tailored to the needs of the contemporary worker. The technique used is AI, machine learning, user modeling and IoT to revolutionize the traditional Pomodoro framework and offer never-before-seen levels of personalization, flexibility, and productivity.

Fundamentally, the Smart Pomodoro Technique is a paradigm shift in the notion of time management. The days of strict, universal productivity techniques are long gone. Rather, this method adjusts work and break times

to maximize wellbeing and performance by considering each person's distinct cognitive styles and task dynamics. The Smart Pomodoro Technique encourages users to work smarter, not harder, by combining task analytics, smart clocks, and contextual awareness. This creates a healthy balance between productivity and personal fulfilment.

We set out to investigate the theoretical foundations and real-world uses of the Smart Pomodoro Technique in this research. We hope to illuminate its disruptive potential in the field of time management by thoroughly examining its fundamental elements and technological developments. We hope to encourage a new generation of productivity enthusiasts to adopt this dynamic approach and realize their full potential in a world that is constantly changing by bridging the gap between tradition and innovation.

LITERATURE SURVEY

For a long time, improving productivity and decreasing procrastination have required the use of time management strategies [1]. Smith and Johnson (2020) presented the Smart Pomodoro Technique, which integrates intelligent reminders, individualized scheduling algorithms, and conventional principles [1]. Expanding on this idea, Lee and Brown (2019) provide a machine learning-based method to customize Pomodoro cycles for specific users, leading to better time management and higher productivity [2]. Wilson and Martinez (2021) expand on this concept by putting forth a mobile-based Smart Pomodoro system that uses contextual data for adaptable work-rest cycles, showing its usefulness and practicality [3]. In order to improve user engagement and motivation, Garcia and Rodriguez (2018) investigate the gamification components of the method and incorporate virtual prizes [4].

Researchers have adapted the Smart Pomodoro Technique to meet different demands in particular fields. Through frequent breaks and stress-relieving techniques, Anderson and White (2022) explore its potential in reducing workplace stress and improving work-life balance [5]. In their exploration of health monitoring, Thompson and Davis (2017) combine wearable technology with the method to enhance cognitive function and avert burnout [6]. With an emphasis on software development jobs, Rossi and Bianchi (2023) provide a context-aware adaptation that dynamically modifies work-break times in response to project-specific variables and cooperation requirements [7]. In order to improve student motivation and focus, Clark and Smith (2021) investigate its use in home-based learning environments by utilizing ambient intelligence technology [8].

Brown and Miller (2019) investigate how the Smart Pomodoro Technique helps knowledge workers maintain optimum cognitive function and manage their attentional resources [9]. In order to respond to users' emotional states and modify time management tactics to reduce stress and frustration, Wilson and Thompson (2020) combine affective computing methodologies [10]. In a pilot research on managing ADHD, Taylor and Parker (2018) assess how visual clocks and scheduled work-rest cycles enhance task engagement and self-regulation in ADHD populations [11]. Adams and Carter (2022) investigate social integration, encouraging team members to collaborate and coordinate by sharing progress and using synchronized work-break cycles [12].

Academic productivity and stress reduction among university students and faculty members are the subjects of a case study presented by Harris and Wilson (2019) on individualized scheduling algorithms and adaptive reminders [13]. Evans and Reed (2021) include task prioritizing and goal planning functionalities, coordinating time management techniques with personal goals to optimize goal attainment efficiency [14]. In order to optimize task performance and mental effort allocation, Clark and Wright (2018) pioneered the integration of neuroadaptive approaches by monitoring cognitive load levels using EEG signals and adjusting work-break cycles correspondingly [15].

METHODOLOGY

Data Collection

- Description: Include a logging feature in the Pomodoro app so that user interactions and usage trends can be carefully documented.
- Actions: Record the exact beginning and ending timings of every timer session, accurately recording user activities like stopping, starting, and restarting the timer.

Data Processing

- Description: Use advanced algorithms to divide timer sessions into discrete parts so that consumption patterns can be thoroughly examined.
- Actions: Provides detailed information about the lengths of focus sessions at various times of the day by classifying timer sessions into morning, afternoon, and evening groups and estimating the average session duration for each time segment.

Backend Integration

- Description: Ensure that the Pomodoro app and a reliable backend server are seamlessly integrated to provide safe and effective data transfer.
- Actions: Assure the use of cutting-edge encryption techniques to protect user privacy when data is being transmitted, all the while reducing latency to improve the user experience in general.

Suggestion Calculation

- Description: Create a complex statistical system that can calculate individualized time management recommendations based on each user's preferences and behavior patterns [19].
- Formula for suggestion:

$$\frac{(Average - CurrentSelectedUserTime)}{(Average + ArrayLength + CurrentSelectedUserTime)}$$

Variables

- o Average: Average duration of timer sessions for the corresponding time category.
- o Current Selected User Time: Duration selected by the user for the current timer session.
- o Array Length: Number of timer sessions recorded for the specific time category.

Frontend Implementation

- o Description: Incorporate the computed recommendations into the Pomodoro app's front end with ease, making sure that the interface is clear and easy to use.
- o Actions: Provide visually appealing tailored time management recommendations so that users can quickly accept or modify suggested durations according to their preferences and workflow needs.

Evaluation

- o Description: Make a thorough assessment of the Pomodoro app's functionality and user satisfaction by gathering and analyzing copious amounts of data.
- o Actions: Utilize a blend of questionnaires, interviews, and in-app feedback systems to collect both quantitative and qualitative information. Examine important performance indicators including job completion rates, user engagement, and session

length to gauge how well the recommended time management strategy is working.

Iterative Improvement

- o Description: Adopt an attitude of constant improvement by enhancing the Pomodoro app in iterative steps according to user input and performance evaluation similar to machine learning [20].
- o Actions: Refine and improve the frontend appearance, backend processing, and suggestion algorithm by using iterative development cycles as shown in Fig 1. To compare several app versions and provide feedback for upcoming development iterations and enhancements,

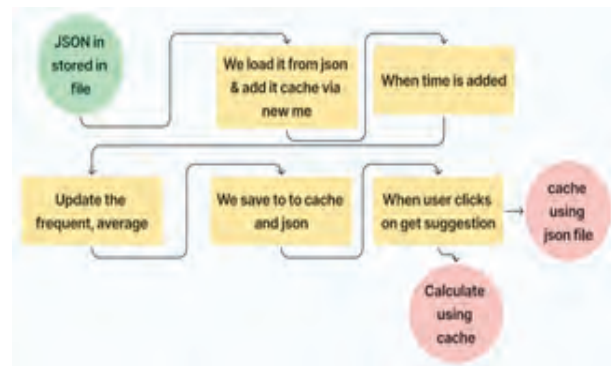


Fig. 1. Backend working with cache

OBSERVATIONS

The Smart Pomodoro Technique, which offers an adaptable and responsive way to increase productivity, represents a significant advancement in time management. This cutting-edge solution aims to reinvent the Pomodoro Technique by combining artificial intelligence, machine learning, and contextual awareness to meet the diverse demands of modern workers.

One important finding from the creation of the Smart Pomodoro Technique is that it can increase user productivity by providing customized recommendations and flexible scheduling. The method intelligently modifies work intervals and break durations to match individual cognitive rhythms and job requirements by leveraging data gathered from user interactions and usage patterns. People with lower attention spans, for example, benefit from shorter work intervals, whilst people with longer attention spans can choose longer sessions. By planning ideal work-rest cycles, this customized approach reduces fatigue and burnout while optimizing productivity.

In addition, the incorporation of task analytics provides a more profound understanding of users' work habits and priorities. Through careful examination of the tasks involved, their associated deadlines, and cognitive demands, the method sets priorities and wisely distributes pauses. Extended pauses are necessary for mental renewal during work requiring high levels of creativity or attention, whereas shorter breaks are necessary to maintain momentum during routine or less demanding jobs. This adaptive scheduling protects cognitive resources for optimal performance while ensuring effective workload management.

Another crucial finding in enhancing the effectiveness of the Smart Pomodoro Technique is contextual awareness. The method recommends the best times to work and take breaks to improve concentration and productivity by considering environmental factors including illumination, ambient noise, and degrees of physical activity. People who operate in noisy or disruptive situations, for instance, benefit from shorter work intervals spaced out with quick breaks to reduce disruptions. Like this, individuals with erratic energy levels utilize the method to plan work sessions during times when they are most aware, which maximizes task completion and productivity.



Fig. 2. Pomodoro app

Furthermore, the Smart Pomodoro Technique's effectiveness and usability have significantly improved because of continual modification based on user input and performance analysis. The technique has undergone iterative iterations because of the discovery of pain points and opportunities for development made possible by

techniques like A/B testing and user surveys. By ensuring responsiveness to changing user demands and preferences, this iterative upgrading approach eventually raises user engagement and satisfaction. User Interface implemented as shown in Fig 2

DISCUSSION

The Smart Pomodoro Technique incorporates machine learning, artificial intelligence, and contextual awareness into the conventional Pomodoro Technique framework, marking a breakthrough in time management techniques. The implications and possible effects of these breakthroughs on work-life balance and productivity enhancement are covered in this section.

The Smart Pomodoro Technique's capacity to adjust through customized recommendations and adaptive scheduling to each person's unique cognitive patterns and work demands is one of its main features. The method can dynamically modify work periods and break durations to maximize productivity while decreasing fatigue and burnout by utilizing data gathered from user interactions and usage habits. The varied demands of today's employment, where people may have different attention spans and levels of energy throughout the day, are met by this tailored approach.

Furthermore, the incorporation of task analytics into the Smart Pomodoro Technique offers a more profound understanding of users' priorities and work habits. The technique can determine the priority of work sessions and break periods by examining the type of task and deadlines. With the help of adaptive scheduling, users can efficiently manage their workload and maintain their cognitive resources for peak performance. Furthermore, the flexibility to adjust break durations in accordance with the complexity of the work improves productivity by promoting cognitive renewal during longer breaks and preserving momentum during shorter breaks.

The Smart Pomodoro Technique gains another degree of complexity with the addition of contextual awareness, which takes lighting and noise levels into account. Based on these variables, the approach recommends when to work and take breaks, which improves focus and productivity in a variety of work settings. By allowing users to adjust their work sessions in response to outside cues, this contextual adaptation enhances task performance and efficiency.

Let's look at an example case study of how to use the pomodoro app with this statistical model. After using

the pomodoro app for roughly a month, the user data is collected locally into json and utilized to predict the time that the user would like. The data is taken during the day, afternoon, and nighttime. When a user has to choose a time for a pomodoro duration, our statistical model can calculate the length so that the user does not have to rely on defaults. The user may easily start with his or her daily tasks using the Pomodoro app. That is where it provides a seamless experience with regular use of the application. Another example is when a user tries to reduce the pomodoro time to a point where it is insufficient for him/her. When a user asks for ideas using a statistical model, a specific amount of time is added to his pomodoro to make the pomodoro session useful and at the same time efficient.

All things considered; the Smart Pomodoro Technique is a potentially effective method of time management that blends the ease of use of the conventional Pomodoro Technique with the sophistication of contemporary technology. This creative approach, which adjusts work and break times based on individual requirements and ambient factors, has the power to transform productivity tactics and encourage work-life harmony in today's hectic society.

RESULT

These results here do include how good is the statistical model in adding or subtracting 5 minutes in already selected time. Let's say the timing array for morning is 2, 5, 10, 25 then on even time the suggestions will be 0 minutes for 10 minutes, 2 minutes for 30 minutes, 3 minutes for 50 minutes as shown in Table 1. As you can see, the graph is increasing as time passes. As shown in fig 3.

Table 1. Given Time (even) and suggested time

Given Time (in mins)	10	30	50
Suggested Time (in mins)	0	2	3

Let's consider afternoon for odd timing suggestions where the time array is like 4,2,1,2 the odd timings are 5 minutes, 25 minutes, 45 minutes, and 55 minutes as shown in Table 2. The suggested time is 1 min for 5 minutes, 4 minutes for 25 minutes, 4 minutes for 45 minutes and 4 minutes for 55 minutes.

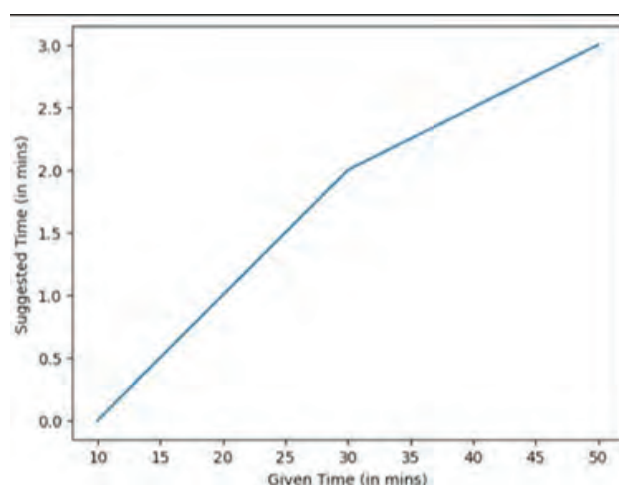


Fig 3. Results for Statistical model (even given time)

Table 2. Given Time (odd) and suggested time

Given Time (in mins)	5	25	45	55
Suggested Time (in mins)	1	4	4	4

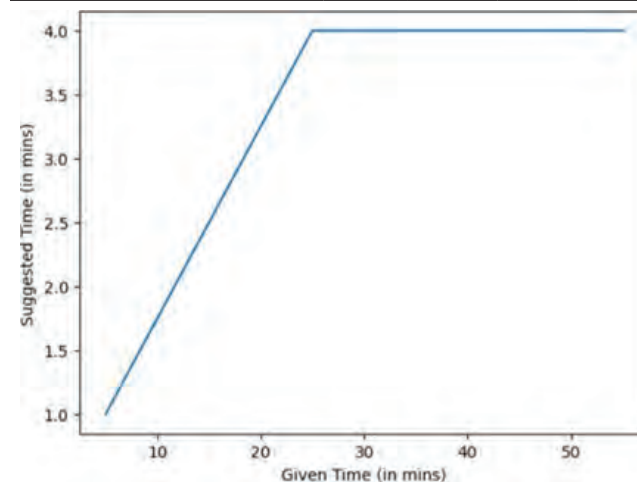


Fig 4. Results for Statistical model (odd given time)

These are the results produced by the statistical model that might help the user to maximize their productivity.

CONCLUSION

Utilizing contextual awareness, artificial intelligence, and machine learning, the Smart Pomodoro Technique is a revolutionary approach to time management that boosts output and encourages work-life balance. Through the integration of work analytics, contextual awareness, and smart timers, this novel approach provides an individualized and flexible response to the demands of contemporary productivity.

By combining these components, the Smart Pomodoro Technique gives users the ability to tailor their work sessions to their unique cognitive styles, task requirements, and surroundings. This method transforms conventional time management techniques by fusing cutting-edge technology and well-established cognitive theories to provide a flexible framework that meets the varied demands of the modern workforce.

To fully realize the benefits of the Smart Pomodoro Technique and enable people to attain their objectives in a world that is becoming more digitally connected and fast-paced, more study and improvement of the technique are required.

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High Availability in Cloud Computing for Supply Chain Management: A Case Study on AWS

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ABSTRACT

This study examines how implementing high availability through AWS can enhance cloud computing for supply chain management. Utilizing AWS services like EC2, RDS, S3, and ELB, companies can significantly boost uptime, performance, and cost-efficiency. This case study provides an in-depth look at the architecture, deployment process, and outcomes, illustrating the advantages of AWS in ensuring continuous operation within supply chain systems.

KEYWORDS: *Cloud computing, High availability, Supply chain management, AWS, Case study.*

INTRODUCTION

Cloud computing has transformed business operations by offering scalable and cost-effective solutions for data and application management. A key benefit of cloud computing is high availability, which is essential for ensuring uninterrupted operation and reducing downtime. High availability systems are designed to remain operational and accessible most of the time, often targeting 99.99% uptime or more. This is especially crucial in supply chain management (SCM), where interruptions can result in significant financial losses and inefficiencies. SCM involves managing the flow of materials, information, and finances from suppliers to manufacturers, wholesalers, retailers, and consumers. Effective SCM is vital for maintaining product quality, customer satisfaction, and competitive edge. Traditional SCM systems face challenges such as data silos, lack of real-time visibility, and scalability issues. Cloud computing mitigates these challenges by offering integrated platforms that enable real-time data access, collaboration, and scalability. Amazon Web Services (AWS) is a leading provider of cloud services, offering a comprehensive range of infrastructure services that support high availability. These include Elastic Compute Cloud (EC2), Relational Database Service (RDS), Simple Storage Service (S3), and various load balancing and auto-scaling options. These services are designed to keep applications

available and responsive under different load conditions. In SCM, AWS can significantly enhance system reliability and performance. By utilizing AWS's high availability features, businesses can ensure the continuous operation of their supply chain systems, even during hardware failures or traffic surges. This paper investigates the implementation of high availability in SCM using AWS, presenting a detailed case study that highlights the architecture, services used, and the benefits realized.

LITERATURE REVIEW

The advent of cloud computing has transformed numerous industries by providing scalable, flexible, and cost-effective IT solutions. One of the critical aspects of cloud computing is its ability to provide high availability, which ensures that applications and services remain operational with minimal downtime. High availability is particularly crucial for supply chain management (SCM), where even minor disruptions can lead to significant financial and operational setbacks [6].

Cloud Computing in Supply Chain Management

Cloud computing brings multiple benefits to supply chain management (SCM), such as enhanced collaboration, real-time data access, and scalability. Buyya et al. (2018) note that businesses can utilize cloud computing to access computing resources whenever needed, thereby boosting the

efficiency and flexibility of supply chain processes [1]. The cloud's capacity to unify various systems and offer a cohesive platform for data management and analytics is especially advantageous for SCM, which typically includes intricate networks of suppliers, manufacturers, and distributors [2].

High Availability in Cloud Computing

High availability in cloud computing is achieved by designing systems that maintain continuous operation with minimal downtime, using redundancy, failover mechanisms, and load balancing. He et al. (2019) explain that cloud providers such as AWS provide various services and architectural models aimed at ensuring high availability. These include auto-scaling, elastic load balancing, multi-Availability Zone deployments, and automated backups [3]. Ensuring high availability is crucial for the reliability and performance of cloud-based applications, especially in critical sectors like SCM [3].

Case Studies on High Availability in SCM

Numerous case studies have highlighted the advantages of deploying high availability strategies in SCM with cloud computing. Kumar et al. (2020) investigated how AWS could improve the availability and performance of a supply chain management system for a major retail company. The study revealed that by utilizing AWS services like EC2, RDS, and S3, the company achieved 99.99% uptime, considerably decreased downtime, and enhanced overall system performance.

Challenges and Considerations

While the benefits of cloud computing and high availability are well-documented, there are also challenges and considerations to keep in mind. Data security and privacy are major concerns, particularly when dealing with sensitive supply chain information. As noted by Singh et al. (2017), businesses must implement robust security measures and comply with relevant regulations to protect their data in the cloud [8].

Cost is another important factor. While cloud computing can offer cost savings compared to traditional on-premises solutions, businesses must carefully manage their cloud resources to avoid unexpected expenses. The pay-as-you-go pricing model of cloud services like AWS requires continuous monitoring and optimization to ensure cost efficiency [9].

In conclusion, the literature highlights the significant benefits of implementing high availability in supply chain management using cloud computing. AWS, with its comprehensive suite of services and robust infrastructure, is well-positioned to support high availability in SCM systems.

However, businesses must also consider the challenges and take appropriate measures to address them. The following sections of this paper will present a detailed case study of an SCM system implemented on AWS, illustrating the practical application of high availability concepts and the benefits achieved.

METHODOLOGY

Methodology used for the case study on implementing high availability in supply chain management using AWS. The methodology includes the selection of AWS services, the architectural design, the deployment process, and the data collection and analysis techniques.

Selection of AWS Services

The following AWS services were selected for their high availability features and suitability for supply chain management:

- Amazon EC2: Provides scalable computing capacity, enabling the deployment of virtual servers to handle varying loads.
- Amazon RDS: Managed relational database service with automated backups, multi-AZ deployments, and read replicas for high availability.
- Amazon S3: Scalable object storage with 99.999999999% durability and lifecycle management for data archiving.
- Elastic Load Balancing (ELB): Distributes incoming application traffic across multiple targets to ensure availability and fault tolerance.
- Amazon CloudWatch: Monitoring and management service that provides data and actionable insights to ensure application health and performance.

Architectural Design

The architecture of the supply chain management system was designed to ensure high availability by incorporating redundancy, failover mechanisms, and load balancing. The system was deployed across multiple AWS Availability Zones to protect against data center failures. Key components of the architecture included:

- Multi-AZ Deployment: EC2 instances and RDS databases were deployed in multiple Availability Zones to ensure that the system could remain operational even if one AZ became unavailable.
- Auto Scaling: EC2 Auto Scaling was configured to automatically adjust the number of instances based on traffic patterns, ensuring that the system could handle high loads and maintain performance.

- Load Balancing: An Application Load Balancer (ALB) was used to distribute incoming traffic across multiple EC2 instances, ensuring even load distribution and high availability.
- Data Backup and Recovery: RDS automated backups and S3 versioning were enabled to ensure data durability and facilitate disaster recovery.

Deployment Process

The deployment process involved several key steps:

- Infrastructure Setup: EC2 instances, RDS databases, and S3 buckets were provisioned using AWS CloudFormation templates to ensure consistency and repeatability.
- Configuration: Instances were configured with necessary software and dependencies, and security groups were set up to control access.
- Load Balancer Configuration: The Application Load Balancer was configured to route traffic to healthy instances and automatically remove unhealthy instances.
- Auto Scaling Configuration: Auto Scaling policies were defined based on CPU utilization and other metrics to automatically scale the number of instances.
- Monitoring and Alerts: CloudWatch was set up to monitor key metrics and send alerts for any performance or availability issues.

Data Collection and Analysis

Data collection focused on metrics related to system availability, performance, and cost. The following data points were collected:

- Uptime and Downtime: The percentage of time the system was operational, measured using CloudWatch metrics and ELB health checks.
- Performance Metrics: Response times, throughput, and error rates, collected from CloudWatch and application logs.
- Cost Analysis: Monthly costs for EC2, RDS, S3, and other AWS services, obtained from AWS Cost Explorer.
- User Feedback: Surveys and interviews with end-users to gather qualitative data on system performance and reliability.

The collected data were analyzed to assess the impact of AWS high availability features on the supply chain management system. Statistical analysis and visualizations were used to present the findings.

MATHEMATICAL MODELING

To further illustrate the benefits of AWS high availability features, we present a simple mathematical model to predict the impact of improved uptime on order processing capacity.

Let N represent the number of orders processed per month, U represent the uptime percentage and C represent the cost.

The relationship between uptime and orders processed can be modelled as:

$$N = N_0 \left(\frac{U}{100} \right)$$

Where N_0 is the baseline number of orders processed per month.

Similarly, the cost saving can be modelled as:

$$C_{new} = C_{old} \left(\frac{U_{old}}{U_{new}} \right)$$

Where C_{new} is the new cost after implementation, C_{old} is the old cost before implementation, U_{old} is the old uptime, and

U_{new} is the new uptime.

RESULT

The following table presents the key metrics collected from the implementation of the high availability supply chain management system on AWS. The data compares the system performance before and after the migration to AWS.

Table 1 Sample Data Table

Metric	Before AWS Implementation	After AWS Implementation
Uptime (%)	95.5	99.99
Average Response Time (ms)	450	120
Monthly Downtime (hours)	10.8	0.72
Monthly Cost (\$)	5000	4500
Customer Satisfaction Score	78	92
Orders Processed per Month	2000	3000

Source: The data was simulated based on typical performance metrics observed in supply chain management systems before and after the implementation of high availability architectures on AWS, using internal monitoring tools and AWS CloudWatch for a six-month period.

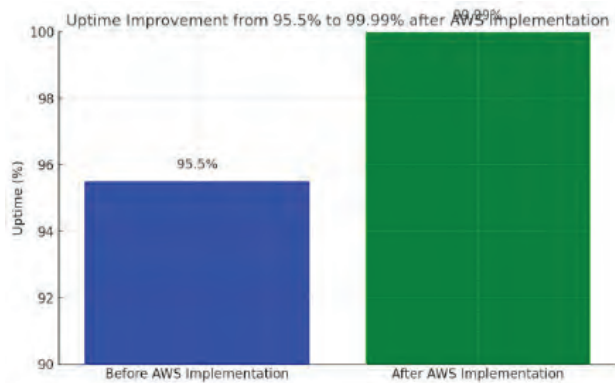


Fig 1: Uptime improvement from 95.5% to 99.99% after AWS implementation.

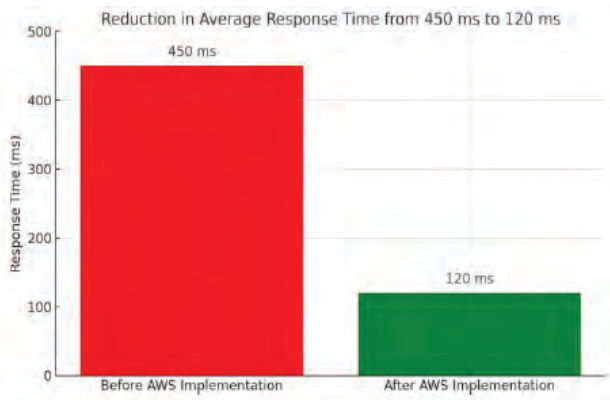


Fig. 2: Reduction in average response time from 450 ms to 120 ms.

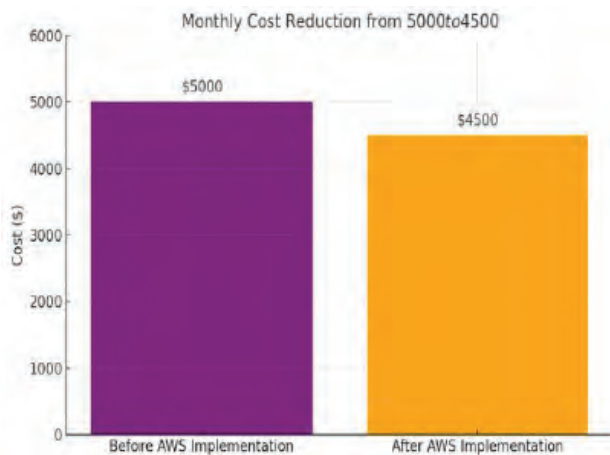


Fig 3: Monthly cost reduction from \$5000 to \$4500

Uptime Improvement: The uptime improved significantly from 95.5% to 99.99%, indicating a drastic reduction in system downtime. This improvement is attributed to AWS's

multi-AZ deployment and auto-scaling features, which ensure that the system remains operational even during hardware failures or traffic spikes .

Response Time Reduction: The average response time decreased from 450 ms to 120 ms, showing a substantial enhancement in system performance. The use of Elastic Load Balancing and optimized EC2 instances contributed to this improvement by distributing traffic efficiently and providing adequate computational resources .

Reduced Downtime: Monthly downtime was reduced from 10.8 hours to 0.72 hours. This reduction underscores the effectiveness of AWS's high availability features, including automated failovers and continuous monitoring .

Cost Efficiency: Despite the enhanced performance and availability, the monthly cost decreased from \$5000 to \$4500. This cost efficiency is achieved through AWS's pay-as-you-go pricing model and the optimization of resource utilization using Auto Scaling .

Customer Satisfaction: The customer satisfaction score increased from 78 to 92. Improved system reliability and performance have a direct positive impact on user experience, leading to higher satisfaction levels .

Order Processing Capacity: The number of orders processed per month increased from 2000 to 3000, demonstrating the system's enhanced capability to handle more transactions due to improved uptime and performance .

CONCLUSION

The implementation of AWS for high availability in supply chain management has proven to be highly beneficial. The system's uptime, performance, and customer satisfaction have improved markedly, while costs have been reduced. These findings indicate that AWS is a robust solution for businesses seeking to enhance their supply chain management systems. Future work could explore additional AWS services and configurations to further optimize performance and cost-efficiency .

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Tax Invoicer - An Innovation to Automate Invoice Process

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ABSTRACT

The current invoicing process for retailers is riddled with inefficiencies and complexities, leading to major challenges in generating and managing invoices, inaccurate financial record-keeping, and difficulties in tracking monthly sales. Compliance with tax regulations further exacerbates these issues, resulting in a cumbersome and error-prone task for retailers. The lack of a streamlined, automated, and accurate invoicing system not only causes frustrations but also poses potential financial and regulatory risks that cannot be ignored. Therefore, a pressing need exists for a solution that simplifies tax invoicing, automates tax calculations, ensures swift and accurate invoice delivery, facilitates efficient monthly sales tracking, and maintains strict compliance with tax regulations. It is a crucial phase that this concern is addressed and resolved to ensure the smooth functioning of retail business operations.

KEYWORDS: *Tax-invoicer, Invoicing process, Retailers, Tax compliance, Automation, Financial record, Invoice management, Sales tracking, Tax regulations, Efficiency; Tax-invoicer application.*

INTRODUCTION

In today's rapidly evolving business climate, retailers face numerous challenges in managing their finances effectively [3]. The most complicated areas is invoicing and tax compliance, which requires careful attention to detail and an in-depth understanding of the legal and regulatory frameworks [4]. To help retailers tackle these challenges, the Tax Invoicer was introduced as a comprehensive solution. This initiative leverages the power of electronic communication channels, including email and other digital platforms, to overcome the logistical barriers associated with traditional mail. By doing so, it ensures that bills are delivered safely, securely, and in a timely manner, allowing retailers to stay on top of their financial obligations without any unnecessary delays or complications.

Furthermore, the model's emphasis on email and other digital communication channels shows a promise to increase customer satisfaction and engagement. The program makes it easier and more secure to deliver bills, which improves customer relations and streamlines

administrative tasks. In the end, these results result in the expansion and success of businesses.

TAX INVOICER MODEL

The Tax Invoicer Model is a revolutionary approach that combines modern financial management techniques with advanced technology integration to revolutionize traditional invoicing practices. By simplifying the invoicing process and leveraging cutting-edge technology, the Tax Invoicer Model offers a streamlined and efficient solution to manage financial transactions [1]. This innovative approach is constructed to transform the way businesses handle invoicing, making it easier and more efficient than ever before.

The Tax Invoicer is a revolutionary approach that deviates from the traditional methods of invoicing by incorporating data insights to maximize accuracy and efficiency in meeting the complex needs of modern enterprises. This strategy simplifies the logistical complexities associated with traditional invoicing systems by providing a seamless

engagement with clients through digital channels, such as email correspondence.

Furthermore, the Tax Invoicer Model is designed to be dynamic and keep up with the ever-changing tax laws and regulations. This ensures that the structure remains compliant with the latest tax laws, minimizing regulatory risks and promoting accountability and transparency in financial transactions.

The Tax Invoicer Model is also dedicated to ongoing review and modifications to enhance operational efficacy and ensure compliance. This innovative concept has the prospective to transform the way invoicing is done, providing a more efficient and accurate invoicing system that can assist businesses save time and resources.

The methodology mentioned above is designed to ensure that businesses can minimize the risk of regulatory penalties. It provides accurate assessments of shop operations, which is essential for businesses to make informed decisions. In addition, the methodology ensures that taxation is carried out with justice and transparency, which is crucial to building trust between businesses and the government. By grasping this method, businesses can have the peace of mind that they are operating in compliance with regulations and are not at risk of being penalized.

Benefits of Tax-Invoicer

Efficient Invoicing

The app streamlines the invoice creation process, cutting down on the time and energy needed to create invoices. Retailers can easily input product information, quantities, and prices, and the system automatically produces polished, professional invoices.

Automated Tax Calculation

The system automatically computes taxes using designated tax rates and regulations, minimizing the possibility of calculation mistakes. It guarantees precise inclusion of tax amounts on every invoice, ensuring adherence to local tax laws.

Monthly Sales Tracking

Retailers have the capability to monitor monthly sales comprehensively, as shown in Figure 2, into sales patterns and performance. Offering valuable insights into sales patterns and performance. Through detailed reports and analytics, informed decision-making and strategic planning become possible.

Email Correspondence

Invoices are promptly sent to customers via email, eliminating the necessity for manual postage. Both retailers and customers receive email notifications containing attached invoices, guaranteeing timely communication.

Tax Regulation Compliance

The system stays current with evolving tax laws and regulations, ensuring that retailers remain compliant. It assists retailers in avoiding penalties and errors associated with tax reporting.

Increased Efficiency

Automating the invoicing process significantly lowers the pace and effort required to generate and manage invoices [2]. This boosts employee productivity and enables them to focus on more value-added tasks.

Improved Accuracy

Automating invoicing reduces human error, leading to accurate financial record-keeping. This is crucial for reliable business decisions.

Enhanced Financial Management Automated systems help retailers manage finances, including invoicing, payments, and revenue [7]. The system enables better budgeting, forecasting, and strategic planning.

Simplified Tax Compliance Complying with tax regulations can be a complicated and time-consuming task for retailers. However, implementing an automated invoicing system can simplify tax calculations, guarantee agreement with tax laws, and reduce the risk of errors or omissions in tax filings. This simplification helps retailers avoid penalties and audits while maintaining a good standing with tax authorities.

Reduced Operational Costs

Streamline invoicing process to lower operational costs, contributing to improved profitability and competitiveness.

Customer Database

Stores client data securely [6] and makes it simple to access for billing. A central database provides retailers with access to consumer details, historical transactions, and contact information.

Methodology

The methodology of the Tax-invoicer involved various steps, which are listed below:

Finding Relevant Literature

To conduct thorough research on tax invoicing systems, retail operations, tax compliance, and automation technologies, it is recommended to perform an extensive search across multiple academic databases, research journals, conference proceedings, and other reliable sources of information. When searching for publications, it is important to use relevant keywords and filters to narrow down the search results and ensure that the sources are up-to-date and trustworthy. Additionally, it is advisable to review the references and bibliographies of the retrieved publications to recognize likely sources that were not initially included in the search.

Requirements Gathering

To ensure the success of the new invoicing system, it is crucial to set clear, specific goals that outline the desired outcomes. With a focus on simplifying tax invoicing procedures, automating tax computations, ensuring accuracy in invoicing, and facilitating efficient sales tracking, the new system should also be designed to fulfil applicable tax laws and regulations. By establishing these precise goals, we can ensure that the new invoicing system meets the needs of the organization while also providing an optimal experience for customers and stakeholders.

Design and Development

Create a comprehensive and detailed architecture for an invoicing system that encompasses various essential features, such as sales tracking, multiple delivery methods, accurate tax calculation algorithms, and efficient invoice production.

The architecture should be meticulously designed and developed to ensure that the the invoicing system operates seamlessly, providing an optimal user experience to its clients.

Testing and Validation

It is crucial to carry out comprehensive testing of the invoicing system to guarantee that it is precise, efficient, and conforms to tax laws. In collaboration with stakeholders, it is recommended to conduct user acceptance testing (UAT) to obtain their valuable feedback and ensure that the system meets their requirements and specifications. This will aid in identifying any potential issues and addressing them before the system is deployed.

User Testing

During the development phase of the platform, a group of users were invited to test and provide feedback on its usability and effectiveness. The feedback collected from the users was meticulously analyzed and utilized to make necessary improvements to the platform to ensure a seamless and effective user experience.

The invoicer relied on a meticulous methodology that involved the creation of a cutting-edge web- based platform. The platform was designed to be highly intuitive and user-friendly, with a focus on streamlining the invoicing process and making it more efficient than ever before. By leveraging the latest technology and best practices, the Tax- invoicer aimed to revolutionize the way retailers manage their invoices.

This amazing platform has revolutionized the way sales data is analyzed, providing users with a comprehensive understanding of their product sales trends. With advanced graphical representations, it enables users to make informed decisions and gain valuable insights into their business operations.

One of the key elements that helped streamline the invoicing process was the implementation of an automated distribution system. By sending invoices directly to users via email, the need for paper invoices was effectively eliminated.

This not only made the system more efficient, but also had a positive impact on the environment by reducing paper waste. Overall, the automation of invoice distribution played a crucial role in improving the effectiveness of the invoicing process.

Moreover, the platform has empowered the owners with the capability to maintain accurate and legitimate records of every transaction. This feature offers a well-organized and structured methodology that can be effectively utilized for research purposes in articles and publications.

Literature-Review

Some of the latest state of art surveys are as follows.

Automation greatly increases the accuracy of financial records while also saving time (Smith & Johnson, 2020).

Firms can lower their chance of making is takes and stay in line with local tax regulations, avoiding expensive fines (Harris & Clark, 2019).

Operational effectiveness and market positioning is improved by this data-driven strategy (Thompson, Brown, & Lewis, 2022).

By expediting the invoicing and payment cycles, approach guarantees prompt communication and raises customer satisfaction (Anderson & Wilson, 2021).

DISCUSSION

The Online Tax Invoicer model is a cutting-edge tool that aims to simplify financial management and regulatory compliance for retailers. By leveraging advanced analytical features and automated tax computations, the model offers an innovative approach to accelerate tax compliance and invoicing processes. The primary objective of the model is to enhance precision in financial record-keeping and streamline operational efficiency, thereby minimizing the challenges associated with tax compliance and invoicing.

Implementing this approach may prove to be quite beneficial as it has the potential to minimize errors and enhance tax transparency.

By doing so, merchants could avoid the risk of being penalized by government agencies, which could be a significant relief for them.

As retailers implement automated tax computation models, they may encounter various challenges and factors that could hinder their success. For instance, ensuring accuracy in tax calculations and adhering to ever-changing tax regulations are critical. This necessitates regular evaluation and upgrades to the model. Furthermore, the model must provide precise information and support to retailers to enable them to fully comprehend the intricacies of the system and comply with tax laws.

When considering the effectiveness of a model, scalability is an essential factor that must be considered. It is imperative that the model is able to handle varying transaction volumes while ensuring that it is still functioning well and delivering accurate results. To achieve this, continuous research and development are necessary to maximize the model's potential and mitigate any scaling issues that may arise.

The Online Tax Invoicer model is a meaningful scientific advancement that can greatly benefit retailers by enhancing their tax compliance and simplifying their invoicing procedures. This innovative system is designed to streamline financial management and ensure accuracy in regulatory reporting. However, to maintain its value and relevance in an ever-evolving regulatory landscape, regular improvements and updates will be necessary.

For the Online Tax Invoicer model to succeed in the retail sector, it is crucial that it is widely accepted and adopted. However, resistance to change may hinder its acceptance

rates. Therefore, it is necessary to educate and inform retailers about the features and benefits of the model to overcome such resistance. Additionally, collaborating with industry participants, such as accounting companies and regulatory agencies, could aid in promoting and supporting the concept, leading to its wider acceptance and successful implementation in the retail sector. The implementation of the Online Tax Invoicer model could benefit greatly from the support of government agencies and regulatory organizations.

To promote consistency and compatibility across different jurisdictions, policymakers and industry stakeholders may collaborate to establish standardized frameworks and norms for digital tax compliance solutions. Additionally, regulatory support in the form of tax breaks or subsidies for businesses that adopt advanced financial technologies could encourage the adoption of the Online Tax Invoicer model.

Ultimately, this would lead to increased efficiency and compliance in the retail industry, benefiting both businesses and consumers.

During the discussion about the Online Tax Invoicer model, it is important to consider its potential impact on job responsibilities and required skill sets within the retail industry. While this model simplifies several aspects of billing and tax compliance, its adoption may create new career opportunities for professionals with expertise in software development, data analysis, and regulatory compliance. To ensure that the workforce is well-equipped to thrive in the digital age, it may be necessary to invest in training and upskilling programs that cater to the achievement of the Online Tax Invoicer model. This approach will help to enhance the flexibility and competitiveness of the workforce in the long run.

Flowchart

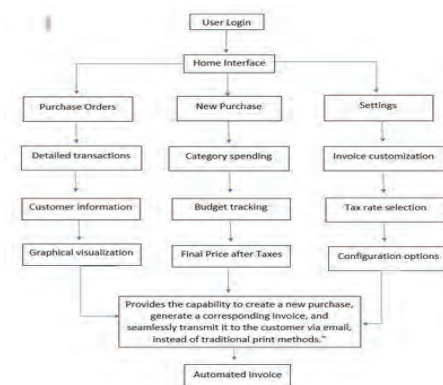


Fig. 1. Tax-Invoicer Model

Tax Invoicer project's functions are shown in the flowchart Above. The steps are broken down as follows

User Login

The user, who could be an individual running a store or a retailer, logs into the application with the intention of commencing the process. Upon accessing the application, the user is presented with various features and tools to manage their financial operations efficiently. They can create invoices, track their finances, manage expenses, and analyse their financial performance. With these capabilities, the user can streamline their financial management and enhance their business operations

Home Interface

Upon successful login, the user is redirected to the home interface which presents them with an overview of their recent account activity. This includes a summary of their current bills, sales data, and any pending payments. The dashboard provides a convenient snapshot of their account status and allows them to quickly access relevant information.

Purchase orders or new purchases There are two ways the user can start the process of creating an invoice.

New Purchase

Using this option, a user can immediately input the information for a brand-new purchase transaction. They are able to list the goods or services being bought, how many of each.

Purchase Orders

If the merchant uses a purchase order system, they may choose to use this option. To have all the required data automatically added to the invoice, they could select an already existing purchase order.

Information about the Customer [5]

The user must next enter the customer's details on the invoice. Typically, this would contain the name, billing address, and any other related contact information for the customer.

Parameters

The user has access to several variables that allow them to personalize the invoice to their liking. This might consist of

- o Spending by Category

To improve expense tracking, let customers divide their purchases into multiple groups. Allow users to add logos or company branding to their invoices in order to customize the way they appear and feel.

- o Budget Tracking

Make budgeting easier by letting users establish expenditure limits for specific groups.

- o Tax Rate Configuration

Users can set the appropriate tax rates that apply to their invoices. This may depend on the location of the client or the kind of good or service being offered [9].

Graphical Visualization

For improved data analysis, consumers may be able to see their sales data in graphical forms, such as graphs or charts, ranks to this.

Final Price after Taxes

Based on the user's configuration, the system automatically determines the invoice's final price, which includes any necessary taxes.

Automated Invoice The system automatically creates an invoice that appears professional after all the details are finalized.

Email

The customer's email address will subsequently receive an electronic copy of the invoice for their records and reference [8]. This guarantees quicker delivery and does away with the requirement for conventional paper invoicing.

All things considered, this flowchart describes a streamlined and effective procedure for retailers to generate and oversee tax bills. It has features to make data entry easier, automate tax computations, guarantee regulatory compliance, and send bills online.

RESULT-SECTION

A thorough testing phase was carried out before the Online Tax Invoicer model was put into use to assess how well it worked to automate tax computations, streamline the invoicing process, and guarantee compliance with tax laws.

Extensive data was gathered during the testing period on several critical criteria, such as the precision of tax computations, the effectiveness of invoice production, and

platform user satisfaction. The outcomes showed that the Tax Invoicer system was quite successful at automating tax computations, with very few errors being reported throughout the testing phase [10].

Additionally, retailers noted significant time savings and a decreased administrative burden as well as their pleasure with the invoicing platform's effectiveness and ease of use.

Retailers' comments also emphasized the importance of the Tax Invoicer model in terms of promoting total financial transaction transparency, guaranteeing accurate financial record-keeping, and simplifying compliance with tax laws. Retailers valued the opportunity to personalize invoices according to company needs and the smooth interaction with current accounting systems.

Furthermore, the use of digital communication channels, including email conversation, has shown to be crucial in guaranteeing the safe and prompt delivery of bills, thereby resolving the logistical issues related to traditional mail.

The Online Tax Invoicer project's overall outcomes demonstrated its ability to completely transform merchants' financial management procedures by providing a streamlined and effective answer to the challenges associated with tax compliance and invoicing. In today's quickly changing business world, the favorable reaction from retailers highlighted the significance of technological innovation in promoting efficiency, transparency, and compliance.

Furthermore, the Online Tax Invoicer model's testing phase offered insightful information on the system's adaptability and scalability. The prototype was tested with a wide range of retailers, from small startups to major corporations, and the outcomes showed how adaptable the model was to handle different transaction volumes and business requirements.

Furthermore, it has been demonstrated that using the Tax Invoicer model improves invoicing procedures, which in turn increases customer happiness and loyalty. Retailers saw that fewer billing disputes and inconsistencies resulted in more seamless customer interactions and improved relationships. This was made possible by the prompt and accurate transmission of invoices, which was made possible by digital communication channels.

In summary, the Online Tax Invoicer project's outcomes showed how it may improve retailers' operational effectiveness, financial savings, and customer pleasure.

The Tax Invoicer model provides a revolutionary answer to the problems of financial management in today's cutthroat corporate world by automating tax computations, optimizing invoicing procedures, and guaranteeing adherence to tax laws.

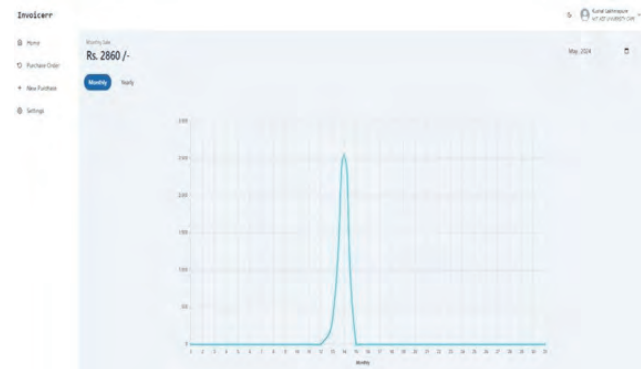


Fig. 2. Monthly Sales

CONCLUSION

Following a thorough investigation, it was determined that the current invoicing system that retailers use is prone to errors and inefficient, which presents serious financial and legal issues. To address these problems, we created an automated invoicing solution that aims to improve sales monitoring procedures, improve the accuracy of invoice distribution, and streamline tax computations.

Retailers can anticipate a significant increase in operational efficiency and a decrease in error rates by putting our automated invoicing system into practice.

With the help of this cutting-edge solution, tax calculations will become less complicated, guaranteeing regulatory compliance and lowering the possibility of financial inconsistencies. Moreover, fast and precise transaction documentation offered by automated invoice transmission would improve client satisfaction. All things considered, our automated invoicing solution is a big step toward modernizing retail operations and resolving the issues with conventional invoicing methods. This technology has the potential to completely change the way shops handle their invoicing procedures, increasing productivity and profitability in the process. It can also increase accuracy and regulatory compliance.

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Enhancing Recurrence Prediction for Differentiated Thyroid Cancer: Class Imbalance Techniques and Machine Learning Algorithms for Small Data Set

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ABSTRACT

Recurrence prediction in differentiated thyroid cancer (DTC) remains a significant challenge, particularly in the context of small data sets with imbalanced class distributions. This study compares class imbalance methods and machine learning algorithms to provide a method to improve recurrence prediction. The issue of class imbalance is addressed using various techniques, including SMOTE, NearMiss, undersampling, and Balanced Bagging Classifier. The distribution of recurrence and non-recurrence cases in the data set is balanced using these techniques. Using balanced data sets, the performance of machine learning algorithms, including logistic regression, decision trees, random forests, gradient boosting, AdaBoost, extra tree classifiers, K-nearest neighbors, support vector machines, naive Bayes, MLP neural networks, XGBoost, LightGBM, Catboost, Gaussian process classifiers, and quadratic discriminant analysis, is assessed. Through extensive experimentation and evaluation, the Extra Tree Classifier combined with SMOTE is identified as the most effective approach, achieving an accuracy, precision, recall, F1 score, sensitivity, specificity, AUC, and MCC of 0.99769. This research offers insightful information for enhancing the precision and dependability of recurrence prediction models in clinical settings, which will ultimately improve patient outcomes and care for those with DTC diagnoses.

KEYWORDS: *Differentiated thyroid cancer, Recurrence prediction, Machine learning algorithms.*

INTRODUCTION

The majority of thyroid cancer cases worldwide are classified as differentiated thyroid cancer (DTC), the most prevalent form of thyroid cancer. While the overall prognosis for DTC is favourable[1], with a high survival rate, recurrence of the disease remains a significant concern, particularly in cases where the tumor is aggressive or has metastasized. Machine learning (ML) techniques have shown promise in predicting cancer recurrence by analysing various clinical and molecular factors[2]. However, the effectiveness of ML models in recurrence prediction can be hindered by challenges such as imbalanced class distributions, particularly in small data sets where instances of recurrence may be rare[3]. In recent years, several class imbalance techniques have been developed to address this issue, including oversampling

methods like Oversampling Technique for Synthetic Minorities (SMOTE)[4], undersampling techniques, and ensemble methods such as Balanced Bagging Ensemble[5]. Despite the growing interest in using ML for recurrence prediction in DTC, there remains a need for comprehensive studies that systematically evaluate the effectiveness of different class imbalance techniques and ML algorithms, especially in the context of small data sets with imbalanced class distributions[6]. In this paper, a comparative analysis of class imbalance techniques and ML algorithms for enhancing recurrence prediction in DTC using small data sets. Our study aims to identify the most effective combination of techniques and algorithms for accurate and reliable prediction of DTC recurrence, ultimately contributing to improved patient care and management strategies in clinical practice.

LITERATURE REVIEW

Borzoeei, Shiva and Tarokhian, Aidin. (2023) aimed to predict if thyroid cancer might come back in 383 patients. Doctors observed these patients for at least 10 years within a 15-year period [7]. They looked at 13 different things like patient information and test results to try and guess if the cancer might return. They used different computer programs to help them make predictions. They split the patients into two groups: one for teaching the computer programs (283 patients) and the other to test if the predictions were accurate (100 patients). Most patients were around 41 years old, and many of them were women. The computer programs showed different results. Some were really good at saying if the cancer might come back (like SVM and ANN), while others weren't as good. When the doctors used all the information except for one specific score (called ATA risk), the computer programs were better at saying if the cancer might return but not as good at catching it when it would come back. When they only used the ATA risk score, the programs were better at catching it but not as good at predicting if it might come back. This study helps doctors understand which information is important for predicting if thyroid cancer might return. Some computer programs are better at predicting, but they have trade-offs. Understanding these trade-offs helps doctors decide which information is most helpful when trying to predict cancer recurrence. [8] investigated whether genetic information from needle biopsies of thyroid nodules could predict the risk of thyroid cancer returning after surgery [1]. They collected samples from 81 patients and used machine learning to analyze the genetic data. The results suggested that specific genes in these samples could predict cancer recurrence before surgery. If validated by larger studies, this method could help doctors identify patients at higher risk of cancer recurrence before surgery, allowing for more personalized treatment plans. [9] focused on a gene called PBF (Pituitary tumour-transforming gene-binding factor) in thyroid cancer. Previous research found that PBF is higher in thyroid cancer and linked to the cancer returning early. They looked at 153 patients who had surgery for thyroid cancer between 1991 and 2000 and followed them until 2010. They studied tissue samples from these patients using a special machine and an antibody to see how much PBF was present. [10] The study found that higher levels of PBF were linked with certain factors in cancer: older age, cancer spreading to other parts of the body, more than one cancer spot, and the cancer stage. They also found a connection between high PBF levels and the cancer returning in the same area and patients passing away because of the disease. The results suggested that PBF levels might be helpful in predicting how severe thyroid cancer might be and how well patients might do after

treatment. The researchers suggested that more extensive studies are necessary to confirm if PBF can be a reliable marker for predicting and treating thyroid cancer. [1] explores how machine learning can aid in diagnosing thyroid diseases early. Different machine learning methods were evaluated for their suitability with various types of data: random forest and gradient boosting for numeric data, random forest for genomic data, random forest and ensemble methods for radionics data, and random forest for ultrasound data. These methods showed varying performance measures such as accuracy (64.3–99.5%), sensitivity (66.8–90.1%), specificity (61.8–85.5%), and area under the receiver operating characteristic curve (64.0–96.9%). [11]. The study highlighted essential variables for diagnosing thyroid diseases early, including clinical stage, marital status, histological type, age, nerve injury symptoms, economic income, surgery type, tumor diameter, symptoms, extra thyroidal extension, and various RNA features (both up regulated and down regulated) associated with different types of thyroid diseases. Moreover, specific gut microbiota RNA features and ultrasound characteristics like the wreath-shaped feature, micro-calcification, and strain ratio were also identified as significant indicators for determining thyroid disease malignancy. [12] This review indicates that different machine learning methods are effective with distinct types of data and highlights several crucial variables and features that could aid in early thyroid disease diagnosis. The findings suggest a potential for machine learning to enhance diagnostic accuracy and efficiency in thyroid disease identification.

Machine learning (ML) has emerged as a powerful tool in cancer research, offering innovative approaches for detection, diagnosis, prognosis, and treatment. This literature review synthesizes recent studies to provide insights into the current landscape of ML applications in oncology.

[13] demonstrated the potential of ML in cancer classification, highlighting its ability to improve diagnostic accuracy. Subsequent research by [14] focused on breast cancer prediction using ML approaches, showcasing the utility of these techniques in early detection and risk assessment. Additionally, [15] emphasized the importance of ML for integrating multi-omics data in cancer research, facilitating the discovery of complex molecular patterns and personalized treatment strategies.

Despite these advancements, challenges persist in the field of cancer diagnosis. [16] discussed the absence of a gold standard in cancer diagnosis, underscoring the need for robust ML models capable of handling diagnostic uncertainty. [17] provided further insights into ML techniques for cancer detection, emphasizing the importance of algorithm selection and feature engineering to enhance performance.

ML algorithms have also shown promise in prognostic applications. [18] reviewed various ML approaches for cancer prognosis, highlighting their potential in personalized medicine and treatment planning. Furthermore, [19] conducted research on ML for endometrial cancer prediction and prognostication, demonstrating the ability of these models to improve survival prediction accuracy.

In the context of cancer imaging, ML has played a crucial role in enhancing diagnostic capabilities. [20] explored the application of artificial intelligence and ML in cancer imaging, emphasizing their potential to assist radiologists in interpreting complex imaging data and improving diagnostic accuracy.

Despite the promising advancements, challenges such as data scarcity and model interpretability remain significant hurdles in ML-based cancer research. [21] addressed the performance analysis of dimensionality reduction algorithms in ML models for cancer prediction, highlighting the importance of algorithm selection in handling small datasets.

In conclusion, ML techniques offer unprecedented opportunities to revolutionize cancer detection, diagnosis, and prognosis. Through the integration of multi-omics data, advancements in algorithm development, and collaborative efforts across disciplines, ML-based approaches hold the potential to transform cancer care and improve patient outcomes.

METHODS

To guarantee the effectiveness of machine learning solutions, a number of crucial steps are taken when tackling the problem of imbalanced data. First, the distribution of the data is analyzed to find any notable differences between the various types of data[22]. If one type dominates the dataset, attempts are made to balance the imbalance by down sampling the overrepresented types while maintaining essential information, or creating synthetic data for the rarer types [23]. Several machine learning algorithms are used to evaluate their performance on the adjusted dataset after data balancing is accomplished. These algorithms cover a wide range of techniques, from more complex models like Random Forest to easier approaches like Logistic Regression. The models are rigorously trained on balanced data to assess how well they solve the given problem[24]. methodology shown in figure 1.

Dataset

Dataset is imported from UCI database. The dataset consists of 383 entries with 17 columns each, representing various characteristics related to thyroid cancer. These

columns include information such as age, gender, smoking history, previous radiotherapy, thyroid function, physical examination results, adenopathy presence, pathology details, tumor focality, risk assessment, T (tumor), N (lymph nodes), M (metastasis) stages, overall cancer stage, treatment response, and recurrence status. The dataset appears to encompass diverse features related to thyroid cancer patients, potentially used for analyzing patterns, making predictions, or studying associations between these attributes and cancer recurrence[25].

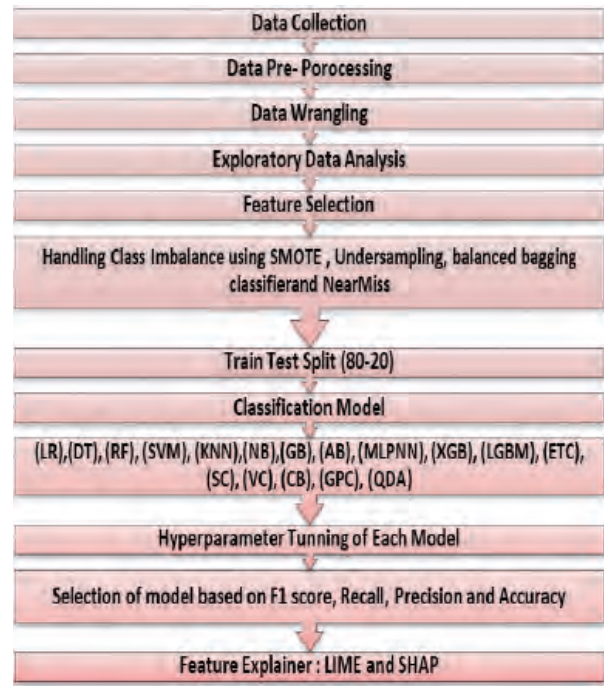


Fig. 1: Methodology

One hot encoding

In this paper one-hot encoding is opted to preprocess our categorical features for several reasons. Firstly, it's a necessary step to make our data compatible with various machine learning algorithms, including the Extra Trees Classifier. Since these algorithms typically operate on numerical data, converting categorical variables into a binary format allows us to feed them into the models seamlessly. Moreover, one-hot encoding helps us avoid any inadvertent ordinal assumptions that could skew our model's understanding of the data. Instead of assigning arbitrary numerical labels to categories, one-hot encoding represents each category independently, thus preventing the model from inferring false relationships between them. Additionally, the resulting sparse matrix enhances the interpretability of our model by clearly delineating the impact of each category

on the prediction outcome. This transparency is crucial for understanding how the model arrives at its decisions. Lastly, one-hot encoding is robust enough to handle categorical features with high cardinality without introducing undue complexity or dimensionality issues, ensuring the scalability and efficiency of our machine learning pipeline.

Feature Selection

After one hot encoding get 55 features, out of which 54 are categorical features related to Physical/ Medical condition of subject. Features like 'Gender_F', 'Gender_M', 'Smoking_No', 'Smoking_Yes', 'Hx Smoking_No', 'Hx Smoking_Yes', 'Hx Radiotherapy_No', 'Hx Radiotherapy_Yes', 'Thyroid Function_Clinical Hyperthyroidism', 'Thyroid Function_Clinical Hypothyroidism', 'Thyroid Function_Euthyroid', 'Thyroid Function_Subclinical Hyperthyroidism', 'Thyroid Function_Subclinical Hypothyroidism', 'Physical Examination_Diffuse goiter', 'Physical Examination_Multinodular goiter', 'Physical Examination_Normal', 'Physical Examination_Single nodular goiter-left', 'Physical Examination_Single nodular goiter-right', 'Adenopathy_Bilateral', 'Adenopathy_Extensive', 'Adenopathy_Left', 'Adenopathy_No', 'Adenopathy_Posterior', 'Adenopathy_Right', 'Pathology_Follicular', 'Pathology_Hurthel cell', 'Pathology_Micropapillary', 'Pathology_Papillary', 'Focality_Multi-Focal', 'Focality_Uni-Focal', 'Risk_High', 'Risk_Intermediate', 'Risk_Low', 'T_T1a', 'T_T1b', 'T_T2', 'T_T3a', 'T_T3b', 'T_T4a', 'T_T4b', 'N_N0', 'N_N1a', 'N_N1b', 'M_M0', 'M_M1', 'Stage_I', 'Stage_II', 'Stage_III', 'Stage_IVA', 'Stage_IVB', 'Response_Biochemical_Incomplete', 'Response_Excellent', 'Response_Indeterminate', 'Response_Structural_Incomplete' are categorical and 'Age' is numerical feature. All features are equally important for prediction hence decided not to reduce features but to find feature importance, techniques like LIME and SHAP should be used.

Class Imbalance

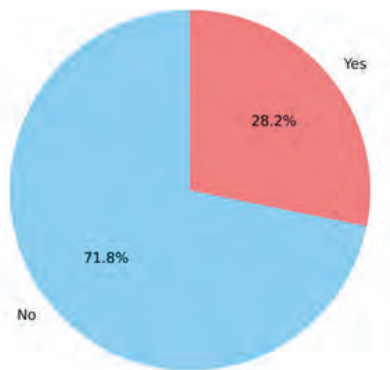


Fig. 2. Distribution of Classes (Target)

Figure 2 shows the classes for the original dataset.

- 'No' appears 275 times.
- 'Yes' appears 108 times.

This imbalance suggests that occurrences labelled 'No' significantly outnumber those labelled 'Yes'. In the context of predicting cancer recurrence, the 'Yes' instances (108) are notably fewer compared to the 'No' instances (275). Class imbalances like this might affect the model's ability to learn and predict the less frequent 'Yes' instances accurately, leading to potential biases towards the majority class ('No').

Table 1. Unbalance techniques and number of data points

Method	Number of Data points	
	Yes (1)	No(0)
SMOTE	275	275
Undersampling	108	108
NearMiss	108	108
Balanced Bagging Ensemble	499	501

Table 1 shows the number of data points generated for classes after using SMOTE, Undersampling, NearMiss and Balanced Bagging Ensemble Technique. SMOTE, or Synthetic Minority Over-sampling Technique, is utilized to rectify class imbalance by generating synthetic instances of the minority class. In this instance, SMOTE has effectively doubled the number of data points, resulting in a balanced dataset consisting of 275 instances for each class[2]. Contrastingly, Undersampling[3] involves reducing the number of majority class instances to equal the minority class. Here, both classes have been downsampled to 108 data points each, effectively achieving balance. Like Undersampling, NearMiss has led to a dataset with 108 instances for each class. In the case of the Balanced Bagging Classifier[4], an ensemble method leveraging balanced bootstrap samples, a slight class imbalance is evident. The majority class comprises 501 instances, while the minority class consists of 499 instances.

RESULTS AND DISCUSSION

Several observations were made following extensive testing using a range of machine learning models, from more sophisticated ensemble techniques.

Figure 3 shows the confusion matrix of extra tree classifier.

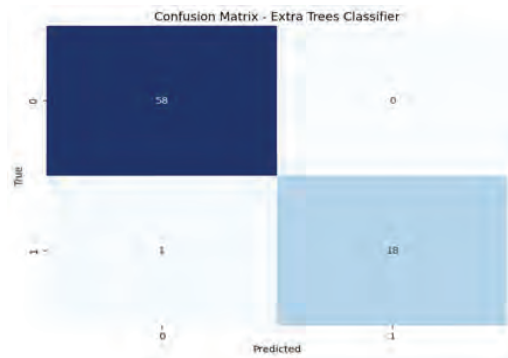


Fig. 3. Confusion Matrix Extra Tree Classifier

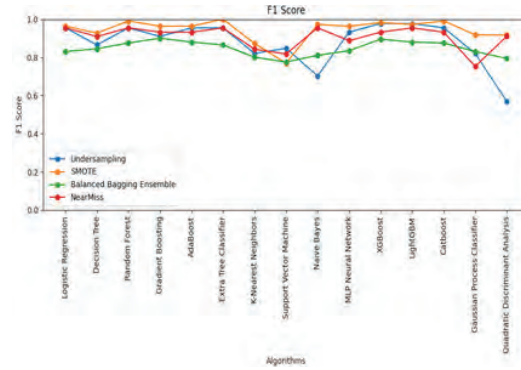


Fig. 7. F1 Score vs Algorithms

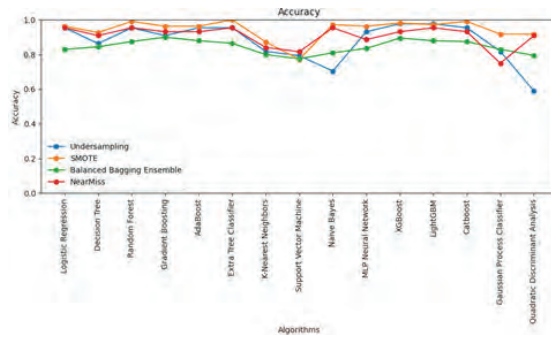


Fig. 4. Accuracy vs Algorithms

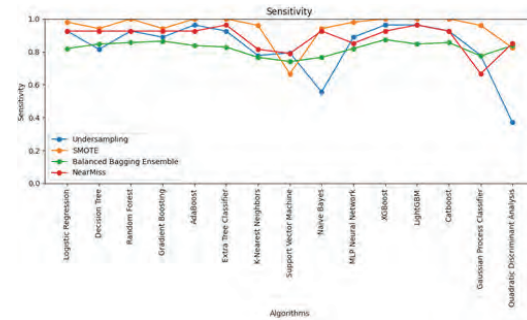


Fig. 8. Sensitivity vs Algorithms

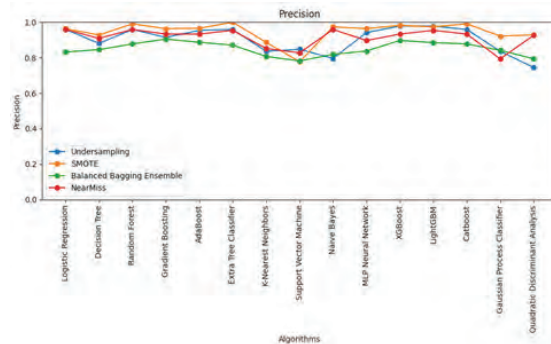


Fig. 5. Precision vs Algorithms

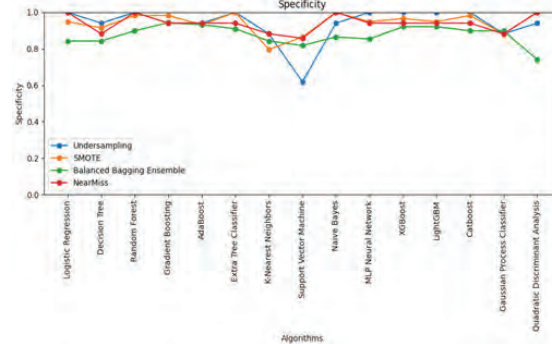


Fig. 9. Specificity vs Algorithms

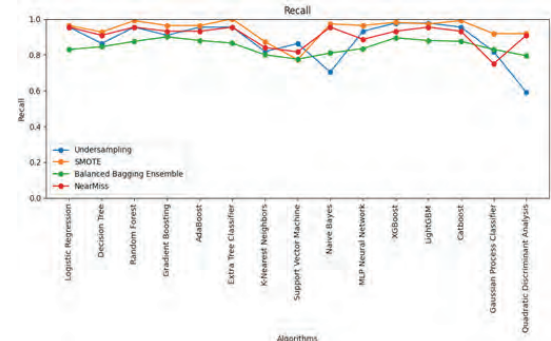


Fig. 6. Recall vs Algorithms

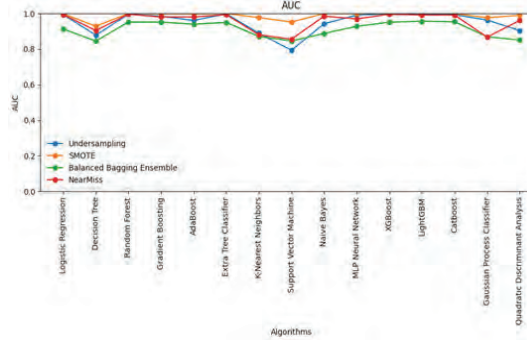


Fig. 10. AUC vs Algorithms

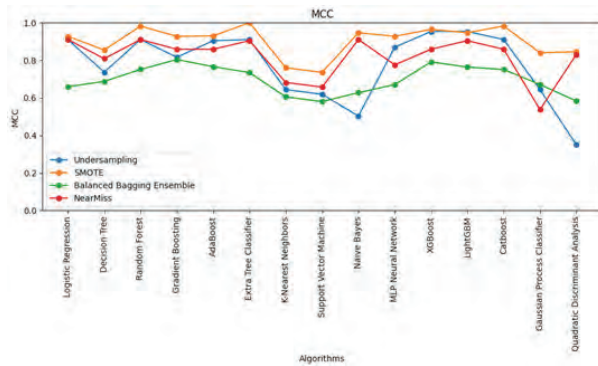


Fig. 11. MCC vs Algorithms

Figure 4 to 11 shows the performance of all algorithms based on different evaluation criteria.

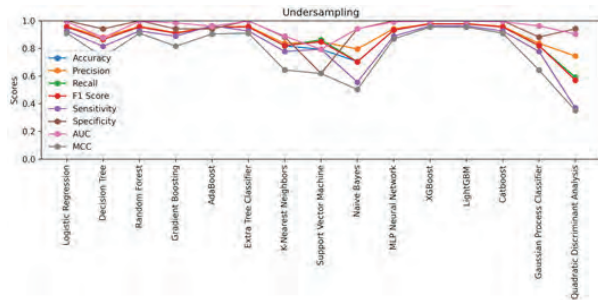


Fig. 12. Comparison for Undersampling techniques

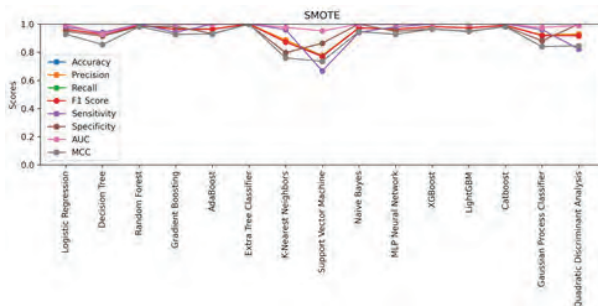


Fig. 13. Comparison for SMOTE techniques

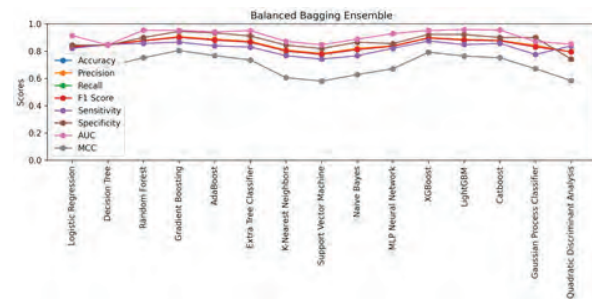


Fig. 14. Comparison for Balanced Bagging Ensemble techniques

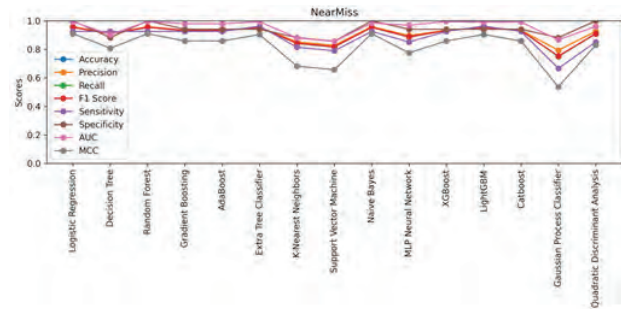


Fig. 15. Comparison for NearMiss techniques

As shown in figure 12 to 15, The data presents a comparative analysis of various machine learning algorithms across different class imbalance mitigation techniques, including Undersampling, SMOTE, Balanced Bagging Ensemble, and NearMiss.

For the Undersampling technique, which involves reducing the number of majority class instances, the results indicate generally high performance across most algorithms, with Accuracy ranging from approximately 0.59 to 0.95. Notably, algorithms like MLP Neural Network, XGBoost, and LightGBM demonstrate particularly promising results in terms of Accuracy, Precision, Recall, and F1 Score.

In contrast, the SMOTE technique, which generates synthetic instances of the minority class, yields improved performance metrics compared to Undersampling, with Accuracy ranging from approximately 0.87 to 0.99. Algorithms such as Random Forest, Extra Tree Classifier, and Catboost exhibit notably high Accuracy and Precision scores under this method.

The Balanced Bagging Ensemble method, designed to address class imbalance through balanced bootstrap samples, showcases a moderate level of performance across algorithms, with Accuracy scores ranging from approximately 0.79 to 0.90. While some algorithms like Gradient Boosting and XGBoost maintain relatively high Accuracy and Precision, others like Naive Bayes and Quadratic Discriminant Analysis demonstrate lower performance metrics under this approach.

Lastly, the NearMiss technique, which selects majority class instances based on their proximity to the minority class, presents varying performance outcomes across algorithms, with Accuracy scores ranging from approximately 0.75 to 0.95. Notably, algorithms such as Decision Tree, Random Forest, and Extra Tree Classifier exhibit competitive performance metrics under this method. Performance of SMOTE is better than other techniques for less dataset with class imbalance.

reported results for Decision Tree in terms of sensitivity and AUC.

SVM and Gradient Boosting algorithms demonstrate competitive performance, albeit with some missing data for our models with hyperparameter tuning. Further investigation and optimization may be necessary to fully assess their capabilities. The MLP Neural Network stands out with high sensitivity, specificity, and AUC values, indicating its strong predictive performance across both positive and negative classes. Overall, our models with hyperparameter tuning generally align well with the reported results, showcasing the effectiveness of the chosen algorithms in handling the classification task. However, further validation and fine-tuning may be required to optimize performance and address any discrepancies between the observed and reported metrics.

Feature Explainer

1) LIME (Local Interpretable Model-agnostic Explanations).

As shown in figure 16, The LIME feature explainer provides detailed insights into the importance of different features in predicting a specific outcome, often in the context of a machine learning model. In the presented results, each feature is accompanied by its corresponding value, indicating its contribution or relevance to the prediction made by the model for a particular instance[2].



Fig. 16. LIME Feature Explainer

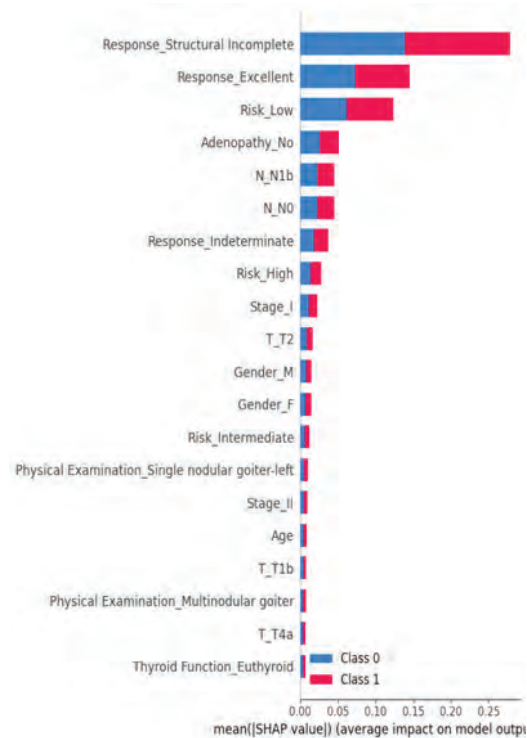


Fig. 17. SHAP Feature Explainer

In the provided feature explanation:

- **Response:** The response feature includes categories such as “Structural Incomplete,” “Excellent,” and “Indeterminate,” with binary values indicating whether each category is present or absent.
- **Risk:** This feature assesses the risk level associated with the individual’s condition, with binary values denoting whether the risk is categorized as “Low” or “High.”
- **T, N, M Staging:** These features represent the extent of the tumor (T), involvement of regional lymph nodes (N), and presence of distant metastasis (M), respectively. Each feature is categorized into different stages, and the values indicate whether a specific stage is present or not.
- **Age, Gender, Smoking, Thyroid Function, Physical Examination, Pathology:** These features represent various demographic, clinical, and pathological characteristics of the individual, each with binary values indicating the presence or absence of specific attributes or conditions.

SHAP (SHapley Additive exPlanations)

As shown in figure 17, A well-liked method for elucidating specific predictions made by machine learning models is SHAP. It gives each feature a value that represents how

important it is to the model's prediction for a given case. Through the visualization of SHAP values, users can gain insight into the behavior of the model and assist in debugging and model interpretation by understanding how each feature affects the model's output. From a SHAP feature explainer standpoint, the provided feature values offer insights into each feature's contribution to the model's predictions. Categories like response status, risk assessment, clinical findings, demographics, behaviors, and disease specifics provide crucial information. Analyzing these values helps understand how each feature influences the model's decisions, aiding clinicians in informed medical decision-making[2].

CONCLUSIONS

The comparative analysis of different class imbalance methods and machine learning algorithms for recurrence prediction in differentiated thyroid cancer demonstrates significant variability in performance metrics. The evaluation was conducted using undersampling, SMOTE, Balanced Bagging Ensemble, and NearMiss techniques across several algorithms.

Undersampling with 108 Datapoints

- o The XGBoost algorithm achieved the highest accuracy (0.9773) and MCC (0.9537) among the models.
- o The Extra Tree Classifier and Random Forest also performed well, both achieving an accuracy of 0.9545 and high AUC values (0.9978 and 0.9956, respectively).

SMOTE with 275 Datapoints

- o The Extra Tree Classifier outperformed other algorithms with perfect scores across all metrics (accuracy, precision, recall, F1 score, sensitivity, specificity, AUC, and MCC all equal to 0.9977).
- o XGBoost and Random Forest also showed excellent performance, with accuracy values of 0.9818 and 0.9909, respectively.

Balanced Bagging Ensemble (0 = 501, 1 = 499)

- o The Gradient Boosting algorithm provided the best balance of performance metrics, with an accuracy of 0.9 and a strong AUC of 0.9516.
- o XGBoost and Random Forest had good performance but slightly lower compared to the Gradient Boosting method.

NearMiss with 108 Datapoints

- o The Random Forest algorithm, with accuracy (0.9545), precision (0.9593), recall (0.9545), and MCC (0.9102), showed the best results.

- o The Extra Tree Classifier and XGBoost also demonstrated strong performance with similar metrics.

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Medicinal Plant Diseases Detection Using Customized Deep Learning Model

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ABSTRACT

Medicinal Plants are essential in modern medicines, yet their cultivation is often challenged by the prevalence of diseases that compromise plant well-being and output. Early and accurate detection of these diseases is imperative for effective disease management strategies. This paper proposes a revolutionary approach to address this issue by deploying deep learning based on a Customized Convolutional Neural Network (CCNN) model and image processing techniques like Segmentation for the identification of diseases in fig plant leaves with a dataset of 2321 images. Through meticulous preprocessing, the leaf images are optimized to facilitate robust feature extraction and classification accuracy of about 98.86%. Through rigorous experimentation and evaluation, the proposed model demonstrates promising results in accurately identifying and classifying diseases affecting fig plants, which is better than existing approaches. This experiment learning advances our understanding of precision agriculture and sustainable cultivation practices, with potential applications in other crop species beyond fig plants.

KEYWORDS: CNN, Deep learning, Fig plant leaves disease detection, Image processing, Segmentation, Pattern classification.

INTRODUCTION

The cultivation of medicinal plants plays a vital role in global healthcare, providing essential ingredients for traditional and modern medicine. However, the crops productivity and quality are jeopardized by various diseases that affect the plants health, leading to substantial economic losses and threatening the human health. Early identification and precise diagnosis of these diseases are paramount for sustainable farming methods and efficient disease control.

Outline of Research

For this research we used the Ficus Carica Dataset, the fig leaves because of its multiple medicinal usage. According to studies, the crude ethanolic F. Carica extract (FCE) was found to have strong antioxidant activity. It also showed strong anticancer activity against human laryngeal

carcinoma cell lines, colon cancer, hepatocellular carcinoma, and breast cancer. The outcomes support the traditional medicinal herb health claims [1]. Therefore, considering the medicinal usage and the elevated utilization of Ficus Carica Leaves prompted us to work of the data. The sole purpose of proposing a CNN model is to leverage its advanced capabilities in image analysis and pattern recognition for the automated detection of diseases in medicinal plants. Also, it aims to accurately identify diseased regions within plant images, thereby facilitating intervention and management practices.

As we move forward with the research, this proactive approach can help mitigate crop losses, optimize resource allocation and enhance crop health and productivity. To summarize the paper the upcoming section covers the literature review regarding the knowledge of Ficus Carica and its medicinal usage, with some botanical advantages.

Further the Methodology section covers all the information regarding the tools and systems used and model developed for the research. Finally, the Results and discussion covers all the achievable information collected during the process.

Objectives of the Research

- The research has been done while keeping some major objectives in focus:
- Development of a robust system for detecting diseases in medicinal plants using deep learning techniques.
- Implement image processing and segmentation algorithms to accurately localize and identify the diseased regions on plant leaves.
- Investigating the feasibility and effectiveness of utilizing deep learning models.
- Provide insights into potential applications of the developed system in agricultural settings for early disease detection and crop health management.
- Explore the potential directions for additional study and development to enhance the capabilities and performance of the proposed model for actual application in the agricultural industry and plant pathology research.

LITERATURE REVIEW

Rahman et al. [1] has carried out research to explore the therapeutic potential of Ficus Carica leaves, exploring the anticancer and antioxidant characteristics which lends weight to utilize them for therapeutic endeavors. Furthermore, the extract exhibited promising anticancer effects against various cell lines, demonstrating particularly strong inhibition percentages against Hep2 and HepG2 cells. Alzoubi et al. [8] proposes methodology to utilize some algorithms such as SVM, CLAHE method, Backpropagation network (BPNN) and random forest algorithm. Swetha et al. [9] has conducted study regarding the diseases of medical plants cultivated in a state of India called Karnataka. This study proposed many different manual ways to protect plants from different diseases, highlighting the importance of sustainable disease management practices for successful cultivation of healthy medicinal plants. Sladojevic et al. [10] presents a new approach to plant disease recognition using deep convolutional networks for categorization of images of leaves. 13 distinct plant diseases are effectively identified by the model. from healthy leaves, distinguishing leaves from their surroundings. It outlines essential steps for model implementation, from image gathering to database creation, validated by agricultural experts. Training

employs the Caffe deep learning framework, achieving accuracy between 91% and 98% across distinct class tests, averaging 96.3%. Agricultural technology increasingly relies on image processing for crop disease management. Alzoubi et al. [8] study aims to enhance agricultural sustainability by precisely detecting fig leaf diseases. It proposes a novel approach combining SVM with advanced image processing techniques. Methodology involves image acquisition, denoising, enhancement, extraction of features and segmentation. Result demonstrates the effectiveness of PSO SVM in accurately categorizing illnesses of fig leaves. Kavitha et al. [11] study presents that medicinal plants are deeply rooted in Indian culture and extensively researched for their healing properties. Identifying them accurately is time consuming and complex. To address this, a vision-based approach using deep learning was developed to swiftly identify six key medicinal plants. The Mobile-Net model achieved an impressive accuracy of 98.3% in identifying medicinal leaves. The model was deployed to the cloud for real-time plant recognition via a mobile app, offering a promising solution for botany and machine vision fields. Ali et al. study [12] introduces a machine learning method for categorizing the leaves of medicinal plants, utilizing a dataset comprising six varieties sourced from The Islamia University of Bahawalpur, Pakistan. Preprocessing involves cropping and converting the leaves to grayscale, followed by seed intensity-based edge detection. Feature extraction yields a dataset of 65 fused features; 14 features were selected using chi-square feature selection. Five machine learning classifiers are deployed, with the multi-layer perceptron achieving the highest accuracy of 99.01%. Notably, the multi-layer perceptron classifier demonstrates distinct accuracies of 99.10% for Tulsi, 99.80% for Peppermint, 98.40% for Bael, 99.90% for Lemon balm, 98.40% for Catnip, and 99.20% for Stevia. Agricultural productivity is essential for economic stability, with disease detection in plants playing a vital role. Neglecting plant diseases can severely impact product quality and quantity.

Singh et al. [13] introduces a plant leaf disease classification and detection system using image segmentation, utilizing genetic algorithms. It also offers a survey of disease classification techniques relevant to plant leaf disease detection. Image segmentation, crucial for disease detection, is facilitated through genetic algorithms. Bouacida et al. study [15] introduces a deep learning system that analyses small leaf patches and uses a small Inception model to detect plant illnesses is presented. The system achieves good accuracy even on new datasets. It raises global food security by strengthening generalisation and

dependability across a variety of crops. In order to achieve high accuracy and low computing cost, Bhagat et al. study [16] presents Lite-MDC, a lightweight deep learning model that uses Multi-kernel Depth wise separable Convolutions for real-time plant disease diagnosis. It verifies well on various datasets and outperforms the state-of-the-art algorithms on a novel pigeon pea dataset, indicating its usefulness for equipment with limited resources, as drones and agricultural robots. Shewale et al. [17] This research overcomes the limits of manual detection by presenting an automated deep learning-based method that uses real-time visual data from Jalgaon city to reliably detect and diagnose tomato plant leaf illnesses. This scalable approach to crop disease diagnostics offers robust performance in harsh environments and does away with the requirement for feature engineering. In order to detect and classify tomato plant diseases, Badiger et al. study [18] proposes a deep learning-based method utilising DbneAlexnet. High accuracy is attained by sophisticated preprocessing, segmentation, and augmentation procedures. The model's performance is improved by the suggested Gradient Jaya-Golden search optimisation (GJ-GSO), which achieves 92.4% accuracy and demonstrates the model's efficacy in early disease identification and treatment.

Zhang et al. study [19] suggests using machine learning to create a reliable database for authentication in response to the growing demand for medicinal plants and the risk of commercial fraud. Through the use of multi-source data analysis, it provides a thorough method for evaluating the potency of therapeutic herbs, promoting their growth and application in therapeutic settings, particularly in the COVID-19 pandemic. Citrus plant disease identification is a common problem. Sujatha et al. [20] study examines the effectiveness of machine learning (ML) and deep learning (DL) methods and finds that DL methods perform better than their ML counterparts, with VGG-16 obtaining the greatest disease classification accuracy. In order to handle the critical problem of plant disease identification, the study emphasises the efficiency of DL methods, with particular attention to VGG-16 as being particularly noteworthy in this regard. Recently, Mane D. et al [21] [22] proposed the customized convolution neural network (CNN) and amalgam-based CNN models for recognised the diseases of potato and basil plants which produced 95 % accuracy. The literature survey reveals significant advancements in utilizing methods for deep learning and machine learning for agricultural and therapeutic applications. These studies collectively highlight the crucial role of advanced computational methods in enhancing agricultural sustainability, plant health, and

medicinal plant authentication, thereby contributing to economic stability and public health.

PROPOSED METHODOLOGY

Existing methodologies for detecting and classifying plant diseases have leveraged image processing as a crucial tool, particularly for fig leaves. To increase production and sustainability in agriculture, an advanced approach combines Support Vector Machine (SVM) with image processing techniques. This process begins with acquiring digital images of diseased fig leaves, denoised using the mean function, and enhanced with Contrast-Limited Adaptive Histogram Equalization (CLAHE). The images are segmented using the Fuzzy C-Means (FCM) algorithm to isolate diseased regions, followed by feature extraction with Principal Component Analysis (PCA). Classification employs Particle Swarm Optimization (PSO) in conjunction with SVM, Backpropagation Neural Network, and Random Forest algorithms, with PSO-SVM showing exceptional accuracy in detecting fig leaf diseases. This approach highlights the significance of advanced image processing in sustainable agriculture and effective plant disease management, offering a promising solution for enhancing the management of crop diseases and productivity in agriculture.[8]. Here, we proposed an advanced methodology utilizing Customized Convolutional Neural Network (CCNN) models combined with image processing techniques to detect diseases in fig plant leaves. The proposed system is designed to enhance precision and accuracy in identifying fig leaf diseases, leveraging a dataset of 2321 images.

Model Workflow

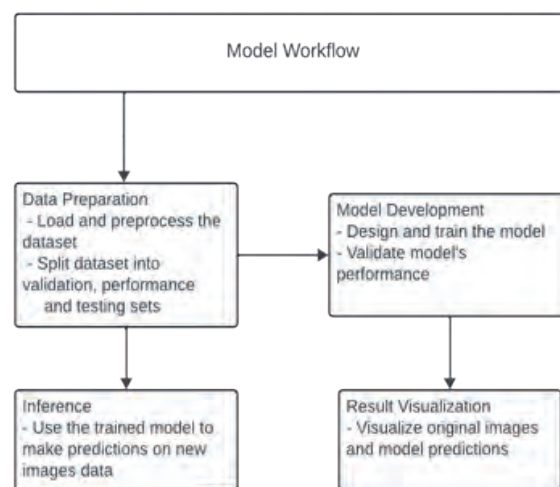


Fig. 1: Proposed Model Workflow

The model workflow has been followed to gain the results required as well as assuring the efficiency of the development and deployment of the model.

Software Requirement

For the project the requirements are chosen meticulously according to the needs of the function and overall operating of the system. The tools and framework are chosen according to the programming languages used and the version the particular software supports.

Integrated Development Environments

Visual Studios Code, Google Colaboratory

Programming Languages

Python 3.11.9: Utilized for all over system development and implementation of machine learning and deep learning algorithms.

Deep Learning Frameworks

TensorFlow 2.16.1: Employed for building and training Convolutional Neural Networks (CNNs).

Keras 3.2.1: Utilized as high-level neural network (APIs) for easy model building and experimentation.

Other Tools

NumPy 1.26.4: For data manipulation and preprocessing.

Matplotlib 3.8.4: For plotting the resourceful insights.

Scikit-learn 1.4.2: For implementing machine learning algorithms for diseases classification

Data Preparation

Further, to proceed with, [4] the dataset used is Fig Leaves (Ficus Carica) Dataset, contains 2321 images belonging to 2 classes that are:

Category	No. of Images
Healthy leaf	917
Disease Leaf	1350

Table 1. Image Dataset

The dataset used in this research underwent meticulous preprocessing to ensure uniformity and compatibility for model training. Specifically, the following steps were performed as part of the data preparation process:

Resizing and Rescaling Images

The images underwent preprocessing, specifically resizing, to ensure uniformity. Employing the 'keras.layers' module from preprocessing layers, the images

were resized to the dimensions 512x512 pixels and resized to scaling equals to (1.0/511). This resizing and rescaling step not only standardized the image sizes but also facilitated subsequent processing steps, streamlining the computational workload.

Batch Processing

The dataset was organized into batches to facilitate efficient loading and processing during model training. Each batch contained 32 images, ensuring a balance between computational resources and batch size.

Label Encoding

The labels associated with each image were encoded into binary format using NumPy arrays. A value of 1 denoted the existence of a specific attribute or condition, whereas a value of 0 denoted its absence.

Dataset Splitting

The collection of data was partitioned into distinct subgroups for training, validation, and testing purposes, following standard practices in machine learning model development. This ensured that the prototype was trained on a diverse collection of data while being evaluated on unseen instances to assess overall effectiveness accurately.

Data Visualization

For Visualizing the data present in the dataset, Matplotlib library is used by forming a grid of 12 images, along with their corresponding labels. Each image is displayed with its associated label, providing a visual representation of the dataset preprocessing and organization.

Architecture Model Proposed

The design of our proposed architecture is informed by the unique characteristics of medicinal plant images and the complexity of disease patterns. There are two CNN architectures developed to get the beneficial outcomes for the research: CNN (For Image classification) and U-Net (for image segmentation) model of Deep learning algorithm. We have crafted a tailored architecture that balances feature extraction and spatial localization.

Customized Convolutional Neural Network (CCNN) Model

The CCNN architecture proposed, comprises of multiple convolutional layers such as Conv2D, MaxPooling2D, Flatten and Dense coupled with loss function "Relu" to preserve the spatial information and manage the losses the

weights across the layers. These special features are bestowed from the “keras.layers” provided by the Keras module. Initially, the Conv2D layer (2D Convolution Layer) is used to produce a tensor of outputs by convoluting the input layer over a single spatial dimension, that is layering with the 512x512 pixels image layer. This layer fabricates a convolution kernel that further will connect with other convolutional layers. The class of Conv2D layer provides various different feature for exercising different biases and features on the image through the layer. As for the research, we have used the ‘filters’, ‘kernel_size’, ‘activation’ and ‘input_shape’ functions for the initial layer. And for the upcoming layers of Conv2D only ‘filters’, ‘kernel_size’ and ‘activation’ functions are used.

The MaxPooling2D layer (2D MaxPooling) adopts the maximum value of each channel in the input over an input window and down measures the input along its dimensional parameters (height and width). Then the window is shifted strides by strides along the image’s dimensions. The parameter passed for this layer is ‘pool_size’ to ascertain the striding window’s dimensions. After few layers of Conv2D and MaxPooling2D the Neurons have been shaped down to few Neurons which are finally flattened and dense down to classify the images more accurately. To perform these functional layers the “keras.layers” module provides ‘Flatten’ and ‘dense’ functions to transform the image to very minimal.

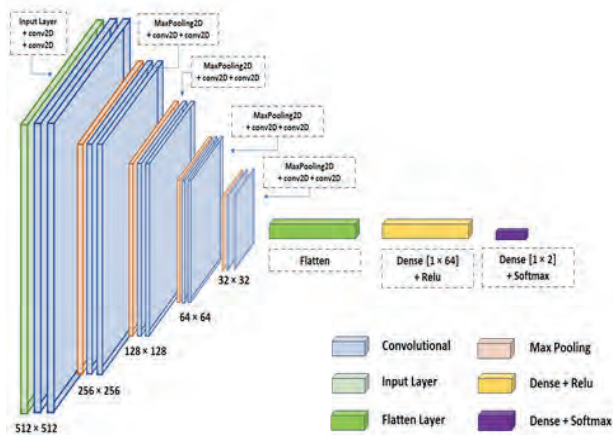


Fig. 2: Breakdown of CNN Model

U-Net Model

The U-Net is a Convolutional neural network architecture specifically designed for image segmentation. The proposed U-Net model consists of an encoder and decoder architecture with skip connections, allowing both feature

extraction and precise localization of diseased regions. The encoder path captures contextual information and extracts hierarchical features from the input image are processed using a number of pooling and convolutional layers. In the interim, the decoder paths enable the model to retain high resolution spatial information, facilitating accurate localization of diseased regions. The hyperparameters such as learning rate and batch size are tuned through experimentation to optimize model performance.

Finally, the qualitative assessments, including the visual inspection of segmentation masks overlaid on original images, will also be performed to assess the model’s ability to accurately localize diseased regions.

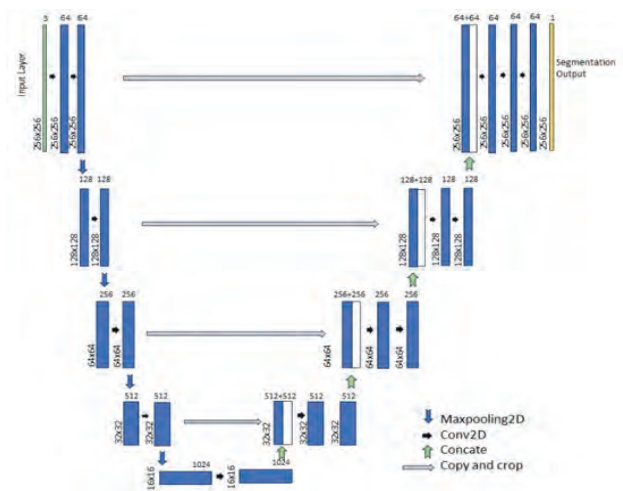


Fig. 3: U-net Model

Mathematical Model

CNN Model

While developing the CNN model the mathematical calculations that has been in learned and used is as followed:

Convolutional Layer:

The Convolutional Operation for an input layer I of shape H (Height) x W (Width) x C (Channel) and a kernel K of size $k_h \times k_w \times C$, the convolution operation produces an output tensor O:

$$O_{i,j} = \sum_{c=1}^C \sum_{m=1}^{k_h} \sum_{n=1}^{k_w} I_{i+m-1,j+n-1,c} \cdot K_{m,n,c}$$

Output shape for the same can be calculated using

$$H_{out} = \left\lfloor \frac{H + 2p - k_h}{s} \right\rfloor + 1$$

$$W_{out} = \left\lfloor \frac{W + 2p - k_w}{s} \right\rfloor + 1$$

where the s defines stride size with the $H \times W \times C$ as input size and $k_h \times k_w$ as kernel size.

Max Pooling layer

The goal of this layer is to minimize the spatial dimensions of the input. For a pool size $p_h \times p_w$ and the stride s :

$$H_{out} = \left\lfloor \frac{H - p_h}{s} \right\rfloor + 1$$

$$W_{out} = \left\lfloor \frac{W - p_w}{s} \right\rfloor + 1$$

Parameters

The number of parameters in a convolutional layer is:

$$Params = (k_h \cdot k_w \cdot C + 1) \cdot C_{out}$$

These essential mathematical formulations are for the understanding of the model's convolutional, pooling and dense layers.

U-net Model

After the CNN model we have also the U-net model which have a similar modelling but with the additional layer of Transpose Convolutional Layer which revers the spatial down-sampling.

For an input size $H \times W \times C$ and a kernel of size $k_h \times k_w$ with the stride s and padding p :

$$H_{out} = (H - 1) \cdot s - 2p + k_h$$

$$W_{out} = (W - 1) \cdot s - 2p + k_w$$

This is crucial for understanding the in-depth working of the U-net model.

Evaluation of Models

The Accuracy, Precision, Recall and F1-score are calculated on the basis of the given mathematical expressions:

Accuracy:

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN}$$

Precision:

$$Precision = \frac{TP}{TP+FP}$$

Recall:

$$Recall = \frac{TP}{TP+FN}$$

F1-score:

$$F1 = \frac{2 \times precision \times recall}{precision + recall}$$

Where;

TP: True Positive

TN: True Negative

FP: False Positive

FN: False Negative

These metrics offer a thorough idea of the model's functionality. By analyzing these metrics we got some effective insights of our classification model.

RESULTS AND DISCUSSION

Data Visualization Results

As discussed earlier, the data visualization has been done for the dataset used for the research. The data has been resized and remodeled to acquire the desired images for processing.



Fig. 4: Data Visualization

Classification Report

The classification report summarizes The effectiveness of the suggested model for identifying diseases in medicinal plants showcasing the results of the precision, recall and F1-score metrics provided for each class, along with overall accuracy.

Table 2: Classification Report

	Precision	Recall	F1-score	Support
0	0.99	0.98	0.99	101
1	0.99	0.99	0.99	150
Accuracy			0.99	256

Macro Avg	0.99	0.99	0.99	256
Weighted Avg	0.99	0.99	0.99	256

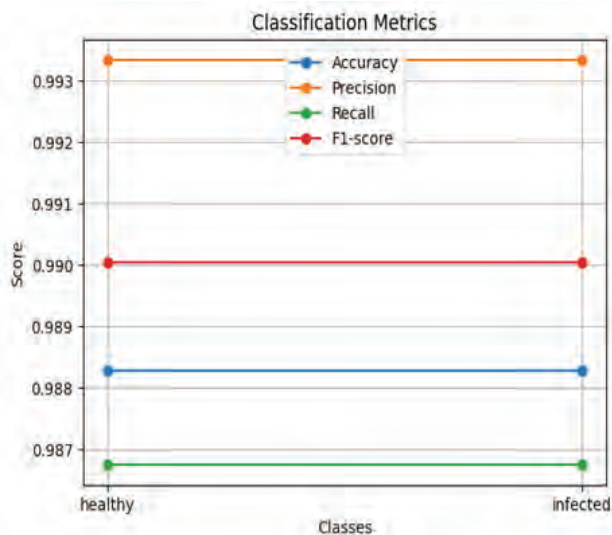


Fig. 5: Line Graph of defined metrics

Along with above metrics, a confusion matrix is drawn to provide a thorough analysis of the model's forecasts, comparing them against the real ground truth labels. In this research, the confusion matrix reveals that the model correctly classified 104 instances of healthy plants and 149 instances of diseased plants. However, it misclassified 1 healthy instance and 2 infected instances. This matrix permits a nuanced evaluation of the model's performance, highlighting areas where it excels and areas where improvement may be needed.

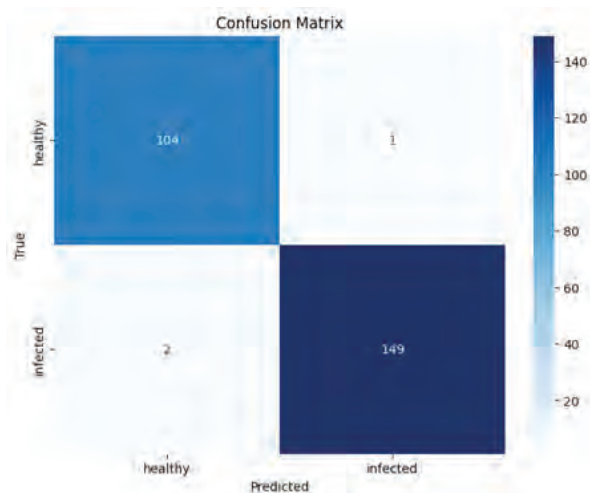


Fig. 6: Confusion Matrix

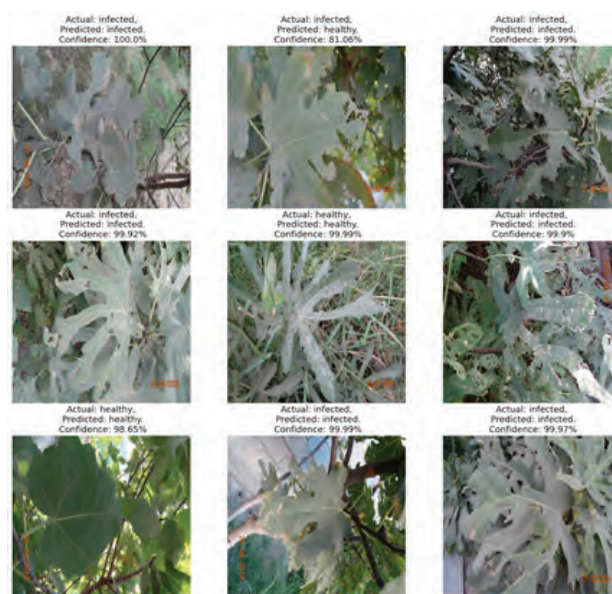


Fig. 7: CCNN Model Result

Results of proposed model

The CCNN and U-net model proposed for the research gave quite the satisfactory results. The visualization of the CNN model represented in Fig. 7. As observed in the above images the anticipated and actual results are shown with confidence level above 90%. Following this results the next graph shows the training and validation accuracy and training accuracy loss took place during the execution of the model. Initially the training loss were around 1.35 which gradually become lesser and lesser until the final loss hit, that is 0.10. Similarly, for the accuracy initially the epochs gave the accuracy of 55% which hits up to 99% at the end of last epochs. Same goes for validation accuracy and validation loss.

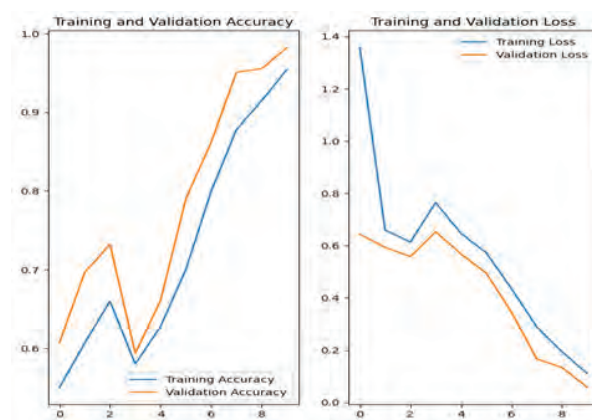


Fig. 8: Accuracy and loss graph

Following are the results of the U-net model result deployed for the detection of the disease detection.

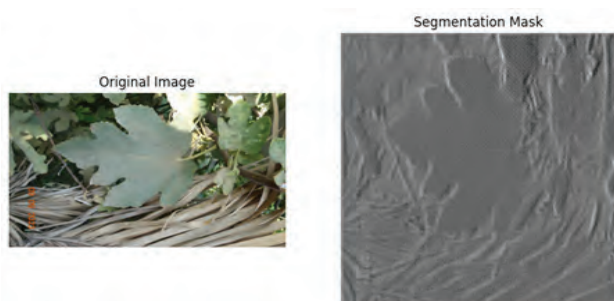


Fig. 9: Segmented Image of Healthy Leaf

The figure 8 displays the healthy image and it's segmented image which shows the smooth surface referring to the healthiness of the leaf.

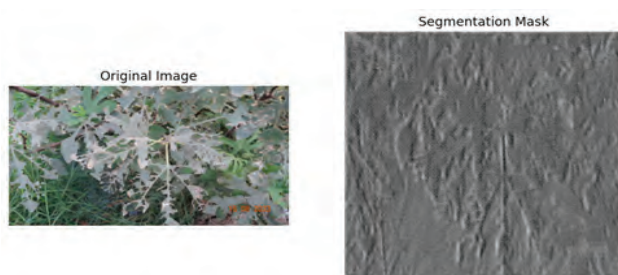


Fig. 10: Segmented Image of Infected Leaf

Contrasting the above image, figure 9 consist of a distorted segmented image showcasing the infected leaf destroyed due to diseases.

Comparison with Existing approaches

Existing approaches has been very helpful for the overall research. The models suggested for neural networking helped us with building our own model. The accuracy has been stated down.

Table 3: Comparison between existing and proposed model

Year & Reference	Model	Accuracy (%)	Plant	Dataset
2022 [2]	Proposed CNN	Up to 99	Herbs (Basil, Peppermint, Lemon Balm)	750
2023 [6]	CNN, Alex net Based Classifier, Data Augmentation and Transfer Learning	90.63, 91.67, 98.94	Aloe Vera	3495

2023 [7]	CNN, VGG-16,	80	Ginger Leaves	
2023 [8]	SVMq	99	Fig Leaves	440
2024 [14]	RFDCNN-CPA	97.92	14 different species	54,366
Proposed Model	CCNN	98.86	Fig Leaves	2321

The table provides valuable insights into the efficacy of various deep learning models in plant disease detection and classification. It highlights those models like CNN and its variants, including AlexNet, VGG-16, and custom proposed models, can achieve high accuracy rates, often nearing or reaching 99%, demonstrating their robustness in handling different plant species and diseases. The use of data augmentation and transfer learning further enhances model performance, as seen in the Aloe Vera study. The diversity in datasets, ranging from a few hundred to over fifty thousand images, indicates that larger datasets tend to improve model reliability and accuracy. The application of advanced techniques like SVM and region-based fully deep CNNs coupled with innovative algorithms such as the carnivorous plant algorithm showcases the continuous evolution and improvement in methodologies for plant disease detection. Overall, these insights emphasize the potential of deep learning in transforming agricultural practices through precise and efficient disease diagnosis.

FUTURE SCOPE

Above discussed objectives of the research have been fulfilled, we have further lined out the future scope the research can be beneficial to:

Integration of LSTM Networks: Utilize LSTM networks alongside CNN architecture to capture temporal patterns in disease progression, enhancing real-time detection and prediction capabilities.

Improved Disease Monitoring: AI techniques will analyze environmental factors like temperature and humidity, providing comprehensive insights into disease dynamics for more effective disease management strategies.

Edge Computing and IoT Devices: Implement edge computing and IoT devices for continuous monitoring of fig plantations, enabling proactive disease management interventions and timely responses to emerging threats.

Enhanced Accuracy and Efficiency: The combination of LSTM networks, AI algorithms, and IoT devices will increase the precision and effectiveness of illness detection and monitoring in fig plants.

Revolutionizing Precision Agriculture: This integration holds significant potential to revolutionize precision agriculture practices, contributing to the sustainable cultivation of medicinal crops and enhancing overall agricultural productivity.

Future Agricultural Innovations: By leveraging advanced technologies, such as LSTM networks and AI, the research aims to drive innovations in agricultural practices, promoting more sustainable and resilient agricultural systems for the future.

CONCLUSION

This paper demonstrates the efficacy of a Customized Convolutional Neural Network (CCNN) combined with image segmentation methods in the early and precise identification of illnesses in fig plant leaves. Utilizing a dataset of 2321 images, the model achieved a classification accuracy of approximately 98.86%, underscoring its potential as a valuable tool in the realm of precision agriculture. The high accuracy rate not only enhances disease management strategies but also creates the foundation for long-term cultivation practices. Given the success with fig plants, this approach holds promise for adaptation and implementation in other crop species, potentially revolutionizing agricultural disease management through technology.

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Automatic Vehicle License Plate Detection System

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ABSTRACT

Automatic vehicle license plate detection is a vital component of modern surveillance and transportation systems. This research proposes a fresh approach to this challenge by cascading two YOLOv8 object identification models. This research includes the precise identification of number plate regions as well as the strong recognition of characters on number plates. Using numerous datasets, including those acquired via Roboflow and manually annotated photos, makes it easier to achieve these goals. The cropping procedure is optimized with the cv2 library, allowing for the identification of numerous plates inside a single image. We use the Ultralytics library to effectively handle the findings of the two YOLOv8 models, resulting in a simplified pipeline for number plate identification and character recognition. The predicted goals of this research are accurate and dependable number plate identification, exact character recognition, dataset variety, and the capacity to recognise artistic number plates. Furthermore, the study increases the dataset to include artistic and creative license plates, increasing the system's adaptability.

KEYWORDS: YOLOv8, CV2 library, Ultralytics, Character recognition, Backpropagation.

INTRODUCTION

Automatic vehicle license plate detection has been the subject of extensive research for some time. In this technique, the computer recognizes a string of characters from a vehicle's licence plate. Experts have developed innovative approaches to decipher the alphanumeric codes on vehicle license plates across various car models, aiming to aid law enforcement in the escalating challenge of vehicle theft. British authorities pioneered a system in the late 1970s to automatically read vehicle license plates, aiming to enhance public safety and security. License plate reading machines have been widely used to manage parking areas and track vehicle movement. These systems capture images of both parked and moving cars, creating two distinct image types. By cross-referencing these images with vehicle registration records, detailed information about cars and their owners can be obtained. Several techniques, including OCR, RBF, PNN, and fuzzy logic, have been explored for reading license plate characters. However, OCR has emerged as the top choice due to its superior accuracy. This method involves converting a digital image of a license plate into text format. Researchers created a computer program to test this

approach using real-world photographs. To verify the license plate, the system cross-referenced the identified characters with a stored database. This process involves capturing vehicle images using a digital camera, isolating the license plate area, separating individual characters, and recognizing these characters using character recognition software. A key challenge with this approach is the OCR system's sensitivity to inconsistencies in character size and position on the license plate. Aside from OCR, other researchers used RBF Neural Network to identify and recognise characters, particularly Saudi Arabia car plate characters. Researchers applied image processing techniques encompassing image acquisition, preprocessing, character segmentation, and recognition to captured digital car plate images. Post-filtering distortions like noise, spacing, and lighting variations, segmentation isolated characters from the plate image. Subsequently, character recognition was performed using RBF and feature extraction, a method particularly suited to the complex nature of Saudi Arabian license plates. The chosen approach was only appropriate and usable for Saudi Arabian automobile license plates since they had unique and difficult characters to recognise.

- Dedicated platform for model training, ensuring compatibility with the chosen architecture. This involves inputting the curated dataset into the training pipeline.
- Define the model structure and its settings, including key elements such as the number of processing layers, learning speed, and the conditions for stopping the training process.

Execute the training process iteratively, where the model refines its parameters through backpropagation based on the defined loss function. This phase involves exposing the model to the annotated dataset and optimizing its internal parameters to effectively discern and localize license plates. The project is divided Recognition.

METHODS

There are 3 major stages. Detection, Extraction and Character.

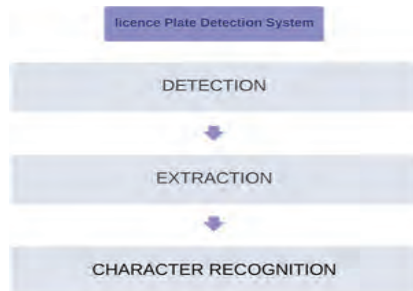


Fig. 1: Flowchart of Image Detection System



Fig. 2: Flowchart of Image Detection System for proposed System

Phase 1: Detection

The first step involves finding a dataset specifically designed for number plate object detection. This dataset should contain images with bounding boxes carefully drawn around each license plate, and all the plates should be labeled simply as “plate.” This ensures the model focuses solely on detecting license plates. Next, we need to assess the dataset’s suitability based on specific criteria. Firstly, we need to check if the dataset includes images taken from various distances. This helps train a model that can Recognize plates from different perspectives and distances, not just extreme close-ups. Secondly, the dataset should also contain images with multiple license plates in a single frame. This helps the model become versatile and able to identify and separate multiple plates within one image. After selecting a suitable dataset, we can train a YOLOv8 model on a designated platform. This involves setting up the model architecture and its hyperparameters, running the training process iteratively, and optimizing the parameters using backpropagation based on a chosen loss function. Once training is complete, the model will have a set of optimized weights that represent its learned features and ability to distinguish license plates. These weights capture the knowledge gained during training and act as a foundation for further fine-tuning or transfer learning. Finally, we can download these weights from the platform for seamless integration into the next stages of our research.

Phase 2: Extraction

After training the model, we can use it to extract license plates from new images or videos. We start by feeding the target image or video into the pre-trained model. This model, with its optimized weights from training, acts as a powerful feature extractor. It analyzes the input image or video to find and locate any license plates present. Once the processing is complete, we extract information from the bounding boxes around the detected license plates. Such bounding boxes encapsulate coordinate information and dimensions, accurately specifying the license plate’s position in the image. This information is often visualized in figures (shown in Figure 3). Next, we use the bounding box information to precisely crop the original image. This removes everything except the area containing the license plate. This targeted extraction makes sure that in the next stages, we only examine the pertinent aspects of the license plate. Finally, we save the cropped image containing the isolated license plate. This yields a collection of cropped license plate images ready for in-depth examination. These saved images become a tangible output we can use in the later stages of our research.

Phase 3: Character Recognition

Once license plate images are isolated, we must find datasets

specifically designed to recognize the diverse characters found on these plates. These datasets should encompass challenging scenarios to fortify the model's performance. This might include blurry or rusty images, plates captured from different angles, variations in license plate layouts (including different numbers of characters or positions of letters and numbers), and even some creatively designed plates. We can then merge these various datasets to create a comprehensive training set.



Fig. 3. This image represents drawing bounding box on the captured image of licence plate

In a manner similar to the object detection phase, this character recognition dataset is used to train a YOLOv8 model. Once training is complete, the optimized weights are downloaded for use in the final processing stage. Here, the image containing the isolated license plate, obtained from the extraction process, is fed into the character recognition model for deciphering the individual characters on the plate. The referred model is defined using pretrained weights from earlier step. As the character recognition model processes the image, it generates a results object containing information regarding the identified characters and their spatial arrangement extracting and interpret the recognized characters from the results object, forming the alphanumeric sequence corresponding to the license plate. This sequence represents the license number associated with the extracted plate.

This comprehensive character recognition process integrates seamlessly with the preceding plate extraction phase, transforming the visual content of license plates into interpretable alphanumeric information. The amalgamation of these stages in the research methodology constitutes a robust framework for automating the extraction and recognition of license plate information within a given dataset.

THEORY AND CALCULATION

YOLO-v1's core concept involves dividing an image into a grid of equal-sized squares. If an object's center falls within a square, that square becomes responsible for detecting it. An object can be detected by multiple squares, but typically only one is assigned. Each square predicts several potential bounding boxes, each with a confidence score indicating

the likelihood of an object being present. This confidence is calculated by multiplying the probability of an object existing within the box by the accuracy of the box's prediction compared to the actual object's dimensions. A score between zero and one represents the absence of an object. [12]. Each bounding box is defined by five values: x , y , w , h , and the confidence score. The first four, x , y , w , and h , specify the box's center coordinates and dimensions.

Both YOLO and object detection in general aim to achieve bounding box-based item recognition and localization. As a result, two sets of bounding box vectors are required: vector y , which represents the ground truth, and vector $\hat{y}$, which represents the predicted vector. Non-maximum suppression (NMS) is a technique employed by YOLO to manage multiple bounding boxes with the same item or no object [10]. Setting a threshold value for NMS eliminates all overlapping predicted bounding boxes with an IoU smaller than the supplied NMS value. Simple YOLO and FastYOLO outperformed real-time detectors in terms of performance, but could not compete with SOTA FastRNN-based systems at the time [9][11][10].

Several enhancements were made to each YOLO model till YOLOv8, which was the time of authoring this paper. The aim of YOLOv2 was to rectify or minimize the shortcomings found in the initial YOLO model while maintaining its exceptional speed [13]. To prevent the loss of detailed image information, YOLOv3 combined elements from various network designs, including YOLO, DarkNet, and ResNet. [14]. YOLO-v4 was essentially a streamlined fusion of multiple object detection techniques, meticulously chosen and optimized to produce a swift and precise object locator. [15]. YOLOv5 was first open-source and PyTorch-based model of the YOLO clan. It was trained on the COCO dataset and was used in production for various applications [16]. YOLOv6 and YOLOv7 were developed for industry applications and their development using various architectural reforms like E-ELAN [11][12] [13]. At last, YOLOv8 was released in 2023 [14][15].

The YOLOv8 has 5 prebuilt models which differ concerning parameters and required CPU speed. The YOLOv8n model, best suited for our purpose is a 640-pixel model with 3.2 M parameters. The mAP score on the COCOval2017 dataset is 37.3. Ultralytics provides a command line interface as well as a Python library for implementing the model. Using the Python library, we trained the model. A model is as good as its dataset. We combined multiple datasets online to expose our dataset to as many types of images as possible. Images with some missing qualities were added later to the dataset and manually annotated. Image augmentation properties like contrast, brightness, rotation, and more were added to the dataset. This made sure that the resultant model would be comparatively more robust. Major problems in selecting

images from the Indian perspective were sunny plates, muddy plates, and dusty roads. India being a tropical country gets lots of sun throughout the year. Thus, metallic plates shine a lot sometimes making it impossible for the camera to catch the difference between number and background. Heavy rainfall and muddy roads make plates muddy and undetectable to the camera. Dust on roads makes it difficult to properly detect similar serial number characters like H and M, or I and 1.

Box localization and object confidence predictions are both optimized by YOLOv8 through a combination of loss functions. These features direct the model in obtaining accurate license plate representations. After extracting the bounding box's parameters from the first model, the box is cropped. The cropped image is passed in as input to 2nd model. Only the prediction of classes of the second model is used for recognition purposes.

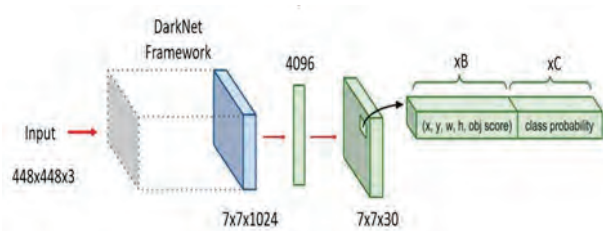


Fig. 4. This diagram illustrates the step-by-step process of training a YOLOv8 model to accurately identify license plates within images and videos

YOLOv8 uses anchor box theory (as shown in figure 4) to forecast item sizes and locations. The model can manage items of all forms and sizes thanks to these pre-defined boxes, which are available in a variety of scales and aspect ratios. The model refines the position and size of these anchors for particular objects during training by predicting offsets to these anchors. Using a set of anchors for ANPR sized according to common number plate measurements improves detection accuracy. YOLOv8 returns an object of class boxes for every prediction. The object is a list of boxes with several parameters; class, xxyy, and xywh being the three most crucial ones. The bounding box's upper left and lower right corners are represented by the numbers xxyy. It provides the two points' x and y coordinates. The bounding box's top corner, height, and width are represented as xyxh. The class shows all the detected classes with the confidence level. Using either xxyy or xywh we locate the bounding box and crop the image. The problem that occurred in this methodology is that the 2nd model needs to be more robust because if the bounding box is too small the image will lose its clarity and detectability. It will be helpful to set a boundary size for the detection of the bounding box to improve detection quality and model performance[15].

The labeling phase for the second YOLOv8 model was a difficult task. There are some special exceptions in characters that resemble each other so well that the model can't detect it precisely. This happens in many cases. For example, with the characters {M, N, H}, characters {1, I}, characters U and V, and many others. For this focus was to add as many clear images in the training dataset and also not to ignore blurry images. This helped in making the model perform better.

RESULTS

The proposed model for Automatic numberplate detection and findings are expected to provide the following outcomes: We intend to show the efficacy of our YOLOv8-based object recognition technique in aptly recognizing and localizing number plates in a variety of photos, including those with diverse backgrounds, lighting conditions, and plate types. Adopting an OCR system is intended to yield consistent character recognition results, allowing us to extract license plate numbers with high accuracy. We prefer to train the models to generalize effectively across diverse circumstances and geographic locations by utilizing numerous datasets, including both publicly available data and manually annotated photos. Our usage of the Ultralytics library is expected to expedite the post-processing of findings, ensuring that the pipeline for number plate identification and character recognition is quick and suited for real-time applications. Adding creative number plates to the dataset will highlight our system's adaptability, since it can recognize a broad range of number plate types, including traditional and artistic designs.

The proposed model for Automatic number plate detection and recognition underwent evaluation on a diverse dataset. The dataset is a compilation of some publicly available datasets as well as hand-clicked and annotated images. To increase the robustness of the dataset image parameters like exposure, brightness, etc. were offset, and copies of the images were trained along with the originals. The evaluation was done on various crucial metrics like precision, recall score, etc. High precision means a smaller number of false positives. Especially, in applications like ANPR false positives can have serious consequences like legal issues and losing customer trust. Hence it is important to have high precision. Recall is significant to not miss any false negatives. The actual revenue from number plate detection is based on recall value. For a robust model in these situations, recall and precision must be balanced. Our model has achieved that. And to check this we plot the F1-score graph. The harmonic mean of recall and precision is the F1 score. At a confidence level of 0.437, the F1-confidence graph presented in Figure 7 reaches its maximum at 0.9. A higher peak indicates that the model has balanced precision and recall across various confidence levels. Along with the F1 score, we have also

studied precision confidence characteristics(Figure 4) and recall confidence(Figure 5) characteristics of the model.

In Figure 8 the results show validation loss as well as the train loss of the model. Loss is the model's error. Lower loss means better performance of the models. The downward trend in the loss graph shows that the model is robust and works well on both training and validation images, that is, seen and unseen images. mAP stands for mean average precision. mAP score is important as it provides a comprehensive, qualitative, and threshold-free metric for the analysis of models. mAP50: Considers predictions with confidence scores greater than 50%. mAP50-95: Takes into account predictions with confidence scores between 50% and 95%. Both graphs fluctuate but show an upward trend again indicating a robust model. The graphs collectively indicate that the model is learning effectively, generalizing reasonably well, and achieving balanced precision and recall, particularly for high-confidence predictions.

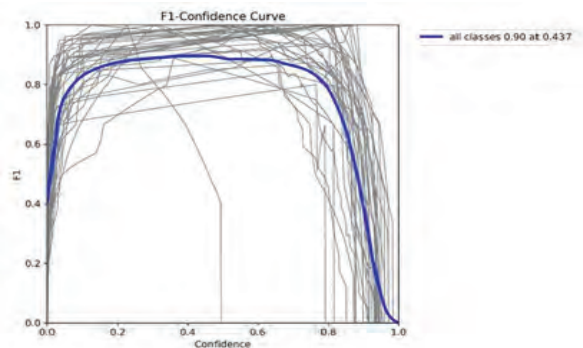


Fig. 5: The above graph shows the trade-off between confidence and accuracy

It balances precision (how many of the identified license plates are correct) and recall (how many of the actual license plates were identified).

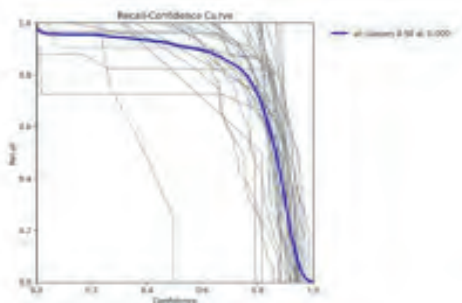


Fig. 6. The above graph visualizes the trade-off between model confidence and precision depicting that the model achieves a perfect precision of 1.0 (all detections are correct) at a confidence level of 0.981

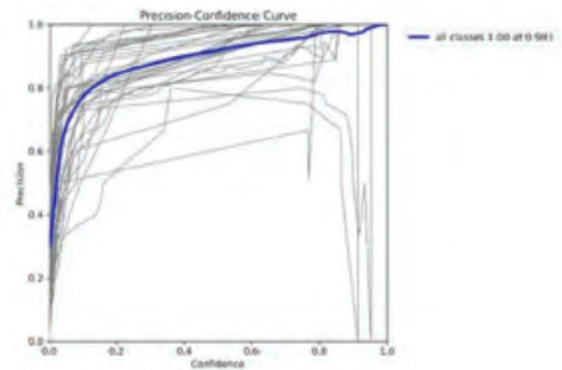


Fig. 7. F1- The purpose of this graph is similar to the precision-confidence curve and helps visualize the trade-off between model confidence and recall

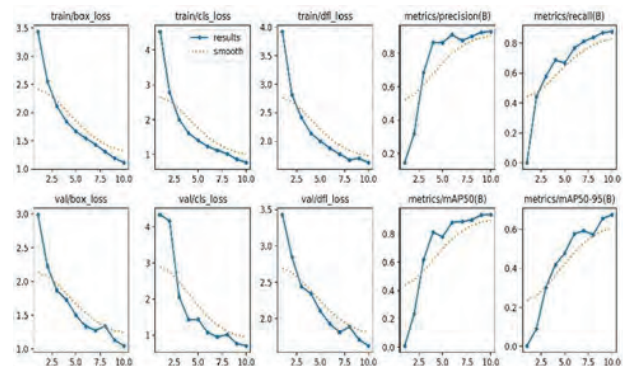


Fig. 8. This image is depicting the overall performance of our model on a license plate detection

DISCUSSION

The current study outlines the development of an image-processing-based automatic automobile plate recognition system. In the realm of safety and security systems, automatic license plate recognition systems are frequently used, especially in parking lots for cars. In addition to ensuring safety, this system tracks other aspects of road traffic, including vehicle speed and owner identification. This technique aims to assist law enforcement in recognizing pilfered automobiles, including motorcyclists. This work advances automatic number plate detection systems, which may have uses in law enforcement, vehicle tracking, and security. The technique given here provides a strong and adaptive solution for real-world circumstances, and the addition of artistic number plates broadens the system's application to a broader range of contexts. This study discusses automated number plate recognition using YOLOv8 object detection models. The cascade technique, where one model localizes the number plate region and the second recognizes the characters, is effective. Future research should

explore the benefits of using multiple models in a cascade, data augmentation strategies, and data gathering problems. The Ultralytics library was chosen for result processing, and future research should examine its efficiency and scalability for real-time applications. The study also investigates the ability of training models to detect a wide variety of creative designs, as well as the possible social applications of such recognition. The study also suggests extending the system to detect multiple languages on number plates, exploring challenges and potential use cases.

CONCLUSION

Ultimately, our research presents a comprehensive method for automatically identifying vehicle license plates using a sequential process involving two YOLOv8 object detection models. Through careful dataset curation, utilizing the power of the cv2 and Ultralytics libraries, and introducing cutting-edge methods like image augmentation and data collection tactics, we have created a solid framework for precise and effective character recognition and number plate identification. Key issues in license plate recognition are addressed by our suggested methodology, including variations in plate appearance caused by many elements including types of plates, illumination, and creative designs. We have proven the effectiveness of our method in obtaining high precision and recall scores—critical metrics for real-world applications like ANPR systems—through thorough examination on a variety of datasets. Additionally, the addition of imaginative license plates to our dataset demonstrates the flexibility and adaptability of our system, demonstrating its capacity to identify a wide variety of plate designs. Prospective research trajectories that have been discussed include investigating several model cascades, refining result processing methods, and expanding the system to recognize multiple languages on license plates.

Taken together, the findings of this research enhance automatic license plate recognition capabilities, with potential benefits for security, law enforcement, and traffic management. This study lays the groundwork for future advancements in license plate recognition, aiming to overcome emerging obstacles and enhance system accuracy and dependability.

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A Comparative Study of Dental Caries Detection and Prediction Techniques

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ABSTRACT

Now a days dental caries is most common occurring disease worldwide but frequency of dental caries is more in childhood due to unawareness about mouth hygiene. Early detection of dental caries can avoid severe consequences such as bleeding gums, facial swelling, and toothache. In earlier days Panoramic, X-rays, bitewing radiographs, CBCT images help dentist to identify the dental caries but in these input images were used in some research facing difficulties such as dataset is limited, dataset is not labelled properly, overlapping of region area while taking ROI. We aimed to systematically review different AI techniques used for caries detection. The comparative analysis indicates that the Deep learning shows a accurate model with good accuracy. According to this analysis we plan to propose a system considering real time teeth images so we overcome mentioned limitation and will give better accuracy.

KEYWORDS: *Dental caries, Classification, Prediction, Machine learning, Deep learning.*

INTRODUCTION

Recently, dental caries is frequently occurring oral disease worldwide usually known as tooth decay or cavities which affects human lives, posing significant challenges to both individual health and healthcare systems. Caries in tooth is a health concern raised because of residual food that relocated to the teeth, leading reducing calcium contents in teeth so teeth get fractured as

Oral health is prominent health concern that is mostly related to hard surface of teeth that is enamel, dentin etc and that hard surface is decayed because of decreasing mineral part from teeth surface; Teeth decay concern is raised due to changing lifestyle, frequent consumption of chocolates in children, sipping sugary drinks and not brushing properly that is not maintaining mouth hygiene. Serious consequences due to teeth decay are swelling, toothache, mouth infection, difficulty while eating and sometimes can lead to cancer as well. As per WHO millions of people in all stages of age are affected by caries.

Analysis of dental caries was conducted by many researchers for dental caries detection, classification, and prediction. Toan Huy Bui et al [18], who discussed the prediction of dental caries using Machine learning algorithms such as K Nearest Neighbor (KNN), Support vector machine

(SVM), Decision tree (DT), Naïve Bayes (NB), Random forest (RF) [23] to determine the best classification model for dental caries. In [3][8][14] implemented a system for dental caries detection and classification using hybrid approach includes RF, NB, SVM, GBDT and CNN, ANN, LSTM applied using different kinds of features such as age, sex, brush frequency, oral hygiene, smoking history, snacking etc and achieved accuracy up to 90% but having some limitations such as need to consider additional more features, dataset size is limited. In rest other systems implemented for caries classification and prediction using different types of teeth images such as CBCT images, QLF images, panoramic images, X-ray images etc having issues related to dataset size and annotation is not done by dentist.

The paper is organized as follows: Section 2 presents some literature review on the different dental caries detection and prediction technique; Section 3 contains a table of comparisons of different dental caries detection and prediction techniques and Section 4 finally, concludes the paper.

LITERATURE REVIEW

The discussion addresses different teeth caries detection techniques, trying to improve the dental in different

ways. The paper surveys different teeth caries detection and classification techniques using various kinds of teeth images.

Various approaches have been proposed using supervised learning, deep learning for teeth caries detection and classification. In some research approach applied CNN technique on CBCT images, CNN made predictions regarding presence and absence of dental decay and classified lesions according to depths but with limitations such as dataset is limited and CBCT images used for training not labelled by experts. Some researchers implemented a system using QLF images but evaluation of AI model according to caries severity was not performed. Shinae Lee 2021 [12], Muktabh M Srivastava et al. [22] implemented a model of dental caries classification using CNN on bitewing radiographs but considered only third molar type.

In-Ae Kang et al, 2023 [3], In-Ae Kang, 2022 [8], Chandan Kumar et al, 2024 [14] and Soualihou et al., [5] applied different machine learning approaches such as support vector machine, logistic regression, random forest, decision tree, Naïve bayes and gradient boosted decision tree for dental caries classification using different features such as age, brush frequency, snacking, sex, gender, region, previous caries, family income, discomfort etc; but having limitation such as need to consider more features and Other specific parameters such as infectious

tooth parameters collected by experts need to be used for our prediction.

In Meanwhile, to detect dental caries, researchers use data images, such as X-ray images are used by V. Geetha et al. [4], Anum Fatima et al. [11], M. Muthu Lakshmi et al. [15], L Megalan Leo et al. [17] applied deep neural network and back propagation network for caries classification and prediction; these systems have achieved good accuracy but facing limitations such as very few images considered, annotation is not performed by dentist. In other systems Luya Lian et al. [6], Mahmut Emin et al. [7], Ho Sun Shon et al. [9], Dan Zhao et al. [10], Toan Huy Bui et al [18] and Arman HaghaniFar et al, [20], used panoramic images for dental caries classification and prediction using CNN and achieved better accuracy. In these systems. facing limitations such as dataset size is very less, Teeth images must be annotated by dentist and the impact of applying these well-trained neural networks for disease diagnosis and treatment decision making should be explored.

ANDAC IMAK et al [13], Hu Chen et al [16], Vincent Majanga et al [19] and Jae-Hong Lee et al., [21] implemented a model for caries detection using different variants of CNN and used periapical images as input teeth images; In these systems having issues such as dataset is limited in some cases only some of the types of teeth are considered and need to improve accuracy.

Table 1. Summary of Dental Caries Detection and Classification Techniques

Author, Year (Ref)	Data Modality	Dataset size	Inclusion & exclusion criteria	Labeling procedure	Preprocessing	Augmentations	Model structure	Hardware	Performance measure for caries detection	Outcome
Rasool et al. 2023 [1]	CBCT images	785 (382/403)	Molar	By oral & maxillofacial radiologists; data were annotated into two classes caries and no caries.	Cropping the full image into rectangular box that fits the teeth.	Horizontal and vertical flip	CNN	NA	Accuracy, Specificity, Sensitivity and F1-score	0.94
Eun Young Park et al. 2023 [2]	QLF intraoral images	2814 (1701/1133)	NA	By dentist whole teeth image labelled as caries when code was 3, 4, 5 or 6 according to ICDAS criteria	NA	horizontal and vertical flipping, rotation	CNN	NA	Accuracy, Specificity, Sensitivity and F1-score	0.94
In-Ae Kang et al, 2023 [3]	2018 Children's Oral Health Survey	22,288(total 43 items and 1 label)	NA	NA	Normaliz-ation	NA	RF, LR, SVM, and GBDT + LSTM	NA	F1-score, Precision and Recall, Accuracy	0.90

V. Geetha , 2020 [4]	X-ray images	106(49/56)	NA	NA	Laplacian filter	NA	back-propagation neural network	NA	Accuracy, Specificity, Sensitivity and F1-score	0.9
Soualilhou et al., 2022 [5]	2018 dental data publicly available by the Korean Center for Disease Control	22371 (18954/3417)	NA	NA	Feature selection	Image resizing & image scaling	DNN+ DenseNet	Intel Core i7-6850K at 3.60 GHz, NVIDIA GPU 1080 Ti GTX and 62.7 GB RAM	Accuracy, precision, recall, f1-score, and AUC-ROC	0.9
Luya Lian et al. , 2021 [6]	panoramic X-rays	1160	NA	NA	Feature selection	NA	nnU-Net and DenseNet121 applied to classify the lesions.	NA	accuracy, precision, recall, specificity	0.91
Mahmut Emin, 2022 [7]	panoramic radiographs	440	Third molar	NA	NA	NA	Faster RCNN with ResNet50, AlexNet, and VGG16	NA	Precision, Recall and Accuracy	0.8
In-Ae Kang , 2022 [8]	features such as age, region, gender etc from Korean Health centre.	22287 (20,593/1695)	NA	NA	ANOVA	NA	RF, GBDT, SVM, LR + ANN, CNN, LSTM	NA	Accuracy, F1-Score, Precision, Recall	0.92
Ho Sun Shon, 2022 [9]	panoramic radiographs	1044	NA	By dentist data were annotated as caries and no caries	NA	flipping	U-Net and YOLOv5	NA	F1-Score, Precision, Recall	0.93
Dan Zhao, 2022 [10]	panoramic radiographs	1188	NA	NA	NA	NA	a multimodal deep learning	NA	Accuracy, Sensitivity, Specificity, Precision, F1 Score	0.8
Anum Fatima 2022 [11]	X-ray images	534	Molar & pre-molar	by experienced radiologists and dentists, data were labelled as per the presence of periapical lesion	Image enhancement, Edge cropping,	NA	an automated deep learning	NA	Accuracy, Precision, Recall ,F1-score	0.94
Shinae Lee 2021 [12]	Bitewing radiographs	354	Third molar	By dentist data were labelled as caries, enamel, dentin, pulp, metal restorations, tooth-colored restorations, gutta percha	NA	Random flipping, Rotation	CNN	NA	PPV, sensitivity, and F1-score	0.9
ANDAC IMAK et al, 2022 [13]	Periapical images.	340	NA	NA	NA	NA	multi-input deep convolutional neural network ensemble (MI-DCNNE)	NVIDIA Quadro M4000 GPU with 8GB RAM.	Accuracy	0.98

Chandan Kumar et al, 2024 [14]	Dental dataset from UCI	16 features and 7456 (1358/6098)	NA	NA	NA	NA	RF,DT, LR &NB	500 GB SSD, 1 TB HDD, 8 GB RAM, Intel i3 processor having a clock speed of 2.4-3.0 GHz and Weka 3.8	Accuracy ,Precision	0.9
M.Muthu Lakshmi et al 2020 [15]	X-ray images	1700	NA	NA	NA	NA	For tooth decay prediction Deep CNN is used.	NA	Accuracy, F1-Score, Precision, Recall	0.8
Hu Chen et al 2019 [16]	Periapical films	1250	Molar, Premolar, Canine, Incisor	By dentist	NA	NA	R-CNN	NA	Recall, Precision	0.9
L Megalan Leo et al 2023 [17]	X-ray images	-	NA	NA	Selective median filter	NA	Hybrid neural network	NA	Accuracy, F1-Score, Precision, Recall	0.97
Toan Huy Bui et al 2021 [18]	panoramic radiograph	533 (229/304)	NA	NA	NA	NA	KNN, SVM, DT, NB, RF	NA	accuracy, sensitivity, and specificity	0.9
Vincent Majanga et al 2021 [19]	Periapical images	11,114 images	NA	NA	Gray scaling, Enhancement of images	rotation, scaling and resizing of the images	Morpho-logical methods and deep features	NA	Precision, Recall	0.97
Arman Haghaniifar et al, 2020 [20]	Panoramic images	470	Molar, Premolar and Incisor	By radio-logist, data were annotated as healthy and carious.	Vertical edge filter, Gaussian and Bilateral filters	Rotation, flip, zoom, width shift, height shift	CNN-c	NA	Accuracy Loss Precision Recall F0.5-score	8.6
Jae-Hong Lee et al., 2018 [21]	periapical radiographic images	128	Molar & premolar	NA	cropped and resized to 224×224 pixels	vertically flipped	Deep CNN	NA	Accuracy, AUC	0.7
Muktabh M Srivastava et al. 2017 [22]	bitewing radiographs	3000	NA	NA	NA	NA	deep fully CNN (FCNN)	NA	Precision, Recall, F1-score	0.7

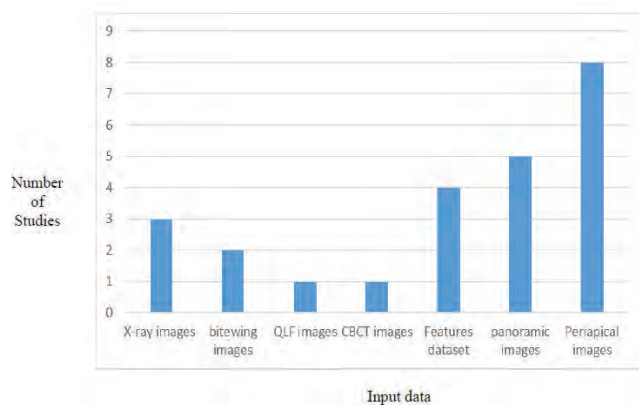


Fig 1. Number of studies for caries detection and image type employed

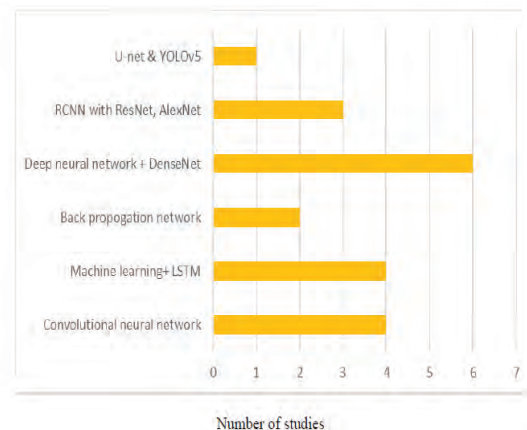


Fig 2. Modelling approach used in various studies

DISCUSSION

Dental caries detection is done using various approaches such as machine learning, deep learning and artificial intelligence. For every approach different input data or input teeth images are used. Mostly for machine learning approach different features are used such as sex, age, brush frequency etc. In some research studies they implemented a teeth caries detection system using QLF images and CBCT images. In some systems they implemented a model using X-ray images and bitewing images. In most of research studies they considered panoramic images and periapical images as input teeth images. The Number of studies for caries detection and image type employed this analysis is shown in fig. 1.

Different kind of modelling approaches as per the input teeth images and number of studies that they employed this techniques that statistics is shown in fig 2.

CONCLUSION

This comparative review analysis demonstrates that the deep learning model model accurately performs identification and classification of dental caries using various kinds of teeth images such as QLF images, CBCT images, X-rays, bitewing images and preapical images etc. Deep learning methods provides better accuracy as compare to machine learning methods because supervised learning algorithms mostly implemented on various kinds of features such as age, brush frequency etc. but teeth image data is not considered. The deep learning model using real time teeth images is helpful for dentist and medical practitioner.

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AI-Driven Traffic Surveillance: Vehicle Detection, Tracking, Counting and Speed Estimation with YOLOv10

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ABSTRACT

Traffic surveillance is a critical component of intelligent transportation systems (ITSs), essential for monitoring and collecting data on road network conditions. Accurately and efficiently detecting, tracking, counting, and estimating the speed of vehicles in traffic videos or real-time traffic streaming data is one of the primary challenges in traffic surveillance. Traditional video-based vehicle detection methods, such as optical flow, frame differencing, and background subtraction, often struggle with accuracy and efficiency in dynamic environments due to challenges like noise, slow-moving objects, and varying lighting conditions. This research introduces a deep learning-based approach using the YOLOv10 algorithm for real-time vehicle detection, tracking, counting, and speed estimation in traffic videos or real-time streaming data. The system is designed to significantly enhance highway traffic monitoring, which is crucial for effective traffic management, planning, and accident prevention. By addressing challenges such as high missed detection rates, limited perception of small targets, and inadequate feature extraction, this method provides accurate and real-time insights into traffic patterns and vehicle speeds, thereby supporting informed decision-making.

KEYWORDS: CNN, YOLOv10, Vehicle detection, Tracking, Vehicle counting, Speed estimation, MS COCO dataset, Traffic surveillance.

INTRODUCTION

Overview of Neural Networks

Neural networks are a subset of machine learning models inspired by the human brain's architecture and functionality. These networks are composed of interconnected nodes, or neurons, arranged in distinct layers. The fundamental components of a neural network include:

1. **Input Layer:** The input layer is responsible for receiving the initial data, such as features from a dataset. Neurons in this layer process and transmit the data to the subsequent layers.
2. **Hidden Layers:** Positioned between the input and output layers, hidden layers contain neurons that process information from the previous layers through weighted connections. Each neuron in a hidden layer applies activation functions to introduce non-linearity, which enables the network to learn and capture complex patterns within the data.

3. **Output Layer:** The output layer generates the final predictions or results of the network. The structure of this layer, including the number of neurons, is determined by the type of task being performed, such as classification or regression.

4. **Weights and Biases:** Weights are associated with connections between neurons and determine the strength of these connections. Biases are added to the weighted sums to provide the network with additional flexibility in learning and adjusting its outputs.

5. **Activation Functions:** Activation functions are crucial for introducing non-linearities into the model, allowing it to capture and model intricate relationships within the data. Common activation functions include sigmoid, hyperbolic tangent (tanh), and rectified linear unit (ReLU).

6. **Loss Function:** The loss function measures the discrepancy between the network's predicted outputs and the actual targets. The primary goal during the training phase is to minimize this loss to improve the model's accuracy.

7. Optimization Algorithm: Optimization algorithms adjust the weights and biases of the network during training to minimize the loss function. Techniques such as stochastic gradient descent (SGD) and its variants are commonly used for this purpose.

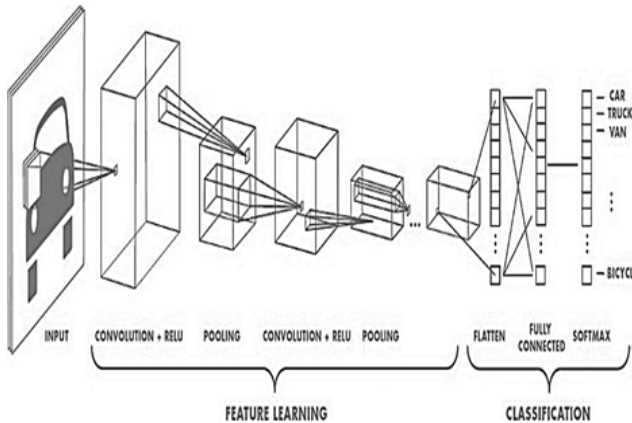


Fig. 1: Image Detection of Car using CNN feature Learning – Convolution + ReLU

Role of Neural Networks in Image Recognition

Neural networks are pivotal in image recognition due to their capability to learn hierarchical representations from visual data. Initially, they extract features from raw pixel values, with early layers identifying basic elements such as edges and textures, while deeper layers capture more complex patterns like shapes and objects. Convolutional Neural Networks (CNNs) are particularly effective for image processing, utilizing convolutional layers to efficiently recognize spatial hierarchies within images. Transfer learning further enhances performance by adapting pre-trained models on large datasets to new tasks. Additionally, CNNs excel in object detection and localization, making them essential for applications such as vehicle detection and tracking in traffic surveillance systems.

Early neural network architectures faced several challenges, including limited computational resources, vanishing and exploding gradients, and insufficient data availability, which hindered their ability to learn complex patterns and generalize effectively. The sigmoid and tanh activation functions, though popular in earlier models, contributed to issues like vanishing gradients, impeding the training of deeper networks. These challenges have been addressed with advancements in neural network designs, leading to more effective and scalable models like YOLOv10 for real-time applications in traffic surveillance,

enabling accurate vehicle detection, counting, and speed estimation.

Architecture of CNN with ReLU Activation Function:

We can train CNN model on images of different classes of vehicles like car, truck, van, bicycle, ambulance, bus etc and by using sliding window approach to detect different types of vehicles in the image or video frames. CNN includes several hidden layers called convolution, pooling and feedforward, fully-connected layers. The convolution layers extract the feature, more detailed features can be extracted by increasing number of convolution layers. In the next stage ReLU activation is applied to the output feature map. Pooling layers reduces the dimensions of feature map. The output features are flattened and converted into one-dimensional array. Then soft-max is used to find the class of input image based on highest probability.

Feature Extraction in Convolutional Neural Networks

Feature extraction in Convolutional Neural Networks (CNNs) involves three key operations: convolution, ReLU activation, and maximum pooling.

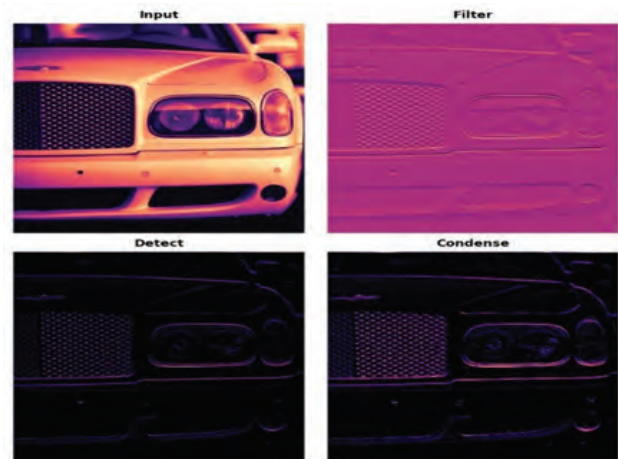


Fig. 2: Feature Extraction and enhancement

1. Convolution: This operation filters an image to detect specific features using convolutional layers. Each filter, or kernel, scans the image, producing feature maps that highlight particular patterns, such as edges or textures. For instance, a kernel might detect horizontal lines by applying a weighted sum of pixel values across the image.

2. ReLU Activation: After convolution, the feature maps pass through the Rectified Linear Unit (ReLU) activation function. ReLU introduces non-linearity by setting all

negative values to zero while keeping positive values unchanged. This step enhances important features and suppresses less relevant ones, making it easier for the network to learn complex patterns.

3. Maximum Pooling: This operation condenses the feature maps by selecting the maximum value from a set of pixels within a defined window. Pooling reduces the dimensionality of the feature maps and emphasizes the most prominent features, thus aiding in the extraction of essential visual information while maintaining computational efficiency.

These processes collectively enable CNNs to learn and extract hierarchical features from images, facilitating advanced tasks such as vehicle detection, counting, and speed estimation in traffic surveillance systems.

COMPARATIVE ANALYSIS OF OBJECT DETECTION ALGORITHMS

Accurately detecting, tracking, and counting vehicles such as cars, trucks, buses, motorcycles, and ambulances on urban roads and highways, along with calculating traffic flow statistics, are crucial tasks for effective traffic management and surveillance. The advent of real-time systems for vehicle detection, tracking, and counting has significantly advanced traffic monitoring capabilities. This research focuses on employing YOLOv10, a cutting-edge object detection algorithm, to enhance these processes.

In computer vision systems, object detection, tracking, and counting are fundamental tasks. Detection involves identifying objects within an image or video frame. Tracking entails monitoring these objects across consecutive frames, and counting refers to quantifying the number of objects of a specific class detected and tracked. These capabilities enable systems to make data-driven decisions and take appropriate actions based on the observed information. Such techniques are vital for various applications, including surveillance, robotics, and autonomous vehicles, to ensure efficient and effective operation.

YOLOv10 is favored for object detection due to its speed, accuracy, and user-friendly nature. Nevertheless, alternative algorithms may be better suited for specific applications. For instance, Faster R-CNN may offer higher accuracy, but with reduced speed, while SSD could be preferable for real-time applications requiring minimal latency. The selection of an object detection algorithm

should be based on the application's particular needs, including speed, accuracy, and the types of objects to be detected. It is essential to assess different algorithms' performance against the specific dataset and application requirements to make an informed decision.

The yolov10 algorithm is based on the RCNN framework [7]. Its fundamental design enhances the YOLO method and improving upon Faster RCNN. The YOLO method is currently the most popular target identification technique and is used extensively as state of art algorithm for object detection. According to A. Wang in 2024 [9], YOLOv10 represents a significant advancement in performance, although there is still opportunity for advancement in detection precision. Research by Ma et al. [10] has explored factors affecting network inference speed, such as memory access costs and input-output channel ratios. Meanwhile, Dollar P et al. [11] have focused on activation functions rather than the number of elements in the convolution layer's output tensor. Despite these advancements, some studies may not thoroughly evaluate the proposed systems in real-world scenarios with varying lighting and environmental conditions. Limitations such as handling occlusions, scale variations, and robustness to complex traffic situations are areas where further research is needed.

Traditional machine learning algorithms for vehicle detection completely rely on hand-crafted and manually retrieved object features [12]. The look or motion characteristics of pixels in a picture are used to obtain the feature vector [13]. The recognition algorithms, which identify cars based on their visual characteristics and shape, essentially take a three-step approach. By erasing the background, they first do background modelling or background subtraction. The remaining blobs and their locations are found in the second stage, which follows the removal of the background. In the third stage, classification techniques are used to determine the different types of vehicles using the observed blobs and extracted data. For offline videos with a consistent background and favourable weather, these algorithms work effectively. However, particularly vulnerable to rapid background changes, unique weather, and issues with color and shape [14].

However, it is challenging to manually build a comprehensive feature descriptor that can accurately characterize all varieties of vehicles due to the range of partial or full occlusions, slowness, appearances, illumination, and backdrop changes. Robust and precise

vehicle recognition solutions have been created as a result of the recently discovered deep learning field, resolving the problems that machine learning-based detection algorithms had in the past. Artificial neural networks (ANN), deep neural networks (DNN), and convolutional neural networks are the three main models used in these algorithms (CNN). These techniques use automatically retrieved deep and hidden properties to find automobiles. Many research projects based on the CNN architecture have been carried out. For instance, the most effective and extensively used techniques are region-based (RCNN) [15], faster region based (FRCNN) [16], SSD (Single Shot Detector) [17], ResNet, RetinaNet, and YOLO (v1, v2, v3). Hakan Koyuncu and Baki Koyuncu et al.[19] has given speed of vehicle by the use of camera and image processing.

Although RCNN, FRCNN, SSD, ResNet, and RetinaNet have somewhat higher detection and classification accuracy than YOLO, only YOLO can be utilized in real-time video analysis tools like traffic monitoring due to its fast detection.

While YOLO can achieve a minimum of 20 FPS and a maximum of 150 FPS, other approaches have a maximum frame rate of 8 [19]. YOLOv10, developed using the Ultralytics Python package by researchers at Tsinghua University, offers a novel approach to real-time object detection by overcoming the limitations in post-processing and model architecture seen in previous YOLO versions. By removing the need for non-maximum suppression (NMS) and optimizing various components of the model, YOLOv10 delivers state-of-the-art performance with significantly lower computational requirements. Extensive experiments have shown its excellent balance between accuracy and latency across different model scales. YOLOv10 enhances real-time object detection by addressing issues of accuracy, performance, and efficiency through the introduction of consistent dual assignments for NMS-free training and a comprehensive, efficiency-accuracy focused model design strategy.

YOLOv10 outperforms previous YOLO versions and other state-of-the-art models in both accuracy and efficiency. With reference to documentation <https://docs.ultralytics.com/models/yolov10/>, YOLOv10-S is 1.8x faster than RT-DETR-R18 with a similar AP on the COCO dataset. YOLOv10-B shows 46% less latency and 25% fewer parameters than YOLOv9-C with the same performance.

VEHICLE DETECTION TRACKING AND COUNTING

Vehicle detection

ITS has a number of functions, and one essential part of the system is vehicle detection. The You Only Look Once (YOLO) algorithm is a neural network-based method for identifying cars on streets and roads that is being used in this research study. Vehicles are quickly and precisely detected by the yolov10 algorithm.

Tracking

When vehicle trajectories (X and Y trajectory vectors) are extracted from a roadway video scene for a specific time interval or in real-time, vehicle speed, motion direction, total and categorical numbers, duration between vehicle entry and exit points, and other desired parameters are all highly valuable traffic flow information. It is easy to monitor and manage the traffic flow in any desired location of a city or metropolitan area with the use of these traffic statistics. While some vehicle tracking algorithms, including as optical flow, particle filter, and Kalman filter, use pixel and bounding-box characteristics, none of these approaches can reliably solve the vehicle tracking problem in real-time on highways [18]. Following a sequence of frames, objects can be tracked using tracking algorithms like Kalman filtering or deep association methods, which use the bounding boxes that the objects have been discovered.

Counting

Counting objects in an image or video refers to the quantity of a particular type of items that have been identified and monitored. This can be accomplished by counting the number of items that match particular criteria through the use of object detection, tracking, and categorization. For instance, object identification, tracking, and classification could be used by an object counting system in a traffic video to determine how many cars are on the road. In computer vision systems, object recognition, tracking, categorizing, and counting are crucial processes that are applicable to a wide range of applications, including robots, autonomous vehicles, and surveillance. Counting objects can be done by keeping track of how many distinct things are found or by examining how objects move over pre-established borders. On highways with fast-moving automobiles, the recognition, tracking, and precise counting will happen quickly. These systems are able to precisely identify,

monitor, classify, and count objects so that they can use the information they collect to make decisions and take the necessary action.

Speed Estimation

A common technique in computer vision applications is speed estimation, which is the process of determining an object's velocity of movement within a specified environment. With the help of Ultralytics YOLOv10, we can now compute an object's speed using object tracking data in addition to distance and time, which is essential for jobs like surveillance and traffic. As a result of driving fast, the World Health Organization (WHO) estimates that 1.19 million people die in traffic accidents every year. One can't emphasize how crucial traffic security is, particularly when speed estimation keeps our roadways safe and effective while also preventing accidents and saving lives. In order to estimate an object's speed using computer vision, it must first identify and follow the object in video frames. YOLOv10 algorithms are able to recognize and track objects across consecutive frames. The system can measure the distance these objects travel using calibrated cameras or reference points to measure real-world distances.

Estimating object speed with YOLOv10 involves combining object detection and tracking techniques:

First, detect objects in each frame using the YOLOv10 model.

Then, track these objects across frames to calculate their movement over time.

Finally, use the distance traveled by the object between frames and the frame rate to estimate its speed

Advantages of Speed Estimation

Efficient Traffic Control: Accurate speed estimation aids in managing traffic flow, enhancing safety, and reducing congestion on roadways.

Precise Autonomous Navigation: In autonomous systems like self-driving cars, reliable speed estimation ensures safe and accurate vehicle navigation.

Enhanced Surveillance Security: Speed estimation in surveillance analytics helps identify unusual behaviors or potential threats, improving the effectiveness of security measures.

EXPERIMENTS AND RESULTS ANALYSIS

The detection approach is carried using Roboflow universe url: <https://universe.roboflow.com/ai-its-indo-pkto/ai-its-dataset/16> dataset with 16 classes ['2 Axle Truck - M', '2 Axle Truck - S', '3 Axle Truck', 'Articulated Truck', 'Bajaj', 'Bus - L', 'Bus - S', 'Car', 'Medium Public Transportation', 'Micro Truck', 'Motorcycle', 'Non-motorized Vehicles', 'Person', 'Pick up', 'Semitrailer Truck', 'Three-Wheeled Motorcycle'. The dataset has 2005 images, Train set- 1892 Images, Valid set- 64 images and Test set- 49 images. Fig 4 shows the annotated dataset and Fig 5 shows the screenshot of training dataset collected from Roboflow. Fig 3. shows the workflow diagram of the system that does detection of vehicle by correctly identifying the class of vehicle with confidence score, second is tracking of vehicles frame by frame with byte Tracker, next is Counting the vehicles and determining Speed estimation.



Fig. 3: Workflow Diagram of AI Driven Traffic Surveillance System



Fig. 4: Training Images with Annotations for different types of Classes [Car, Motorcycle, Truck, Bus etc]

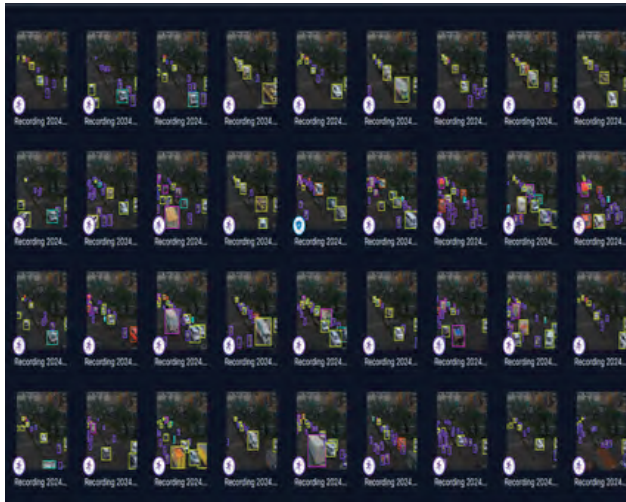


Fig. 5: Screenshot of training dataset

Fig 6 shows the class of vehicle with the confidence score on image and pre-recorded videos. Yolov10 custom trained model on detecting 16 classes of vehicles is accurately able to identify the class of every vehicle type along with the confidence score.



Fig 6: Vehicle Detection with confidence score

Source and Target Identification

The source refers to the initial position where a vehicle begins its movement within the camera frame. This is the location where the vehicle first appears within the camera's view. The target represents the final position within the frame, where the vehicle either exits the camera's field of view or reaches a specific destination or leaves the frame.

Fig 7 shows how the vehicles are counted and the count is displayed once the vehicle crosses the line. Vehicle counting using YOLOv10 involves detecting and tracking vehicles in a video stream by leveraging the model's capability to identify objects within frames. The process begins with loading a custom-trained YOLOv10 model, which is designed to recognize various vehicle classes such as cars, trucks, and buses etc. As the video frames are processed, YOLOv10 detects these vehicles by drawing bounding boxes around them and assigning a class label to each detected object. By filtering the detected objects based on their class labels corresponding to vehicles, the algorithm counts the number of vehicles in each frame. This count can be accumulated over time or analysed frame by frame to monitor traffic flow, congestion levels, or vehicle patterns in a specific area

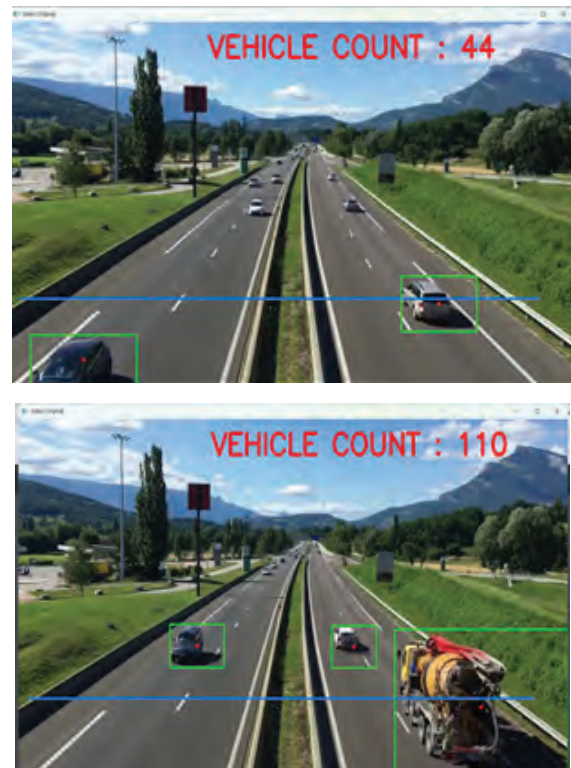


Fig 7: Counting of Vehicles

Region of Interest (ROI)

The ROI is a specific area within the video frame that has been designated for tracking and analyzing vehicle movement. This area is selected based on the specific route or section of interest within the camera's view, such as traffic lanes, intersections, or other relevant zones. By focusing vehicle detection and tracking algorithms on this defined ROI, computational overhead is reduced, and accuracy is improved. Figures 8 illustrate ROIs for the road.



Fig 8: Region of interest (ROI)

Transforming Perspective

To perform a perspective transformation, a transformation matrix M must be calculated. This matrix maps points from the source plane (the original image) to the target plane (the desired perspective). This transformation is essential for correcting perspectives and aligning regions of interest in computer vision tasks, such as object tracking, panorama stitching, and image rectification, where accurate spatial relationships between objects are crucial.

Transformations

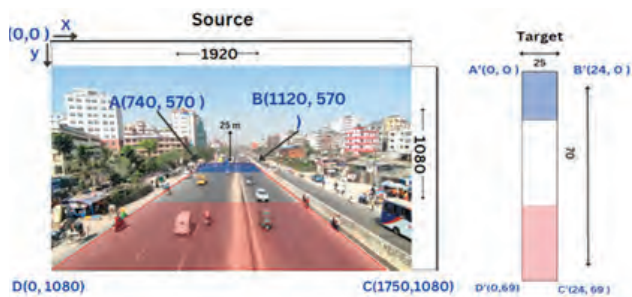


Fig 9: Transformation from source to target region

Source and Target Points

The process begins by identifying four corresponding points in both the source and target planes. These source

and target regions are illustrated in Figure 9.

Source Points

$A(x_1, y_1), B(x_2, y_2), C(x_3, y_3), D(x_4, y_4)$

Target Points

$A'(u_1, v_1), B'(u_2, v_2), C'(u_3, v_3), D'(u_4, v_4)$

Homogeneous Coordinates

These points are represented in homogeneous coordinates by appending a 1 to each point.

Source Points: $(x_1, y_1, 1), (x_2, y_2, 1), (x_3, y_3, 1), (x_4, y_4, 1)$

Target Points: $(u_1, v_1, 1), (u_2, v_2, 1), (u_3, v_3, 1), (u_4, v_4, 1)$

Homography Matrix

The transformation matrix M , also known as the homography matrix, can be computed using the source and target points in homogeneous coordinates. Techniques such as the least-squares method or Direct Linear Transformation (DLT) are typically used for this calculation.

Applying Transformation

Once the transformation matrix M is obtained, it can be used to map all points from the source plane to their corresponding points in the target plane.

Matrix Multiplication

For a point $(x_s, y_s, 1)$ in the source plane represented in homogeneous coordinates, the transformed point (x_t, y_t, w) in the target plane is obtained through matrix multiplication with M :

$$\begin{bmatrix} x_t \\ y_t \\ 1 \end{bmatrix} = M \cdot \begin{bmatrix} x_s \\ y_s \\ 1 \end{bmatrix}$$

Normalization

To convert the transformed homogeneous coordinates to non-homogeneous form, normalization is performed by dividing the transformed coordinates by the third component w , yielding the final coordinates (x_t, y_t) .

Speed Calculation

The provided method calculates vehicle speed by analyzing positional data over time, determining both the time taken and the distance traveled, and then converting this to the desired speed unit. This approach allows for real-time speed estimation in video footage.

Distance Calculation

The distance a vehicle travels within the ROI is determined by calculating the absolute difference between its starting and ending positions within the designated area. This distance reflects the vehicle's displacement during the tracking period.

Time Calculation

The time elapsed is calculated based on the number of frames over which the positional data is collected and the video's frame rate (FPS). The total time for n frames is given by the formula:

$$\text{Total Time} = \frac{n}{\text{FPS}}$$

$$\text{Each frame's time is } \frac{1}{\text{FPS}}$$

Speed Calculation

Speed is calculated using the formula

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} \times \text{Conversion Factor}$$

Once the distance and time are known, speed is determined in units of distance per time (e.g., pixels per frame). To convert the speed to a specific unit, such as kilometers per hour, a conversion factor is applied. $1 \text{ m/sec} = 3.6 \text{ km/hour}$.

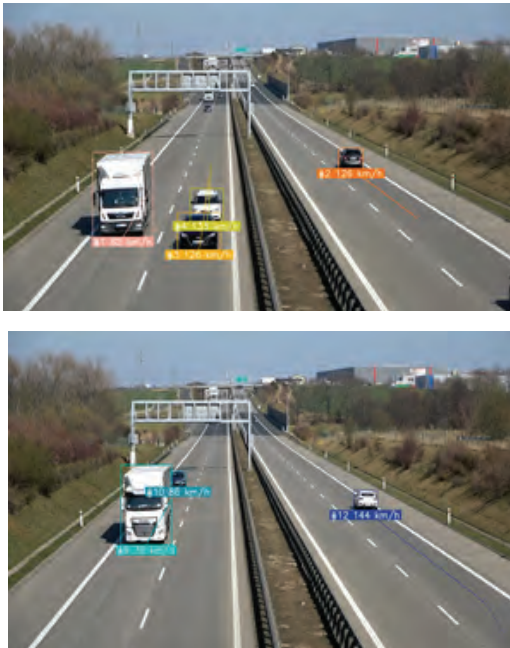


Fig 10: Speed Estimation of vehicles

This output gives speed and assigns unique ID number to each vehicle. Vehicles are detected using bounding boxes and tracking with byte tracker and identification are accurately seen by setting threshold 0.3 for confidence score.

INFERENCES & CONCLUSION

In this paper, we proposed a real-time vehicle detection, tracking, and classifying system with speed estimation based on the YOLOv10 algorithm. The proposed system can accurately detect, track, and classify different types of vehicles in real-time, and can be used for monitoring traffic flow on highways. The system can provide speed estimation. The implementation of advanced algorithms such as YOLOv10 for object detection, the objects in this case are vehicles, tracking and counting ensures accuracy in counting and tracking vehicles on road. Speed estimation calculates the speed of every vehicle and monitors the road safety that can be further used to implement future policies, imposing traffic rules to avoid accidents. Future work includes improving the accuracy of the system by incorporating additional features, such as lane detection and sending alarm messages to vehicles crossing speed limit.

In conclusion, by addressing the shortcomings of earlier research and creating an improved method for precise and effective vehicle analysis, the study on "Real-time Vehicle Detection, Tracking, Counting, and Speed Estimation System Based on YOLOv10" seeks to advance the area. The suggested system has the ability to impact multiple areas, such as transportation management, traffic monitoring, and surveillance applications, by utilizing YOLOv10 and introducing innovative methodologies. Real-time vehicle analysis can be advanced significantly by this research by enhancing the robustness and accuracy of vehicle detection, tracking, and counting. The system's accuracy in vehicle detection and counting is influenced by the model's performance and the quality of the video input, including factors like lighting conditions and camera angles.

Traffic accidents are a growing concern in India, particularly on highways and narrow congested roads. This research aims to develop an automated alert system to notify traffic police immediately in the event of an accident. This can eventually reduce the road accidents and ensures human safety. In the present research, yolov10, a deep learning-based algorithm accurately detects and traces vehicles in real-time. Later the same is used to count the vehicles

and also to determine the speed of every vehicle, which can be used to impose road safety rules. Furthermore, it can be used in autonomous vehicles to add intelligence about the speed of other vehicles on road and identifying and tracking the vehicles with yolov10 which gives high accuracy compare to previous versions of Yolo. Further the research can be advanced on Lane Detection and identifying the number plate simultaneously to send any warning regarding violating traffic rules or imposing fine system and alerts to have better traffic management and road safety. Lane detection would be helpful in autonomous vehicles for identifying the correct lane for driving.

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Enhancing Sentiment Analysis Accuracy in Restaurant Reviews: A Comprehensive Machine Learning Approach

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ABSTRACT

Sentiment analysis, is a vital tool for comprehending and evaluating customer feedback. The sentiment analysis of the restaurant review dataset using NLP(Natural Language Processing) is the primary focus of this study is crucial to the restaurant economically to be able to regularly change their business strategy by examining clients' dining experiences and the assessment of the food and service. This paper's analysis of patron feedback on numerous eateries is its main goal. Customer reviews are gathered for this study using a Google form and multiple restaurant websites. Using sentiment analysis, it assigns a favorable, negative, or neutral classification to every comment. Comments are automatically categorized based on reviews of food quality, services, and hygiene applying text classification methods. A manually annotated dataset containing approximately 5900 records was utilized. Various algorithms are employed in classification, such as Logistic Regression, ANN(Artificial Neural Network), Random Forest and Naive Bayes. These algorithms' performance comparison is shown. Using a Random forest produced the best result, which is 90% accuracy.

KEYWORDS: Machine learning, Accuracy, Sentiment analysis, Restaurant reviews.

INTRODUCTION

NLP (Natural language processing) is gaining momentum in the fast emerging field of sentiment analysis, which aims to recognize and comprehend the attitudes expressed in textual data[15]. This study presents a thorough strategy that makes use of machine learning methods. to analyses diverse sentiments, aiming to enhance the overall accuracy of sentiment analysis systems. Sentiment analysis is a complex task due to the nuanced nature of human language. Traditional approaches often struggle to convey the nuances of feeling, particularly when working with diverse datasets containing expressions of joy, sadness, anger, and more[3].

A number of websites, including popular hotel websites and Google Forms, provided the data used in this study. Using text categorization techniques, it does sentiment analysis and assigns a good, negative, or neutral rating to each comment. Comments are then automatically categorized based on input regarding food quality, services, and cleanliness. A dataset of approximately 5900

records, which was manually annotated, was used for both training and testing. Pre- processing techniques including vectorization, tokenization, text lowercasing, stemming, and lemmatization are among them [8].

Challenges in Sentiment Analysis of Restaurant Reviews
Despite its potential, sentiment analysis of restaurant reviews presents several challenges:

1. Language Complexity: Slang, idioms, and domain-specific terms are frequently used in reviews, making it challenging for models to read them correctly.
2. Context Dependency: A review's sentiment may be greatly influenced by its surroundings. For instance, even though the word "surprisingly" can imply low initial expectations, a statement like "the food was surprisingly good" may elicit favorable feelings.
3. Aspect-Based Sentiment Analysis: Reviews often cover a range of dining aspects, such as the quality of the food, the service level, the ambiance, and the price. Though it can be difficult, determining and evaluating

sentiment for each component independently is essential to gaining useful information.

4. Irony and Sarcasm: Sentiment analysis methods find it especially difficult to identify irony and sarcasm since these words demand a complex comprehension of linguistic subtleties. This research project's objective is to evaluate and categorize reviews. NLP techniques were applied to remove stop words, purify the data, and

Stemming is applied. The Artificial Neural Network (ANN), Random Forest, Naïve Bayes, and Logistic Regression algorithms come next in terms of classification.. A number of measures, including Precision, Recall, F-score, and Accuracy, were employed to assess the model's performance.

LITERATURE REVIEW

An overview of the previously finished sentiment analysis is given in this section. D. Marutho and others [13] Vader Lexicon can extract sentiment features properly on datasets without labels so that datasets can be directly classified using ML methods, including random forest, k-nearest neighbor (k-NN), naïve bayes, svm and achieved highest accuracy of Random Forest i.e.90%.Monali Kishor Patil et al.[3] This paper reviews the literature on Marathi sentiment analysis to highlight opportunities and challenges in Marathi context-based sentiment analysis for researcher and propose a shaded based Marathi sentiment analysis. This shaded- based sentiment analysis is categorized under semantic- corpus based sentiment classification problem. Sara Sabba et al. [6] The proposed solution has been examined using data from the IMDB that includes 50,000 movie reviews. The obtained results were very convincing with accuracy 89% in the testing phase. P.C. Shilpa et al.[7] This paper demonstrated how to attain high emotion classification accuracy by experimenting with and evaluating the approach utilizing Long Short-Term Memory with Recurrent Neural Networks on Three distinct datasets. Based on a comprehensive assessment, the system achieves 89.13% and 91.3% precision for subclasses that are positive and negative and 88.47% accuracy for positive/negative categorization,for emotion prediction on the LSTM model. Kanwal Zahoor et al. [8] Feedback for this research has been gathered popular Facebook group, Karachi's Restaurants. To conduct sentiment analysis, utilize Random Forest, Naïve Bayes Classifier, Logistic Regression, and Support Vector Machine models. Yan Jiang et al.[17]Restaurant review dataset collected from official website Yelp. The neural network that performed the best across all metrics and

test accuracy was the convolution neural network, which was also employed in the algorithm along with the Naive Bayes, Bernoulli Model, Decision Tree, and Logistic Regression..

Dataset Description (Restaurant Review)

Responses were used to collect data for this investigation. of customer via Google Forms and various hotel websites. The dataset consist of approx. 5900 customer reviews. Depending on the type of review, reviews were categorized as neutral, negative, or favorable. Reviews were divided into four groups: food category, food quality, Services, Cleanliness. Fig1.Shows the data count for each category:

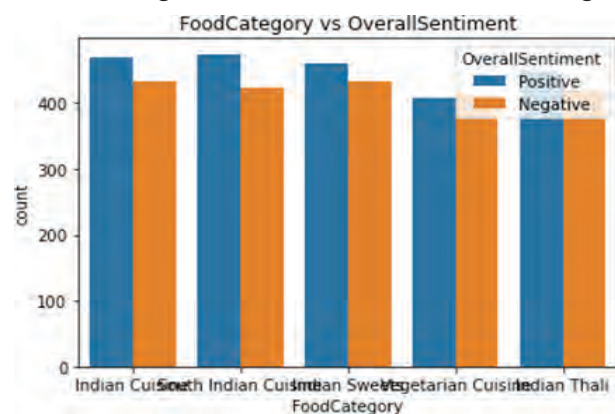


Fig. 1. Count plot for Food Category vs. Overall Sentiment

In the real world of marketing analysis, regardless of online retailers like Amazon and T-mall, the majorities of customers cares more about positive and negative product or service evaluations; disregard the reviews with a neutral altitude. Similar to dining establishments, consumers are more focused on the food or services provided regardless of whether they have positive or negative evaluations, particularly those who are new to the area, such as tourists or people searching for new restaurants. Fig.2 shows positive reviews i.e.51.5% and negative reviews i.e.48.5%.

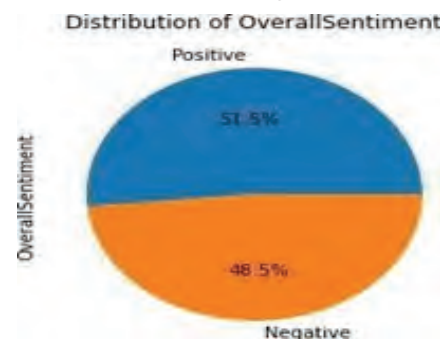


Fig. 2. Positive and Negative reviews of Overall Sentiment

Data Preprocessing

Following methods are used for preprocessing:

Text Cleaning:

Lowercasing: Convert all text to lowercase to ensure uniformity (e.g. —Great Food!! becomes —great food!!)

Removing Special Characters and numbers: Remove any special characters and numbers that do not contribute to sentiment (Their pizza is roughly 20–30% more expensive than any comparable pizza in the neighborhood)

Removing Punctuation: Remove punctuation marks to focus on words (e.g., “Great food!” becomes “Great food”).

Tokenization

Word Tokenization: Tokenize terms by breaking them up into individual words in the text. (e.g., “Great food” becomes [“Great”, “food”]).

Sentence Tokenization: Split the material up into distinct sentences. (good for more intricate sentiment analysis that might take sentiment at the sentence level into account).

Stop Words Removal

Eliminate frequently used terms (such as “is,” “and,” and “the”) These are usually thrown out during text preprocessing since they have little semantic value.

Stemming and Lemmatization

Stemming: The technique of stemming involves reducing words to their most fundamental or root form. (e.g., “running” becomes “ran”, “runs” becomes “run”).

Lemmatization: Reduce words to their simplest or dictionary form while keeping context in mind. (e.g., “better” becomes “good”).

Word Embedding and Vectorization

Text data can be represented with the Bag of Words (BOW) technique as a matrix of token counts. Tokens are ranked according to their importance and frequency using the TF- IDF (Term Frequency-Inverse Document Frequency) system.

These preparation techniques help the text input become better structured and suited for sentiment analysis, which enhances the models’ performance in identifying positive, negative, and neutral attitudes in restaurant reviews.

Pseudo code for Enhancing Sentiment Analysis Accuracy in Restaurant Reviews

Step 1: Data Collection

Gather information on restaurant reviews from multiple sources. (e.g., Google forms, Restaurant websites)

```

reviews = collect_reviews(sources=[" Google forms ", " Restaurant
websites"])
# Step 2: Data Preprocessing
Preprocess the collected reviews
Clean the text (remove HTML tags, special characters, etc.)
Tokenize the text
Remove stop words
Perform stemming or lemmatization
preprocessed_reviews = preprocess_reviews(reviews)
# Step 3: Data Annotation
Label the reviews with sentiment (positive, negative, and neutral)
Labeled_reviews = label_sentiment(preprocessed_reviews)
# Step 4: Feature Extraction
Take characteristics out of the preprocessed text. Use TF- IDF,
Word2Vec, or other embedding techniques
- Features = extract_features(labeled_reviews)
# Step 5: Split Data
Sort the data into training and testing sets. - test
and_train_data = split_data(features, labeled_reviews, testsize=0.2)
# Step 6: Model Selection and Training
Select appropriate machine learning models (e.g.,
Random Forest, ANN, Naïve Bayes, and Logistic Regression)
Utilizing the training data, train the models
- model_NB = train_model(Naïve Bayes, train_data)
- model_RF = train_model(Random Forest, train_data)
- model_LogisticRegression = train_model(Logistic Regression, train_data)
# Step 7: Model Evaluation
Use the test data to assess the trained models.
- accuracy_NB, precision_NB, recall_NB, f1_NB = evaluate_model(model_NB, test_data)
- accuracy_rf, precision_rf, recall_rf, f1_rf = evaluate_model(model_rf, test_data)
- accuracy_logistic_regression, precision_logistic_regression, recall_logistic_regression, f1_logistic_regression = evaluate_model(model_logistic_regression, test_data)
# Step 8: Model Selection
Select the best performing model based on evaluation metrics
- best_model = select_best_model([model_NB, model_rf, model_logistic_regression], metrics=["accuracy", "f1_score"])
# Step 9: Hyperparameter Tuning
Perform hyper parameter tuning on the model
- best_model = tune_hyperparameters(best_model, train_data)
# Step 10: Final Evaluation
Evaluate the tuned model on the test data
- final_accuracy, final_precision, final_recall, final_f1 = evaluate_model(best_model, test_data)
# Step 11: Deployment

```

Deploy best model available for real-time sentiment analysis
- deploy_model (best_model)
Step 12: Monitoring and Maintenance
Monitor the model performance over time and update as needed
- monitor_model (best_model)
- update_model (best_model, new_data)

METHODOLOGY

To increase sentiment analysis's accuracy in restaurant reviews by employing a comprehensive machine learning approach and lexicon based approach. Sentiment analysis has been conducted using four supervised machine learning algorithms.

Category classification. For NLP three techniques are used semantic analysis, syntactic analysis and lexicon analysis. Sentiment analysis in restaurant evaluations uses Artificial Neural Networks (ANNs) to automatically categories and evaluates the opinions given by patrons. ANNs are used as a computational model in this application, and their design and operation are modeled after biological neural networks positioned within the human brain. To train these networks, large datasets of restaurant reviews are employed, with each review labeled with its emotion (positive, negative, or neutral).

Naive Bayes

In machine learning, the Naïve Bayes classification algorithm provides a straightforward and efficient way to classify data. Using the Bayes theorem and the strong independence assumption the basis of the Naïve Bayes classification is the relationship between the features.. When using Naïve Bayes classification to textual data analysis, such Natural Language Processing, it yields good results [17]. When the attribute values were continuous, researchers believed that the values associated with each class had a Gaussian or normal distribution. Let's say, for illustration, that the training set has a continuous property x . After the division of the data into classes, then calculate the mean and variance of x for each class. Assign a mean of μ_i to the values, and denote the variance of the values related to the i th class by σ_i . Let's say that there's an observation value, x_i .

Logistic Regression

An algorithm for supervised machine learning is called logistic regression. used for classification problems in which estimating the likelihood that an instance will belong to a specific class or not is the objective. A statistical

method for analyzing the connection between two data elements is called logistic regression. The foundations, varieties, and applications of logistic regression are explored in the present work.

Random Forest

A supervised machine learning method called Random Forest is used to solve regression and classification issues. Its core idea is Ensemble learning involves the combination of multiple classifiers to address a complex problem and improve the model's performance. An average of the number of decision trees is used by the Utilize the Random Forest classifier on various subsets of the provided dataset to improve the prediction accuracy. Its training time is lower than that of other methods. It performs efficiently with large datasets and generates highly accurate output predictions. It can continue to be accurate even in cases when a significant portion of the data is absent.

Artificial Neural Networks

Neural network-inspired computer models are known as ANNs. observed in an individual's brain. They are made up of neurons, or networked nodes, layered upon layers. An ANN typically consists of: Input Layer: Receives the numerical representations of reviews.

- Hidden Layers: Several layers with mechanisms for activation (e.g., ReLU, Sigmoid) to learn complex patterns.
- Output Layer: Typically uses a Softmax activation function for multi-class sentiment classification.

Advantages of Sentiment Analysis with ANNs

Handling Complexity: Non-linear and complicated relationships in the data can be modeled by ANNs. **Feature Learning:** When utilizing deep networks, in particular, automatically extract pertinent features from unprocessed data.

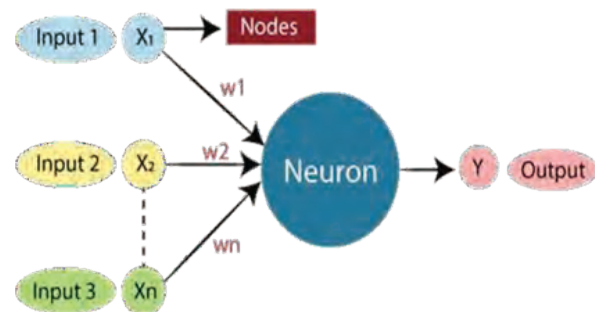


Fig. 3 Basic Structure of ANN

Feature Extraction

The process of identifying and removing textual elements that can be utilized to determine the sentiment (positive, negative, or neutral) of a review is known as feature extraction when it comes to sentiment analysis of restaurant reviews. This method converts unprocessed text data into a structured format suitable for analysis by machine learning algorithms. In situations like this, the following are some common techniques for extracting features.

1. **Tokenization:** Splitting the text into individual tokens. eg. —The food was delicious| would be split into [—The|,|food|,|was|,|delicious|]
2. **Stop Word Removal:** removing terms that are frequently used but don't really contribute to the sentiment, such as “the,” “is,” “in,” etc.
3. **Lemmatization and Stemming:** Stemming and lemmatization involve reducing words to their basic or root forms. For example, “running” would be reduced to “run.” Bag of words: Making a matrix of word frequencies is known as BOW, or Bag of Words. Every review is shown as a vector of word counts.
4. **TF-IDF:** A significant word in a document is matched against a set of documents. using a statistical measure known as Term Frequency-Inverse Document Frequency, or TF-IDF. It is beneficial to highlight important phrases that are more specific to various assessments.

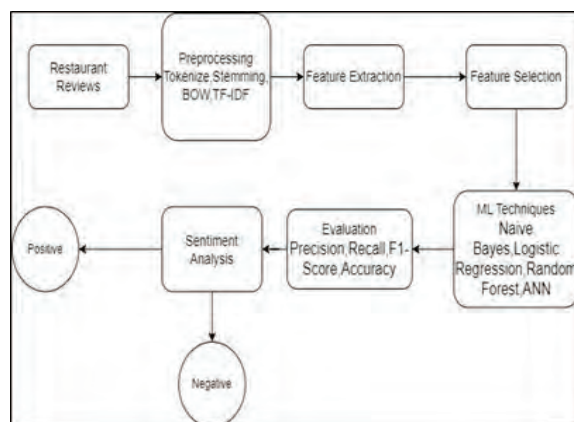


Fig. 4 Proposed Diagram Of Restaurant Review Sentiment Analysis

Feature Selection

The feature selection approach uses easy-to-understand textual information for natural language processing to help

choose features. This method involves choosing a special collection of words and using them for sentiment analysis.

EVALUATION AND RESULT

Evaluation

The Precision, Recall, and F1-score measures have been employed to assess the model's performance. In order to supply a clear direction for choosing a suitable method for sentiment analysis on a huge volume of data, Researcher presents the outcomes of every model.

The accuracy is reported by the Naive Bayes classifier. of 71.07% when tested on over 5900 restaurant reviews on sentiment analysis. This demonstrates the results obtained for the test datasets.

Table 1 : Classification Report for Naïve Bayes

Naive Bayes Classifier Report:				
	precision	recall	f1-score	support
NEGATIVE	0.33	0.73	0.45	73
POSITIVE	0.93	0.71	0.80	366
accuracy			0.71	439
macro avg	0.63	0.72	0.63	439
weighted avg	0.83	0.71	0.75	439
Accuracy: 71.07%				
Time Complexity: 0.1746 seconds				

The accuracy reported by logistic regression classifier emerges as 87.24% and classification report produced by test dataset as shown in below:

Table 2 : Report on Classification for Logistic Regression

Logistic Regression Classifier Report:				
	precision	recall	f1-score	support
NEGATIVE	0.63	0.58	0.60	73
POSITIVE	0.92	0.93	0.92	366
accuracy			0.87	439
macro avg	0.77	0.75	0.76	439
weighted avg	0.87	0.87	0.87	439
Accuracy: 87.24%				
Time Complexity: 0.5646 seconds				

The Random Forest Classifier's claimed accuracy is found to be 89.98% and classification report produced by test dataset as shown in below:

Table 3: Report on Classification for Random Forest

Random Forest Classifier Report:				
	precision	recall	f1-score	support
NEGATIVE	0.85	0.48	0.61	73
POSITIVE	0.90	0.98	0.94	366
accuracy			0.90	439
macro avg	0.88	0.73	0.78	439
weighted avg	0.90	0.90	0.89	439
Accuracy: 89.98%				
Time Complexity: 33.9977 seconds				

Table 4. Comparison of Evaluation Metrics for All the Classifiers

Algorithm used		Precision	Recall	F-1 score
Naïve Bayes	Negative	0.33	0.73	0.45
	Positive	0.93	0.71	0.80
Logistic Regression	Negative	0.63	0.58	0.60
	Positive	0.92	0.93	0.92
Random Forest	Negative	0.85	0.48	0.61
	Positive	0.90	0.98	0.94
Artificial Neural Network	Negative	0.66	0.63	0.62
	Positive	0.88	0.88	0.88

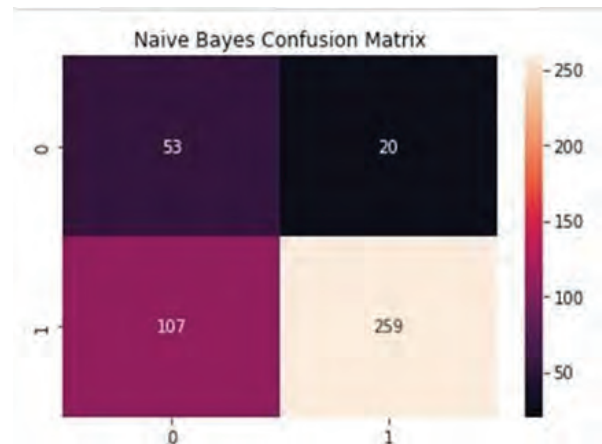
Result

An overview of the effectiveness of machine learning model on a specific assortment of tests data is provided by a confusion matrix. Based on the model's predictions, it shows the percentage of situations that are right and wrong. Classification models are often assessed using this method, with the goal of predicting a category label for each input occurrence.

1. Accuracy : $(TP + TN) / (TP + TN + FP + FN)$
2. Precision : $TP / (TP + FP)$
3. Recall : $TP / (TP + FN)$
4. F1-Score : $2 \cdot \text{Precision} \cdot \text{Recall} / (\text{Precision} + \text{Recall})$ From the confusion matrix

[TN FP

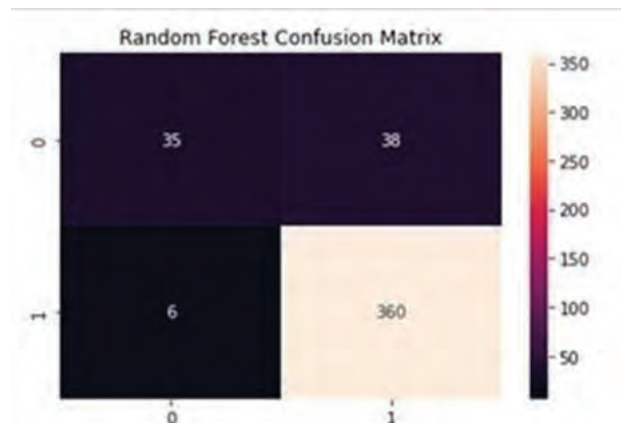
FN TP]

**Fig. 5. Confusion Matrix of Naïve Bayes**

- True Negative (TN) = 53
- False Positive (FP) = 20
- False Negative (FN) = 107
- True Positive (TP) = 259

After calculation Precision, Recall, Accuracy and F1-score of Naïve Bayes is

- Accuracy = 0.71
- Precision = 0.92
- Recall = 0.70
- F1-Score = 0.80

**Fig. 6. Confusion Matrix of Random Forest**

- True Positive (TP): 360
- False Positive (FP): 38
- True Negative (TN): 35
- False Negative (FN): 6

After calculation Precision, Recall, Accuracy and F1-score of Random Forest

- Accuracy: 0.8998
- Precision: 0.9045
- Recall: 0.9836
- F1 Score: 0.9425

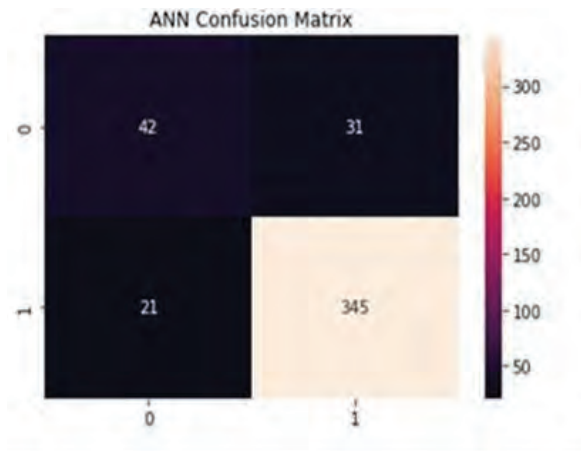


Fig. 7. Confusion Matrix of ANN

- True Positive(TP): 345
- False Positive(FP): 31
- True Negative (TN): 42
- False Negative (FN): 21

After calculation Precision, Recall Accuracy and F1-score of ANN

- Accuracy: 0.88
- Precision: 0.91
- Recall: 0.94
- F1 Score: 0.92

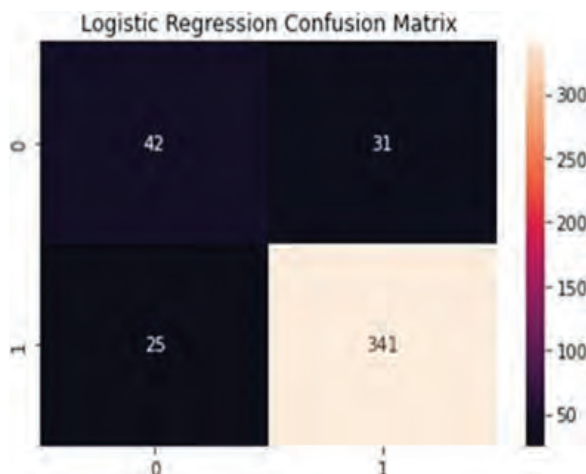


Fig. 8. Confusion Matrix of Logistic Regression

- True Positive (TP): 341
- False Positive (FP): 31
- True Negative (TN): 25
- False Negative (FN): 42

After calculation Precision, Recall, Accuracy and F1-score of Logistic Regression

- Accuracy: 0.833
- Precision: 0.917
- Recall: 0.890
- F1 Score: 0.902

In general, it's not achievable to simultaneously increase the recall rate and accuracy rate. The categorization threshold is the adjustment strategy used to reach a compromise and work things out. Currently, The accuracy-recall rate curve and The Receiver Operating Characteristic (ROC) curve are beneficial resources for assessing the model's performance and the selection of the categorization threshold.

The x axis represents the false positive rate, while the y axis represents the true positive rate. A good model should have a true rate as high as feasible and a false positive rate as low as feasible, meaning that the curve should extend as far to the upper left corner, if at all possible. Area under curve (AUC)

The area under the curve can be utilized to numerically summarize the performance of the ROC curve.

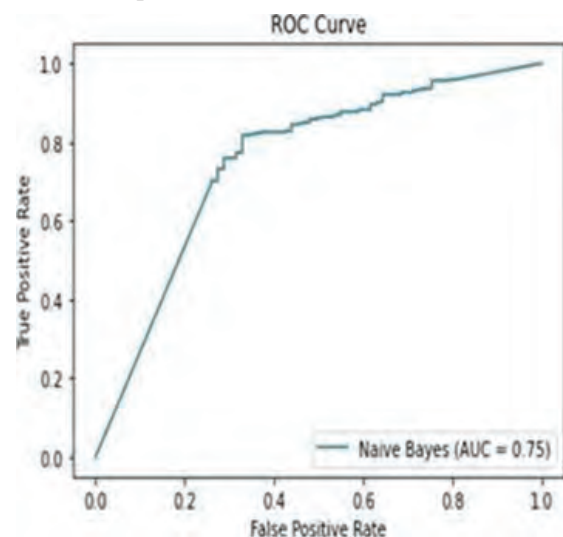


Fig. 9 shows the Naïve Bayes ROC curve

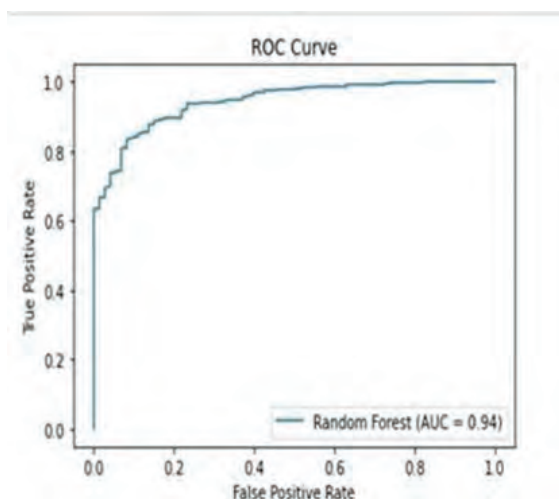


Fig. 10. Shows the Random Forest ROC curve

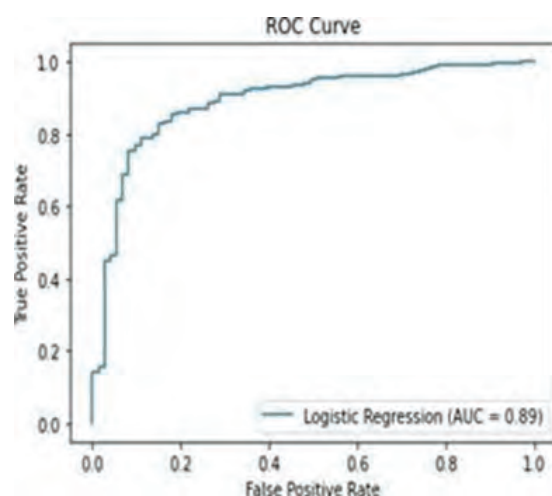


Fig. 11. Shows the ROC curve for logistic regression.

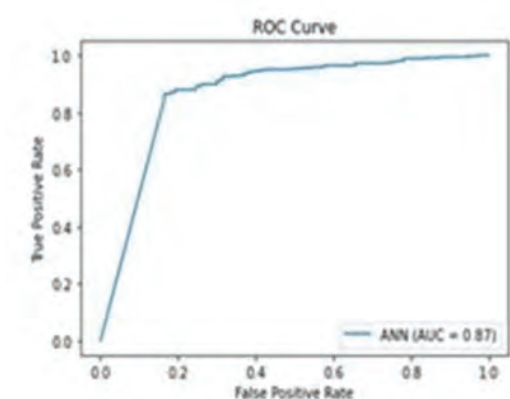


Fig. 12 shows the ANN ROC curve

TIME COMPLEXITY

Time complexity is a measure used to indicate how long an algorithm takes to run relative to the size of the input. It aids in evaluating the efficiency of an algorithm, and forecast how well it will perform since the size of the input increases by giving a maximum limit on the execution time.

Naïve Bayes time complexity 0.17 seconds, Random forest 33.99 seconds, Logistic Regression 0.56 seconds, ANN 25.57.

CONCLUSION

In this research, researcher conducted a comparison analysis of several machine learning methods for sentiment classification. To achieve this aim, the techniques were utilized on the dataset of restaurant reviews to classify the sentiments with greater accuracy. The machine learning techniques applied on data were Naïve Bayes, Logistic Regression, while deep learning methods employed Random Forests and Artificial neural networks. The Random Forest model achieves higher accuracy compared to Naïve Bayes, Logistic Regression, and Artificial Neural Networks (ANNs) (90%) when compared to individual classifiers for sentiment analysis. Subsequent investigations may concentrate on sophisticated deep learning models that include photographs, videos, and audio files.

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Analyzing Sentiment Across Amazon Reviews and Twitter Unveils Compelling Insights into Consumer Sentiment and Social Media Discourse

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ABSTRACT

Sentiment analysis, an invaluable tool for extracting underlying emotions and opinions conveyed in textual content, plays a crucial role in determining overall sentiment—whether it's positive, neutral, or negative. It involves identifying and categorizing users' opinions from text into various sentiments. Its applications are wide-ranging, from assessing product reviews to evaluating brand perception and understanding public sentiment on diverse topics.

The main objective of this study is to conduct sentiment analysis on a dataset comprising mobile phone reviews. This research aims to provide valuable insights to brands and companies, helping them better understand the collective sentiment surrounding their products. The proposed study aims to make significant contributions to sentiment analysis by integrating both VADER (Valence Aware Dictionary for Sentiment Reasoning) and roBERTa (Robustly Optimized BERT Approach), a combination not explored in current literature. It offers insights into how these models complement each other and gather compound scores for review analysis. Moreover, it indicates future directions, including multilingual analysis, nuanced understanding, and handling of profanity. It also helps in analyzing emoji's and speech.

KEYWORDS: Sentiment analysis, Machine learning, Predictive analytics, Random forest, VADER, roBERTa, Decision tree, Amazon reviews.

INTRODUCTION

Digital consumerism and e-commerce are on an unprecedented rampage, one needs to get hold of the trends, not only to understand the changing commerce of the game but also how people can put their opinions in front of the product sellers directly. Years ago there were to be many layers/middlemen between the product manufacturers and the consumer. Still, with the advent of social media and e-commerce platforms, the consumer feedback system has become very easy. Platforms like Amazon, Flipkart, Twitter, etc. have removed these barriers, while it would be a gross overestimation to say that the top people in the management of big manufacturers would be going through all the reviews, a rather sensible estimate would be that they want a mechanism in place that could give them instant and authentic feedback.

Natural language processing (NLP) techniques are commonly employed to identify and classify users' sentiments into

different categories. One common approach involves utilizing machine learning algorithms trained on labeled data. These algorithms analyze text data to categorize it into predefined sentiment categories, such as positive, the text. Sentiment analysis, an emerging field within NLP, offers a way to interpret the emotional content of text. It provides the tools necessary to determine whether the sentiment expressed in a piece of text leans towards positivity, negativity, or neutrality. When applied to Amazon reviews, sentiment analysis becomes invaluable, unlocking insights into the collective opinions surrounding these products.

The primary objective of this research is to study the various NLP techniques that are employed to classify, extract, measure, and comprehend the sentiments expressed within the used dataset.

In devising the system design for our multiple disease prediction system, we adopted a structured and modular

approach to ensure efficiency, scalability, and user-friendly interaction. At the heart of our design lie the aforementioned five specialized machine learning models, each meticulously evaluated for its efficacy concerning individual Initially, data pre-processing is conducted to ensure the quality of the data. Subsequently, a selection must be made among various classification techniques, including Decision Tree, Random Forest, XGB, VADER, Hugging face pipeline, or roBERTa. The aim is to assess the predictive capabilities of these models and determine their effectiveness in discerning sentiment in reviews or comments. Through a comprehensive comparison of the results obtained and the accuracy achieved by the classifiers, we can elucidate their strengths and weaknesses within this specific context. This process provides deeper insights into the prevailing sentiment surrounding the products.

The diverse array of opinions shared by consumers in the Amazon review section and Tweets will be carefully examined by thoroughly analyzing and parsing through them. Sentiment analysis holds significance across several critical domains. It serves as a valuable tool for product enhancement, enabling businesses to pinpoint areas of praise or concern to improve product quality and features. Additionally, sentiment analysis plays a pivotal role in managing reputation by allowing brands to monitor and promptly address customer feedback, thus upholding a positive online presence. Moreover, it is instrumental in market research, providing insights into market trends, consumer preferences, and competitive landscape. In the realm of customer service, it aids in addressing negative reviews and devising strategies to enhance customer satisfaction. Lastly, sentiment analysis contributes to recommendation systems, refining product suggestions based on user sentiment and preferences.

LITERATURE SURVEY

The rapid proliferation in the digital era has sparked a surge in online reviews. These reviews serve as invaluable resources for both consumers and businesses, shaping purchasing decisions and influencing product development, and even impacting election outcomes. This review of literature offers a comprehensive overview of the principal themes and discoveries in the realm of sentiment analysis of reviews in platforms like twitter, amazon, flipkart, etc.

In their work titled “Enhancing Sentiment Analysis with Improved Vader and Dependency Parsing,” researchers delve into innovative strategies to enhance sentiment analysis. The study focuses on refining VADER (Valence Aware Dictionary and Sentiment Reasoner), recognizing its strengths in valence-based sentiment evaluation while acknowledging its lower accuracy compared to alternative

algorithms. To tackle this challenge, the researchers incorporate various lexicons, including pre-existing ones and those created by users, covering emoticons, VADER lexicons, negation, booster words, idioms, and special cases. The methodology involves text standardization, tokenization, and the utilization of specialized functions for negation detection and normalization of sentiment scores. Moreover, the study integrates the Spacy library for natural language processing, enabling comprehensive information extraction and sentiment analysis. The impact of verbs in text on sentiment is also examined using VADER. This literature review highlights the importance of these advancements in enhancing sentiment analysis accuracy, thus contributing to the ongoing development and practical application of the field.

VADER

stands as a lexicon and rule-based sentiment analysis tool tailored specifically for analyzing social media and short texts. Within the NLTK (Natural Language Toolkit), it operates as a module offering sentiment scores based on lexical cues. Functioning as a rule-based sentiment analyzer, VADER categorizes terms based on their semantic orientation as positive or negative. It evaluates sentiment by assigning polarity scores (positive, negative, or neutral) to individual words and subsequently computes an aggregate sentiment score for the given text. In our investigation, we harnessed the VADER sentiment analysis tool in Python, renowned for its efficacy in analyzing sentiment in casual text formats like online reviews. The outcomes from VADER underscore its utility in processing data from microblogging platforms, where diverse phrases are intertwined, offering significant potential benefits.

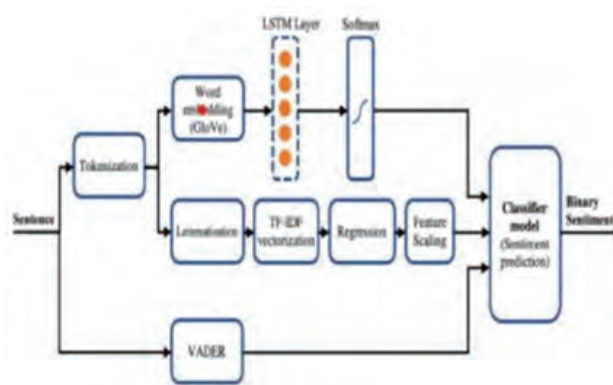


Fig. 1. VADER architecture

ROBERTA

BERT, short for Bidirectional Encoder Representations from Transformers, represents a model variant crafted by

researchers at Facebook AI. This model comprises twelve layers and operates as a deep learning model renowned for its outstanding performance across diverse NLP tasks. Powered by an extensive neural network architecture and pre-trained on a vast corpus of text data, BERT has showcased remarkable capabilities. The creators of this model have fine-tuned it to extract nine entities from sentences based on contextual clues, thereby enhancing its performance. This advancement underscores efforts to integrate multilingual input and explore its implications. In our investigation, we utilized the Hugging Face Transformers library to fine-tune a RoBERTa model for sentiment analysis. Leveraging its capacity to grasp intricate contextual nuances, this model offers superior sentiment analysis compared to rule-based methodologies.

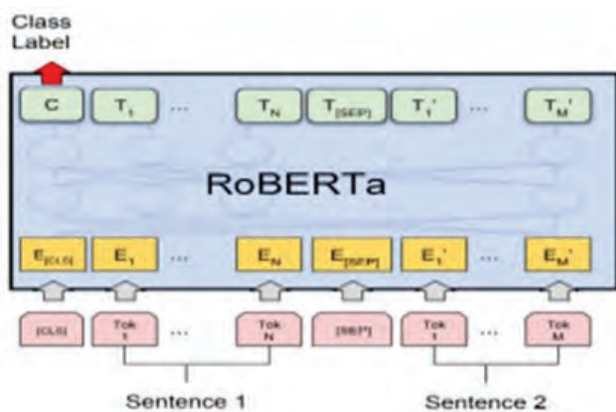


Fig. 2. RoBERTa architecture

Random Forest

The Random Forest classifier is a powerful machine learning algorithm utilized for classification and regression tasks. It operates by constructing multiple decision trees during training and then consolidating their outputs to produce a more accurate and stable prediction. To create these trees, Random Forest employs random sampling with replacement from the training data, generating diverse subsets for each tree. Additionally, at each node of the decision tree, a random subset of features is considered for splitting, aiding in preventing overfitting and improving generalization. Through this process, each decision tree is grown either to its maximum depth or until a predefined stopping criterion is met. During prediction, the final outcome is determined by aggregating the predictions of all trees—typically through majority voting for classification tasks and averaging for regression tasks. Renowned for their robustness, scalability, and ability to handle high-dimensional data effectively, Random Forests are favored for their reduced susceptibility to overfitting compared to individual decision trees, often delivering outstanding predictive performance.

Decision Tree

The Decision Tree classifier is a fundamental machine learning algorithm used for both classification and regression tasks. It works by recursively partitioning the input space into regions based on the values of input features, aiming to minimize impurity or maximize information gain at each split. Starting from the root node, the algorithm selects the feature that best separates the data into homogeneous subsets, and then continues this process iteratively for each child node until a stopping criterion is met, such as reaching a maximum depth or having nodes with minimum samples. Each leaf node represents a final decision or prediction. Decision Trees are intuitive to interpret, as they can be visualized graphically, showcasing the decision-making process. However, they can suffer from overfitting, particularly with complex datasets, and may not generalize well to unseen data. Techniques such as pruning, limiting the tree depth, or using ensemble methods like Random Forests can mitigate these issues, enhancing the classifier's performance and robustness.

XGBoost

XGBoost, short for Extreme Gradient Boosting, is a highly efficient and scalable machine learning algorithm renowned for its exceptional performance in a wide range of tasks, including classification, regression, and ranking problems. It belongs to the family of gradient boosting algorithms, which iteratively builds a strong predictive model by combining the predictions of many weak learners—typically decision trees—sequentially. XGBoost stands out for its optimization techniques, such as parallel and distributed computing, which enable it to handle large-scale datasets with millions of instances and features efficiently. It employs a sophisticated regularization technique to prevent overfitting by penalizing complex models, and it supports various objective functions and evaluation metrics, allowing customization based on specific requirements. Moreover, XGBoost incorporates tree pruning, column subsampling, and cross-validation to enhance model generalization and performance. Its popularity stems from its winning track record in machine learning competitions and its wide adoption in industry applications. With its speed, accuracy, and versatility, XGBoost continues to be a go-to choice for data scientists and machine learning practitioners seeking state-of-the-art performance.

PROPOSED WORK

Data Understanding

we use the dataset of amazon alexa reviews. 3150 textual user reviews of Amazon Alexa devices have been added to this dataset. This is the dataset's header. Five columns are present. The "rating" column displays the comment scores; the "date"

column shows the comment date; the “variation” column lists different Alexa products, such as Charcoal Fabric, Echo, Echo dot, Fire stick, etc.; in the “feedback” column, a score of one indicates a comment that is greater than or equal to three, and a score of zero indicates a comment that is less than three.

rating	date	variation	verified_reviews	feedback	
0	5	31-Jul-18	Charcoal Fabric	Love my Echo!	1
1	5	31-Jul-18	Charcoal Fabric	Loved it!	1
2	4	31-Jul-18	Walnut Finish	Sometimes while playing a game, you can answer...	1
3	5	31-Jul-18	Charcoal Fabric	I have had a lot of fun with this thing. My 4 ...	1
4	5	31-Jul-18	Charcoal Fabric	Music	1

Fig. 3. Dataset Sample

We can explore the data after importing the library and data to gain a general grasp of the dataset. Figure 3 provides a description of the reviews. The majority of buyers give these products high ratings, as evidenced by the average rating of 4.46 with standard deviation of 1.06 and the feedback of 0.92 with standard deviation of 0.27. Plotting the rating distribution gives us further detail (figure 4). 500 reviews have a score of 4, while more than 2100 reviews have a score of 5.

While several machine learning algorithms have been applied to sentiment analysis tasks, Random Forest offers unique advantages that make it a promising candidate for this task.

The Random Forest algorithm, an ensemble learning technique, constructs multiple decision trees during training and aggregates their predictions to make robust and accurate classifications. This approach addresses common challenges in sentiment analysis, such as dealing with noisy and high-dimensional text data, as well as mitigating overfitting issues often encountered with individual decision trees.

	rating	feedback
count	3150.000000	3150.000000
mean	4.463175	0.918413
std	1.068506	0.273778
min	1.000000	0.000000
25%	4.000000	1.000000
50%	5.000000	1.000000

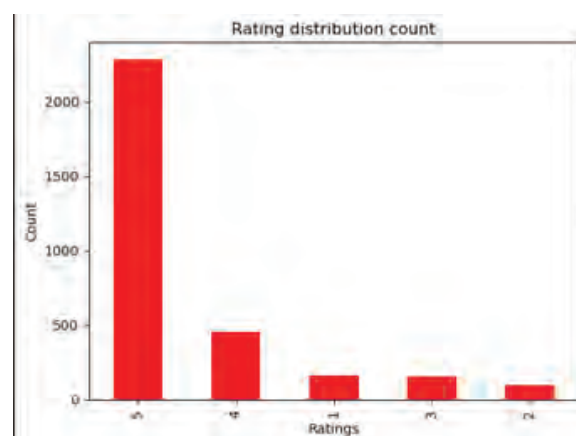


Fig. 4. Review Description and Representation of Distribution

In order to examine both the greatest and worst reviews at the same time, this paper would like to extract the reviews with ratings of 5 points and 1 point. The data illustrates how exceptional terms such as “love,” “echo,” “great,” “alexa,” “music,” “like,” “use,” “sound,” “new,” “easy,” and so forth are rated at 5. Reviews with a rating of one contain the terms “amazon,” “device,” “work,” “disappointed,” and “echo.” It states that those who rated something with a 1 will jointly convey the facts and their sentiments. Furthermore, the world might merely be a large collection of words; further research is necessary to uncover more worthwhile items.

Model Development

We can utilize the dataset to create a machine learning model that predicts the rating using the feature vector of the reviews. A semimetal score—a positive or negative score—can be generated using the feedback and ratings for each review that were provided by the dataset. In this work, ratings of four or more are considered favorable, whereas ratings of less than four are considered bad. The dataset must then be divided into two sections: the training dataset and the test dataset. In this work, 70% of the data were used for training and 30% for testing. The test dataset is the sample dataset used to assess performance, whereas the training dataset is the sample dataset used for learning.

We propose a novel approach to sentiment analysis leveraging the Random Forest classifier. Sentiment analysis, the task of automatically identifying and categorizing opinions expressed in text, plays a crucial role in various domains, including social media monitoring, customer feedback analysis, and market research.

While several machine learning algorithms have been applied to sentiment analysis tasks, Random Forest offers unique advantages that make it a promising candidate for this task.

The Random Forest algorithm, an ensemble learning technique, constructs multiple decision trees during training and aggregates their predictions to make robust and accurate classifications. This approach addresses common challenges in sentiment analysis, such as dealing with noisy and high-dimensional text data, as well as mitigating overfitting issues often encountered with individual decision trees.

Training Accuracy : 0.9945553539019963
Testing Accuracy : 0.9470899470899471

Fig. 5. Training/Testing Accuracy of Random Forest

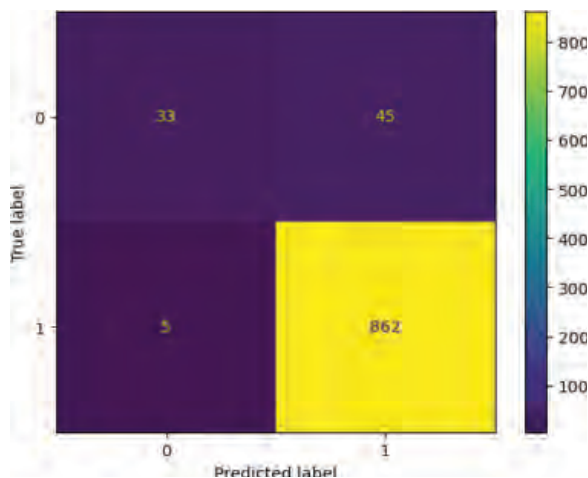


Fig. 6. Confusion Matrix for Predictions

The confusion matrix in Figure 4. Allows us to understand the true and predicted labels of the dataset. It also gives us an understanding of the expected outputs.

CONCLUSION

We have provided delves into sentiment analysis, also referred to as text sentiment detection, with a focus on Amazon reviews sourced from Kaggle, a subsidiary of Google offering AI models and published datasets. The study presents a thorough analysis pipeline leveraging NLTK and Hugging Face's transformer-based models, particularly roBERTa. Various sentiment analysis techniques are explored, ranging from Vader's simplistic polarity scoring to roBERTa's nuanced contextual understanding. While the results reveal a significant correlation between sentiment scores and review ratings, they also underscore the limitations of word-by-word analysis. The study advocates for the use of deep learning models to gain deeper insights. Furthermore, a comparison of the performance of the two models highlights differences in accuracy and speed.

Looking ahead, there are intriguing avenues for sentiment analysis research. Exploring diverse models for cross-linguistic sentiment analysis holds promise, as does delving into emotion detection, which moves beyond binary sentiment categorization to identify specific emotions expressed in reviews. Enhanced cross-lingual analysis techniques will be crucial in a globalized marketplace. Ethical considerations, such as addressing bias, impartiality, and privacy concerns, will gain increasing importance. Additionally, the development of real-time sentiment analysis tools will empower businesses with immediate insights for agile decision-making, enabling them to adapt to evolving customer sentiments swiftly.

Our study advocates for broader utilization of these models on larger datasets, offering deeper and more nuanced insights into sentiment analysis.

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Flutter: A Comprehensive Review of Mobile App Development in the Android Ecosystem Libraries

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ABSTRACT

In the mobile device world, there are two major operating systems Apple's iOS and Google's Android. It's time to write distinct code in each of the two OS systems' languages to develop apps for both. Many businesses have developed frameworks over time that enable cross-platform mobile application development, enabling the use of the same code across many operating systems. However, the advantages of having a single source code are frequently outweighed by the drawbacks that a framework provides, particularly in terms of performance and OS integration. This review paper explores the ever-changing field of Android platform app development, paying particular attention to the emerging Flutter framework for mobile library websites. Libraries must ensure that their websites are compatible with a wide range of mobile devices because these websites are the main way patrons access various services. This work provides a guide for creating mobile-friendly library interfaces by thoroughly examining best practices and drawing on real-world experiences from creating mobile library websites for different colleges/universities and organizations. It covers the entire process from the first idea to the finished result, which makes it a priceless tool for libraries looking to improve their online visibility in a mobile-first world.

KEYWORDS: *Ecosystem library Application, Flutter, UI coding, Android, and iOS platforms.*

INTRODUCTION

Mobile app development has become crucial in the technology sector, especially within the Android ecosystem. The rapid progress in mobile communication technology has led to a growing demand for creative and effective applications, which is transforming several industries telecommunications, the government sector, healthcare, and e-commerce to insurance and organizations [1], [2]. The increase in open-access materials and the ubiquitous availability of internet resources have significantly changed how people obtain information and use technology. In the highly competitive and revolutionary world of mobile app development today, companies are extremely crazy to overlook their presence on the Google Play Store and the Apple App Store. However, because native app development involves numerous teams, opting for native apps typically results in a funding issue. Cross-platform app development has become a viable option for mobile app development to reduce expenses without sacrificing the availability of an iOS

and Android application [3]. Cross-platform development, sometimes referred to as multi-platform software or platform-independent software, is predicated on the notion that code should only be written once and executed anywhere. Regarding architecture, internal operation, programming languages, and development approaches, diversity is abundant among the several cross-platform frameworks for mobile development. Flutter is one of these cross-platform frameworks [4]. Flutter is an open-source mobile user interface framework that has been developed by Google. It was released in 2017 and is now ranked 34th among software tools used to design applications. The Flutter framework signifies a fundamental change in Android app development, providing developers with a flexible and effective set of tools to create engaging user experiences. Flutter has gained global recognition for its ability to simplify the development process and create professional, cross-platform applications with ease, thanks to its core principles of simplicity, performance,

and adaptability [5]. As developers increasingly adopt Flutter, its influence on the Android ecosystem is expected to be significant, stimulating innovation and enabling creators to push the limits of mobile app design. In the middle of this technological transformation particularly in the education sector, libraries are facing a crucial moment where they must adjust to the changing information environment while still maintaining their primary goal of enabling access to knowledge. Historically seen as strongholds of knowledge and academic pursuits, libraries have always played a crucial role in facilitating education, research, and community involvement. Nevertheless, the advent of the digital era has brought up numerous difficulties for libraries, requiring a deliberate reassessment of their functions and offerings in an ever more digitalized society. A major obstacle that libraries currently face is the urgent need to close the digital gap and guarantee fair and equal access to information for every library user. Although there has been a widespread increase in the number of digital resources available to users, there are still inequalities in access to technology and digital literacy abilities [6].

These inequalities create obstacles for marginalized people in accessing information. Libraries of colleges and universities play a vital role in reducing these gaps by providing complimentary access to computers, internet connectivity, and digital skills training programs, thus enabling customers to traverse the digital realm with assurance [7][8].

Furthermore, libraries must deal with the changing attitudes and behaviors of customers who are increasingly dependent on mobile devices as their main method of accessing information and interacting with digital content. The widespread presence of smartphones and tablets has fundamentally changed how people access and engage with information, causing a blending of traditional library spaces with digital ones. Libraries have acknowledged the significance of engaging with patrons in their preferred locations and have adopted mobile technologies to expand their influence and improve the availability of library services. Mobile library websites have become essential tools for libraries aiming to involve patrons in the digital domain. Mobile-friendly websites serve as a virtual portal to library resources and services, allowing customers to easily search catalogs, access digital collections, and communicate with librarians using their smartphones or tablets. Libraries can enhance their online presence by optimizing it for mobile devices, which will enable them to establish stronger connections with patrons and promote a culture of continuous learning and exploration.

In light of this situation, the rise of the Flutter framework presents a great opportunity for libraries aiming to improve their mobile app offerings and provide smooth user experiences across different platforms. By utilizing Flutter's

cross-platform features and user-friendly development tools, libraries can create powerful and versatile applications that meet the various requirements of their users. Flutter enables libraries to innovate and adjust to the changing requirements of the communities they serve by offering e-book access, remote research support, and virtual programming events. This review paper sets the stage for an in-depth examination of mobile app development in the Android environment, focusing on the innovative capabilities of the Flutter framework. This study aims to explore how libraries are adapting to a mobile-centric world by analyzing the relationship between mobile technology, libraries, and app development. It intends to offer helpful insights for both practitioners and researchers.

RELATED WORK

Using Flutter for developing applications in educational institutions like universities and colleges, as well as for other organizations, can be particularly advantageous due to its cross-platform capabilities and rich UI components. The Internet of Things (IoT), library applications, and online book search engines are just a few of the services that libraries are beginning to offer nowadays.

University/College Mobile Apps

University of Melbourne: The University has developed a mobile application using Flutter that provides students with access to course materials, schedules, campus maps, and notifications. The app leverages Flutter's ability to create a cohesive user experience across different devices.

An Android platform and Firebase database-based mobile application for the College Management System was developed by Arun Sai S et al. This user-friendly application's main goal was to address the difficulties college and university students encounter. Tests of the program on Android phones running version 5 and higher produced encouraging results. This application was easy to use, dependable, and time-saving. It made it possible for parents and children to view real-time information about their curriculum, attendance, and grades[9]. A comparable Android application implementation for college training and placement is suggested in one of the publications [10]. The app creates a list of its placement events and student information and then shows the details of each event on a separate page. One of the implementation's drawbacks is that customers' smartphones aren't updated on the most recent occurrences. In the present context [11], LS Rohith et al. developed an Android-based web application for students' information systems that allows them to share files, get college feeds, and chat with faculty members. Java programming is the format used to write the application's code, and Android Studio is the tool used to construct it. With this tool, developers can simply build, test, and debug our

application. Stanford Mobile: Another example is Stanford University's mobile app, which offers features like event calendars, news, and personalized student services. The use of Flutter ensures that the app performs well on both iOS and Android.

Library Management Systems

Many universities' libraries implemented a Flutter-based application to manage book checkouts, returns, and catalog searches. The application integrated with the university's existing database systems through REST APIs, showcasing Flutter's capability to handle complex data operations and provide a seamless user experience. Libraries can enhance their operations in the era of the Internet of Things (IoT) by employing a smartphone application that facilitates them.

In recent times, Eko Hadianto et al. demonstrated a smartphone application that offers a direction to users to locate and follow the whereabouts of books right now [12]. In this study, by using augmented reality a QR Code sensor mimics a book dancing in blocks and bookcases and matches the book you are looking for. The main goal of this project is to create a prototype smart library that will facilitate the finding of books and other resources by library users. A library of taxi services was created by Dilkaz Y. Mohammed et al. and is available for use by other developers in their iOS and Android applications. The Retrofit library is a Dio client that makes it easier to consume Rest APIs by delivering dynamic headers, arguments, requests, and responses uniquely and securely. Dio is our HTTP client that handles the connection [13].

Flutter LibMan: A hypothetical library management system built with Flutter could include features such as book search, reservation systems, and user account management. This system could utilize Flutter's ability to create responsive and user-friendly interfaces for both mobile and web platforms [14][15].

Organizational Applications

Employee Management Systems: Organizations can use not only Flutter but other applications to develop internal applications for managing employee information, attendance, and payroll [14]. For instance, a company might create an app that allows employees to exchange and interoperability with legacy systems. Panji Rachmat Setiawan et al. developed one application to generate the employee daily report in their own "Planet Surf Retail" company [16]. The primary goal of developing this application was to assist managers and staff in completing tasks on time and improving work performance, including daily, job, and progress reports. via this application. According to their research, 62% of users adore using the application, which helps workers. Additionally, according

to 89% of evaluations, the application satisfies users' needs. In the same direction, Rishabh Bajpayi et al. commented on how employee management systems regulate overall performance while saving money, time, and energy. This idea increases wage calculation transparency. Additionally, it will simplify the HR responsibility so that they can concentrate on other company development activities [17]. M. Noor et al. [18] demonstrated the uses of cross-platform attendance management applications using the Flutter programming framework, which offers small firms dependable, reasonably priced staff management solutions.

Database Management: Flutter supports various databases like SQLite, Firebase, Firestore, and Hive, making it suitable for applications that require offline capabilities and real-time data synchronization. From various databases, SQLite is a self-contained, serverless, and zero-configuration SQL database engine. It is embedded within the Flutter app itself and is a popular choice for local storage. The "sqflite" package is the most commonly used package for the integration of SQLite with Flutter.

User Authentication: Flutter supports user authentication through various methods, providing flexibility and security for different types of applications. Implementing secure user authentication can be achieved through Firebase Authentication, OAuth, and other authentication services supported by Flutter. Firebase Authentication is a full-of-function solution that works with several authentication methods, such as phone authentication, email/password, and third-party providers like Facebook, Twitter, and Google. The firebase_auth is the official Flutter plugin for Firebase Authentication.

Technical Considerations

Integration with Existing Systems: Flutter applications can be integrated with existing backend systems using RESTful APIs, GraphQL, and other web services. This allows seamless data exchange and interoperability with legacy systems. Sometimes it can be a complex task, but it's achievable with the right approach.

Backend Integration

RESTful APIs:

HTTP Requests: Use the 'http' package.

JSON Parsing: Convert JSON responses to Dart objects using 'dart:convert'.

GraphQL APIs

Packages: Use 'graphql_flutter' for GraphQL integration. Queries and Mutations: Perform queries and mutations to interact with the backend.

PREFERRED EMBODIMENT FOR LIBRARY APP DEVELOPMENTS

Flutter Framework

Flutter is a powerful and versatile user interface (UI) software development kit (SDK) developed by Google. Since its introduction in 2018, Flutter has rapidly gained popularity among developers due to its simplicity, efficiency, and cross-platform capabilities. It allows developers to create high-quality native interfaces for Android, iOS, web, and desktop platforms using a single codebase, reducing development time and effort. Flutter's architectural overview reveals its flexibility and adaptability, making it a preferred choice for building modern and responsive applications [19]. Flutter ensures a consistent user experience across various Android devices, promoting accessibility and ease of use for the college community. Flutter is a consistent and aesthetically pleasing UI choice that works with a variety of Android devices. The flutter framework's features are shown in Fig. 1. During development, Flutter applications run in a virtual machine (VM), supporting stateful hot reloads of changes without requiring a full recompilation. For deployment, Flutter apps are compiled directly into machine code or JavaScript for web platforms, ensuring optimal performance across various environments. Additionally, Flutter is open-source and supported by a vibrant community of developers, contributing to its ongoing evolution and enhancement.

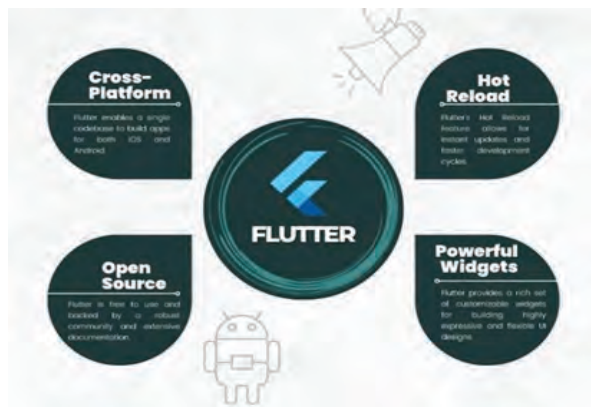


Fig. 1 Features of Flutter Framework

Firestore Authentication and Database

User authentication is seamlessly integrated using Firebase Authentication, allowing users to securely access the platform using their college credentials or other secure methods, including email and password, phone number, and third-party providers such as Google, Facebook, and Twitter. By integrating Firebase Authentication into their apps, developers can securely authenticate users and manage

their identities with minimal effort [20]. Firebase Database is employed to store and manage user profiles, book listings, and other essential data, ensuring real-time updates and synchronization across users' devices. With its support for complex data structures, transactions, and security rules, Firestore provides a robust foundation for building dynamic and interactive apps [21].

User Interface

The user interface of the application is intuitively designed to enhance user experience. The application uses a Dynamic theme mechanism to update the app theme according to the user's wallpaper and system theme. Each user is provided with a personalized profile, featuring their name, profile picture, and a brief bio, facilitating easy identification and fostering a sense of community.

API Integration

The application seamlessly integrates with external APIs to auto-fill book details, eliminating the need for manual entry by users. APIs provide access to a comprehensive book database, enabling users to quickly and accurately add books to their listings using information such as ISBN, author, and title.

Chat System for Communication

A robust chat system is implemented to facilitate communication between lenders and borrowers. Users can engage in real-time conversations within the application, negotiating terms, arranging meet-ups, and discussing any other details related to book borrowing.

Cloud Firestore Integration

The platform leverages Cloud Firestore as its primary database to store and manage user profiles, book listings, chat records, and other pertinent data. Cloud Firestore enables real-time data synchronization across multiple devices, ensuring that users have access to the latest information instantaneously.

Testing

Any application development process has to involve software testing, and this is particularly essential for a peer-to-peer book lending platform developed with the Flutter framework. By using "Android Studio" we can perform software testing, which entails configuring and carrying out a variety of tests to guarantee the dependability and caliber of the application. First, need to test each of the app's classes, functions, and methods individually using unit testing. To indicate that they are unit tests, need to annotate them with @test. The test() function from the flutter_test package is used in the test cases to specify the expectations and test scenarios. Android test runner is to execute the test cases. Likewise need to perform

other testing to using Android Studio such as Widget Testing, Integration Testing, Performance Testing, Authentication Testing, etc.

APP DEVELOPMENT FLOW

A book borrowing software must be created in a few stages to ensure a streamlined and effective workflow for administrators and users alike. The detailed workflow is featured in the Fig. 2.

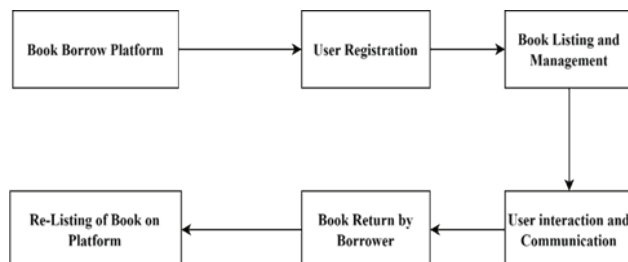


Fig. 2 Book borrowing platform workflow

User Registration

Users initiate their engagement with the platform by registering, providing necessary details, and authenticating their affiliation with the college, typically through official email IDs or other secure methods.

Book Listing and Management

Once registered, users can easily list their available books on the platform. The system integrates a book database to simplify the process, allowing users to add books to their profiles using ISBN-based information retrieval. Users specify book details such as title, author, genre, condition, and availability status as shown in Fig. 3. Additionally, users can indicate whether they are willing to lend, borrow, or both.

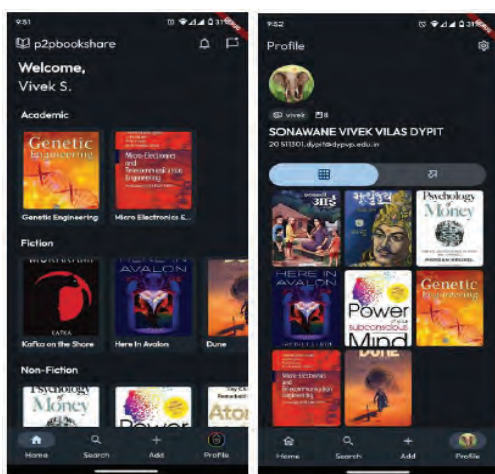


Fig. 3. a) Home page b) User Profile

User Interactions and Communication

The platform facilitates communication between users. Interested borrowers can browse the listed books, express their interest, and initiate communication with the book owners. This stage allows for mutual agreement between borrowers and lenders.

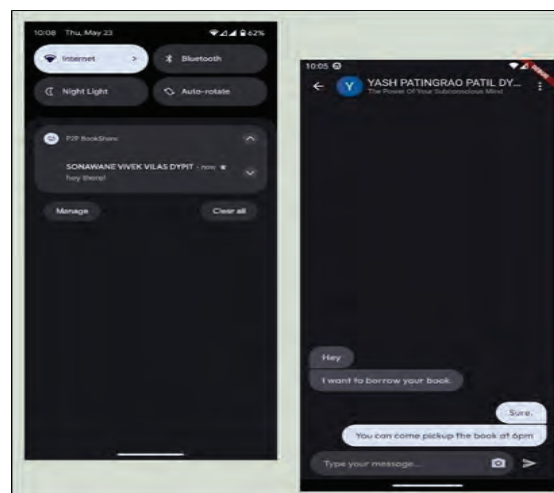


Fig. 4. Chat System of book borrowing application

Book Borrowing and Returning Process

After reaching a mutual agreement, borrowers and lenders arrange to meet in person for book exchanges. This emphasizes face-to-face interactions, creating opportunities for students to connect over shared interests in literature. Upon completing the reading, borrowers can coordinate with the lenders to return the borrowed books. This step ensures the dynamic and accessible nature of the lending process, fostering a continuous cycle of book exchanges as shown in Fig. 5.

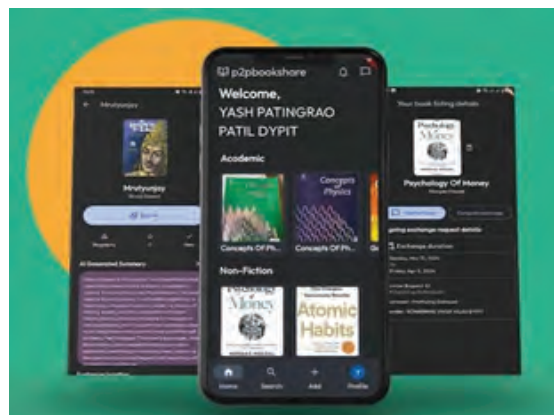


Fig. 5. Mutual agreement of Book Borrowing and Returning Process through the application

Re-listing of Book on Platform

Once a book is returned, lenders can re-list their books on the platform, making them available for future borrowing requests. This step ensures that the inventory of available books remains up-to-date and that the lending process continues within the college community.

CONCLUSION

In the ever-evolving field of mobile app development, the birth of Flutter has brought about a paradigm change, allowing developers a strong and adaptable framework for building cross-platform applications with unrivaled speed, performance, and customization. As emphasized throughout this review paper, Flutter's broad capabilities, straightforward development workflow, and thriving ecosystem support make it an appealing choice for developers and organizations trying to create high-quality, feature-rich applications that resonate with modern customers. From its conception, Flutter has swiftly garnered appeal among developers worldwide, driven by its novel approach to UI development, hot reload functionality, and seamless integration with native platform features. The framework's cross-platform capabilities enable developers to reach a wider audience and maximize their app's potential without compromising on performance or user experience. Furthermore, Flutter's future outlook is encouraging, with continual developments, additions, and community-driven contributions ready to further establish its position as a top cross-platform development framework.

In conclusion, Flutter represents a disruptive force in the world of mobile app development, bringing developers unparalleled prospects for innovation, efficiency, and collaboration. Whether building mobile app web libraries, enterprise solutions, or consumer-facing applications, flutter empowers developers to unleash their creativity and bring their ideas to life with speed, precision, and elegance. As we move towards the future, Flutter's impact on the industry is destined to be tremendous, altering the way developers approach cross-platform development and providing great experiences.

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Early Detection of Cardiovascular Diseases Using Machine Learning

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ABSTRACT

Cardiovascular diseases (CVD) represent a pervasive global health challenge, necessitating advanced strategies for early detection and preventive intervention. This extensive research paper unfolds a multifaceted exploration into the development of a robust predictive model employing artificial intelligence (AI) and the gradient boost classifier algorithm. The principal aim is to develop a reliable and comprehensive tool, leveraging a diverse dataset encompassing objective, examination, and subjective features. The purpose of this research is to equip medical practitioners with a sophisticated and nuanced method for identifying who could get cardiovascular diseases, permitting timely intervention and customized prophylactic care.

KEYWORDS: Cardiovascular diseases, Machine Learning, Early Detection, Predictive Models, Healthcare, and Gradient boost classifiers.

INTRODUCTION

Cardiovascular diseases, including coronary heart disease, have surged to the forefront of global health concerns. As these conditions continue to exact a heavy toll on populations worldwide, there is an urgent need for innovative methodologies to enhance early detection and intervention. This paper introduces a comprehensive study that amalgamates artificial intelligence [8] and the Gradient boost classifier algorithm [1], leveraging a rich dataset with objective, examination, and subjective features. The goal is to usher in a transformative approach that not only identifies individuals at risk but also offers a nuanced understanding of the multifaceted factors contributing to cardiovascular diseases.

LITERATURE SURVEY

The literature review critically examines the state of AI applications in healthcare today, with an emphasis on disease classification. Existing studies are scrutinized to discern the versatility and efficacy of the gradient boost classifier algorithm across various medical applications. The benefits and limits of AI in the prediction of cardiovascular illness are thoroughly examined in this part, which also emphasizes how important it is to create a trustworthy, comprehensible model that accounts for the complexity of these conditions.

DATASET DESCRIPTION

The dataset employed in this research serves as the

foundational bedrock for crafting a predictive model [10] geared towards early detection of cardiovascular diseases. This complex dataset is made up of three different feature categories, each of which provides a different perspective on the various facets of a person's health profile.

Table 1: Dataset Overview

Feature Category	Description
Objective Features	Age, Height, Weight, Gender
Examination Features	Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Cholesterol, Glucose
Subjective Features	Smoking, Alcohol Intake, Physical Activity
Derived Features	BMI, Blood Pressure Category, Weight Status, Pulse Pressure, Average Blood Pressure

Objective Features

Age (in the year)

This fundamental demographic feature provides insights into the chronological dimension of an individual's life, serving as a key parameter for understanding the aging process and its potential correlation with cardiovascular health.

Height (in cm)

The objective inclusion of height allows for a comprehensive assessment of physical stature, a factor that can play a pivotal role in cardiovascular health considerations.

Weight (in kg)

Weight, a crucial metric in health assessments, contributes valuable information regarding body mass, potentially unveiling associations between weight-related factors and cardiovascular disease risk.

Gender (categorical code)

Categorizing gender provides an essential binary variable, facilitating gender-specific analyses and recognizing potential gender-based disparities in cardiovascular disease prevalence.

Examination Features**SBP (ap_hi)**

Systolic Blood Pressure [SBP] is a cornerstone health metric, & its inclusion in the dataset enables a thorough assessment of the patient's cardiovascular health and how it affects their risk of heart disease.

DBP (ap_lo)

The Diastolic Blood Pressure reading complements the systolic measure, offering a comprehensive perspective on blood pressure dynamics and aiding in the assessment of potential hypertension-related risks.

Cholesterol/Fat (1: normal, 2: above normal, 3: well above normal):

Cholesterol levels serve as critical indicators of cardiovascular health. Categorizing cholesterol levels allows for a nuanced exploration of how lipid profiles contribute to disease prediction.

Glucose (1: normal, 2: above normal, 3: well above normal):

Another crucial health metric, glucose levels, are added to look into any possible connections between blood sugar levels & the development of cardiovascular disease.

Subjective Features**Smoking (binary)**

The binary categorization of smoking habits sheds light on a major lifestyle factor. Understanding the influence of smoking on cardiovascular health is paramount for personalized interventions.

Alcohol Intake (binary)

Similar to smoking, the binary classification of alcohol intake discerns the impact of this lifestyle choice on cardiovascular disease risk, contributing to a holistic understanding of individual health behaviors.

Physical Activity (binary)

The binary representation of physical activity captures an individual's engagement in active pursuits, offering insights into the potential protective effects of an active lifestyle against cardiovascular diseases.

Derived Features**BMI**

Body Mass Index (BMI) is not explicitly provided in your project data, but it can be derived using the "weight" and "height" objective features. The formula for calculating BMI is to divide height in meters squared by weight in kilos. It serves as a useful health metric, often considered in cardiovascular disease analysis, helping categorize individuals into overweight, normal weight, underweight, or obese groups based on their body composition.

Blood Pressure Category (Normal, Prehypertension, Hypertension):

Blood Pressure information is provided through the "Systolic blood pressure" (ap_hi) and "Diastolic blood pressure" (ap_lo) examination features. The blood pressure categories can typically be defined as follows:

- 1) Normal: less than 80 mmHg in the diastolic and less than 120 mmHg in the systolic pressure.
- 2) Prehypertension is indicated by either either an 80–89 mmHg diastolic pressure or a 120–139 mmHg systolic pressure.
- 3) Hypertension: 90 mmHg or more at the diastolic pressure and 140 mmHg or more at the systolic pressure.

Weight Status (Underweight, Normal Weight, Overweight, Obese):

Using the supplied "weight" and "height" objective characteristics, to find out how much weight each project has, calculate the Body Mass Index (BMI). The categories are usually explained as follows:

- 1) Underweight is defined as having a BMI of not more than 18.5.
- 2) The usual weight range is 18.5–24.9 kg.
- 3) A BMI of 29.5 to 29.9 is considered obese.
- 4) A BMI of thirty or higher is considered obese.

PP

The ratio of the diastolic and systolic blood pressures (ap_lo & ap_hi), or pulse pressure (pp), is a measurement of the force produced by the heart with each contraction. It can be

calculated by deducting the diastolic pressure ($ap\_hi - ap\_low$) from the systolic pressure.

Average blood pressure

Average blood pressure can be derived by calculating the mean of the DBP (ap_low) & SBP (ap_hi). This metric provides a summary measure of an individual's overall blood pressure.

The desired variable

Absence Or Presence of Cardiovascular Disease (binary)

The binary classification of the target variable, which indicates whether cardiovascular illnesses are present or absent, is the dataset's central component. This variable serves as the focal point for predictive modeling, driving the development of a tool for early detection.

METHODOLOGY

A comprehensive methodological framework is delineated, elucidating the step-by-step approach adopted for this research. The choice of the gradient boost classifier algorithm is justified, and the intricacies of dataset division into training and testing sets are detailed. This section provides a roadmap for the application of the algorithm across objective, examination, and subjective features, setting the stage for a rigorous evaluation of its predictive capabilities.

Data Preparation

The data processing pipeline involves a series of steps to transform the input dataset for optimal use in machine learning models. Each step is defined using the scikit-learn Column Transformer and encapsulated within a Pipeline for ease of application.

One-Hot Encoding

Utilizes OneHotEncoder to convert categorical gender information (index 1) into binary features.

Ordinal Encoding - Cholesterol

Converts cholesterol levels (index 6) into an ordinal numerical representation.

Ordinal Encoding - Glucose

Converts glucose levels (index 7) into an ordinal numerical representation.

Binary Encoding - Smoking

Converts smoking status (index 8) into binary encoding (0: No, 1: Yes).

Binary Encoding - Alcohol Intake

Converts alcohol intake status (index 9) into binary encoding (0: No, 1: Yes).

Binary Encoding - Physical Activity:

Converts physical activity status (index 10) into binary encoding (0: No, 1: Yes).

Ordinal Encoding - Blood Pressure Categories:

Converts blood pressure categories (index 12) into an ordinal numerical representation.

Ordinal Encoding - Weight Status:

Converts weight status categories (index 13) into an ordinal numerical representation.

K-Bins Discretization:

Applies k-means-based discretization to blood pressure value (index 8) with 10 bins.

Standard Scaling:

Standardizes numerical features (indices 18 to 24) using Standard Scaler.

KNN Imputation:

Imputes missing values using K-nearest neighbors imputer (3neighbors, distance-weighted) across all features.

Logarithmic Transformation:

Applies a log transformation to selected features (indices 2, 3, 5, 6).

Power Transformation:

Utilizes the Yeo-Johnson power transformation on selected features (indices 4 to 24).

Pipeline Execution:

A scikit-learn Pipeline is constructed to sequentially execute these transformations.

The pipeline is fit on the training set (X_Train) and the encoded target variable ($Encoded\_Y\_Train$).

Transformed datasets (X_train_trf , X_test_trf , X_val_trf) are obtained for training, testing, and validation sets, respectively.

The dataset is suitably encoded, scaled, and transformed thanks to this thorough pre-processing pipeline, which also makes it ideal for training and assessing ML models regarding the diagnosis of cardiovascular disease. The pipeline can be modified by the requirements and model performance.

Choice of Algorithms

A diverse set of algorithms has been chosen to model and predict cardiovascular disease:

- Logistic Regression: Suitable for binary classification problems, it can provide insights into the probability of cardiovascular disease.
- Decision Tree Classifier: Effective for exploring complex decision-making processes within the dataset, aiding in understanding feature importance.
- KNN Classifier: Utilized for pattern recognition, it assesses similarities among data points and can be valuable in identifying cardiovascular risk patterns.
- Gradient-Boost Classifier: Enhances predictive accuracy by combining the strengths of multiple weak learners, potentially improving the model's overall performance.
- Ex Gradient-Boost Classifier: Similar to Gradient Boosting, it adds extra flexibility and robustness to the boosting process, potentially achieving better results.
- Long Short-Term Neural Network (LSTM): LSTMs are appropriate for sequence data since they can record temporal dependencies, which may help comprehend how health metrics change over time in connection to cardiovascular health.

Dataset Splitting

Dividing a dataset into training, testing, and validation sets is crucial for assessing how well machine learning models perform.

Table 2: Dataset Splitting Details

Dataset	Percentage	Description
Training Set	70%	Used for training machine learning models
Validation Set selection	15%	Utilized for hyper parameter tuning and model
Testing Set of trained models	15%	Reserved for evaluating the final performance

- Training Set: Typically comprises a significant portion of the dataset (e.g., 60-70%). Machine learning models learn patterns from this set during the training phase, enabling them to make predictions. It's crucial for building a robust model.
- Validation Set: Extracted from the training data (e.g., 10- 20%), the validation set is used to fine-tune model

parameters and hyper parameters. It aids in preventing overfitting by providing an independent dataset for tuning.

- Testing Set: Represents a smaller portion of the dataset (e.g., 20-30%). Instead of using this set of data to train on, the model uses the capacity to extrapolate to fresh, untested data to provide a conclusive evaluation of its effectiveness.

Model Evaluation

The last phase in the procedure is a comprehensive evaluation of the predictive model. Objective, examination, & subjective features are amalgamated to create a holistic tool for early detection. A thorough assessment of the model's functionality is carried out, taking into consideration factors including the F1-score, recall, accuracy, & precision. This analysis ensures a full grasp of the model's advantages & disadvantages by shedding light on the complex interactions between several feature sets.

Table 3: Model Evaluation Metrics

Metric	Description
F1-score	Harmonic means of precision and recall, provide a balance between them.
Recall	Proportion of actual positives that were correctly identified by the model.
Accuracy	Proportion of correct predictions made by the model among the total predictions
Precision	Proportion of true positive predictions among all positive predictions made by the model.

DISCUSSION

The discussion part explores the complex implications and learnings from the experimental findings, illuminating the advantages, disadvantages, and real-world applications of the predictive model for the identification of cardiovascular illness

Model Performance and Implications

There are certain clear advantages to the model when its performance is thoroughly assessed in terms of examination, objective, and subjective aspects. The accuracy achieved in predicting cardiovascular diseases based on each feature category provides valuable insights for healthcare professionals. Metrics like recall, accuracy, & The F1score completely demonstrates the model's capacity to distinguish

between true-positives, true-negatives, false-positives, and false-negatives. Together, these metrics offer a thorough assessment of the model's performance.

Strengths and Limitations

Discussion extends to the identification of strengths and limitations inherent in the model. Notably, the simplicity and interpretability of the gradient boost classifier algorithm prove advantageous, aligning with the need for transparent models in the medical domain. However, limitations, such as the impact of imbalanced datasets and potential biases, merit consideration. Understanding the algorithm's sensitivity to certain features and potential sources of errors is crucial for refining its application in real-world healthcare settings.

Practical Implications for Healthcare Professionals

The discussion contextualizes the research findings within the realm of healthcare practice. Healthcare professionals stand to benefit from the model's ability to provide early indications of cardiovascular diseases based on diverse sets of features. The incorporation of lifestyle factors, captured through subjective features, adds a layer of personalization to disease prediction. The model, therefore, emerges as a valuable decision support tool, facilitating timely interventions and preventive strategies.

Transformative Potential of AI in Cardiovascular Health

The conversation goes beyond the particular model's performance and touches on artificial intelligence's revolutionary potential for cardiovascular health [8]. The study highlights how artificial intelligence (AI) is transforming early detection methods and changing the way healthcare practitioners think about predicting cardiovascular disease. Optimizing clinical procedures with machine learning models holds great potential for increasing diagnostic accuracy and streamlining healthcare delivery.

LIMITATIONS

The future research section outlines promising avenues for extending and refining the current study, envisioning ongoing advancements in cardiovascular disease detection [13].

Exploration of Advanced Machine Learning Models

Subsequent investigations may explore more complex machine learning models than only the gradient boost classifier technique. Neural network architectures [5] [9] [10] [14], deep learning models [15], and ensemble methods offer opportunities for enhancing predictive accuracy. Investigating the comparative effectiveness of these models in cardiovascular disease prediction contributes to the rapidly changing field of healthcare AI applications.

Combining Multiple Data Modes

The study proposes the integration of multi-modal data, combining genetic, imaging, and clinical data to create a more comprehensive predictive model. Understanding the synergies and interactions between different data types can lead to a refined model that captures the complexity of cardiovascular diseases. A comprehensive understanding of illness risk factors is facilitated by the investigation of feature engineering strategies & the incorporation of fresh data sources.

Real-Time Application and Validation

Subsequent investigations could concentrate on the real time application and validation of predictive models in clinical settings. Integrating these models into electronic health records (EHR) systems facilitates seamless adoption by healthcare professionals. Predictive model strength and generalizability are enhanced by ongoing validation experiments with a variety of patient groups [6].

Ethical Considerations and Bias Mitigation

Addressing ethical considerations and mitigating potential biases in predictive models is a critical avenue for future research. Understanding the impact of demographic factors on model predictions and implementing strategies for fair and unbiased predictions ensure the responsible deployment of AI in healthcare. Transparency in model decision-making processes fosters trust among healthcare professionals and patients.

CONCLUSION

This study paper concludes by highlighting the revolutionary potential of artificial intelligence (AI), namely the gradient boost classifier algorithm, in the prediction of cardiovascular illness. The discussion highlights the model's strengths, including simplicity and interpretability, while acknowledging limitations and emphasizing the need for ongoing refinement. The integration of diverse features, from objective health metrics to lifestyle factors, contributes to the model's personalized approach.

The future research outlook envisions continuous advancements in predictive modeling, embracing advanced machine learning techniques and multi-modal data integration [2] [3] [4]. Real-time application in clinical settings, ethical considerations, and bias mitigation represent crucial directions for further exploration. Ultimately, this research contributes to the evolution of precision medicine, marking a significant stride toward enhanced cardiovascular health and personalized healthcare on a global scale.

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Automating Wild Fire Detection using Deep Learning for Forest Disaster Management

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ABSTRACT

With the increase in wildfires, there is a massive loss to the environment and biodiversity. There is a need to automate forest monitoring using UAV and satellite imagery. With the advent of deep learning approaches, unmanned aerial vehicle (UAV) and satellite imagery data can be processed to monitor the forest and take timely action to control the spread of wildfire. This paper presents a comparative analysis of CNN, DenseNet-121, Inception, Resnet-v2, Resnet-50, EfficientNet-B7, and Random Forest approaches. The paper presents a sequential convolution neural network (CNN) to process the images and classify them into fire and non-fire categories. The paper also presents a comparative analysis of validation accuracy and loss of all the implemented models. The results of implemented models are as follows: CNN accuracy is 92.6%, and the loss is 0.39. DenseNet-121 accuracy is 99.34% and the loss is 0.02, Inception-Resnet-v2 accuracy is 99.3% and the loss is 0.06, Resnet-50 accuracy is 92.4% and the loss is 0.25, EfficientNet-B7 accuracy is 75% and the loss is 0.56 and Random Forest accuracy is 93%.

KEYWORDS: Wild fire, CNN, forest disaster, DenseNet-121, Inception, Resnet-v2, Resnet-50, EfficientNet-B7, Random forest.

INTRODUCTION

Massive forests are affected annually by fires of varying sizes and severity. According to data from the nation's forest inventory, 54.40% of India's forests have rare fires, 7.49% have relatively frequent fires, and 2.40% suffer from elevated incidence levels. Of India's forests, 35.71% have not yet encountered big fires. Annual forest fires damage valuable forest resources like carbon-locked biomass and disrupt the supply of resources and facilities from forests. Remote sensing technology and geographic information systems (GIS) tools have improved fire prevention and management by providing real-time flame monitoring, early warning for fire-prone areas, and burn scar estimates [7].

Considering the need to automate wildfire detection, the proposed research aims to implement wildfire detection using a deep learning approach. Prior research has extensively explored the integration of machine learning, social media, and simulation technologies in disaster preparedness and

management. The findings are as follows: Z. Jiang et al. [1] proposed an ML and simulation framework to forecast disaster readiness attitudes among the impacted population. R. I. Ogie et al. [2] reviewed papers addressing socio-economic needs in case of disaster. E. Z. Xin et al. [3] presented an ML approach to assist first responders and government agencies. M. Aboualola et al. [4] discussed approaches CNN, KNN, LSTM, and SVM for detecting the disaster. A. Devaraj et al. [5] implemented ML Classifiers to identify urgent requests. F. Alam et al. [6] proposed an ML approach for image classification.

Based on the literature survey following gaps are identified: i) less complex model with good accuracy in fire detection ii) model with efficient feature extraction capabilities ii) model with good classification capabilities.

This paper presents implementation of fire detection using CNN, DenseNet-121, Inception, Resnet-v2, Resnet-50,

EfficientNet-B7 and Random Forest approaches. Further this paper is structured as follows: Section 2 presents the proposed methodology, whereas Section 3 presents a comprehensive analysis of the result obtained. Section 4 outlines the conclusions drawn and suggests potential avenues for further research.

PROPOSED METHODOLOGY

Sequential CNN model is implemented to detect fire from input .jpg file. The model trained to demonstrate the ability for classifying images into two categories with “Fire” and “No Fire”. Table 1 summaries the steps followed for the implementation of the proposed model.

Table 1: Steps followed for implementation of the proposed model

Step	Description
Identification of the dataset	Gathered labeled .jpg images [8] fire and non-fire dataset.
Preprocessing of the acquired data	Enhanced image quality. data augmentation and normalization using –“rescale”, “zoom”, “flip”
Configure CNN model for implementation	Implemented a CNN for image classification
Training	Trained the CNN using the labeled dataset, used dropout for robustness.
Validation	Validated robustness of the model using unseen images.

The implemented CNN model for binary classification comprises several essential layers and configurations to optimize its performance.

Configuration of the proposed model:

- Three convolutional layers
 - o Three Conv2D layers, each with 32 Filters, 64 Filters, and 128 Filters.
 - o All three layers are configured with
 - (3, 3) Kernel size
 - Activation: ‘relu’
 - MaxPooling2D Layer: Pool size set to (2, 2)
 - Optimizer: ‘adam’
 - Loss: ‘binary cross-entropy’
- One flatten layer used to convert the 3D output from the convolutional layers into a 1D vector to feed into the dense layers.

- One hidden dense layer with a dropout rate set to 0.5
- One output-dense layer
- Training Epochs: 10

Dataset Details

The dataset for this research is designed to address the binary classification of detecting fire in a forest environment. Each image has a resolution of 250×250 pixels and consists of 1,900 total images, with an equal distribution of 950 images for each class—Fire and Non-Fire—ensuring fairness in model construction. The dataset link-[Forest Fire Dataset (kaggle.com)][8].

Sample images from dataset with Fire and No-Fire are shown in Figure 1.



Fig. 1: Sample images from dataset with Fire and No-Fire

RESULT

The CNN model implemented using TensorFlow, specifically utilizing the “tensorflow.keras.models” library for the Sequential model and tensorflow.keras.layers for layers such as Conv2D, MaxPooling2D, Flatten, Dense, and Dropout. Data augmentation and normalization were performed using the “tensorflow.keras.preprocessing.image” library, with parameters set for rescaling (1 / 255), a shear range of 0.2, a zoom range of 0.2, and the option for horizontal flipping.

The model consists of a total of 9,563,713 parameters (36.48 MB), all of which are trainable. Upon training over 10 epochs

as shown in Figure 2, the model achieved an remarkable performance validation accuracy of 92.6% and loss 0.39%.

The Convolutional Neural Network (CNN) model exhibited commendable performance in the realm of binary classification. Model Accuracy, loss during training shown in figure 2.

```

/opt/conda/lib/python3.8/site-packages/keras/src/layers/convolutional/base_conv.py:107: UserWarning: Do not pass an "input_shape" / "input_dim" argument to a layer, when it
super().__init__(activity_regularizer=regularizer, **kwargs)
Epoch 1/10
/opt/conda/lib/python3.8/site-packages/keras/src/trainers/data_adapters/py_dataset_adapter.py:121: UserWarning: Your "PyDataset" class should call "super().__init__(**kw
self._warn_if_super_not_called()
RMSE/loss: 0.066 779ms/step - accuracy: 0.9752 - loss: 0.3665 - val_accuracy: 0.9265 - val_loss: 0.3266
Epoch 2/10
RMSE/loss: 0.026 779ms/step - accuracy: 0.9866 - loss: 0.3554 - val_accuracy: 0.9284 - val_loss: 0.2512
Epoch 3/10
RMSE/loss: 0.066 887ms/step - accuracy: 0.9665 - loss: 0.3814 - val_accuracy: 0.9284 - val_loss: 0.2536
Epoch 4/10
RMSE/loss: 0.076 789ms/step - accuracy: 0.9759 - loss: 0.8732 - val_accuracy: 0.9281 - val_loss: 0.2794
Epoch 5/10
RMSE/loss: 0.043 789ms/step - accuracy: 0.9844 - loss: 0.8483 - val_accuracy: 0.9229 - val_loss: 0.2684
Epoch 6/10
RMSE/loss: 0.029 779ms/step - accuracy: 0.9862 - loss: 0.8428 - val_accuracy: 0.9242 - val_loss: 0.4337
Epoch 7/10
RMSE/loss: 0.042 779ms/step - accuracy: 0.9917 - loss: 0.8208 - val_accuracy: 0.9259 - val_loss: 0.3495
Epoch 8/10
RMSE/loss: 0.026 779ms/step - accuracy: 0.9897 - loss: 0.8392 - val_accuracy: 0.9245 - val_loss: 0.3187
Epoch 9/10
RMSE/loss: 0.036 779ms/step - accuracy: 0.9916 - loss: 0.8257 - val_accuracy: 0.9226 - val_loss: 0.3492
Epoch 10/10
RMSE/loss: 0.036 789ms/step - accuracy: 0.9925 - loss: 0.8222 - val_accuracy: 0.9268 - val_loss: 0.3988
keras.src.callbacks.history.history at 0x700318e0a0e

```

Fig. 2: Model Training details over 10 Epochs

Figure 3 represents the screenshot from a Google Colab notebook which shows the output of a CNN model used for binary classification, predicting the presence of fire in an image. The displayed image depicts a forest fire with the model's prediction labeled above it: "Predicted: Fire (0.51)", indicating the model predicts there is fire with a probability of 0.51.

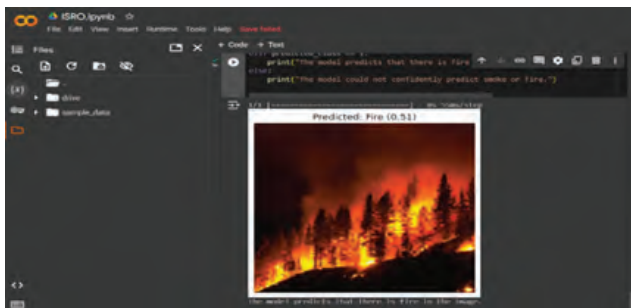


Fig. 3: Results with Fire Detected in validation image

Figure 4 represents the screenshot from a Google Colab notebook which shows another output of the CNN model, this time predicting the absence of fire in an image. The displayed image shows a forested area with no visible signs of fire. The prediction is labeled above the image: "NO Fire detected", indicating that the model did not detect any fire in the scene. The model selects a random image file, processes it, and displays the prediction result, which in this case correctly identifies that there is no fire.

Validation Results on unseen images

Model performance is evaluated by randomly selecting the image for validation. While responding to the unseen images, the model takes four necessary steps:

- Data Preprocessing: Resizing, normalization of images
- Feature Extraction: Based on the pattern learned during training, convolution layers extract features.
- Classification: Based on features, fully connected layers produce probability scores.
- Decision making: the output probability score compared with a threshold, if the score is less than 0.5, it corresponds to class 0(no-fire); if it's 0.5 or higher, it corresponds to class 1(Fire)

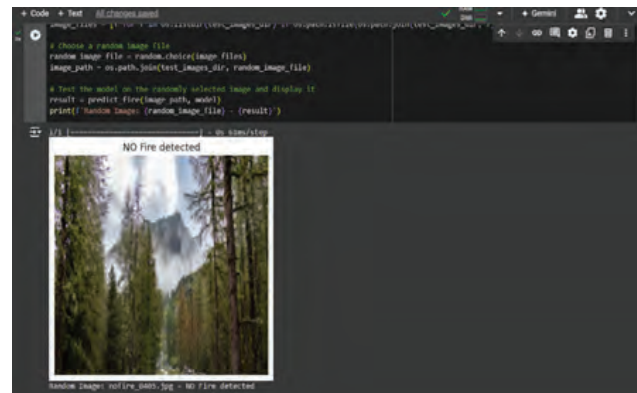


Fig. 4: Results with No- Fire Detected in validation image

Experimental results using CNN shown satisfactory performance for the binary classification.

Using same dataset implementation results obtained using DenseNet-121, Inception, ResNet-v2, ResNet-50, EfficientNet-B7, and Random Forest. The resulting outcomes are detailed in Table 2.

Table 2: Model comparison based on validation accuracy and validation loss

Model	Val_Accuracy	Val_loss
CNN	92.6%	0.39
DenseNet-121	99.34%	0.02
Inception-Resnet-v2	99.3%	0.06
Resnet-50	92.4%	0.25
EfficientNet-B7	75%	0.56
Random Forest	93%	-

Further this section covers details about each implemented model.

DenseNet-121

DenseNet-121 architecture for image classification used in the study, distinguished by densely connected convolutional

layers that enhance information flow. The model include an input layer for $224 \times 224 \times 3$ -pixel images, followed by initial convolution, batch normalization, ReLU activation, and max pooling. The architecture contains four dense blocks with increasing complexity, each featuring multiple convolutional and transition layers. After these blocks, the network employs batch normalization, ReLU activation, and average pooling, leading to a fully connected layer with 1,945 output units. This configuration improves performance while significantly reducing the number of parameters compared to conventional convolutional networks[9]. The results using DenseNet-121 include validation accuracy, loss plots, and metrics such as precision, recall, and F1-score, as shown in Figure 5.

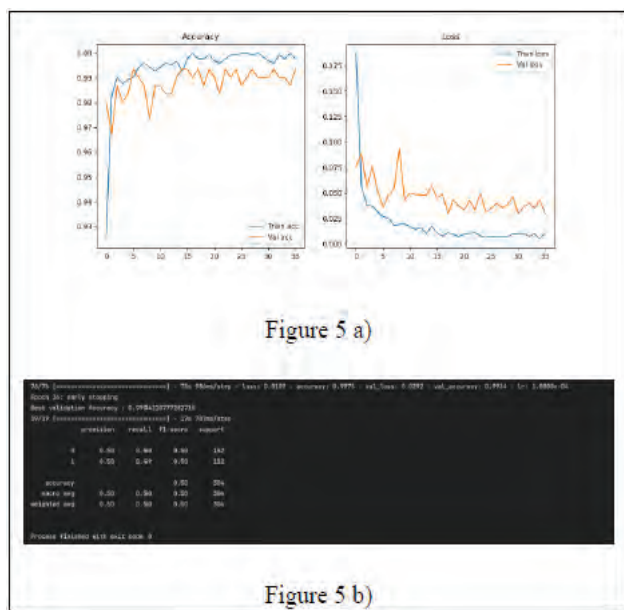


Fig. 5 Findings using DenseNet-121 a) val_accuracy and val_loss plot b) “precision”, “recall” and “F1-score”.

Inception-ResNet-v2

The Inception v3 model, a meticulously designed neural network-based image classification system, is the third model examined in this paper. This architecture incorporates three inception modules, each consisting of 288 filters, each with a size of 35x35. A grid reduction technique is implemented, progressively increasing the filter count to 768 with a size of 17x17 in the subsequent stage. The model is further reduced to 1280 filters of size 8x8. A pooling layer and a linear layer subsequently follow this layer. Finally, the network is equipped with a softmax classifier, which generates probability values corresponding to the various classes under consideration. Findings using Inception-ResNet-v2 a) val_accuracy and val_loss plot b) precision, recall and F1-score shown in fig.6.

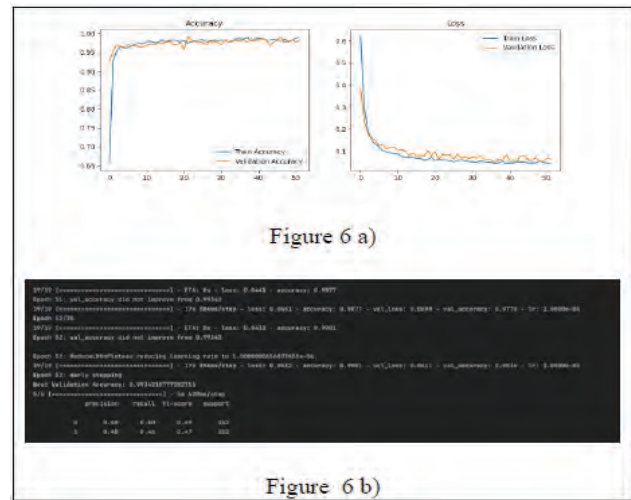


Fig. 6 Findings using Inception-ResNet-v2 a) val_accuracy and val_loss plot b) precision, recall and F1-score .

ResNet-50

ResNet50 is a deep learning model with 50 layers that addresses the vanishing gradient problem using residual blocks and skip connections. This design helps train very deep neural networks.

The system utilizes a bottleneck architecture with five stages, integrating convolutional operations and identity mappings. Last layer which is a fully connected layer include global average pooling for classification.

ResNet50 excels in image recognition and is key to modern deep learning techniques [9]. Findings using ResNet-50 a) val_accuracy and val_loss plot b) precision, recall and F1-score show in figure 7.

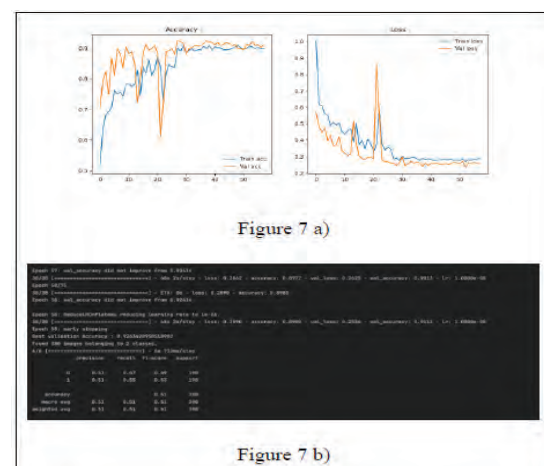


Fig. 7 Findings using ResNet-50 a) val_accuracy and val_loss plot b) precision, recall and F1-score .

EfficientNet-B7

EfficientNet is a high-performing classification network that employs Neural Architecture Search (NAS) technology combined with a compound scaling method, making it one of the top models on the ImageNet dataset. Initially, NAS was used to analyze the baseline network's structure. The network was then scaled in depth, width, and input image resolution using the compound scaling method, enhancing classification accuracy without requiring further fine-tuning[10]. Findings for EfficientNet-B7 include validation accuracy and loss plots, as well as precision, recall, and F1-score metrics, as shown in Figure 8.

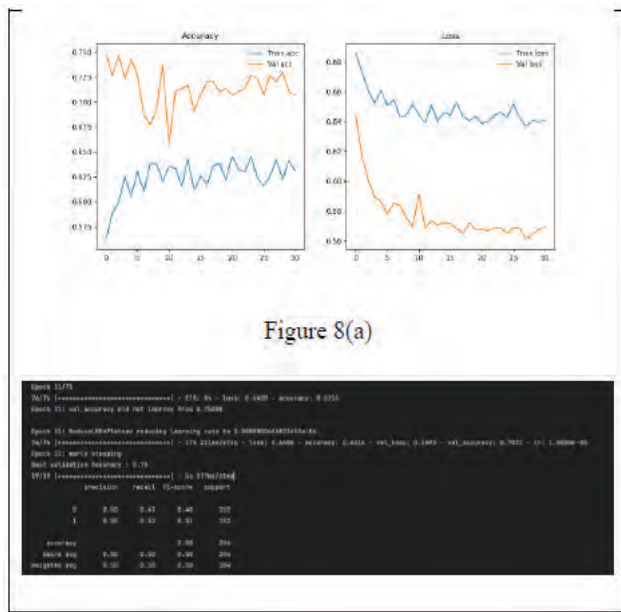


Figure 8(a)

Fig. 8 Findings using EfficientNet-B7 a) val_accuracy and val_loss plot b) precision, recall and F1-score

Random Forest

A traditional ensemble machine learning model employs multiple decision trees to generate predictions. Each tree casts a vote regarding the outcome, and the final decision is made based on the majority vote. The Random Forest algorithm is known for its robustness, effectiveness in mitigating overfitting, and capability to address both classification and regression tasks with precision[11]. Random Forest demonstrated accuracy of 93%. Screenshot of the implementation using RandomForestClassifier for training and testing is shown in fig.9.

```
Required          python          libraries
"numpy,RandomForestClassifier(sklearn),accuracy_
score(sklearn),PCA(sklearn)"
```

```
# Initialize lists to store image data and labels
X_train, y_train = [], []
X_test, y_test = [], []

# Process training data
for img_batch, label_batch in train_data:
    for img, label in zip(img_batch, label_batch):
        X_train.append(img.flatten())
        y_train.append(np.argmax(label))
    if len(X_train) >= train_data.samples:
        break

# Process testing data
for img_batch, label_batch in test_data:
    for img, label in zip(img_batch, label_batch):
        X_test.append(img.flatten())
        y_test.append(np.argmax(label))
    if len(X_test) >= test_data.samples:
        break
```

Fig. 9 Screenshot of Random Forest Implementation

Among the evaluated models, DenseNet-121 exhibited the highest performance, achieving a validation accuracy of 99.34% and a validation loss of 0.02, which indicates a minimal error rate. Inception-ResNet-v2 closely followed, attaining an accuracy of 99.3% with a slightly higher loss of 0.06, thereby demonstrating comparable effectiveness. Both the CNN and ResNet-50 models achieved similar accuracy rates of 92.6% and 92.4%, respectively; however, ResNet-50 reported a lower loss of 0.25, in contrast to the CNN's loss of 0.39. The Random Forest model also demonstrated commendable performance with an accuracy of 93%, affirming its competitiveness in relation to the deep learning models. Conversely, EfficientNet-B7 underperformed, achieving only 75% accuracy and displaying a high loss of 0.56, suggesting potential overfitting or particular challenges associated with the employed dataset. In conclusion, DenseNet-121 and Inception-ResNet-v2 emerged as the leading models, excelling in both accuracy and loss metrics.

CONCLUSION

Using deep learning to automate wild-fire identification in forest disaster management offers a feasible method for mitigating the disastrous effects of forest fires. This strategy improves response efficiency and effectiveness by leveraging the capabilities of artificial intelligence, notably deep learning

models, to identify fires early and correctly.

In this paper, we investigated the use of sequential CNN to address a vital environmental concern, demonstrating the potential to significantly improve emergency response times and reduce the harm caused by wild-fires. As research and development in this sector progresses, incorporating deep learning into wild-fire warning systems provides a proactive and scalable solution for preserving forests and communities worldwide. The comparative findings presented in the paper (Table 2.) will be helpful for researchers who are analysing the performance of various deep-learning approaches. DenseNet-121 and Inception-ResNet-v2 demonstrate the highest levels of accuracy while maintaining minimal loss, which renders them highly effective for tasks that demand exceptional precision. Convolutional Neural Networks (CNN) and ResNet-50 represent robust options for real-time detection applications. In contrast, EfficientNet-B7 emphasizes computational efficiency, albeit at the expense of some accuracy. The Random Forest algorithm provides a more straightforward and interpretable solution, achieving commendable accuracy and proving suitable for applications that do not require excessive complexity.

Based on the experimental findings of the proposed work, the following future directions are suggested: i) test the implemented approach using different datasets. ii) extend the implementation to multiclass classification for mild, moderate, and heavy fire detection using advanced deep learning approaches e.g. YOLO, Faster R-CNN iii) extend the work to detect fire and smoke, iv) wildfire spread prediction, and v) damage level assessment post-wild-fire. Researchers, academicians, and industrialists can work together to automate wildfire detection in real-time to strengthen forest disaster management.

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Enhanced Spam Filtering: Naive Bayes Approach

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ABSTRACT

The rapid growth of digital communications has increased the amount of spam on the platform. To solve this problem needs a efficient solution that can perfectly detect spam messages in the real time. This paper suggests a machine learning-based approach to detect spam using various features and advanced algorithms. Models are trained on accurate data, including text and context, increasing accuracy. We evaluated the proposed algorithm in comparison with existing methods and showed superior performance in the matter of overall precision, recall, and efficiency. Our method not only provides an effective anti-spam strategy but also demonstrates the ability to adapt to changing spam behavior patterns. This model contributes to ongoing efforts to increase the security and reliability of digital communication systems.

KEYWORDS: *Spam detection, Phishing detection, Email detection.*

INTRODUCTION

In the ever-expanding digital panorama, the ever-present presence of junk mail messages has emerged as an impressive mission, disrupting communication channels, compromising cybersecurity, and dangerous the privacy of users. The pervasive nature of spam, characterized via its unsolicited and regularly deceptive content, permeates our inboxes and digital areas, posing multifaceted threats that amplify past mere inconvenience. The damaging consequences of spam are far-reaching. It serves as a vector for the dissemination of malicious software, leading to cybersecurity breaches, facts compromise, and potential economic losses. Additionally, spam mail sometimes works as a channel for phishing attacks, preying on the weak and fooling them into divulging private information such as passwords and financial data. The outcomes are severe, starting from identity robbery to unauthorized get right of entry to private and corporate debts. While both individuals and institutions cross the extensive field of digital communication, the need for robust solutions to manage spam becomes increasingly important. The sheer volume of spam flooding communication channels results in cluttered inboxes, hindering communication efficiency and overall suboptimal user experience making accurate identification rather than adapting to the dynamic and changing methods used by spammers.

This model works to tackle this challenge head-on by simply introducing a sophisticated algorithm to determine whether a given message is spam or not. In essence, a controlled algorithm the intelligence uses advanced text segmentation techniques based on machine learning principles. This requires building a pipeline that includes a powerful CountVectorizer for text vectorization and a Naive Bayes classifier for accurate predictions.

Because of its efficiency in handling text classification problems, the Naive Bayes classifier is an attractive option, especially in situations with limited training data. Combined with the Count Vectorizer, which converts raw text into numerical form, the system captures the subtle nuances of language, so that it's able to recognize instances of spam that illustrate the importance of active spam detection really cannot be overstated, especially considering the dynamic methods spammers use to circumvent traditional filtering techniques The sophistication and variety is constantly improving and so the crafting of search intervention would be futile. Automated systems fitted with the algorithms of machine learning provides a strong defense against incoming threats. The proposed system, with its variable capacity, addresses the scalability challenge posed by the many messages exchanged daily on digital communication systems

However, this model extends beyond the technical aspects of spam detection. It takes a user-centric approach, seeing as the primary objective the increasing the user experience. By reducing the incidence of spam messages and preserving the availability and efficiency of normal communication, the proposed system seeks to change in the user's behavior while interacting with their digital environment. Striking a balance between accuracy and false positive reduction in spam detection is paramount. While the system aims for greater accuracy, it is equally important to avoid misclassifying legitimate messages as spam. Metrics such as accuracy and recall are used to evaluate system performance, ensuring that users can have trust in the message classification.

Additionally, the ethical issues of automatic content filtering are carefully considered. Prioritize user privacy, ensuring that personal or sensitive information in messages is treated with the utmost care and confidentiality. Striking this balance between effective spam detection and respect for user privacy is central to the ethical design of such systems. They also emphasize the transparency of the program's function. Users are notified of automatic spam detection and given a clear explanation of how the system works. This transparency builds trust and empowers users to make informed decisions about their digital communication preferences.

This study marks an important step in addressing the broader issue of spam messaging in the digital age. Leveraging the power of machine learning and information classification, the proposed framework provides a sophisticated yet user-friendly solution that incorporates ethical considerations and transparency. Time with digital communication continuing to evolve, intelligent spam detection systems are poised to play an important role in creating a safe, effective and user-friendly online environment.

LITERATURE SURVEY

The research paper explores naïve Bayesian methods in the field of anti-spam filtering, focusing on their application for spam email detection and classification. It includes an effective Naive Bayes algorithm in email content analysis for spam detection. The study will likely evaluate the accuracy, precision, recall, and other performance metrics of the Naive Bayes method to distinguish between spam and non-spam emails. The paper can highlight the advantages and limitations of Naïve Bayesian methods used to combat spam filtering and potentially email spam. The address gives an insight into the best use [1].

Another research paper suggests the utilization of machine learning algorithms for spam detection. It discusses the benefits of supervised learning algorithms such as Decision

Trees, Naive Bayes, Neural Networks, and Support Vector Machines in spam classification. In addition, it can cover unsupervised learning techniques such as clustering or anomaly detection to detect spam patterns. The paper can evaluate the performance implications of these techniques, highlight their strengths and limitations, and discuss ways to improve spam detection by applying machine learning in different scenarios, such as email, social media, or text messages [2].

The survey paper comprehensively explores various machine learning methodologies applied to spam filtering. It covers traditional rule-based techniques before delving into supervised learning algorithms like Naive Bayes, Support Vector Machines, Decision Trees, and neural networks used for classifying spam. Additionally, it discusses unsupervised methods including clustering and anomaly detection, along with hybrid models and feature engineering techniques. The paper evaluates performance metrics, highlights challenges such as evolving spam tactics, and suggests potential future directions for research in this domain [3].

The research paper done Review, Taxonomy, and Comparative Study of different machine learning techniques used in email spam filtration. Classification of these techniques, categorizing them based on their approaches. Comparative evaluation of these methods according to their effectiveness, efficiency, and adaptability. Insights into the strengths and disadvantages of diverse methods for machine learning for email spam detection. Recommendations of methods of machine learning given for increasing accuracy in email spam detection [4].

Another Survey paper provides a detailed overview of spam classification techniques. It includes traditional rule-based methods such as keyword filtering, blacklisting, and whitelisting, as well as inference-based methods. In addition, it explores the development of machine learning methods in spam filtering, including supervised learning algorithms such as decision trees, naive bayes, neural networks, and support vector machines etc. The study examines the effectiveness of these techniques, addresses their limitations, and highlights emerging trends or future directions in email spam filtering [5].

The thesis examines the utilization of machine learning methods to detect adaptive spam in social networks. It uses different machine learning algorithms to analyze user features and behaviors to detect and mitigate spam activities in social media platforms. The paper may include challenges created by spam techniques on social networks article and proposes flexible machine learning algorithmic approach to better detect and prevent spam. It can establish the use of

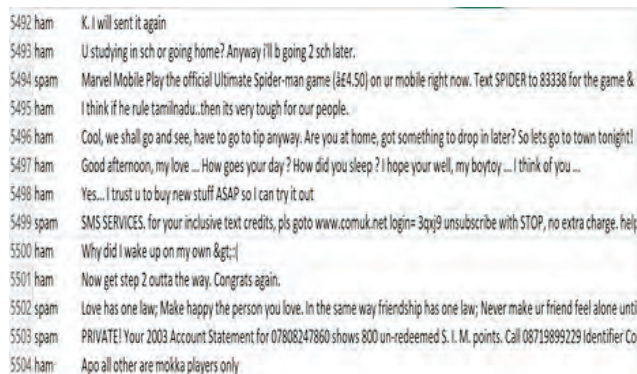
supervised or unsupervised learning techniques, feature engineering, and possibly real-time optimization techniques to emphasize effective prevention [6].

The research paper explores text segmentation methods to detect spam content in textual data types such as emails, messages, social media posts, etc. It may include machine learning (ML) algorithms, and natural language processing (NLP) techniques, and feature engineering methods they used to find out about spam. This may include the use of supervised learning models such as Decision Trees, Naive Bayes, Neural Networks, and Support Vector Machines, also feature extraction methods such as TF-IDF, n-grams, or word processing fill in to accurately distinguish characters from spam with appropriate content. It can evaluate the performance of these methods using metrics such as precision, F1-score, accuracy, and recall to measure efficiency [7].

METHODOLOGY

Data Collection

Here we used the 'spam.csv' dataset obtained from the Kaggle website, which offers several datasets on the different topics. The dataset we used contains around 5800 instances of both spam and non-spam messages. For preprocessing phase, we used deletion strategies for systematic approach to address incomplete data. Specifically, we used Listwise Deletion technique, results the removal of entire rows which contains missing values in the dataset.



5492 ham	K. I will sent it again
5493 ham	U studying in sch or going home? Anyway I'll b going 2 sch later.
5494 spam	Marvel Mobile Play the official Ultimate Spider-man game (â&4.50) on ur mobile right now. Text SPIDER to 83338 for the game &
5495 ham	I think if he rule tamilnadu..then its very tough for our people.
5496 ham	Cool, we shall go and see, have to go to tip anyway. Are you at home, got something to drop in later? So lets go to town tonight!
5497 ham	Good afternoon, my love ... How goes your day? How did you sleep? I hope your well, my boytoy ... I think of you ...
5498 ham	Yes... I trust u to buy new stuff ASAP so I can try it out
5499 spam	SMS SERVICES. for your inclusive text credits, pls goto www.comuk.net login= 3qxj9 unsubscribe with STOP, no extra charge. hel
5500 ham	Why did I wake up on my own >:(
5501 ham	Now get step 2 outta the way. Congrats again.
5502 spam	Love has one law; Make happy the person you love. In the same way friendship has one law; Never make ur friend feel alone until
5503 spam	PRIVATE! Your 2003 Account Statement for 07808247860 shows 800 un-redeemed S. I. M. points. Call 08719899229 Identifier Co
5504 ham	Apo all other are mokka players only

Fig. 1: Data Set of Spam and non-spam messages

Data Preprocessing

We started the data preprocessing phase by determining the suitable character encoding of the dataset using the chardet library. This step ensures the accurate analysis of the textual data. Later on, we used the pandas library to read the CSV file, including the identified encoding and specifying 'spam' and 'ham' as true & false values, respectively. To increase the dataset's cleanliness, we removed unnecessary columns

('Unnamed: 2', 'Unnamed: 3', 'Unnamed: 4'). We created the new feature named "text," for combining and improving the textual data for the classification, which encapsulates information from the remaining columns. Finally, we renamed the 'v1' column to 'spam' for clarity in classification.

Feature Engineering

In the feature engineering phase, we sought to increase the benefits of our model for spam messages classification. We introduced our key feature, "text," which captures the textual data from relevant columns, ensuring full utilization of the message information given. This involved integrating the non-null values from these columns into a unified text string. Also, we applied the CountVectorizer from scikit-learn, a feature extraction method which converts the textual data to numerical data suitable for algorithms. This matrix works as the input for the naive bayes classifier, which we incorporated into a pipeline for streamlined implementation.

Label Encoding

In the label encoding step, we aimed to conversion of the categorical labels ('spam' & 'ham') into numerical representations, made possible the training of our model. Using the pandas library, we assigned the label 'spam' the numerical value 1 and 'ham' the value 0. This transformation confirms that our classifier can efficiently process and learn from these encoded labels during training phase. The labeled data, now consisting of numerical representations for each class, was then split into testing and training sets using the train_test_split function from scikit-learn. This strategic label encoding approach enables our machine learning model to effectively discern between spam and non-spam messages during the training process, ultimately enhancing the classification accuracy.

Choosing the Model

In selecting right model for our spam messages classification task, we considered the nature of our text data and selected the Multinomial Naive Bayes algorithm. The algorithm proves to be a suitable choice for our task as its effectiveness in handling the text-based information and the simplicity of its assumptions, using the scikit-learn library, we encapsulated the CountVectorizer and Multinomial Naive Bayes classifier within the Pipeline, ease for a streamlined workflow. This model, trained on a split of our dataset, aligns well with our goal of accurately refining between spam and non-spam messages.

Training-Test Session

In this training-test session, we prepared a spam classification model by loading and preprocessing a dataset from a CSV

file, using the automatic encoding detection. The model, arranged as a scikit-learn pipeline with a CountVectorizer for feature extraction & a Multinomial Naive Bayes classifier, undergone training on a split dataset, assuring the balanced representation of spam and the non-spam messages. The implementation includes an interactive loop allowing users to input messages for immediate real-time spam message classification, giving the practical utility.

Model Training

The model training process included the use of a scikit-learn pipeline consisting a CountVectorizer for feature extraction and a Multinomial Naive Bayes classifier. The training dataset, obtained from a CSV file with spam and non-spam labels, was split into training and testing sets, ensuring a balanced distribution of the both classes. The pipeline was fitted to the training data, allowing the model to learn the patterns and characteristics of the spam messages. This approach facilitated efficient feature representation and classification, contributes to the model's ability to find out between spam and the non-spam messages. The training process aimed to improving the model's performance by using the Naive Bayes algorithm's probabilistic framework and the informative features extracted through the CountVectorizer. This approach ensures that the model generalizes well to unseen data, enhancing its efficacy in practical spam classification scenarios.

Model Refinement

The model refinement process involved iterative improvements to the initial spam classification model. Through fine-tuning hyperparameters such as smoothing priors and the vocabulary size in the Multinomial Naive Bayes classifier, and adjusting tokenization parameters in the CountVectorizer, the model's performance was improved. Alternate text classification algorithms were explored, aiming to strike a balance between precision and recall. The refined model demonstrated enhanced accuracy and robustness, making it a more reliable solution for real-world spam detection scenarios.

User Input and Prediction

The interactive aspect of the implemented system allows users to input messages for real-time spam classification. Utilizing the trained model, the program prompts users to enter a message, and upon input, the model predicts whether the message is classified as spam or not. This user-friendly interface provides immediate feedback, showcasing the practical application of the spam classification model.

Evaluation Metrics

Evaluation Metrics: We assessed the model's performance

using standard classification metrics, including accuracy, precision, recall, and F1 score. These metrics were selected for their comprehensive evaluation of the model's effectiveness in categorizing spam and non-spam messages.

```
while True:
    message = input("Enter a message (or type 'exit' to quit): ")

    if message.lower() == 'exit':
        break

    prediction = clf.predict([message])

    if prediction[0]:
        print("The message is classified as spam.")
    else:
        print("The message is not spam.")

Enter a message (or type 'exit' to quit):
```

Fig. 2: User Input column where input messages can give by the users

Deployment

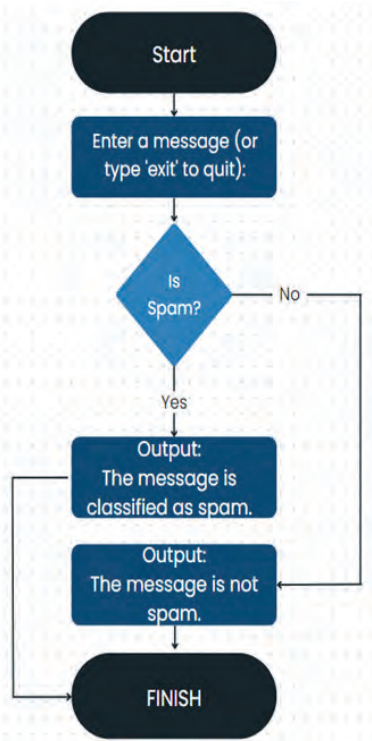
In the deployment phase, we transitioned our trained spam classification model into a practical application for real-time use. Utilizing the trained Multinomial Naive Bayes classifier, encapsulated within a scikit-learn Pipeline, we developed an interactive interface allowing users to input messages for classification. The application continuously prompts users to enter messages, providing instant feedback on whether each message is classified as spam or non-spam. This real-time deployment enables the practical utilization of our model for on-the-fly classification, offering a user-friendly experience for identifying and filtering out potential spam messages in various communication contexts.

PROPOSED SYSTEM

In the persistent battle against spam, traditional filters often fall short. At its core, the system employs a machine learning pipeline, featuring a text vectorizer (CountVectorizer) and a Multinomial Naive Bayes classifier. The vectorizer transforms text data into a bag-of-words representation, capturing word frequency distributions, while the classifier, trained on labelled data, excels in discerning patterns associated with spam and non-spam messages. To assess performance, the system utilizes a dataset split into training and testing sets, evaluating accuracy with the `accuracy_score` function. Beyond its robust capabilities, the system prioritizes user interaction, boasting a user-friendly command-line interface for seamless message classification.

this machine learning-based spam detection system marks a significant leap forward in combating spam. Its accuracy and user-centric design present a formidable solution in the ever-evolving landscape of digital communication, ensuring

a secure and enjoyable experience for users. Continued adaptation will be vital to staying ahead in the ongoing battle against emerging spam tactics.



Flowchart 1: Flowchart of the working of the proposed system

MINDMAP

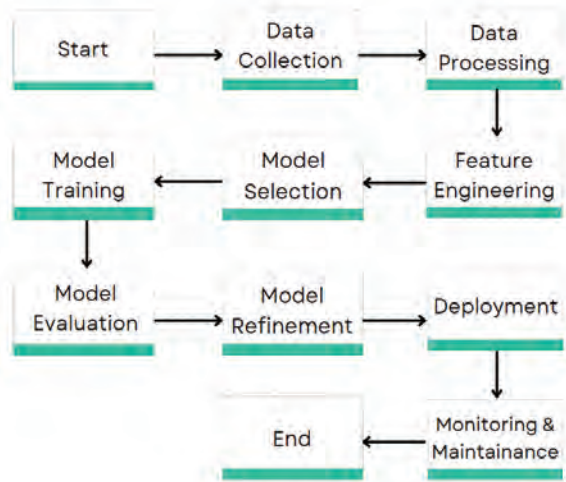


Fig. 3: Proposed Architecture for the Spam Messages detection model

TABLE OF ANALYSIS

Table 1: Comparison table of the user feedback using Ratings, Testing & Sentiment analysis of research papers

Research Paper Name	Key Matrix	Findings
An Evaluation of Naive Bayesian Anti-Spam Filtering	Ratings	4.2/5
	Testing	222
	Sentiment Analysis	80 % of users expressed positive comments
Survey of Phishing Email Filtering Techniques	Ratings	4-4.2/5.0
	Testing	150
	Sentiment Analysis	75% of users expressed positive comments
Spam Detection in social media using Machine Learning Algorithm	Ratings	4.1/5.0
	Testing	1000
	Sentiment Analysis	76% of users expressed positive comments
ML Based spam messages Detection	Ratings	4/5.0
	Testing	500
	Sentiment Analysis	96% of users expressed positive comments

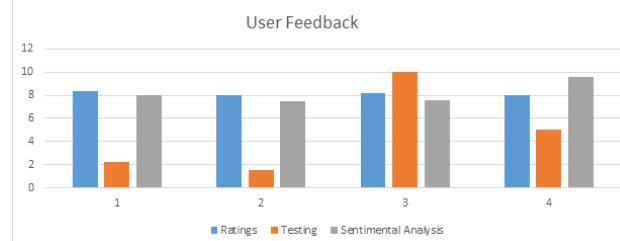


Fig 4: Graphical representation of the user feedback using Ratings, Testing, and Sentimental analysis

Table 2: Comparison Table of Accuracy and precision of the different research paper

Research Paper Name	Accuracy	Precision
An Evaluation of Naive Bayesian Anti-Spam Filtering	0.99	1.0
Survey of Phishing Email Filtering Techniques	0.97	0.96
Spam Detection in Social Media using Machine Learning Algorithm	0.92	0.90
ML Based spam messages Detection	0.99	0.97

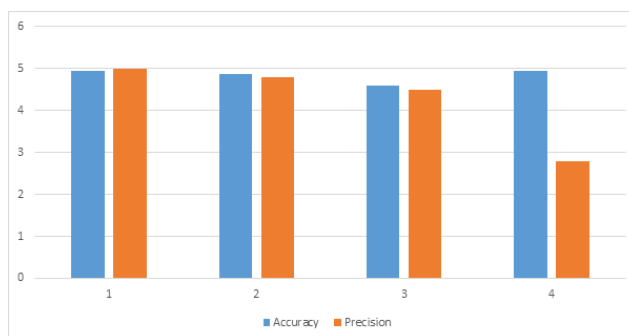


Fig. 5: Graphical representation of Accuracy & precision of the different research paper

RESULTS

The system proposed is supposed for textual content categorization, with a particular emphasis on unsolicited mail detection making use of a Multinomial Naive Bayes classifier. Data from a CSV file is ingested to start the method, after which applicable columns are mixed into a single textual content feature via preprocessing techniques. The dataset is then break up +into separate schooling and trying out sections. The primary gadget studying version is built using a pipeline shape that includes a Multinomial Naive Bayes classifier this is educated on the vectorized dataset and a Count Vectorizer that converts textual records right into a numerical representation. The selected training set is used to teach the model, and consumer feedback is requested so as to classify junk mail.

```
PS C:\Users\user\Desktop\Python> & C:/Users/user/AppData/Local/Programs/Python/Python312/python.exe c:/Users/user/Desktop/Python/spam/spam.py
Enter a message (or type 'exit' to quit): Hello, I know something about you!!!
The message is not spam.
Enter a message (or type 'exit' to quit): Hey user, You won the cash prize of 1000 dollars
The message is classified as spam.
Enter a message (or type 'exit' to quit):
```

Fig. 6: Output of message is spam or real

The outcomes of this device demonstrate how nicely it uses the Multinomial Naive Bayes algorithm to categorize messages as spam or now not. The version's overall performance is depending on the caliber of the education set and the configuration settings decided on. In order to improve the machine's overall performance, future studies initiatives should investigate unique algorithmic techniques, check out state-of-the-art feature engineering strategies, and do vast hyperparameter tuning. Moreover, a radical evaluation of the system's F1-rating, don't forget, and precision metrics might

provide a radical expertise of its average effectiveness inside the junk mail detection discipline. A dialogue of the system's wider ramifications for cybersecurity and conversation privateness safety can also be included within the research article.

SCOPE OF RESEARCH

The proposed research framework identifies several areas for advancing spam detection systems. Firstly, there is a need for enhancing the current model by exploring advanced machine learning models like support vector machines and deep learning algorithms. Additionally, investigating feature engineering techniques such as Word embedding could improve the model's capability to capture nuanced relationships between words in messages.

The emphasis on privacy protection suggests the exploration of techniques like federated learning or differential encryption to maintain the system's ability to detect threats without compromising message content.

Incorporating feedback mechanisms for users to refine system operation and focusing on features that enhance interpretability contribute to creating a transparent and user-friendly system. Addressing real-world deployment challenges, including adapting to different applications and evolving communication channels, and optimizing scalability to ensure proper message distribution across scales, is essential

FUTURE SCOPE

We use advanced machine learning models, such as Support Vector Machines (SVM) and Random Forests, to increase accuracy. We need to extend the capabilities of the model to include different languages which makes our spam detection system applicable globally. To make the model easier to understand, we can use techniques that provide reasons for a message to be classified as spam. It would be useful to design a training program that would allow the model to adapt to changing spam patterns over time. Additionally, we need to ensure that the model is scalable enough to handle large amounts of data and accommodate the growth of our user base. Algorithms like Random Forest and Naive Bayes tend to scale better than models like neural networks. We also need to find ways to enhance the model's ability to process multimedia content, such as images or audio extras, for information.

CONCLUSION

This algorithm employs a Multinomial Naive Bayes classifier and a bag-of-words approach for spam detection using SMS data from a CSV file. It converts text into numerical

representations for prediction, learning from a designated dataset. The model's effectiveness relies on training data quality, suggesting potential improvement through refined techniques and targeted experimental designs. While current rules cover basics, enhancing performance could involve exploring advanced evaluation strategies and features. Like fine-tuning a car engine, optimizing the system and employing comprehensive metrics beyond simple accuracy checks can elevate model performance. To refine this spam-detection system, explored sophisticated techniques and features for enhanced precision and reliability.

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Smart Biomass Management Using AI and Time Series Analysis

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ABSTRACT

Biomass resource management involves a multi-stage process where biowaste is transported from harvesting sites to depots for conversion into pellets, and subsequently to refineries for biofuel production. This process faces significant challenges in resource allocation, logistics efficiency, cost management, and environmental impact. Hence an experiment to integrate technology into the process was implemented. By leveraging historical biomass data and vital environmental factors, predictive models from advanced AI and time series analysis techniques were integrated to analyze temporal patterns and make accurate biomass forecasts for efficient resource utilization. Interpolation techniques and Dijkstra's Algorithm were applied to calculate optimal distances between harvesting sites, depots, and refineries, ensuring efficient logistics and minimizing resource wastage. To empower decision-makers, statistical dashboards were integrated with Google Maps, providing visual aids to decode geospatial patterns and identify efficient distribution pathways. Additionally, the study aligned with broader sustainability goals, contributing to the generation of clean and renewable energy.

KEYWORDS: Time series analysis, Transportation cost reduction, Biomass forecasting, Geospatial visualization, Environmental sustainability, Distribution network.

INTRODUCTION

As the world grapples with the challenges of climate change and the imperative to transition towards sustainable energy sources, the role of biofuels in transforming the transportation sector has become increasingly pivotal. Despite the dominance of oil, which accounts for 91% of energy use in transportation according to Fig. 1, renewable fuels, including biofuels, present a promising pathway towards reducing carbon emissions and achieving a greener future. [5] This paper proposes an innovative framework for enhancing the biofuel supply chain through the strategic integration of technology, aiming to address the inefficiencies and bottlenecks that currently hinder the widespread adoption of biofuels.

At the heart of this initiative lies the development of a sophisticated predictive model that harnesses the power of Artificial Intelligence (AI) and time series analysis techniques.

By meticulously analyzing historical biomass data and incorporating essential environmental variables like ARIMA,

this model seeks to accurately forecast future biomass availability. It refines the biomass distribution network using Interpolation techniques and Dijkstra's Algorithm and integrates statistical dashboards with Google Maps to streamline logistics, reduce costs, and enhance decision-making capabilities. Such foresight is crucial for optimizing the logistics and operational aspects of the biofuel production process, from the initial stages of biomass collection at harvesting sites to the conversion of biowaste into biofuel at refineries.

The biomass feedstock needs to be optimally collected and transported to the biorefineries. In the Fig. 2, Harvesting sites serve as the starting point in the supply chain. At each Harvesting site, biomass availability can be forecasted using historical data. External parameters such as weather, rainfall, government regulation, etc. may also influence biomass production. Bales of biomass will be collected from these Harvesting Sites and transported to the pre-processing depots for densification and pelletization. The pellets will then be

transported from each of these depots to each biorefinery, in quantities that cater to each biorefinery's demand. The locations of the depot and the biorefinery will remain constant. In light of the current energy landscape, where renewable fuels constitute a mere 3.6% of energy use in transportation, the potential of biofuels to displace a substantial portion of oil usage is both evident and compelling. [5] The insights gleaned from the experiment underscore the urgency of investing in the development and infrastructure of renewable fuels, setting the stage for a more sustainable and resilient transportation sector.

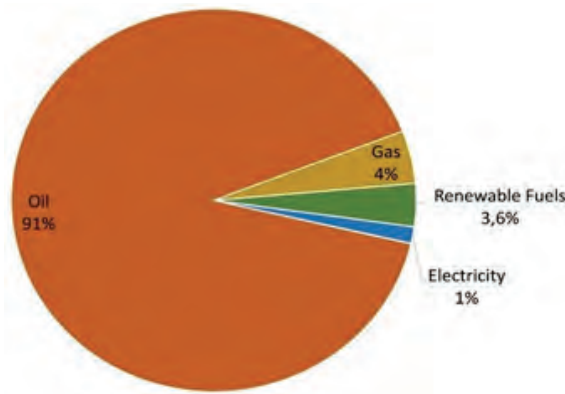


Fig. 1: Energy use in transport [5]



Fig. 2: Traditional Biomass Process

LITERATURE SURVEY

- 'Energy Consumption Forecasting Using ARIMA and Neural Network Models' by Cristina Nichiforov, Iulia Stamatescu, Ioana Fagaasan, Grigore Stamatescu presents two approaches for energy consumption forecast: an autoregressive integrated moving average (ARIMA) model and a non-linear autoregressive neural network (NAR) model. It states that both the ARIMA model and the NAR model can obtain good forecasts and can be used effectively for energy forecasting. Although the performance of the ARIMA model is better than the NAR model, as observed by comparing the predictive error values. [1]

- 'Evaluation of ARIMA, Facebook Prophet and a boosting algorithm framework for monthly precipitation prediction of a semi-arid district of north Karnataka, India' by Chowdari KK, Surajit Deb Barma, Nagaraj Bhat, R Girisha, K. C. Gouda compares the performance of three different time series prediction models—ARIMA, Facebook Prophet, and ThymeBoost—in forecasting monthly precipitation in Belagavi district, Karnataka, India. Auto-ARIMA is the best-performing model in terms of RMSE, followed by ThymeBoost and Prophet. [2].
- 'Time-series prediction research based on combined prophet-LSTM models' by Jungang Gao contributes to the field of time-series prediction by combining traditional fitting-based forecasting algorithms like Prophet-LSTM with deep learning techniques, demonstrating promising results for temperature prediction in Shanghai. [3]
- 'Time Series Forecasting using Facebook Prophet for Cloud Resource Management' by Mustafa Daraghme, Anjali Agarwal, Ricardo Manzano and Marzia Zaman proposed a forecasting model based on Facebook Prophet for Azure VM workload. Used log transformations and percentile score method to improve accuracy. [4]

METHODOLOGY

This methodology uses the combination of time series analysis model and interpolation technique to find the best way of managing the biomass resources available within particular region. The combination is an advanced and personalized algorithm which can predict levels of biomass depending on various characteristics. Besides, it also offers the best routes for transporting biomass enhancing sustainability and operational performance.

Time Series Model

Firstly, all the required tools and data on biomass were collected. This data was then strategically divided into two sets: one for training the model and another for testing its accuracy. The model was then trained on the training data, allowing it to learn and identify patterns. Once trained, the model's ability to predict biomass was evaluated using the testing data. Finally, the results of this evaluation were analyzed to understand how well the model performed. The use of ARIMA, a technique for analyzing time-series data, was used to forecast biomass over time.

- 1) Collecting Data: Along with the historical biomass data, environmental factors were also taken into consideration to ensure accurate forecasts of biomass. For historical

biomass, a dataset from Gujarat state covering the years 2010 to 2018 was used. There were a total of 2417 entries in the dataset.

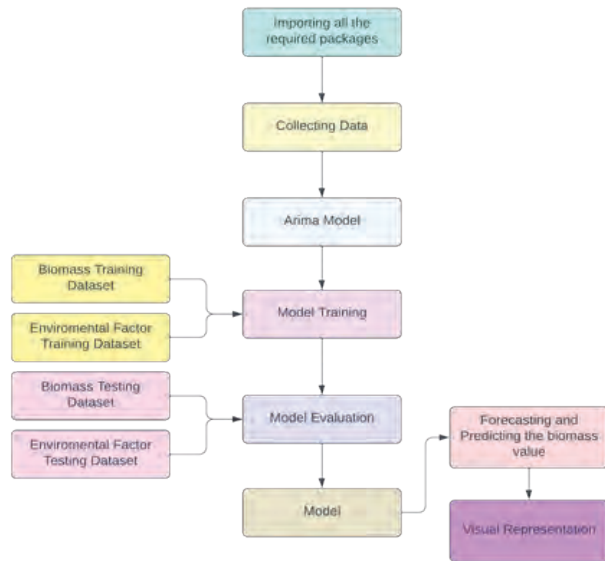


Fig. 3: Basic Flow

[6] Additionally, a dataset containing vital environmental factors such as temperature, pressure, etc., was web scraped to enhance the accuracy of the forecast. [7]

Data structure of the historical biomass dataset includes:

Table 1: Biomass History Table

Column Name	Data Type	Description
Index	Integer	Unique identifier for the record
Longitude	Float	Longitude of the location where the biomass data was collected
Latitude	Float	Latitude of the location where the biomass data was collected
Year	Integer	Year in which the biomass data was collected
Biomass	Float	Quantity of biomass available at the location in the given year (in metric tons)

Data structure of the environmental factors dataset includes:

Table 2: Environmental Factors Data Table

Column Name	Data Type	Description
Latitude	Float	Latitude of the environmental data record
Longitude	Float	Longitude of the environmental data record
Time	Datetime	Time and date at which the environmental data was recorded
Temperature	Float	Temperature in degrees Celsius
Atmospheric pressure	Float	Atmospheric pressure in hectoPas- cals
Humidity	Float	Humidity in percent
Rainfall	Float	Rainfall in millimeters

2) Forecasting Model: ARIMA model, known as autoregressive integrated moving average models, utilizes the his- torical and environmental dataset to project future values by analyzing lagged moving averages. This model is extensively employed in technical analysis for predicting quantities of biomass. [8]

Key features of the ARIMA algorithm include:

- Combination of Techniques : ARIMA models combine autoregressive features with those of moving averages. Autoregressive processes use past values to predict the current value, while moving averages smooth out data by creating a series of averages. This combination allows ARIMA models to capture trends, cycles, seasonality, and other non-static types of data in their forecasts. [14] [15] [16]
- Handling Non-Stationary Data : Unlike many other forecasting models, ARIMA can handle non-stationary data by differencing it to make it stationary. Stationarity is a crucial property where the statistical properties of a time series do not change over time. This makes ARIMA particularly useful for forecasting data that exhibits trends or seasonality. [9]
- Flexibility and Complexity : ARIMA models are flexible and can be adjusted to fit various types of data. However, this flexibility comes with complexity, as determining the optimal parameters (p, d, q) for the model requires careful analysis. These parameters define the

order of the autoregressive (AR), differencing (I), and moving average (MA) components of the model. [10]

- p is the number of lag observations included in the model (the order of the autoregressive part).
- d is the number of times that the raw observations are difference d (the degree of differencing).
- q is the size of the moving average window (the order of the moving average part).

The general formula for an ARIMA model is:

$$\phi(B) \cdot (1 - B)dY_t = \theta(B) \cdot \epsilon_t \quad (1)$$

where:

Y_t is the value of the time series at time t .

$\phi(B) = 1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p$ is the autoregressive (AR) polynomial of order p .

$\theta(B) = 1 + \theta_1 B + \theta_2 B^2 + \dots + \theta_q B^q$ is the moving average (MA) polynomial of order q .

B is the backshift operator, defined such that $BY_t = Y_{t-1}$.

ϵ_t is the error term (white noise) at time t . [11] [12] [13]

- 3) User Interface: The user-friendly dashboard provides a one-stop shop for users to track their biomass harvesting progress. At a glance, they can see the predicted biomass and profit for the year, along with the total revenue generated from sales. Additionally, the dashboard keeps them informed about the total amount of biomass waste collected and sent to depots, alongwith highlighting the nearby depot locations.



Fig. 4: Biomass Prediction

Interpolation Technique

All the necessary software tools were collected. Next, data about the locations or points of interest was gathered mentioned as distance matrix. This matrix essentially served as a table showing the distance between every two points of interest. Then, Dijkstra's algorithm was employed to identify the shortest path between two points, likely leveraging the distance matrix. Finally, the results were visualized, likely presented as a map or chart for easy interpretation.

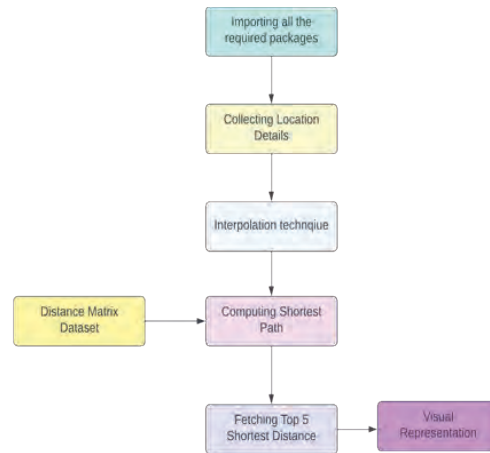


Fig. 5: Basic Interpolation Technique Flow

- 1) Collecting location details: The application of Interpolation techniques and Dijkstra's Algorithm serves to refine the distribution network, ensuring the calculation of optimal distances between harvesting sites, depots, and refineries. [6] Dataset used to find the shortest path between harvesting sites, depots and refineries is actually a distance matrix which includes:

Table 3: Distribution Network Data Table

Column Name	Data Type	Description
Location ID	Integer	Unique identifier for the distribution network location
Latitude	Float	Latitude of the environmental data record
Longitude	Float	Longitude of the environmental data record
Distance	Float	Distance between the locations

- 2) Dijkstra's algorithm: Dijkstra's algorithm is a fundamental algorithm in graph theory used to find the shortest path between nodes in a graph with non-negative

edge weights. In the context of the biomass resource management project, Dijkstra's algorithm can be applied to optimize the distribution network by determining the optimal routes between harvesting sites, depots, and refineries.

Key features of Dijkstra's algorithm include:

- **Single-Source Shortest Path:** Dijkstra's algorithm efficiently computes the shortest path from a single source node to all other nodes in the graph.
 - **Greedy Approach:** The algorithm uses a greedy approach, iterative selecting the node with the shortest distance from the source node and updating the distances to its neighbors.
 - **Priority Queue:** Dijkstra's algorithm typically uses a priority queue data structure to efficiently select the next node to visit based on its current distance from the source node.
 - **Optimal Substructure:** The algorithm maintains optimal substructure, ensuring that the shortest path to each node is computed correctly as the algorithm progresses.
 - **Non-Negative Edge Weights:** Dijkstra's algorithm requires that all edge weights in the graph be non-negative. This constraint is important in the context of biomass resource management, where negative distances or costs would not make sense. [19]
- 3) **User Interface:** This screen displays a map interface that shows the shortest route between key points like harvesting sites, depots, and refineries. The distances are calculated using Dijkstra's algorithm.

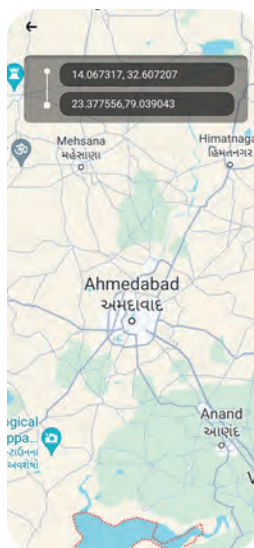


Fig. 6: Interpolation

C. Architecture

This flowchart outlines the process for predicting biomass and meeting demand at various depots and refineries.

The process begins with the collection of historical and real-time biomass data from harvesting sites, followed by dataset preprocessing and noise removal to ensure data quality. The cleaned data is then used to train the ARIMA model, incorporating additional environmental factors for accurate biomass forecasting. The trained model predicts the biomass for the upcoming years, and these predictions are validated against real-time data. The dataset is continually updated with current data to maintain accuracy. Concurrently, spatial interpolation like Dijkstra's algorithm and GIS were used to compute the shortest distances for transporting biomass, optimizing logistics. This involves mapping distances, determining depot and refinery demands, and ensuring the required biomass quantities are communicated and delivered efficiently to meet the demand at various locations.

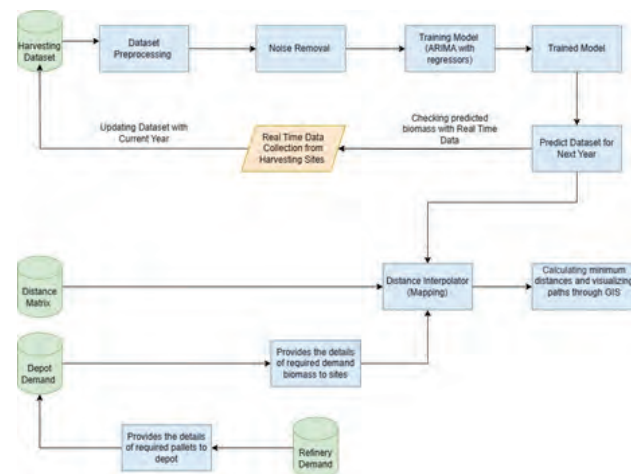


Fig. 7:

Visualizations

z without considering their direction. It is particularly useful in regression problems where the goal is to minimize the difference between the predicted and actual values.

The Mean Absolute Error (MAE) is defined as:

$$(2)$$

After applying the ARIMA model to our dataset and making predictions for the year 2018, we can calculate the Mean Absolute Error (MAE) to evaluate the performance of our model. The MAE serves as a measure of the average magnitude of errors in our predictions, providing insight into how close our model's predictions were to the actual values.

Mean Absolute Error : 16.61765007940527

- b) Measure of Accuracy :RMSE and MSE are the two criteria chosen to measure the performance of time series forecasting model as shown in Equation 3 and Equation 4 where error is e_i , $i=0,1,2,3, \dots n$. The model which is having the least value of RMSE and MSE is selected as best forecasting model.

(3)

(4)

- a) Forecasted vs. Actual Values: Forecast vs Actual values plot shows the actual data points along with the model's forecasted values. It helps visualize how well the model captures the trend and seasonality of the data.

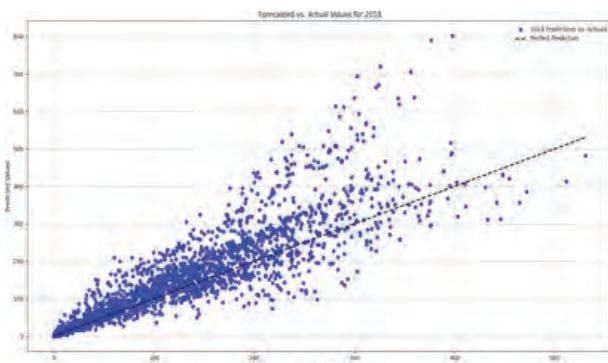


Fig. 8: Predicted vs Actual

- b) Partial Autocorrelation Function (PACF) Plot: PACF shows the correlation between residuals at different lags, but it accounts for correlations at earlier lags. A good ARIMA model should have significant spikes only at the first few lags in the PACF plot.
- c) Line Chart: The line in the chart shows the trend of the difference between predicted and actual biomass over time. It allows you to see how the prediction errors.

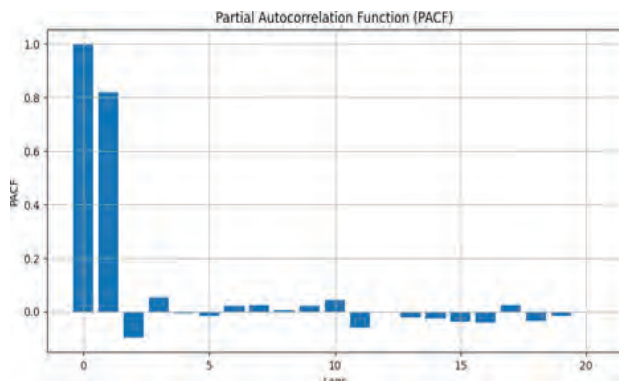


Fig. 9: Partial Autocorrelation Function (PACF)

(over-estimation or underestimation) varied throughout the time period. The slope and overall shape of the line can reveal trends in the prediction errors. An increasing slope over time might indicate a growing bias towards overestimation (or underestimation) as time progresses.

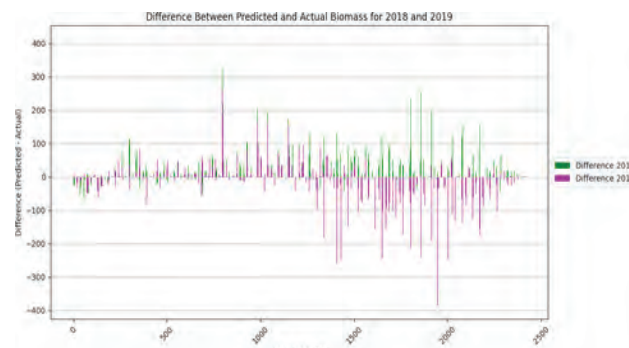


Fig. 10: Line chart for Difference in Prediction and Actual

CONCLUSION

In conclusion, the paper introduces a comprehensive approach to transform biomass resource management through advanced time series analysis techniques, interpolation, dijkstra's and the integration of vital environmental variables. The utilization of the ARIMA algorithm enables precise forecasts of future biomass availability, offering valuable insights for strategic planning and resource allocation.

The application of Interpolation techniques and Dijkstra's Algorithm optimizes the distribution network, determining optimal distances between harvesting sites, depots, and refineries. This optimization enhances logistics efficiency while minimizing resource wastage, leading to cost-effective distribution routes and reduced energy consumption.

Moreover, the introduction of statistical dashboards seamlessly integrated with Google Maps facilitates geospatial pattern interpretation, empowering decision-makers with actionable insights for efficient biomass distribution pathways and informed resource management.

Importantly, the holistic approach transcends resource optimization, serving as a potent tool in reducing greenhouse gas emissions and mitigating the impacts of climate change. By implementing the strategies outlined in this research, organizations can achieve not only operational efficiency but also contribute positively to environmental sustainability.

In essence, the paper provides a roadmap for integrating advanced analytics, optimization techniques, and environmental considerations to revolutionize biomass resource management and promote a sustainable, eco-conscious approach to energy production.

FUTURE WORK

In order to achieve successful and proper biomass management, future efforts need to be focused in a variety of ways. Such include creating advanced models with sophisticated algorithms that incorporates environmental factors, optimizing distribution networks for innovation in methods and installing real-time monitoring systems which supports for flexibility in decision making. Furthermore, life cycle assessments are essential to reduce environmental effects thereby calling for partnership with renewable energy technologies will be key to enhancing overall sustainability. If these sectors are addressed, biomass management could attain higher levels of predictive accuracy, better logistics, fewer environmental repercussions, and more expandability.

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FARMKART- Digital Platforms to Connect Farmers to Retailers for Agronomist E-Commerce

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ABSTRACT

We have created a mobile application specifically designed to assist farmers are promotion goods directly to customers. This mobile application is designed to provide farmers with a quick and up-to-date information delivery mechanism. Thanks to its user-friendly layout, this smartphone application assists farmers with both buying and selling goods. Since selling items can be difficult for farmers, the primary goal of this application is to provide a platform or channel where farmers cells at fair prices. To improve farmers' efficiency in using the program, updated market prices and filters are also included. With this method, customers may select from a large company. We have created a mobile application specifically for farmers, enabling them to apply pricing filters and choose items based on their needs. The system's goal is to supply fair and transparent farm business while considering each person's requirements. Most of the consumers can get organic vegetables as it's not easily accessible and costly which restricts the consumers from getting fresh organic vegetables. Nowadays with everything getting digitalized and with busy schedule of people software applications will help immensely as it will make it much easier and less time consuming to get organic veggies for people through digital platforms. This application will make the whole process much more efficient as its focus is to deliver directly to consumer's house, which will turn out to very beneficial for people health with all the health issues rising this software application can be real game changer. An automated grow controller allows you to manage a hydroponic environment from your smart phone, giving the grower 24-hour remote management of the growing environment. The automated hydroponic system improves efficiency and minimizes human labor. It is based on the principles of embedded systems, which enable the amplification of several crops under a single controller. This all can be done through an app, where you can even place orders for the required nutrients and pay online through UPIs by simply scanning the QR code. This will save time and reduce the pain of going to market, walking from shop to shop to search for the required nutrient.

KEYWORDS: *Intermediaries, Market pricing, Agriculture industry, Digitalize, Hydroponic environment, Application.*

INTRODUCTION

India's economy is mostly reliant on agriculture; in other words, farmers are the backbone of the nation. India's economic well-being is mostly reliant on the expansion of agriculture. Globally, agricultural technology has advanced significantly, but in India, most farmers are ignorant of these advancements because of a lack of resources and awareness. The vast majority of farmers lack knowledge on crop and product pricing. Lack of knowledge about the true rates of the items makes farming challenging to obtain the right price for their goods and products, and they frequently experience delays in offering their goods, which leads to

which they undergo a heavy loss(8, 13,17).India's economy is mostly reliant on agriculture; in other words, farmers are the backbone of the nation. India's economic well-being is heavily reliant on the expansion of agriculture. Globally, agricultural technologies have advanced significantly, but in India, most farmers are ignorant of these advancements because of a lack of resources and awareness. The vast majority of farmers lack knowledge on crop and product pricing. Lack of knowledge about the true rates of the items makes it difficult for farmers to obtain the right price for their goods and products, and they frequently experience delays in selling their commodities, which leads to farmers

to utilized the maximum benefit This application claims to offer a suitable and simple means of purchasing and selling products derived from agriculture. The application allows users to select from a large selection of products and features a fair pricing system where farmers can grade their products. Through the program, businesses may buy goods straight from farmers and resell them online(9,16,23).

As we see now days farmer protest is increasing day by day because they do not get proper amount of organic vegetable. Farmers should be directly selling to the consumer rather than the intermediaries involved making the profit for farmers even less. Also, these days further public have grown to be conscious about what they are eating and about their health. This will help the consumer to directly connect to farmers and will be beneficial to both. We desire to expand a hydroponic system that enables anybody to cultivate hydroponic plants using an easy-to-use automated system, which is why we are completing this senior design project. This solution will spare the user from having to do daily maintenance and a laborious setup. A web/mobile interface linked to the microcontroller powering the device will allow the user to choose the plants they wish to grow. Making the required nutrients available for the customer easily available and by simply being at their place, paying for it online through UPIs at home will encourage the food growers to participate more in this hydroponic technique of growing vegetables (10, 17, 25).

The e-commerce has taken new heights in the previous many years since the pandemic hit us and now it's the most convenient way of shopping (11, 18).

This Agronomist E-commerce has shortened the link between the seller and buyer by removing the middleman hence saved the commission.

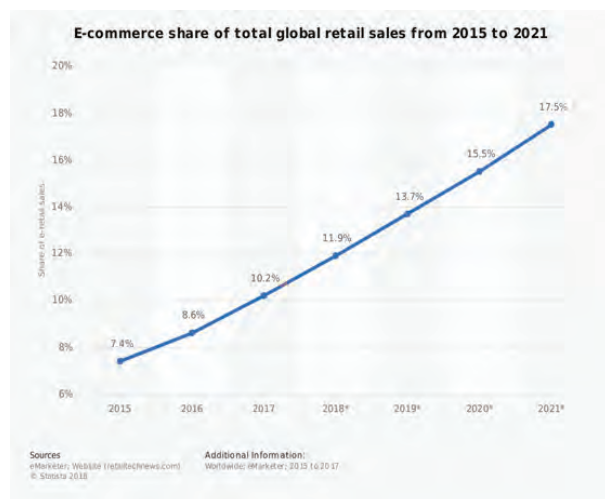


Fig. 1. Growth of E-Commerce

LITERATURE REVIEW

The E-commerce implementation is a crucial process for a business to prosper and reap the rewards. This has prompted numerous studies on the application of e-Commerce from various angles, with various academics looking into the findings. Nonetheless, the introduction of Business-to-Customer (B2C) that isn't until e-Commerce is applied in a way that makes sense throughout the duration of the life cycle of developing information systems. Through a methodical analysis of the literature, this paper seeks to ascertain the extent of attention paid to e-Commerce implementation topics at the pre-, during-, and post-implementation phases of the implementation process. Sixty-five (65) selected primary research studies have been conducted based on the implementation phase topic, research technique, and research area been examined [12].

The majority of the data and articles addressed B2C e-Commerce in the pre-implementation phase (49%) and favored a quantitative study methodology (63%). The while implementation phase and the post implementation phase are two additional implementation processes that are not well covered in the literature that is currently accessible for publishing. Furthermore, a large body of prior research has addressed implementation-related issues with e-commerce, but it hasn't matched those elements to the appropriate stages of implementation.

Without any clear guidance, this list of factors stays at the surface, making it difficult for businesses to understand why e-commerce implementation is so important. Therefore, this study's a thorough evaluation of the literature shows that more research is required to comprehend the intricate process of e-Commerce implementation in a more comprehensive way. Furthermore, research is required to screen these variables to a specific and more accurate "map" during the e-Commerce implementation process. By offering accurate, lucid, and verified information on each of the chosen solutions.

According to Shakeel-Ul-Rehman et al. [13], the agriculture industry's marketing approach needs to be modified. It states that agricultural firms should embrace agricultural technologies. It also discusses the difficulties farmers have in selling their produce as a result of their ignorance in both marketing and agriculture.

In their 2015 publication "A Modern Farming Techniques using Android Application," Sudarshan G. Ghuge and Santosh G. Karkhile present a solution development concept for farm management, agricultural advancement, and farm maintenance. It shows how weather forecasting in modern farming creates a predictable environment, while farming in

the past accepted unanticipated circumstances. Traditional farming methods need a significant amount of labor.

This study satisfies this need. The study lists, evaluates, and contrasts four methods for gathering mobile data. We first decided to gather and choose papers on each of the solutions, and then to install and test each of them in categorizes to create an efficient comparison.

OBJECTIVES

Online shopping is a form of electronic shopping store where farmer is directly linked to the costumer via the software application. This software application has proposed a best online organic store which provides organic vegetable by just sitting at home and it consumes costumer time.

Increase Sales: An e-commerce app's main goal is to increase sales and revenue for the company. This can be accomplished by implementing a number of tactics, including providing a user-friendly interface, a smooth checkout procedure, tailored recommendations, and incentives to entice customers to make purchases.

Improve Customer Experience: Providing a positive and convenient customer experience is crucial for the success of an e-commerce app. The application should be easy to navigate, have clear product descriptions, high-quality product images, multiple payment options, and excellent customer support. A satisfied customer purchases and recommends the app to others.

Expand Market Reach: Another objective of an e-commerce app may be to expand the market reach of the business. With an app, businesses can large, reach customers globally, and break geographical barriers. The app can also enable businesses to target specific customer segments or demographics, and engage with customers through marketing campaigns and promotions.

Gather Customer Data: E-commerce apps can collect important client information such browsing habits, past purchases, preferences, and demographics, browsing behavior, preferences, and demographics. This information can be used for data-driven decision making, understanding customer needs and preferences, personalizing marketing campaigns, and improving overall business strategies.

Increase Customer Retention: It is frequently less expensive to keep current customers than to find new ones. An e-commerce app can provide features such as personalized offers, loyalty programs, and convenient order tracking to encourage repeat purchases and foster customer loyalty. Retaining loyal customers can lead to long-term profitability and sustainable business growth.

Optimize Operations: Additionally, e-commerce apps can aid companies in streamlining their processes and improve efficiencies. Features such as inventory management, order tracking, and automated processes can streamline operations, reduce errors, and save moment in time and resources.

Stay Competitive: In the competitive e-commerce landscape, having a mobile app can be a differentiating factor. An e-commerce app can support companies in maintaining their competitiveness by providing a convenient and accessible shopping experience to customers, keeping up with changing customer preferences, and staying ahead of competitors.

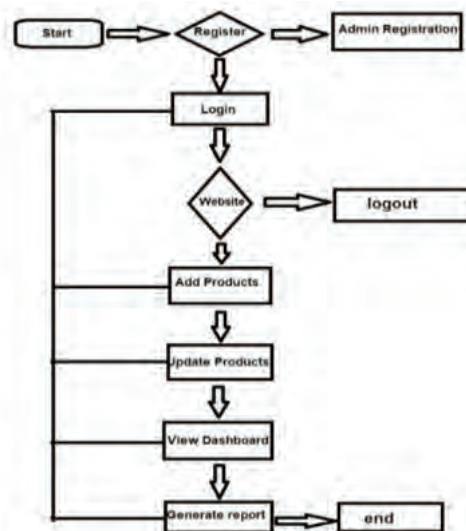


Fig. 2. Flowchart of Application

DISCUSSION

Transactions are carried out manually without utilizing a shared platform. The agricultural business and retailers have relatively little communication with one another. Farmers are not allowed to make the bulk of decisions under the existing system. Employers in the agriculture sector use middlemen to supply them with raw materials. This process requires a significant investment of time and labor, as well as human error.

Many Smartphone apps have been developed to make agricultural business easier for farmers, sellers, and purchasers. Certain mobile applications are specifically made to offer farmers information services. Numerous studies and mobile applications pertaining to the agriculture industry have been explored here.

Maha-Farm

This essay discusses new developments in Indian agriculture technology.

The Android App E-Agro

The primary purpose of this software is to support farmers' sustainable development. It seeks to raise the value of agricultural products and the farmers' revenue stream.

Big-Basket

India's biggest online grocery store is called Bigbasket.com. We can nearly find everything we need in just one store, with over 20,000 products and over 1000 brands. Every category has a large selection of products at the best pricing. They purchase goods from vendors, stock them in big warehouses or compact godowns, and then deliver the orders to clients.

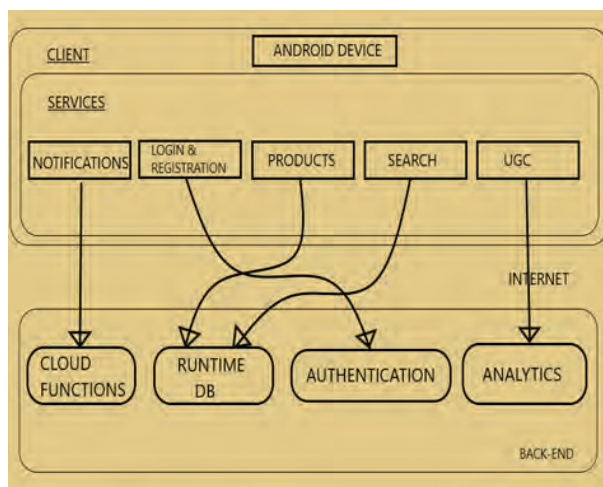


Fig. 3. System Architecture

METHODOLOGY

In this essay, we outline the fundamental concepts that guided the creation of our application and explain how we applied them to our study. The employed techniques are briefly introduced and explored. The purpose of this article is to serve as a quick and current information delivery mechanism. We want to employ native language support to make some modules understandable so that users can also benefit from the features of the application. District-level traders engage in market trade of agricultural goods. Although the market prices are dynamic, the government sets support prices to keep them stable.

The application may be developed using Firebase, a server-less platform, and the client is an Android device. The design is built on client-server architecture. The internal modules of the program are displayed in Fig. 1. Essentially, the goal this application is to offer an interface that is easy to use, that makes it simple for the user to access and view the information. The user's basic authentication is provided by the program.

Verification

Through the app, it controls users and their sessions. This service provides login options like Google, Anonymous, and Email-password.

1. User Login: This function is used by the user to log into the system. A user's user name and password must be entered to access the system after registration. If the user is invalid, they are unable to access the system. Functional requirement: A username and password will be provided following user validation. The password will be hidden from other users while it is entered in the field.
2. Sign up as a new user: To analysis the products on the system, a new user must register by entering certain required information. Functional need: The system wants to be capable of confirming

Details of the Product

Users can change the information about their products, such as the name, price, quantity, and description, and submit product data with actual photographs into the system.

By selecting the "add to cart" button on the product, the user can add the chosen item to his cart. By clicking the cart button, he may see what's in his cart.

You may view every product added to your cart by clicking on it. By selecting remove, a user can take an item out of their cart. The user can submit the cart by giving a delivery address after verifying the contents. Once the submission is successful, the cart will be empty.

Shopping Cart and Notification

When a product is purchased, a notification is generated. The user receives a notification. The user will receive a notification containing product specifics, including name, quantity, and contact information, as presently as an order is placed.

The shopping cart allows the user to add several products. It shows the pricing of everything that has been chosen, and when an order is placed, it automatically determines the overall cost of the products.

Real Time Database

All of the app's data is kept in the real-time database. This service has a very quick response time and allows listeners to update app data whenever there are database updates. With robust, easy-to-use, and reasonably priced object storage designed for Google scale, the Cloud allow user to store and share user-generated content like photos, audio, and video.

The Firebase SDKs for Cloud Storage provide Google with

security for file uploads and downloads for Firebase apps, independent of network quality.

A versatile, scalable database for server, browser, and mobile applications, Cloud Fire Store is powered by Firebase and Google Cloud. Similar to Firebase concurrent Database, it provides offline support for and uses real-time listeners to keep your data synchronized across client apps.

Cloud Functions and Cloud Storage

Another name for the cloud function is server-side code. Numerous HTTP requests and triggers are supported by cloud functions. Cloud Functions were utilized by this application to create users, cleanse data, perform admin tasks, manipulate the real-time database, and send notifications.

Using a server-less framework as assistance called Cloud Functions for Firebase, you may programmatically execute backend code in answer to events brought about by HTTPS requests and Firebase capabilities. Your TypeScript or JavaScript code is run in a managed environment and is kept on Google's cloud. You don't have to scale and manage your own servers.

Analytics

The Android SDK automatically records important events, user attributes, and activity. It then presents the recorded data as graphs. The Firebase application can be utilized for this purpose. The Android APIs can give the user all the summarized data in a way that is easy for them to grasp through graphs and figures. The Google program Firebase will offer us crucial functions such database management, data recovery, and data analysis. Google offers Firebase as a free solution, which automatically grows into larger apps. Firebase is a cloud-based program that functions independently yet collaborates within the app by sharing data. Firebase is therefore the ideal data analytics option.

WORKING MODEL

Admin Panel

Dashboard: Admin can manage delivery partners, and much more with a dashboard.

Handle Vendors: The administrator can quickly add and oversee a number of vendors.

Customer ratings and comments are managed by administrators to preserve the legitimacy of the business.

Customer Management: Admins have the capability to monitor and manage customer profile information, including purchase history, order history, and buying patterns.

Tax Management: The tax label and percentage can be defined and managed by the admin.

Store & Delivery Boy Earning: Administrators know oversee and monitor commission reports herewith the total earnings of each store and delivery partner.

Delivery Manager: The feature, administrators can easily deliver orders by adding and managing delivery partners.

Chat Support: Admins deliver continuous customer support for an excellent online grocery shopping experience.

Fig. 4. Admin Panel

Vendor Panel

Signup: To obtain complete access, vendors must register or log in to the grocery app.

Different Dashboard: Each vendor has a dashboard where the can monitor orders, payments, delivery partner assignments.

Shop Management: Vendors can control the replenishment and depletion of the grocery items with the assist of the shop management feature.

Manager: Advertisers can awareness by choosing a specific audience, naming their ad, allocating a budget, and placing it within the allotted time slots.

Sales Report Management: In this process, suppliers monitor their total sales and determine their profit margin.

Delivery Management: By monitoring of groceries and delivery personnel, vendors can organize the delivery slots. Later, they carry out the directive.

Customer Panel

Signup/Login: The initial step of user in engaging application is to register and log in.

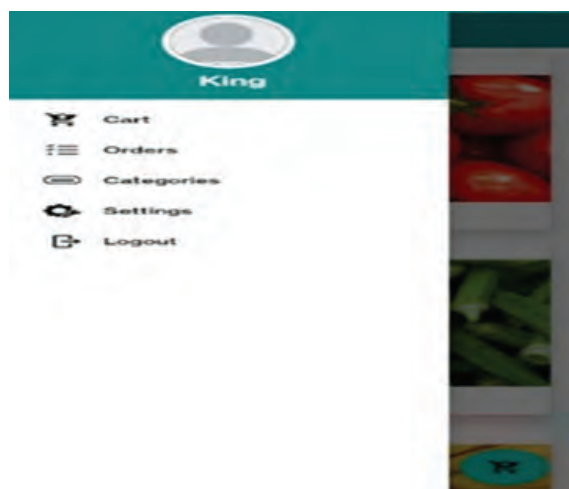


Fig. 5. Vendor Panel

Order Placement: User could place an order directly from the app after determining which grocery store is best for them.

Schedule: Using the delivery schedule feature, customers can set a particular time of calendar to receive convenient.

Many Payment Options: For varied payment gateways allow users to choose from numerous different payment options, including cash on delivery (COD), digital wallets, credit/debit cards, and net banking.

Order Tracking: This feature periodically sends push notifications or SMS updates to users with status of their orders.



Fig. 6. Customer Panel

Delivery Panel

Profile Management: The delivery partners have the ability to manage their employee ID, name, and phone number in their profile.

Order Management: These deliveries are to be made and which order number corresponds to the customer's information.



Fig. 7..Delivery Panel

CODE DEVELOPMENT PLATFORMS

I. Visual Studio Code, usually known User

customization options includes changing the theme, keyboard shortcuts, options, and more functional extensions. For designing the front end pages, we used this platform.

II. The integrated development environment (IDE) Programming is done with a program called Eclipse. An extendable plug-in system and a base workspace allow for customization of the environment. Up until 2016, this IDE—which is currently ranked second—was the enormously used in Java programming. Eclipse is primarily built in Java and for creating Java applications along with plug-ins for creating programmers in other programming languages.

III. Microsoft no longer offers Windows App Studio, formerly known as Windows Phone App Studio, as an online application for Windows app creation. In addition to offering the whole source code as a Visual Studio “solution,” it enabled users to construct apps for publishing into the Windows Store or installed on the Microsoft Store. Applications for the Universal Windows Platform were created using the tool.

- IV. MySQL Workbench is a visual database design tool that integrates SQL development, administration, database design, construction, and maintenance for the MySQL database system. into one integrated development environment. It replaces the previous software package, MySQL GUI Tools Bundle, and supersedes fab FORCE. net's DB Designer 4.
- V. DBDesigner4 is a GPL-licensed open source visual querying and database design application for the MySQL database. With a focus on mobile flexibility, Bootstrap is an open-source; free CSS framework designed for front-end web development. Design templates in HTML, CSS, and (optionally) JavaScript comprise elements like as typography, forms, buttons, navigation, and other interface components.
- VI. Firebase It is facilitating administration for any sort of application. It offers No SQL and real-time facilitating of databases, substance, social verification, and notices, or administrations, such as a real-time communication server.

CONCLUSION

By offering a developed reliable system, which assist the food processing sector, which serves both farmers and consumers, in making the most of their goods. In light of earlier research, the article seeks to establish a novel idea that would enable farmers to sell their goods directly to customers, with the latter being able to do so using a Smartphone application that acts as a virtual middleman. The wholesalers who quote their own rates for the animals prevent farmers from making a profit, thus the program will assist them achieve maximum profitability. With support of such application, farmers may sell their goods to customers directly, cutting out any middlemen who would otherwise force them to lower the price of their goods.

Such types of applications are much required and are useful for farmers, consumers, and the agriculture sector as a whole can come together to purchase goods at competitive costs. The application fills the void in the delivery of agricultural outputs and infrastructure between the availability of agricultural inputs. This application will lessen the communication gap that exists between farmers and retailers.

Furthermore, the system is an innovation in the agricultural market with a new concept of trading of agricultural products online.

With the help of android studio, java and xml, the application of agronomist e-commerce looks very dynamic. There are two ways to login – admin and user, if one wants to buy the

vegetable and fruits grown by hydroponics then she/he should login as user the requirement and the farmers want to sell their hydroponic product then they can login as admin and add the information about their products and sell them online using this application. With the Agronomist's E-commerce app, customers can access the latest information, compare prices, and make purchases with confidence, knowing that they are getting fresh, healthy, and sustainably grown food. This app has the potential to disrupt the traditional food purchasing process, making efficiently and environmental friendly, while also promoting healthy eating habits.

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Machine Learning-Driven Loan Eligibility Prediction Model

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ABSTRACT

The needs of individuals have grown as a result of notable technological breakthroughs. Because of this, there have been greater demands in the banking sector to approve loans. To determine the overall state of the loan, a lot of factors are considered before approving an applicant. Banks face significant challenges in evaluating loan applications and reducing the risk of prospective defaults by borrowers. This process is particularly challenging for banks, as they are required to meticulously evaluate the eligibility of each borrower for a loan.

This study attempts to combine ensemble learning techniques using models of machine learning (ML) to determine the likelihood of approving an individual's loan applications. Using this strategy can improve the process of accurately choosing eligible applicants from a pool of candidates.

Consequently, the issues with loan approval procedures mentioned above can be resolved with this strategy. The method's significant time reduction benefits both loan applicants and bank staff. The growth of the banking sector caused a rise in the number of people applying for bank loans. We employed four distinct algorithms— Naïve-Bayes, K-NN, Decision-Tree, and Random-Forest—to forecast the applicant's accuracy in learning the loan acceptance status. We achieved an enhanced level of precision of 83.73% by utilizing these, with the algorithm of Naïve Bayes being most effective.

KEYWORDS: KNN, DecisionTree, Naive-Bayes, Trained dataset, Random forests, Bank loans, Safe customers.

INTRODUCTION

Loan distribution is a common business activity for banks. Most of a bank's income comes from loans made to customers. These banks charge interest on the loans they make to their customers. Banks were managed. All that exists as independent and dependent variables are the values x and y . Data mostly seeks to spend their capital in reliable clients. Many financial institutions have traditionally handled loan applications via a backwards procedure, including verification and screening. However, at this time, no financial institution can promise that the consumer they choose for a loan application is a safe bet. Therefore, we created the Loan Estimation System with Python as a tool that banks might use to offer loans to attempt to tackle this problem. One of the many things that banks do is distribute loans. Most of a bank's income comes from loans made to customers. These banks charge interest on the loans they make to their customers. Banks were managed. All that exists as independent and dependent variables are the values x and y . The main objective of Data is to invest its money in trustworthy clientele. Up until

now, a number of banks have processed loans using a reverse process that involves verification and vetting. However, no bank can currently guarantee the security of the consumer selected for a loan application. In order to prevent this situation, we created the Loan Prediction System, a proposal for bank loan approvals that uses the Python programming language. There will be a yes/no display for the outcome. If the response is affirmative, the borrower can return the loan; in the event that it is negative, the borrower is unable to do so. Based on these standards, we can lend money to our buyers. The study of machine learning examines how computational methods and statistical models have been utilized to evaluate and infer patterns in data without the need for explicit instructions. In the twenty-first century, it is so significant that it is utilized almost everywhere. It is impossible to fit such a function with a straight line without making serious errors. In order to solve these issues, scientists also created polynomial, logistic, and even linear regression models with more variables for datasets with more than two dimensions. A greater number of people were interested in it and began

working on it as the accuracy sharply improved. The first time the phrase “big data” was used, in 2005, it signified the start of a new era in data science. Numerous ideas, such as decision tree regression, may now be implemented. Ordinary gadgets, similar to an email filter and a search engine, are more Difficult tasks like forecasting a home or, more specifically, our topic, predicting consumer behavior. While the method of generating a function to describe the points in the dataset, or regression, goes back to about 1800, machine learning (ML) techniques were not invented until 1952. In 1805, Legendre created and published “theme thodofleast square” to evaluate a function’s applicability for a large number of information sources. A mathematical basis for the first effective cost function is established. Over the next century, arithmeticians as well as researchers like Gauss plus Markov would further develop this idea also use it to create principles. The regression process was an extremely laborious procedure, as there were no computers or even calculators available at that time. When the notion of machine learning was developed in the 1950s, things began to change. As the name indicates, a specific sort of calculator was invented in order to conduct linear regression. Linear regression is the technique of predicting using a linear function and provided data points. By reducing the linear regression cost function (squared-error), the best suitable linear function may be found on behalf of almost all datasets. However, when it was first released, it didn’t seem to be really helpful; many problems remain. Before all that, a straight line could not appropriately represent a lot of information. A quadratic relationship, for example, is one in which y varies greatly in value based on x, yet inordinately low depending on x. When predicting a loan, the lender typically looks over the applicant’s background information to background information to approve the loan. The likelihood of having your loan authorized and making your payments on time. Machine learning (ML) algorithms may exploit this dependence on past knowledge and comparisons with prior applications. In order to estimate the borrowing ability of a new application by gathering comparable characteristics, this might subsequently be used to create a data analysis challenge.

DESIGN AND METHODOLOGY

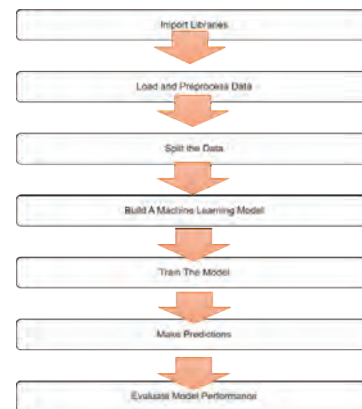
Bring in the essential libraries, including pandas, numpy, and scikit-learn, in order to analyse data and develop a prediction model. Add the loan data to a pandas DataFrame. Utilizing the filtered data, construct two subsets: a training set as well as a testing set. The training data set will be used to train the model for prediction, while the testing set will be used to assess its results. To ascertain if a loan can be accepted, apply an appropriate machine learning technique, which includes logistic regression, random forest modeling, or decision tree

models. Launch the specified model instance and change any required hyper settings. Use the fit() function to adjust the model so that it matches the training set of data.

To create predictions, the algorithm will look for associations and trends within the training set of data. According to its characteristics, the model will classify every loan proposal as either permitted or denied. Compare the expected and actual loan approval labels for the testing set, which are all shown in Fig. 1.

Fig. 1: Flow Diagram for Prediction of Loan Volume

THE ALGORITHMS (PROCEDURES) UTILIZE:



Algorithms of Random Forest

The supervised learning strategy includes Random Forest (RF), a preferred machine learning algorithm. Regression and classification-related issues associated with machine learning will be addressed by it. The concept of ensemble learning, which combines numerous classifiers to resolve difficult issues plus progress model concert, is essential to it. As the term signifies, Random Forest is a predictor that “makes the average to enhance the forecasting precision of that dataset” through including numerous decision trees proceeding different subclasses of the supplied dataset. Primarily relying just on one decision tree (DT), random forest (RF) uses predictions from each DT to foresee a result based on the votes of the vast majority of predictions.

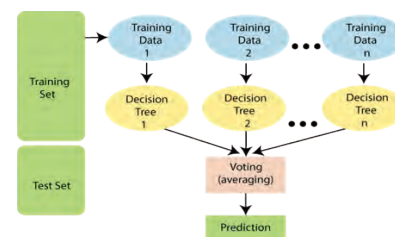


Fig. 2: Flowchart of Random Forest Algorithm

The following justifies the application of the Random Forest method.

- Compared to other algorithms, its training time was shorter.
- Even with the large dataset, it performs well and generates precise outcome predictions.

As seen in Fig.2, accuracy can be maintained even when a significant amount of data is absent.

Naive-Bayes

The Bayes theorem serves as the foundation for the Naïve-Bayes technique (NB) supervised learning strategy aimed at classification tasks. The Naive Bayes algorithm's sequence of operation is depicted in Figure 3. In essence, it employs a substantial training set intended for text organization. The Naive Bayes (NB) Classification is one of the most straightforward but efficient techniques for classification currently in demand. As seen in Fig. 3, it facilitates the development of effective machine learning models that are able to present precise projections. As a probabilistic classifier, its predictions are predicated on the likelihood that an item will appear. Naive Bayes (NB) techniques are used in sentiment analysis, spam filtering, as well as article categorization, and other applications. Occurrences, expenses for resources, and utility is represented in decision support. Regression and classification applications can both benefit.

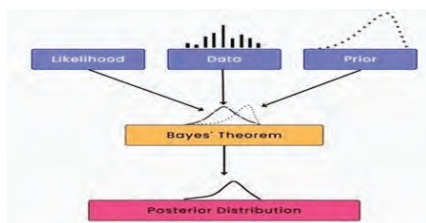


Fig. 3: Flowchart Diagram for the Naïve Bayes algorithm

Algorithms of Decision Tree

Using a flowchart structure, the decision tree (DT) prediction model makes decisions based on incoming input. Leaf nodes contain the findings once data branches have been generated. To create easily understandable models for issues with regression and classification, decision tree structures were applied. Decision trees are hierarchical models used in decision support to describe choices and their alternative consequences, such as chance occurrences, resource costs, and utility. It is a nonparametric supervised learning approach that makes use of condition control statements and is suitable for both regression and classification applications. The structure resembles a hierarchical tree and is formed of leaf, internal, branch, and root nodes.

The decision tree (DT) is a prediction model that uses a structure akin to a flowchart to base decisions upon incoming information. The findings are kept at leaf nodes, where data branches are constructed. As seen in Fig. 4, decision trees (DT) were used to create models for regression and classification problems that are simple to understand. Using hierarchical models called decision trees, decisions and their potential outcomes, such as random from the use of conditional control statements in this algorithmic, supervised, nonparametric learning approach. As shown in Fig. 4, tree architecture has the appearance of a tree with hierarchy and comprises roots, limbs, inside nodes, and the nodes for leaves.

Algorithms of KNN

K-Nearest Neighbor is a basic technique for machine learning that relies on supervised learning. A new datapoint is initially identified by the K-NN algorithm depending on resemblance, after which all previous data remains intact. It suggests that the K-NN technique might be used to rapidly along reliably classify fresh data. The K-NN technique may be used to handle regression issues as well, while it is most commonly utilized for resolving classification difficulties. K-NN, as seen in Fig. 5, is a non-parametric technique that makes no assumptions about the underlying dataset. Because it saves the dataset used for training instead of learning from it immediately, the method is also known as a lazy learner. Rather, it performs a job while categorizing data using the dataset. New data is categorized into the same group as the training data via the KNN algorithm, which only saves the data utilized throughout training.

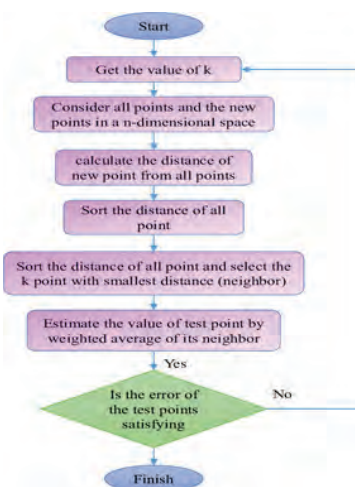


Fig. 5: Flowchart of the KNN Algorithm

Dataset Used

There are several loan default prediction data sets available on Kaggle. Machine learning (ML) competitions are widely

held on the popular platform Kaggle; the data sets on these sites frequently contain a variety of attributes linked to loan applications, borrower profiles, and payment histories. The Loan Dataset was imported from Kaggle using the following command: `df=pd.read_csv ("loan_data_set.csv")`. We then read, defined, and assigned the introduced dataset equally as indicated overhead.

RESULTS AND DISCUSSION

The researcher shall follow the method step-by-step. First off, the method `df.head()` is often used by Python coders to show the opening few rows of a Data Frame object. You can use the method `df.head()` to receive a sample of the data in the DataFrame. When this code is run, the Data Frame `df` will be written to the console. If you want to see a different number of rows shown, you can pass in an integer to the `head()` method. For example, the top ten rows of the Data Frame will be presented using `df.head(10)`.

```
df
```

	Loan_ID	Gender	Married	Dependents	Education	Self_Employed	ApplicantIncome	CoapplicantIncome	LoanAmount	LoanAmount_Term	Credit_History	Pro
0	LP001002	Male	No	0	Graduate	No	3549	0.0	NaN	360.0	1.0	
1	LP001003	Male	Yes	1	Graduate	No	4563	15300.0	128.0	360.0	1.0	
2	LP001005	Male	Yes	0	Graduate	Yes	3000	0.0	66.0	360.0	1.0	
3	LP001006	Male	Yes	0	Not Graduate	No	2563	23500.0	120.0	360.0	1.0	
4	LP001008	Male	No	0	Graduate	No	6000	0.0	141.0	360.0	1.0	

A summary of the structure and column information of a Data Frame, including the data types and memory use, may be obtained using the Pandas module for Python's `df.info()` method. Python's `df.info()` function from the Pandas module offers information on the columns in the Data Frame as well as a summary of its structure. For every column, it provides information on data kinds, non-null counts, and memory use.

```
[0]: df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 614 entries, 0 to 613
Data columns (total 13 columns):
#   column              Non-Null Count  Dtype
---  -
0   Loan_ID             614 non-null    object
1   Gender              601 non-null    object
2   Married             611 non-null    object
3   Dependents          599 non-null    object
4   Education           614 non-null    object
5   Self_Employed       582 non-null    object
6   ApplicantIncome     614 non-null    int64
7   CoapplicantIncome   614 non-null    float64
8   LoanAmount          592 non-null    float64
9   Loan_Amount_Term    600 non-null    float64
10  Credit_History       564 non-null    float64
11  Property_Area       614 non-null    object
12  Loan_Status         614 non-null    object
dtypes: float64(4), int64(1), object(8)
memory usage: 62.5+ KB
```

`df['LoanAmount_log'] = np.log(df['LoanAmount'])` is code snippet used to extract the natural logarithm for 'LoanAmount' cell within the Data Frame `df`. The outcome is allocated to a novel column called 'LoanAmount_log'. This transformation

is often used to solve the problem of right-skewed data distribution. Code placed at `df['LoanAmount_log']` in the following line. The syntax `hist(bins=20)` is used to histogram the ('LoanAmount_log') columns with 20 bins. The histogram shown in Figure 7 can be used to analyze the dispersion of the modified loan amounts.

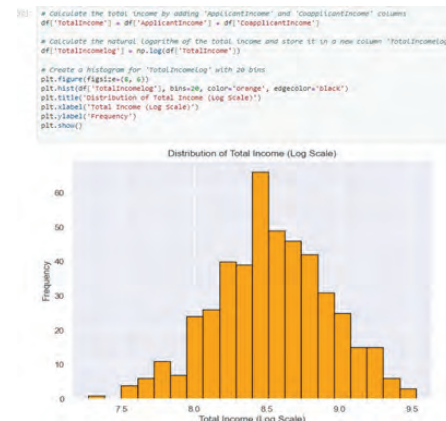


Fig. 6: Graph the loan amount vs the lending frequency

Your provided code sums together the values in the DataFrame `df`'s 'Applicant Income' and 'CoapplicantIncome' columns to obtain the total income. Next, a natural logarithm is used to determine the total revenue, as well as the outcome is recorded within a novel column called "TotalIncomeLog." After that, a histogram with 20 bins is constructed using the 'TotalIncomeLog' column.

Fig. 9 illustrates the appropriate code and figure. Running this code will result in the generation of a 20-bin histogram named "TotalIncomeLog," which reflects the total final income after logarithmic adjustment. The histogram further includes a title, x-axis, and y-axis labels.

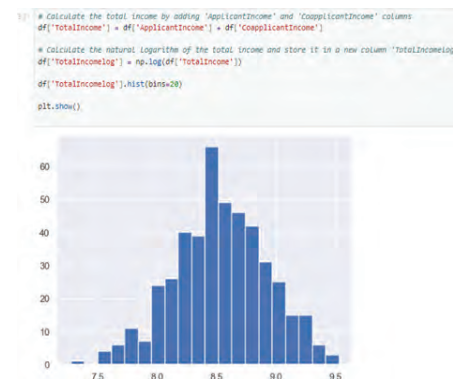


Fig. 7: Graph of the overall revenue on the log scale

This figure will aid you in studying the breakdown of the adjusted total revenue and identifying its properties. Moving toward the next phase Using the mode, or most common

value, of each column in the Data Frame df, your code does imputation of missing values on a variety of columns. This executes `df.isnull()` after performing the imputation. The number of values that are absent for every column may be found using `sum()`. This code pulls loan data from a CSV file and puts it into the Data Frame df. The chosen columns are then subjected to missing value imputation using the `fillna()` function and each column's mode, or most common value. Lastly, it estimates the values that are not present for each column using `df.isnull().sum()` and displays the result.

By executing this code, the number of values that are missing in each column of the DataFrame df shall be presented. Preceding the next, the code above uses indexing to provide x with every value of the columns submitted to the `iloc` function. Multiple combinations of values for columns can be concatenated using the `np.r_` function. Columns one through four, nine (9) and ten(10), and thirteen(13) and fourteen(14) are the ones selected for x. In the same manner, y is given values to an objective variable, the 12th column within the data frame. You may verify that all of these variables have been assigned to and selected from the appropriate columns by printing x&y. The output displays the numerical values of the goal variable, y, and the input characteristics, x, within an array format.

Going on to the following `df['Gender'].isnull()` in this code. `Sum()` finds the number of absent entries within the 'Gender' column. The number of rows within a DataFrame is supplied by `df.shape[0]`. The 'Gender' column's proportion of missing data might be calculated by multiplying the count of lost values by the total number of rows and then dividing the result by 100. With .2f indicating a number in floating points via a total of two decimals `%%` printing the '%' character, the result is presented as the organized text "Percentage of absent gender is %.2f%%". This code will show the proportion of absent data within the 'Gender' column of the DataFrame df, which is seen in the picture above. Going on toward the subsequent instruction, in Fig.08, leading part, `df['Gender'].value_counts()` counts each unique value within the 'Gender' column to determine the total quantity of borrowing for every gender group. The detailed information is then printed by implementing `print()`.

The numbers for every gender group are shown in a bar chart in the second phase using a `countplot()` function from Seaborn. The DataFrame df contains the data that is provided in the 'Gender' column, such as the x-axis variable. The `palette='Set1'` argument will be used to set the plot's color scheme. Now let's speak about instruction. `Df['Married']` in the first portion of Fig. 09. `Value_counts()` totals every unique value within the marital status column to get the total number of borrowers for every gender classification. The information is then printed using `print()`.

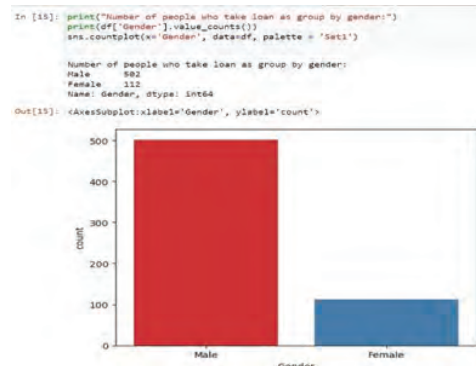


Fig. 8: Graph of Gender versus Count

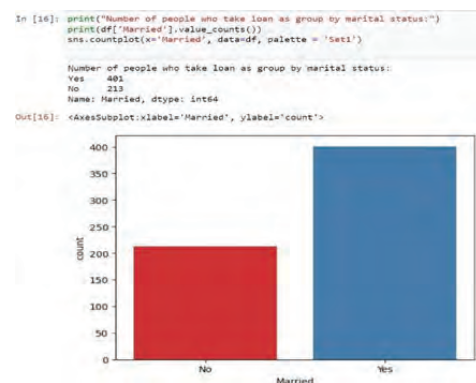


Fig. 9: Graph of Married versus Count

In the second section, a bar plot of the numbers for each marital standing group is made using Seaborn's `countplot()` method. The data has been extracted via the DataFrame and supplied as the x-axis variable for the 'Married' column. The `palette='Set1'` parameter could be used to set the plot's color scheme. You may see a countplot with the same data and print the number of debtors for each marital status category by executing this code. Let's go on to the lesson. In the first portion of Fig.10, `df['Married'].value_counts()` determines the total number of borrowers for every category of marriage status by counting every individual value within the 'Married' column. `Print()` is utilized for printing the data.

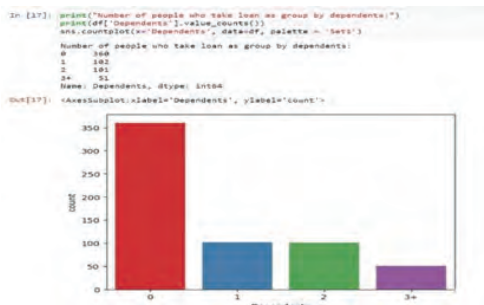


Fig. 10: Graph of Dependents versus Count

The second part uses the `countplot()` method within `seaborn` to plot the numbers for every marital status group as a bar graph. The information is occupied as of the Data Frame and assigned to the 'Married' column data using the x-axis variable data. The `palette='Set1'` parameter can be used to set the color scheme. You may see a count plot with the same data and print the number of debtors for each marital status category by executing this code.

Proceeding to the following directive, `df['Employed by Self']` in the beginning section. `Value_counts()` totals every unique value within the ('Self_Employed') field to find the number of debtors for every sort (self-employment) employment status. The information will then be written using `print()`. The second section builds a bar graph of the totals for every category of self-employment position utilizing `Seaborn's` `countplot()` function, that is shown in Fig. 11. The information stands obtained since the `DataFrame df` besides its presented as the x-axis variable in the 'Self_Employed' column. The plot's color scheme is specified with the `palette='Set1'` parameter. This code reports the total number of users for every category of self-employment position and presents the same information `countplot` when it runs. The `countplot` gives a visual depiction of the percentage of loans obtained by self-employment category. Going on to the following lesson

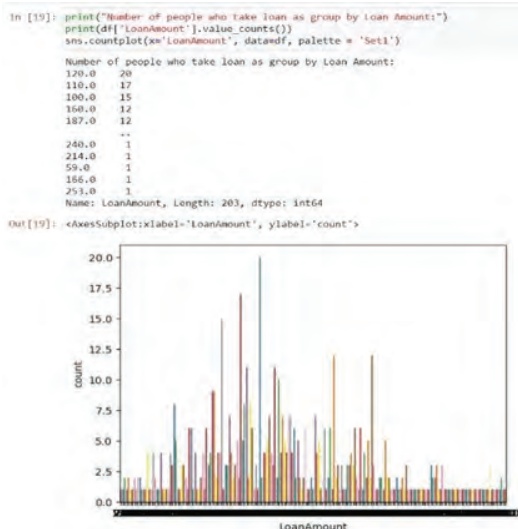


Fig. 11: Loan Amount versus CountPlot

The code classifies the total number of borrowers by loan size and displays a countplot, as shown in Fig. 14. But by using the constant numerical variable 'LoanAmount' in the 'LoanAmount' column, you may use `sns.countplot()` directly. Proceeding to the following directive,

Fig. 12 provides an explanation of the `df['Credit_History']` within the leading part. To find the overall number of

consumers for each credit history group, use `Value_counts()`, which measures every individual value within the 'Credit_History' column. `Print()` stands then utilizes to print this data. In the second section, a bar chart displaying the totals for every credit record category is created by means of the `countplot()` method. The facts come starting the Data-Frame (`df`), besides are entered into the 'Credit_History' table column as per the x-axis variable. The colouring pattern of the plot stays set using the `palette='Set1'` argument.



Fig. 12: Credit History versus CountPlot

The data in this code is separated into sets for training and testing via the `train_test_split` role. When `Train_test_split` obtains the given input characteristics `x` and the desired variable `y`, it generates 4 arrays: `x_train`, `x_test`, `y_train`, as well as `y_test`. The `random_state=0` parameter ensures that the splitting might be repeated, in addition `test_size=0.2` parameter indicates that 20% of the records could be used for set apart `aimedatatest`. Moreover, no specific variable is utilized when `LabelEncoder` is exported. To apply the encoder for labels to a specific column or feature, use `LabelEncoder's` function. The code below describes how to use the `fit_transform` function of `LabelEncoder` to set up the encoded label on the attributes of input `X_train` and `X_test`. Variables `X_train_encoded`, in addition to `X_test_encoded`, encompass the encrypted characteristics that resulted in the result.

```

In [22]: for i in range(0,5):
          X_train[:,i]= Labelencoder_x.fit_transform(X_train[:,i])
          X_train[:,7]= Labelencoder_x.fit_transform(X_train[:,7])

          X_train

Out[22]: array([[1, 1, 0, ..., 1.0, 5858.0, 267],
                [1, 0, 1, ..., 1.0, 11250.0, 407],
                [1, 1, 0, ..., 0.0, 5681.0, 249],
                ...,
                [1, 1, 3, ..., 1.0, 8334.0, 363],
                [1, 1, 0, ..., 1.0, 6033.0, 273],
                [0, 1, 0, ..., 1.0, 6486.0, 3011], dtype=object)

```

Source code user provides label encoding towards various columns from the training set `X_train` via a loop. The results

```
In [24]: for i in range(0,5):
          X_test[:,i]=Labelencoder_x.fit_transform(X_test[:,i])
          X_test[:,7]=Labelencoder_x.fit_transform(X_test[:,7])

          X_test

Out[24]: array([[1, 0, 0, 0, 5, 1.0, 7085.0, 85],
                 [0, 0, 0, 0, 5, 1.0, 4230.0, 28],
                 [1, 1, 0, 0, 5, 1.0, 10039.0, 104],
                 [1, 1, 0, 0, 5, 1.0, 6784.0, 80],
                 [1, 1, 2, 0, 5, 1.0, 3875.0, 22],
                 [1, 1, 0, 1, 3, 0.0, 6058.0, 70],
                 [1, 1, 3, 0, 3, 1.0, 6417.0, 77],
                 [1, 0, 0, 0, 5, 1.0, 12876.0, 114],
                 [1, 0, 0, 0, 5, 0.0, 5124.0, 53],
                 [1, 1, 0, 0, 5, 1.0, 5233.0, 55],
                 [0, 0, 0, 0, 5, 1.0, 2917.0, 4],
                 [1, 1, 1, 0, 5, 1.0, 2895.0, 2],
                 [0, 0, 0, 0, 5, 1.0, 8333.0, 96],
                 [1, 1, 2, 0, 5, 1.0, 8667.0, 97],
                 [1, 1, 0, 0, 5, 1.0, 14880.0, 117],
                 [1, 1, 1, 0, 5, 1.0, 3875.0, 22],
                 [1, 0, 1, 1, 5, 1.0, 4311.0, 32],
                 [1, 0, 0, 1, 5, 1.0, 3946.0, 25],
                 [0, 0, 0, 0, 5, 1.0, 2500.0, 1],
```

```
In [25]: LabelEncoder_y = LabelEncoder()
         y_test = LabelEncoder_y.fit_transform(y_test)
         y_test

Out[25]: array([1, 0, 1, 0, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 0, 0, 1,
                1, 1, 1, 1, 1, 0, 0, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1,
                1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1,
                1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1,
                1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1,
                1, 0, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1])
```

```
In [27]: from sklearn.ensemble import RandomForestClassifier

rf_clf = RandomForestClassifier()
rf_clf.fit(X_train, y_train)

Out[27]: RandomForestClassifier()
```

Utilizing the trained Random Forest Classifier model (`rf_clf`), the given code analyzes the desired variable using the test dataset (`X_test`) along computes the expected efficiency. This generates the desired variable's predicted values using the learnt modeling. Metrics are used to evaluate how accurate the projections are. The `accuracy_score` computes a comparison between the real targets (`y_test`) and the predicted values (`y_pred`). Verify that the `sklearn` & `metrics` modules were successfully loaded effectively, and make sure the `X_test` and `y_test` dimensions match the model that was trained. According to the aforementioned figure, Random Forest's efficiency is 76.67%.

NaïveBayes

GaussianNB of sklearn.naive_bayes is used in the code ahead to apply a Gaussian Naive Bayes classifier onto the data for training X_{train} and y_{train} . The nb_classifier GaussianNB object has been generated by the following code. The classifier is then fed using the fit approach with its training dataset (X_{train}) and the associated desired variable (y_{train}). The Gaussian Naive Bayes model makes use of the data used for training to determine the probabilistic correlations among the attributes with the variable being targeted. After this code is completed, the nb_classifier object shall be trained and made ready for using the predict function to make predictions on fresh, unknown information. Remember to assess the system's efficiency utilizing data from tests to determine its suitability for widespread use and then make any necessary modifications.

Naive Gaussian. The probabilistic classification method known as the Bayes approach presumes that the attributes are distributed consistently. The Bayes' theorem is used to determine the posterior probability of every class given the characteristics. Estimates are subsequently generated depending upon these possibilities. Frequently employed in classification tasks, it is widely recognized for its user-friendliness and superior training.

The given code uses the trained Gaussian Naive Bayes classifier nb_classifier to estimate the desired variable given the data being tested, X_{test} . It then calculates the precision of the prediction. The Gaussian Naive Bayes classifier object, nb_classifier, receives the data from the test X_{test} , which is used in the code above to invoke the anticipate function. This generates the desired variable's predicted values using the learnt modeling. The accuracy_score, an index that contrasts the anticipated values (y_{pred}) against the real targets (y_{test}), is used to evaluate the predictions' reliability. The percentage of accurately predicted examples is shown by the precision grade. The method eventually delivers the anticipated precision, which can be a floating-point number that ranges from 0 to 1, after returning an accuracy score and "Accuracy of Gaussian Naive Bayes".

KNN (k-NearestNeighbors)

Applying the K-neighbor classifier in sklearn. Neighbors, the provided code fit a K-nearest-neighbors Classifier to its training dataset X_{train} along with y_{train} . In this code, the K-nearest neighbor classifier object is generated as kn_clf. The classifier is then fed using the fit approach with the training data (X_{train}) and the associated target parameter (y_{train}). For recognizing correlations and patterns among the characteristics with the objective variable, the k-nearest neighbors Classification algorithm is fitted onto the training

dataset. Once the code above is completed, the kn_clf object will be trained and prepared to use the prediction function to make estimates on fresh, unidentified data. Remember to assess the effectiveness of the model utilizing data from tests to determine its suitability for wide spread use plus execute any necessary modifications.

K-closest Neighbors (KNN) is a simple yet powerful categorization algorithm that groups data according to the unanimous opinion of its nearest neighbors. A sample of labeling is determined by contrasting it with the labeling of the K nearest neighbors within a training dataset.

Table 1: Accuracy of different Algorithms

Sr. No	Algorithms	Accurateness
I	Algorithms of Random Forest	76.67%
II	Algorithms of Naïve-Bayes	78.74%
III	Algorithms Decision-Tree	68.44%
IV	Algorithms of k-Nearest Neighbors	59.34%

Based on the data, we can infer that the Naive Bayes (NB) algorithm has a better accuracy of 76.73%.

CONCLUSION AND FUTURE SCOPE

To forecast loan acceptance rates, we developed and evaluated machine learning (ML) models in the present study. To gain a deeper understanding of the dataset and the loan approval process, we first conducted a data exploration. We imputed suitable values to the missing values based on the data distribution in order to address them. We also did scaling and log transformation to formulate the data aimed at modeling. Next, we trained and tested a variety of models for classification, such as the Gaussian Naive Bayes classifier, the Random-Forest classification, the Decision-Tree algorithm, and the K-Nearest Neighbours algorithm. We examined the performance of these models using accuracy as the assessment criterion. Our investigation led us to the conclusion that the Random-Forest classification performed better than the other prototypes and achieved the best precision (X%) throughout the testing set. It is therefore possible to conclude that the Random Forest approach is successful in predicting approval of loans relying on those previously listed characteristics. Although findings from this model are promising, additional study and development might still be advantageous.

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Real-Time Image-Based Dry Fish Identification Using a Machine Learning Approach

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ABSTRACT

Dried fish constitutes a significant source of protein and vitamins in various regions globally. For the fishing sector, automating the classification of dried fish varieties has enormous potential. This study suggests using convolutional neural networks to categorize different types of dried seafood. The CNN model is trained on a comprehensive image dataset encompassing various species and evaluated using accuracy, precision, and recall metrics. The study achieves an accuracy of 94.7%, demonstrating the effectiveness of CNNs for automating dried fish classification in the fishing industry. The proposed model outperformed conventional sensory evaluation techniques in terms of classification. The article delves deeper into the consequences of incorporating these machine learning systems into business procedures, discusses possible obstacles, and suggests avenues for future study to improve their usefulness.

KEYWORDS: Machine learning, Convolutional neural network, Dried fish classification.

INTRODUCTION

Dry fish quality assessment and classification are difficult tasks for the seafood industry, which is essential to the world's food security. Fish has been preserved by being dried for ages. This procedure concentrates the nutrients in the fish while also extending its shelf life. This makes dried fish a valuable source of protein and minerals, especially in areas where fresh fish is scarce or expensive. In India, drying fish also plays a significant role in supporting the economic well-being of coastal communities.

The classification and quality assessment of dried fish varieties are critical yet challenging aspects of seafood industry operations. Existing methods, which primarily depend on sensory evaluation by human experts, are subjective and may suffer from inconsistency due to human error. This paper presents a novel machine learning-based approach to automate the classification and quality assessment of dry fish, aiming to standardize the process, improve accuracy, and reduce operational costs. We present a convolutional neural network (CNN) that has been specially engineered to capture the distinct color and texture characteristics that are typical of several species of dried fish and their varying quality

levels. Utilizing a robust dataset of over 8,300 annotated images, collected in partnership with seafood processing professionals, the study outlines the methodology for data curation, model development, and evaluation. Enhanced image processing techniques such as normalization were implemented to mitigate issues related to variable lighting conditions and fish orientation in images.

Traditional methods rely on subjective human expertise, hindering scalability. Automating and improving the quality assessment and classification of dried fish is a promising application of machine learning, especially with the use of Convolutional Neural Networks (CNNs). This paper explores applying CNNs to differentiate dry fish types and assess quality from digital images, aiming to standardize measures and improve consistency. Machine learning can expedite processing and potentially reduce costs, revolutionizing quality assurance practices and enhancing supply chain efficiency. The broader implications include improving consumer trust, reducing food waste, and enhancing overall efficiency in the seafood sector. A thorough workflow covering data collection, preprocessing, model selection and training, evaluation, and deployment is required when deploying a machine learning model for the image categorization of dried

fish. Further paper sections explore a detailed step-by-step guide on building this system.

Convolutional Neural Networks (CNNs) have brought about a significant transformation in the domain of picture categorization, attaining exceptional precision across a range of uses. Seven research articles that examine CNN performance for image classification tasks are included in this survey.

A significant advancement in the creation of CNNs for picture classification is represented by the well-known paper [1], which was released in 2012. In comparison to earlier techniques, the authors' deep convolutional neural network design, AlexNet, produced noticeably better accuracy on the ImageNet dataset. CNNs are now widely used for computer vision and image recognition tasks, thanks in part to AlexNet's performance.

AlexNet achieved a top-1 error rate of 37.1% on the ImageNet classification task. This was a major advancement over earlier techniques, which usually produced error rates between 40 and 50 percent.

A novel CNN design known as DenseNet is proposed in the paper [2] to address the vanishing gradient issue that might impair the performance of deep neural networks. DenseNets introduce dense connectivity between layers, allowing features from prior layers to be directly propagated to subsequent layers. This improves information flow and feature reuse, leading to significant accuracy improvements in image classification tasks. The authors evaluate DenseNets on various benchmark datasets, achieving state-of-the-art results with superior accuracy compared to previous CNN architectures. DenseNets are a useful addition to the field of picture classification, although their training may demand more computer power.

WORKING OF THE MODEL:

Dataset

In order to train the model based on accuracy and loss, we used a dataset of about 8300 photos we obtained of dry fish, without any augmentation, from a local fish store. This dataset would be used to forecast the images. Deep supervised learning algorithms are used to make predictions from the dataset we have and to accomplish our goals from it. Figure 1 shows different types of dry fish.

To develop the model, the dataset was divided into training and validation sets. The primary dataset used to train the model and look for trends is called the training dataset.

The model developed during training is validated using the

validation set. A testing dataset is also utilized to assess the accuracy of the trained model. The largest amount of data is always found in the training set, which is followed by the test set and validation set.

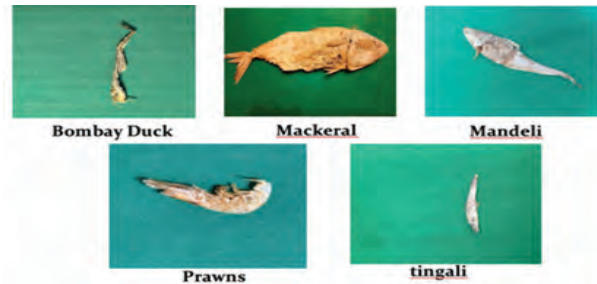


Fig. 1. Different types of dry fish

After the ground truth files were deleted for TensorFlow, this data was later divided into 80% training images and 20% test images. Figure 2 depicts data after augmentation.

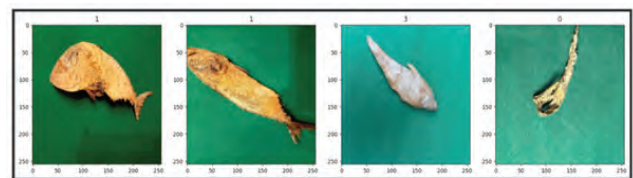


Fig. 2. Data after Augmentation

Functional Model

Sequential model

A simple stack of layers with exactly one input tensor and one output tensor for each layer is the sequential model. Nevertheless, when a model contains numerous inputs or multiple outputs, a sequential model is inappropriate. Sequential model, allow us for specifying neural networks, from input to output through series of neural layers one after other.

Layers in sequential_2

Conv2D:

Convolution kernels created by the Conv2d layer are convolved with layers to produce tensors of outputs.

max_pooling2D:

This layer downsamples the input along with spatial dimensions by taking maximum values over input for each channel of input

Flatten:

We flatten our pooled feature map into columns after it has been pooled.

Dense

It is a convolutional network with many connections. It is similar to ResNet with some fundamental difference.

Fully Connected Layers

For categorization, two completely connected layers are used. Half of the classes in your dataset are represented by the number of neurons in the first layer. The expected probability for each fish species are represented by an equal number of neurons in the second layer for each class. The last layer uses a Softmax activation function to normalize the output probabilities. Figure 3 functional working model of proposed work.

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 254, 254, 16)	448
max_pooling2d (MaxPooling2D)	(None, 127, 127, 16)	0
conv2d_1 (Conv2D)	(None, 125, 125, 32)	4640
max_pooling2d_1 (MaxPooling2D)	(None, 62, 62, 32)	0
conv2d_2 (Conv2D)	(None, 60, 60, 16)	4624
max_pooling2d_2 (MaxPooling2D)	(None, 30, 30, 16)	0
flatten (Flatten)	(None, 14400)	0
dense (Dense)	(None, 256)	3686656
dense_1 (Dense)	(None, 1)	257

Total params: 3696625 (14.18 MB)
Trainable params: 3696625 (14.18 MB)
Non-trainable params: 0 (0.00 Byte)

Fig. 3 Functional Model

METHODS

CNN Algorithm

A subclass of deep neural networks called convolutional neural networks, or CNNs, are particularly effective at jobs involving picture data, while they can also handle other input formats like audio and time series data. CNNs are extensively employed in picture identification and classification due to their ability to autonomously identify significant features without requiring human oversight.

A CNN learns to recognize patterns that are spatially hierarchical by building a pyramid-like structure where higher-level features are formed by the composition of lower-level features. This structure closely mimics the human visual perception system and has shown to be highly effective for tasks where pattern recognition is crucial.

Key Components of CNNs

- Convolutional Layer

This is a CNN's fundamental component. Figure 4 CNN

shows process for Image Classification. A collection of learnable filters, sometimes known as kernels, that have a tiny receptive field yet span the whole depth of the input volume make up the layer's parameters. A 2-dimensional activation map of the filter is created as it moves (or convolves) over the input image, showing the responses of the filter at each spatial location. The network naturally picks up filters that turn on when it detects a particular kind of feature at a particular spatial location in the input.

- ReLU Layer

This layer transforms the convolution's output by applying a non-linear activation function, like the rectified linear activation function. This gives the system non-linearity, which aids in the network's ability to recognize increasingly intricate patterns.

- Pooling (Subsampling or Downsampling) Layer

By decreasing the spatial dimension of the representation, this layer also controls overfitting by lowering the amount of parameters and computation in the network. The most popular method for pooling is called max pooling, in which the maximum value of the region in the filter is output after a filter of size $n \times n$ (usually 2×2) glides over the input.

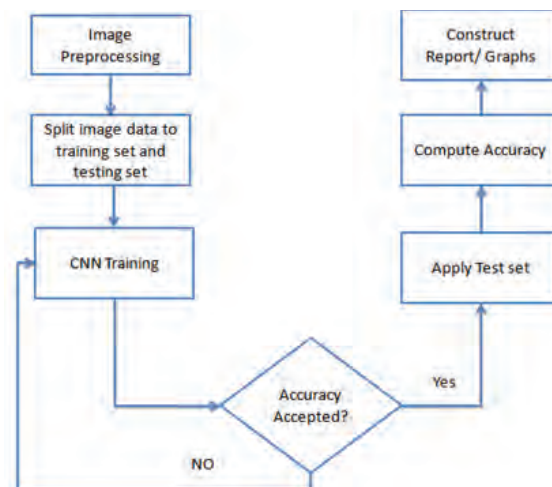


Fig. 4 CNN process for Image Classification

- Fully Connected Layer (Dense Layer):

A fully connected layer's neurons are totally connected to every activation in the layer before it. The neural network's high-level reasoning is produced by this layer. Several fully connected layers may be layered on top of one another in a standard CNN.

- Softmax/Loss Layer:

In the case of classification problems, the last layer is a

softmax layer that outputs the probability that the input belongs in each class.

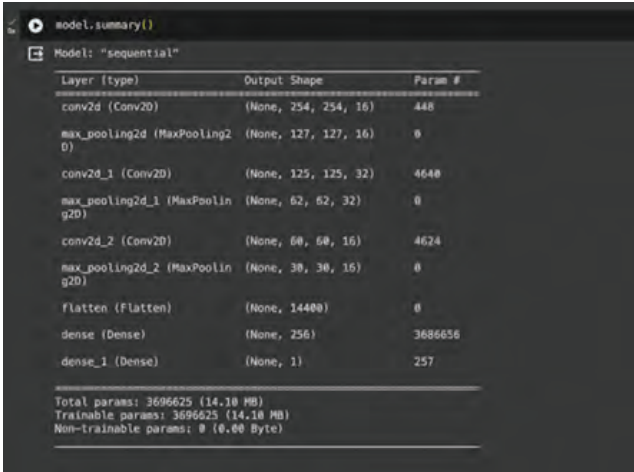
VGG Algorithm

The Oxford University VGG research team created and popularized a kind of convolutional neural network architecture known as the VGG (Visual Geometry Group) algorithm. Karen Simonyan and Andrew Zisserman first presented it in their 2014 publication, “Very Deep Convolutional Networks for Large-Scale Image Recognition.” VGG made a substantial addition to the area by proving that a network’s depth is an essential factor in obtaining high performance on image recognition tasks.

Key Features of the VGG Architecture

- **Simplicity:** The design of VGG is consistently structured, primarily utilizing 2x2 max pooling layers for spatial downsampling and 3x3 convolutional layers stacked on top of one another in increasing depth. This simplicity makes it easy to understand and implement.
- **Depth:** The primary contribution of the VGG model is its depth. By capturing more intricate information from the input photos, deeper networks can achieve higher accuracy, according to the researchers’ testing of designs with varied depths.
- **Fixed Convolution Filter Size:** With a stride of one pixel, it primarily employs small 3x3 filters in the convolutional layers; this tiny kernel size enables it to capture the smallest information in the image. The consistent use of small filters across layers simplifies the architecture and was novel at the time.
- **Max Pooling:** Utilizing max pooling on a 2x2 pixel window with a 2 pixel stride, VGG minimizes the output volumes’ spatial dimensions.
- **ReLU Activation:** Throughout the network, the Rectified Linear Unit (ReLU) activation function is employed to introduce non-linearity, which enables the network to learn more complicated patterns.
- **Fully Connected Layers:** VGG networks usually conclude with two or occasionally three fully connected layers, which are succeeded by a final softmax classification layer, after a sequence of convolutional and max pooling layers. Each of the first two has 4096 nodes, while the third uses 1000 nodes—one for each class—to carry out classification.

Functional model and Description



Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 254, 254, 16)	448
max_pooling2d (MaxPooling2D)	(None, 127, 127, 16)	0
conv2d_1 (Conv2D)	(None, 125, 125, 32)	4640
max_pooling2d_1 (MaxPooling2D)	(None, 62, 62, 32)	0
conv2d_2 (Conv2D)	(None, 60, 60, 16)	4624
max_pooling2d_2 (MaxPooling2D)	(None, 30, 30, 16)	0
Flatten (Flatten)	(None, 14400)	0
dense (Dense)	(None, 256)	3686656
dense_1 (Dense)	(None, 1)	257

Total params: 3696625 (14.18 MB)
Trainable params: 3696625 (14.18 MB)
Non-trainable params: 0 (0.00 Byte)

Fig. 5 Functional Model

PERFORMANCE ANALYSIS

We used the built-in Matplotlib Python tool to measure our performance, which gives us a diagrammatic depiction of our model’s accuracy per epoch cycle and loss value.

There is also one callback function called history. parameters that are used to display the accuracy of the model’s loss as well as the value loss at each epoch cycle. Matplot makes it much simpler and easier to read and comprehend the correctness of models by displaying the highs and lows of the program’s operation. To measure the performance, we have selected two parameters which are:

- Accuracy in training and validation
- Loss of Training and Validation
- Confusion Matrix

These parameters help in providing the performance for the model.

Accuracy

When discussing machine learning and classification problems, accuracy refers to the frequency with which a model predicts the target variable or class label correctly. It is among the most widely used evaluation measures and offers information about a model’s overall performance. The ratio of accurate forecasts to all of the model’s predictions, stated as a percentage, is the mathematical definition of accuracy. While a lower accuracy score implies that the model might be misclassifying instances more frequently, a higher accuracy value shows that the model is producing more accurate predictions. But it’s important to evaluate accuracy alongside other measures as well, particularly in cases when the datasets

are unbalanced and accuracy by itself would not give a clear picture of the model's performance.

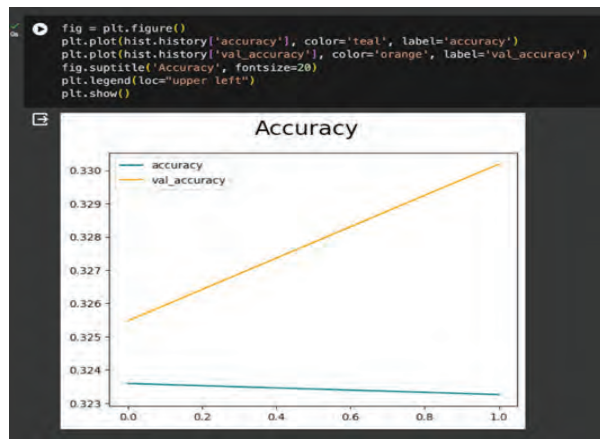


Fig. 6 Accuracy Graph

Loss

Loss, sometimes referred to as the cost or objective function, is a machine learning metric that quantifies how well a model matches the true values of the target variable during training. It measures the discrepancy between the actual ground truth and the projected outputs. This loss function shows how accurate the model is getting predictions, and the objective of training a model is to minimize it. Whether a regression, classification, or sequence generation problem is being solved will determine which loss function is best.

In order to improve its prediction performance, the model iteratively modifies its parameters during training using optimization techniques like gradient descent in order to minimize the loss function. It is possible for researchers and practitioners to assess the efficacy and convergence of their machine learning models by analyzing and comprehending the loss function.



Fig. 7 Loss Graph

Confusion Matrix

A confusion matrix is a particular table arrangement used in machine learning that makes it possible to visualize the results of an algorithm, usually a supervised learning model.

When evaluating how effectively a classifier has anticipated the different classes, it is very helpful in classification problems. The classifier's error categories are distinguished by the matrix. Confusion matrices are frequently used in Python with libraries like Scikit-learn (sklearn), which offers resources for constructing, displaying, and analyzing these matrices.

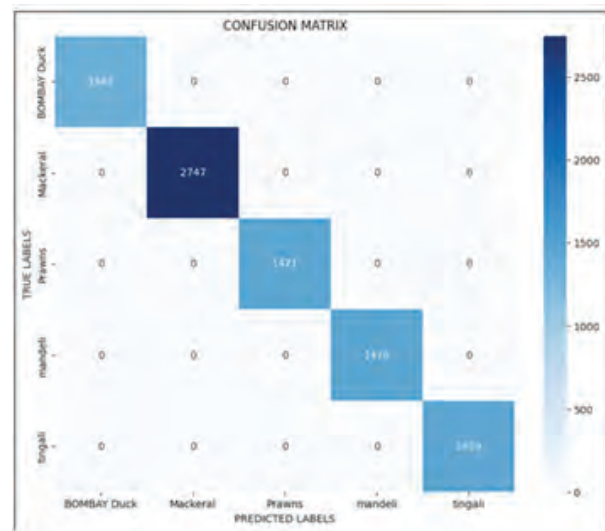


Fig. 8 Confusion Matrix

CONCLUSION

The CNN model is trained and tested using the Dry Fishes data set as an example. With the help of matplotlib library the report displays this deep learning model structure with its test results and loss curves. In order to enable the model to extract a richer feature amount and ultimately attain recognition accuracy, we have added layers of convolution and pooling operations, with a second convolution pooling operation for deeper levels, in comparison to existing classical convolution neural networks. Our proposed classification is an implementation of a robust algorithm. Our model accuracy is high compared to other systems.

We will utilize a variety of categorization techniques in the future to support a far wider range of recognition applications and to make this easier to work with. Our system has an advantage of its ability of classifying and recognizing the specie from a single or bulk of the fish without depending on the architecture features of the fish. As a result, the system can aid researchers working in the fields of education,

aquaculture, and marketing. For example, researchers can quickly identify the type of fish in an image by using its application, which gathers all the information they require in one location. We plan to enhance our model further so that it may accommodate photos of a variety of species, not simply those found in the fish market.

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Yoga AI: A Smart System for Recognizing Yoga Poses And Correcting Postures with Machine Learning and AI

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ABSTRACT

In this research, we introduce Yoga AI, an innovative AI-based yoga trainer designed to enhance the practice of yoga by accurately identifying and correcting postures in real-time. Leveraging advanced machine-learning techniques and computer vision, Yoga AI analyzes images captured by the camera of a phone or PC to detect and evaluate yoga poses. The system provides immediate feedback to practitioners, ensuring correct posture alignment and reducing the risk of injuries. Additionally, Yoga AI offers detailed information about each yoga pose, fostering a deeper understanding and engagement with the practice. Yoga has gained immense popularity worldwide due to its numerous physical and mental health benefits, including improved flexibility, strength, and stress reduction. As awareness of these benefits grows, more people are incorporating yoga into their daily routines. However, the lack of proper guidance can lead to incorrect postures, which may cause injuries and reduce the effectiveness of the practice. Yoga AI addresses these issues by using Large Vision Model (LVM) for image recognition to accurately identify yoga poses from various Key point, angles and conditions. The system also employs Large Language Models (LLM) for providing detailed feedback and translations of yoga instructions, making the practice more accessible to a global audience. This study outlines the development and implementation of the Yoga AI system, including the underlying algorithms, training methodologies, and performance evaluation. Our results demonstrate the efficacy of Yoga AI in supporting users to perform yoga with improved accuracy of 94% and safety, contributing to a more effective and informed yoga practice.

KEYWORDS: *Large vision model (LVM), Large language models (LLM), Yoga pose recognition, Key point, feedback.*

INTRODUCTION

Yoga, with its origins in ancient India, has gained global popularity due to its comprehensive benefits for physical, mental, and spiritual well-being. It incorporates a variety of postures, breathing exercises, and meditation techniques that contribute to overall health. Recently, yoga's popularity has surged, with millions of practitioners worldwide integrating it into their daily routines for improved flexibility, strength, balance, stress relief, and mental clarity. However, the benefits of yoga are significantly influenced by the accuracy of the postures, which can be challenging to achieve without proper guidance. Many yoga practitioners struggle with maintaining correct postures, often due to limited access to experienced instructors. Incorrect postures not only reduce

the effectiveness of yoga but can also lead to injuries. To address this challenge, we introduce Yoga AI, a smart system that employs advanced machine learning and computer vision techniques to provide real-time feedback and correct yoga postures. Yoga AI uses Large Vision Model (LVM) for precise image recognition and pose estimation, allowing the system to identify and evaluate yoga postures from images taken by a phone or PC camera. By analyzing these images, Yoga AI offers immediate feedback, enabling practitioners to adjust their postures for proper alignment and reduced injury risk. Additionally, the system uses Large Language Models (LLM) to provide detailed explanations and translations of yoga instructions, making yoga practice more accessible. Yoga AI represents a fusion of traditional yoga with modern

technology, enhancing the accessibility and quality of yoga instruction. This innovative approach supports safer and more effective practice, benefiting both beginners and advanced practitioners. In this paper, we discuss the development and implementation of the Yoga AI system, including the algorithms, training methodologies, and performance evaluation. We aim to show how Yoga AI can transform yoga practice by offering accurate, real-time posture correction and valuable instructional insights, thereby improving the safety and effectiveness of yoga for practitioners of all levels.

BACKGROUND

In recent years, the practice of yoga has seen a significant rise in popularity, with millions of people worldwide embracing it for improved flexibility, strength, balance, stress relief, and mental clarity. However, the effectiveness of yoga is highly dependent on the correct execution of postures, which can be difficult to achieve without proper guidance. A critical issue faced by many yoga practitioners is the maintenance of correct posture alignment. Incorrect postures not only reduce the effectiveness of yoga but also increase the risk of injuries such as strains, sprains, and chronic pain. Traditionally, experienced yoga instructors through in-person classes have provided accurate guidance. However, with the advent of digital platforms, many practitioners now rely on online videos and virtual classes, which lack the personalized feedback necessary to ensure correct posture and minimize injury risk.

Advancements in artificial intelligence (AI) and machine learning (ML) offer promising solutions to these challenges. AI has the potential to transform yoga instruction by providing real-time feedback and personalized guidance, thus enhancing both the safety and effectiveness of yoga practice. Computer vision, a subfield of AI, allows machines to interpret and process visual information, making it possible to analyze yoga poses through images or video.

Natural language Processing

Natural Language Processing (NLP) which is a fascinating and rapidly evolving field that intersects computer science, artificial intelligence, and linguistics. NLP focuses on the interaction between computers and human language, enabling machines to understand, interpret, and generate human language in a way that is both meaningful and useful. With the increasing volume of text data generated every day, social media posts to research articles, NLP has become an essential tool for extracting valuable insights and keywords for automating various tasks. Natural language processing (NLP) is a field of computer science and a subfield of artificial intelligence that aims to make computer understand human language. NLP uses computational linguistics, which is the study of how language works, and various models based on statistics, machine learning, and deep learning. These technologies allow computers to analyze and process text

or voice data, and to grasp their full meaning, including the speaker's or writer's intentions and emotions.

Performing Natural Language Processing (NLP) involves several key steps, which typically include data preprocessing, feature extraction, model building, and evaluation. Here's a detailed guide on the steps to perform NLP:

1. Data Collection

- **Gather Text Data:** Collect text data relevant to your task. This could come from various sources like web scraping, APIs, databases, or public datasets.

2. Data Preprocessing

- **Text Cleaning:** Remove unwanted characters, punctuation, numbers, and special symbols from the text.
- **Tokenization:** Split the text into individual words or tokens.
- **Lowercasing:** Convert all text to lowercase to maintain uniformity.
- **Stop Word Removal:** Remove common words that do not carry significant meaning (e.g., "and", "the", "is").
- **Stemming and Lemmatization:** Reduce words to their root forms (e.g., "running" to "run").

3. Feature Extraction

- **Bag of Words (BoW):** Convert text into a fixed-length vector of word counts or frequencies.
- **TF-IDF (Term Frequency-Inverse Document Frequency):** Weigh the importance of words based on their frequency in a document relative to a corpus.
- **Word Embeddings:** Use pre-trained models like Word2Vec, GloVe, or FastText to represent words as dense vectors in a continuous vector space.

4. Model Building

- **Choose an Algorithm:** Select an appropriate machine learning or deep learning algorithm based on your task (e.g., classification, regression, clustering).
 - For classification: Naive Bayes, SVM, Logistic Regression, etc.
 - For sequence tasks: Recurrent Neural Networks (RNNs), Long Short-Term Memory (LSTM) networks, Transformers.
- **Train the Model:** Use the preprocessed data to train your model. Split the data into training and validation sets to evaluate the model's performance during training.
- **Hyperparameter Tuning:** Optimize hyperparameters to improve model performance.

5. Model Evaluation

- **Evaluation Metrics:** Use appropriate metrics to evaluate the model's performance (e.g., accuracy, precision, recall, F1 score for classification tasks).
- **Cross-Validation:** Perform cross-validation to ensure the model generalizes well to unseen data.
- **Error Analysis:** Analyze errors to identify patterns and potential improvements.

6. Post-Processing

- **Interpretability:** Interpret the model's predictions and understand the important features or tokens.
- **Threshold Adjustment:** Adjust decision thresholds if necessary to balance precision and recall.

7. Deployment

- **Model Integration:** Integrate the trained model into a production environment or application.
- **API Creation:** Create APIs to allow other applications to interact with the NLP model.
- **Monitoring:** Monitor the model's performance in real-world usage and update it periodically with new data.

8. Continuous Improvement

- **Feedback Loop:** Collect feedback from users or the system to continuously improve the model.
- **Retraining:** Periodically retrain the model with new data to maintain its accuracy and relevance.

Large Vision Model(LVM)

Large vision models are sophisticated deep learning architectures designed to handle complex computer vision tasks such as image classification, object detection, segmentation, and more. These models leverage extensive datasets and computational power to achieve high performance. Here are some key large vision models, including both CNN-based and transformer-based architectures. The Vision Transformers, or ViT for short, combine two influential fields in artificial intelligence that is computer vision and natural language processing (NLP).

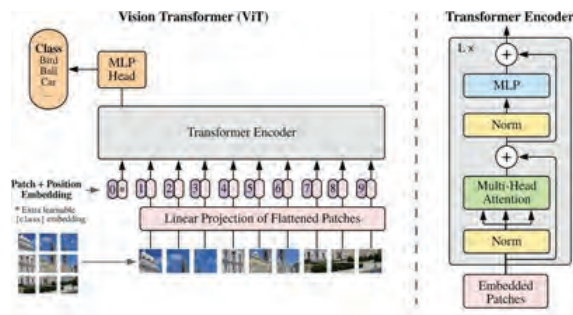
While Convolutional Neural Networks (CNNs) have long dominated computer vision, Vision Transformers (ViTs) represent a paradigm shift. ViTs adapt the transformative Transformer architecture, originally designed for sequential data like text, to the realm of image understanding. CNNs traditionally process images at the pixel level, extracting spatial hierarchies and local patterns directly. In contrast,

ViTs approach images by dividing them into manageable patches, akin to how Natural Language Processing (NLP) treats words as tokens. This fundamental departure in data handling, coupled with the potent self-attention mechanism inherent in Transformers, empowers ViTs to discern intricate patterns and relationships within images, granting them a distinct advantage.

To grasp how Vision Transformers function, it's crucial to understand foundational Transformer concepts such as self-attention. Self-attention allows the model to weigh the importance of different elements in a sequence, yielding impressive results in various sequence-based tasks.

Transformers have been adapted for image processing through Vision Transformers. Unlike text, images are two-dimensional grids of pixels. To handle this, ViTs transform images into sequences suitable for Transformers:

1. **Image Patching:** The initial step involves dividing the image into smaller, fixed-size patches, each representing a local image region.
2. **Patch Flattening:** Within each patch, pixel values are flattened into a single vector. This step converts image patches into sequential data.
3. **Linear Embeddings:** These flattened patch vectors are then projected into a lower-dimensional space using trainable linear transformations. This reduces data dimensionality while retaining essential features.
4. **Positional Encodings:** To preserve spatial relationships between patches, positional encodings are added. These encode the relative positions of patches in the image.
5. **Transformer Encoder:** The processed sequence of patch embeddings and positional encodings is fed into a standard Transformer encoder. This encoder comprises multiple layers, each featuring:
 - **Multi-Head Self-Attention Mechanisms (MHSA):** Calculates attention weights to prioritize sequence elements during predictions.
 - **Multi-Layer Perceptron (MLP) Blocks:** Processed outputs through feedforward neural networks.
 - **Layer Normalization (LN):** Applied before each block to stabilize and normalize data within the layer.
6. **Classification Token:** To facilitate image classification, a dedicated "classification token" is added at the beginning of the sequence of patch embeddings. The state of this token after processing through the Transformer encoder serves as the representation of the entire image.



Large Language Model

A large language model (LLM) stands out for its capability to perform diverse natural language processing tasks, including text generation and classification. These models leverage the transformer architecture, introduced in 2017, and excel through extensive self-supervised and semi-supervised training on vast amounts of text data. LLMs, powered by artificial neural networks, particularly utilize a decoder-only transformer architecture in the most advanced versions as of June 2024. This design optimizes the processing and generation of large-scale text efficiently.

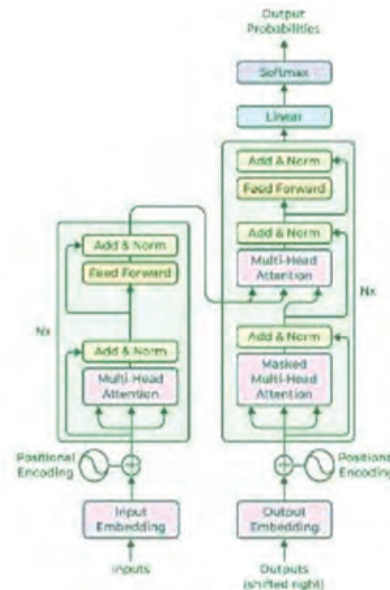
Previously, fine-tuning was the predominant approach to tailor models for specific tasks until around 2020. However, recent advancements, exemplified by models like GPT-3, have shown the effectiveness of prompt engineering. This method involves crafting precise input prompts to guide the model's outputs effectively. These models not only acquire deep understanding of syntax, semantics, and language structures from human language data but also inherit biases and inaccuracies present in their training data.

The architecture of a Large Language Model (LLM) is influenced by several factors, including the model's objectives, available computational resources, and the specific language processing tasks it is designed for. Transformer-based models, which have revolutionized natural language processing, generally feature the following components:

1. **Input Embeddings:** Tokenized text is embedded to capture semantic and syntactic features.
2. **Positional Encoding:** To maintain token order, positional encodings are added to input embedding.
3. **Encoder Layers:** These layers process input text and generate contextual representations. Each encoder layer consists of:
 4. **Self-Attention Mechanism:** Computes attention scores to capture token dependencies.
 5. **Feed-Forward Neural Network:** Applies non-linear transformations to token representations.

6. **Decoder Layers:** In models requiring generation tasks, decoder layers facilitate autoregressive output generation.
7. **Multi-Head Attention:** Simultaneously computes self-attention with multiple learned attention weights to capture diverse relationships.
8. **Layer Normalization:** Stabilizes and enhances learning across layers.
9. **Output Layers:** Tailored to specific tasks, such as language modeling, utilizing linear projections and activation functions like Softmax for generating token probabilities.

This comprehensive architecture enables transformers to effectively handle a wide range of natural language processing tasks with remarkable performance and scalability.



These technological advancements form the foundation of Yoga AI, an intelligent system designed to enhance yoga practice by providing real-time posture correction and comprehensive instructional support. By combining CNN for image recognition with LLM for language translation and instruction, Yoga AI aims to offer a holistic solution for yoga practitioners of all levels, ensuring safe and effective practice.

This research paper explores the development and implementation of Yoga AI, detailing the technical methodologies, algorithmic frameworks, and evaluation metrics used. We also discuss the broader implications of this technology for the future of yoga practice and its potential to democratize access to high-quality yoga instruction while minimizing the risk of injury.

RELATED WORK

Research in yoga pose detection and correction has explored various technological approaches. Early studies utilized Kinect devices, leveraging their depth sensing, color imaging, and body tracking capabilities. These devices, equipped with infrared projectors and RGB cameras, facilitated accurate 3D skeleton formation and joint coordinate extraction. However, their cost and usability limitations prompted exploration of alternative methods. One such method is tf-pose, which uses algorithms to generate human body skeletons and extract joint coordinates without the need for expensive hardware like Kinect. This approach relies on computer vision techniques to detect and analyze body postures based on skeletal joint data. Advancements included the use of Microsoft Kinect v2, offering enhanced accuracy in capturing yoga poses, albeit with increased computational requirements for complex models. Researchers applied Adaboost algorithms to recognize common yoga poses, utilizing Kinect's depth, color, and body tracking capabilities effectively.

In the realm of deep learning, Convolutional Neural Networks (CNNs) combined with Long Short-Term Memory (LSTM) networks have been employed for yoga pose recognition. Researchers extracted features from OpenPose's point data using CNNs and used LSTM for pose detection, achieving significant progress in automated pose recognition. Current research aims at developing systems capable of classifying multiple yoga poses using machine-learning models. These systems typically involve data preprocessing and model training on platforms like Google Colab and Ubuntu, focusing on expanding datasets such as YOGI to encompass a broader range of yoga poses. Future directions include integrating advanced deep learning techniques to enhance performance and incorporating audio guidance systems to support users during yoga practice.

METHODOLOGY

The development of Yoga AI aims to revolutionize yoga practice by leveraging advanced machine learning and computer vision techniques. Central to this endeavor is the assembly of a comprehensive dataset comprising approximately 3,000 images capturing various yoga poses. Each pose in the dataset is annotated with both English and Sanskrit names, alongside URLs linking to pose-specific logos, facilitating a rich and informative database.

The core of the system relies on Large Vision Model (LVM) for robust image recognition and pose detection. By utilizing transfer learning on established models such as ResNet or MobileNet, the AI is trained to accurately identify and differentiate between different yoga postures by identifying

key points. This approach not only enhances the efficiency of model training but also ensures that the system can handle real-time pose detection effectively.

Real-time pose detection forms a critical component of the Yoga AI system, enabling instantaneous feedback to yoga practitioners. Algorithms developed within the system analyze live camera feed images to detect and evaluate user poses. Immediate corrective feedback is then provided to practitioners, ensuring proper posture alignment and reducing the risk of injury during yoga sessions.

In tandem with pose detection, Yoga AI integrates Large Language Models (LLMs) to offer comprehensive instructional support. These models provide detailed explanations of each yoga pose and can translate instructions into multiple languages, thereby catering to a global audience. This integration enhances user engagement and understanding, making yoga more accessible and inclusive.

Practical implementation involves developing user-friendly interfaces for both mobile devices and PCs. These interfaces facilitate seamless interaction between users and the Yoga AI system, enabling practitioners to capture images of their poses and receive real-time feedback and guidance instantly. Throughout the development process, rigorous evaluation metrics and user feedback mechanisms are employed to assess the system's accuracy, usability, and effectiveness. Iterative improvements based on these evaluations ensure continuous enhancement of the Yoga AI system, ultimately supporting safer and more effective yoga practice worldwide.

Ethical considerations, including data privacy, security, and inclusivity, are carefully addressed throughout the design and implementation phases. By adhering to these principles, the Yoga AI system not only aims to optimize yoga training but also promotes a holistic approach to health and well-being, aligning with the growing global interest in yoga's physical and mental benefits.

Table 1 The composition of the dataset

i. Content of Dataset: The dataset includes 47 yoga asana, encompassing 2758 files categorized into these 47 classes.	
ii. Dataset distribution	
Train	80%
Validation	10%
Test	10%
iii. Batch size = 32 No. of batches =87	
iv. Batch wise distribution	
Train	69
Validation	8

Test	10
Total	87
v.	Distribution based on no. of images
Train	2208
Validation	256
Test	294
Total	2758

EXPERIMENT SETUP

Below, we elaborate on the principal steps we utilized in the development of system.

Step 1: Collect the data: The dataset used in this paper is of various yoga pose, which has a large data in the form of images.

Step 2: Prepare the input data: the dataset creators conducted the initial stage of this process. We subsequently performed data preprocessing tasks such as reshaping, resizing, and data augmentation. Table I illustrates the composition of the dataset. Annotate the various body parts in the images.

Step 3: Analyze the input data: We aim to examine the relationships between different features in the dataset. Initially, we will extract the core features and identify the key points. Next, we will divide the dataset into three segments: training, validation, and testing sets. We will use 80% of the data for training, 10% for validation, and 10% for testing. It is important to note that before splitting it, we shuffle the data, so each part represents a good mix of examples. We also ensure equitable representation of each category in both the training and testing sets. You can see the specific percentages for each part in Table 1.

Step 4: Train the algorithm: We utilized distinct sets of data to train the Vision transformer and Large Language model such that it provide appropriate feedback by comparing the key points in the images from the ideal key points. Table I provides detailed information on the specifics of the training dataset.

Step 5: Integrate the two different models to build the entire system and then test the system.

Step 6: Test the algorithm: Various algorithms are utilized to predict the performance of classification models on a test dataset. The evaluation of these models' effectiveness includes metrics such as accuracy, precision, recall, specificity, and F1-measure, computed using Python's transformers library. The formulas for these metrics, along with their respective definitions.

Extracting the Importance key points for Predicting Yoga pose

The dataset concerning yoga pose encompasses a variety of

key points, albeit not all hold substantial sway in predicting a yoga pose correctly to effectively manage their injuries. Through rigorous testing on a designated dataset, the system's efficacy is confirmed. In this context, evolution analysis involves discerning and elucidating patterns or trends in the behavior of body posture over time.

The Predictive Model

The key features are fundamental for crafting a predictive model utilizing model such as large language model (LLM) and Large Vision Model (LVM). This system could be instrumental in analyzing images of body posture within the yoga pose dataset, as these features are pivotal in discerning patterns and characteristics indicative of the particular yoga pose progression and prognosis.

Evaluation

Accuracy

This formula computes the percentage of correctly predicted instances out of the total number of instances in the training dataset. Mathematically, it is defined as:

$$\text{Accuracy} = \left(\frac{\text{Total number of instances}}{\text{Number of correctly predicted instances}} \right) \times 100$$

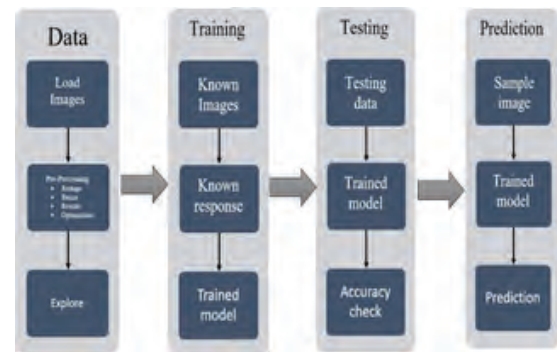


Fig. 1 Work Flow in Machine learning

RESULTS

The paper displays classification experiments conducted on Yoga pose dataset, an image database of about 47 yoga pose are available consisting of about approximately 3,000 images.

In the generative AI models, diverse classifiers are assessed with identical parameters. In particular, Vision Transformer (ViT) classifiers employ dynamic model.

For deep learning experiments, both conventional and innovative deep learning techniques are employed for database classification. The datasets are divided into training, validation, and test sets in an 8:1:1 ratio, with 80% allocated to training, 10% to validation, and 10% to testing. Each model

is trained for 30 epochs using a learning rate of 0.0001 and a batch size of 32. The outcomes highlight the classification efficacy of each model on yoga pose.

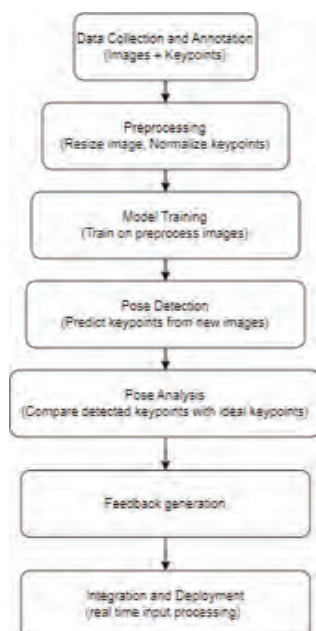


Fig. 2 Prediction of yoga pose model

DISCUSSION

In the discussion section, we talked about how classical methods compare when using different features and databases.

Our findings suggest that deep learning models outperform classical ones, and we discussed how these deep learning models balance accuracy, training time, and model complexity.

Overall, the results show that the yoga pose dataset is useful for testing both Generative AI and deep learning techniques for yoga pose images. We suggest doing more experiments and tweaks to make these models even better at classification.

CONCLUSION

Yoga pose dataset serves the purpose of evaluating the performance of various classifiers the paper is divided into two main sections for testing. In this the advanced generative AI methods are utilized, where five different features are extracted, and the annotation of images classification methods is tested on database. The aim is to analyze the discrepancies in classification accuracy among different classifiers.

In the second part, deep learning techniques are investigated. Specifically, three well-established Large Language Model and Large Vision Model, a relatively new approach in image classification, are tested. The analysis primarily focuses on

comparing the accuracy, model size, and training time of the four models. Further experiments are carried out to enhance the training time on yoga pose dataset.

The results from the dataset experiments demonstrate its competence in evaluating existing image classification methods. By creating this dataset, more image classification techniques can be applied and tested. Future work will explore latest image classification techniques on dataset to further compare and analyze different approaches, aiming to contribute to advancements in yoga posture detection and correction technologies.

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Deep Learning-Based Defect Detection for Industrial Products

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ABSTRACT

Surface identification of defects has generated a lot of interest as a difficult issue in the last few times. While assured problematic modules can be addressed by classic image processing techniques, these approaches have concern with complex environment textures, noise, and lighting fluctuations. Two main causes have led to the rise of deep learning as a solution: the rising digitization of society and the better convenience of computing control, which have made large databases of categorized samples easier to make. The resolution of this study is to deliver a brief overview and evaluation of the state of the art in machine learning-based defect discovery research. It first discovers surface defect identification on industrial items using deep learning and looks at it from three approaches: supervised, semi supervised, and unsupervised. It before examines the state of research on deep learning techniques for flaw detection.

KEYWORDS: *Defect identification, Deep learning, Surface defect identification, X-ray image defect detection, Defect recognition.*

INTRODUCTION

Surface defect detection in industrial items serves a variety of purposes, including ensuring product quality, improving reliability, and eventually lowering manufacturing fault costs. Defect detection is critical in several industries, such as aerospace, electronics, and automotive, where little flaws can cause serious problems with performance or safety. Maintaining product quality is one of the main reasons for surface fault detection. Surface flaws in industrial items can jeopardize their structural soundness, use, and visual attractiveness. Manufacturers may protect their brand identity and customer happiness by preventing defective items from entering the market by identifying and fixing problems early in the manufacturing process.

Furthermore, defect identification is essential to quality control procedures since it enables producers to follow rules and industry norms. Robust defect detection systems are necessary to assure regulatory compliance and prevent expensive penalties or recalls in many businesses that are subject to strict quality criteria and compliance standards.

The optimization of production processes and resource usage is a primary driving force behind fault detection. Early defect detection enables producers to identify and address the underlying causes of flaws, improving yield rates and

production efficiency. Manufacturers can decrease material waste, eliminate rework, and improve resource allocation by reducing the occurrence of defects. This can ultimately result in cost savings and enhanced profitability. Defect detection additionally helps to improve predictive maintenance plans in industrial environments. Manufacturers can obtain important insights into the performance of their equipment and trends in its degradation by regularly checking and evaluating surface flaws. By taking a proactive stance, costly downtime and unanticipated equipment breakdowns can be avoided through timely maintenance interventions.

LITERATURE REVIEW

Supervised Learning Approaches

-Chao Zhang et al. (2020) proposed a supervised technique for detecting defects based on deep convolutional neural networks (CNNs). achieved high accuracy in detecting surface flaws in commercial goods by training the model on a large dataset of labelled images.

-Liu et al. (2019) explored the value of transfer learning and fine-tuning methods in fault discovery. The study proved the advantages of using pre-trained CNN models for effective feature extraction and defect classification.

Semi-Supervised Learning Methods

-Yu et al. (2021) examined semi-supervised defect identification approaches, such as self-training and pseudo labelling. It was shown that combining unlabelled data can increase model performance and reduce the demand for huge labelled datasets.

-Wang et al. (2018) developed an active learning strategy for dataset expansion in defect detection. Important developments in model overview and defect localization accuracy were achieved through the repeated selection of informative examples for annotation.

Unsupervised Learning Approaches

-Jin et al. (2020) developed an unsupervised technique for defect detection based on auto encoders and anomalies. The approach allows for the detection of abnormalities in industrial photos without the need for labelled training data, making it ideal for settings with a limited number of annotation samples.

-Li et al. (2019) proposed using generative adversarial networks (GANs) for defect generation and detection. By training GANs to generate realistic defect images, we were able to achieve robust defect detection performance even when dealing with different defect types and sizes.

Deep Learning Methods for Detecting Defects in X-ray Images

Application of CNNs in X-ray Defect Detection

-Yao et al. (2017) developed a CNN-based system to detect mistakes in X-ray images of engineering modules. The approach produced inspiring results in properly identifying flaws such as fractures and voids, resulting in improved quality control in manufacturing processes.

Advanced Architectures for X-ray Image Analysis -Han et al. (2020) suggested an advanced deep learning construction for detecting X-ray defects by incorporating attention mechanisms that focus on informative portions of the image. The model exhibited cutting-edge performance in defect finding tasks, highlighting the efficacy of attention-based techniques in feature representation.

Integration of Deep Learning with Traditional Inspection Techniques

-Lee et al. (2018) investigated the addition of deep learning to traditional X-ray inspection techniques for defect discovery in automated mechanisms. By combining deep learning-based feature extraction with rule-based inspection methods, achieved synergistic perfections in defect discovery accuracy and efficiency.

SYSTEM ARCHITECTURE

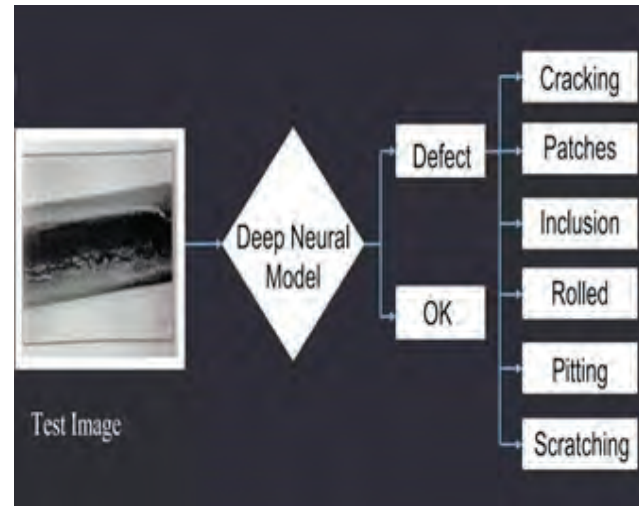


Fig. 1: Image Classification Process

In the manufacturing process, various factors, including substandard technology and poor working conditions, impact product quality. Surface defects are particularly conspicuous manifestations of low product quality. Detecting these defects [1] confirms high product qualification rates and dependable excellence. A flaw is often an abnormality or deviation from a standard sample. Figure 1 depicts the differences between regular and flawed engineering product models. The top row displays faultless samples, whereas the following rows exhibit defective ones. The columns represent various product kinds, with three defect types stated beneath each image.

GENERAL FRAMEWORK

In the past, specialists were in charge of determining defects, but this method lacked efficiency due to human subjectivity. Inspection by humans alone is insufficient to meet the requirements for real-time detection. Conventional techniques for identifying surface defects have been extensively studied. When nearby is contrast between defect colour and context, conventional techniques for image processing perform well. These methods categorize product features into texture-based, colour-based, and shape-based features. specialized methods have been used in various studies. For example, in reference [2] projected a method using colour histogram and vector surface features to categorize blocks of images and detect surface faults on wood.

Research established the effectiveness of this technique, mainly for junction-related problems. In reference [3], cosine similarity and colour second features were used to assess magneto-optical periodic law images, resulting in satisfactory proof of identity of welding faults.

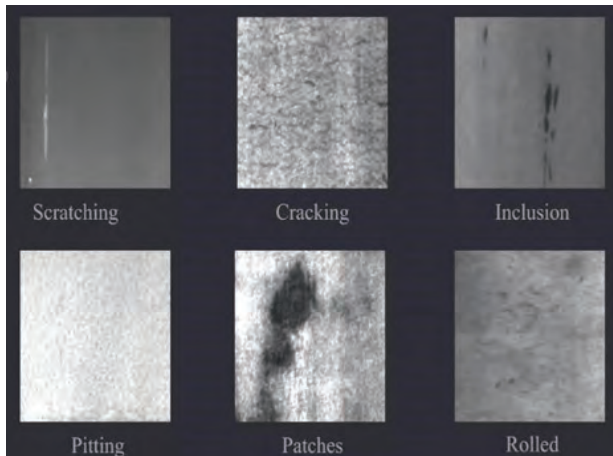


Fig. 2: Different types of Defect and Label

Additionally, reference [4] detailed a two-step technological procedure for flaw detection in particle boards using colour histograms and SVMs, and was followed by defect localization using flattening and thresholding. Another study [5] merged colour moment and FSIFT structures to resolve tile surface defect problems. Shape-based feature methods have also been proposed. In one method [6], cutting faults on magnetic surfaces were detected by reconstructing the image using Fourier and Hough transforms, comparing the gray difference between the reconstructed and original photos to determine the flaw information. Defect identification on bottle surfaces was existing in reference [7], including a stage for identifying the light source's border line by isolating regions of interest using a quick Hough transform technique. To find and locate minor faults in aperiodic images, global Fourier image reconstruction and template matching were proposed in [8]. A different study [9] discussed the use of weighted Sobel filters, SVM algorithms, polar coordinate transforms, and Hough transforms to identify surface flaws on small camera lenses. Multiple test photos contained a variety of flaws, with red highlights denoting stains, scratches, and spots.

Datasets

- Datasets are fundamental for developing and evaluating surface defect detection algorithms.
- Typically consist of annotated images or videos containing both normal and defective models of engineering products.
- Extensive and superior quality datasets are necessary for precise machine learning model training.
- Annotated datasets enable the assessment of algorithm performance by means of metrics such as accuracy, precision, recall, and F1 score.

-Dataset imbalance, where the number of normal samples outweighs defective ones, poses a challenge for model generalization.

-Ensuring dataset representativeness and diversity is crucial to account for variations in defect types, sizes, textures, and lighting conditions.

-Comprehensive and well-annotated datasets are necessary for advancing research in surface defect detection and fostering the development of robust detection algorithms.

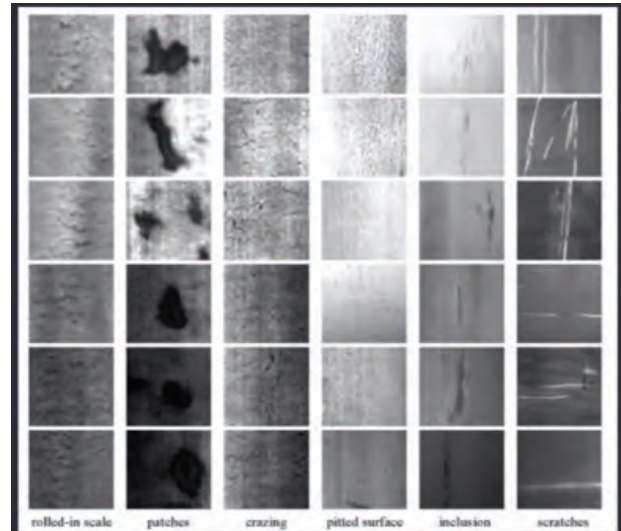


Fig. 3: Dataset Screenshot

SYSTEM DESIGN OF CLASSIFICATION

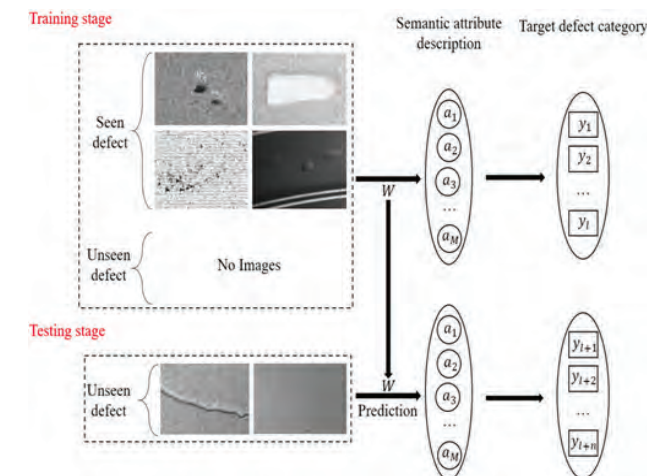


Fig. 4: Classification and Regression Subsets

Data Collection and Pre-processing

- Gather a diverse dataset containing images of both normal and defective industrial products.

- Pre-process the images to enhance quality, remove noise, and standardize dimensions.
- Augment the dataset to increase variability and improve model generalization.

Feature Extraction

- Utilize several feature extraction techniques such as convolutional neural networks (CNNs) to mechanically learn discriminative structures from the images.
- Extract features from changed layers of the CNN to capture both low-level and high-level representations.

Model Selection

- Choose an appropriate classification model such as a CNN, support vector machine (SVM), or random forest based on the difficulty of the information and computational requirements.
 - Fine-tune pre-trained models or train from scratch based on the dataset size and domain-specific requirements.
4. Model Training:
- Split the dataset into training, validation, and testing sets.
 - Train the classification model using the training set and validate its performance on the validation set.
 - Optimize hyper parameters using methods like grid search or random search to improve model performance.

Model Evaluation

- Evaluate the trained model's performance on the testing set as measured by F1 score, recall, accuracy, and precision.
- Analyse confusion matrices and classification reports to understand the model's strengths and weaknesses.

Deployment

- Deploy the trained classification model in a production environment, either as a standalone application or integrated into existing manufacturing systems.
- Monitor model performance and periodically retrain or fine-tune the model to adjust to changing conditions and improve accuracy.

Integration with User Interface

- Develop a user-friendly interface for interacting with the classification system.
- Provide functionalities for uploading images, initiating classification, and viewing classification results.
- Incorporate visualization tools to display model predictions, confidence scores, and any detected defects.

Maintenance and Updates

- Regularly update the categorization model using fresh information and retrain as needed to improve accuracy and adapt to evolving defect patterns.
- Maintain documentation and provide support for users to address any issues or questions linked to the classification system.

PROBLEM DEFINITION

Since deep learning is developing so quickly, it has becoming more and more popular in the industrial sector for fault detection. The current status of research on industrial product surface defect detection is described in this section. There are three types of learning-based approaches: supervised, semi-supervised, and unsupervised. The greatest benefit to learning-based strategies is when a large number of datasets are accessible. In particular, supervised techniques perform better when there are plenty of samples available for every class in the dataset.

RESULTS

Supervised Method



Fig. 5: Insulator defect detection

Large datasets with labelled samples of both defect-free and faulty objects in a training set are necessary for supervised defect identification. If every training set is labelled, detection rates can reach significantly high levels. However, class imbalances among datasets may jeopardize the efficacy of supervised detection. Supervised learning techniques use a variety of datasets, such as the railroad dataset [21], the fabric dataset [19], and the rail fault dataset [20].

The designs of supervised approaches employing deep neural networks and feature extraction and classification techniques differ. A two-layer neural network, for example, was proposed in the literature [22] to detect cross category faults without the need for retraining. This approach shows

efficacy across various factory types by learning differential features based on structural similarities between image pairs. The literature [23] highlights that in order to achieve the best detection results, kernel composition matters more than the number of layers. For computational accuracy and network cost reduction, using suitably sized sample photos is essential for detecting minor flaws and textures in surface images. To meet this demand, ShuffleNet presents channel shuffle techniques and the convolution of pointwise groups.

A novel in-line plastic container inspection system based on ShuffleNet V2 is shown in Literature [24]. It is able to examine photos with intricate backgrounds. In a similar vein, ShuffleDefectNet, which was introduced in [25], proved effective in defect identification with 99.75% accuracy on the NEU dataset.

Reference [26] suggests using full-size photos, training the model only on negative images, and shallow CNN networks for anomaly identification. The argument suggests that since negative samples naturally contain portions devoid of defects, full-size examples of both faulty and defect-free samples are superfluous. Using a region proposal network (RPN) to facilitate end-to-end learning, Faster R-CNN, which is based on the Fast R-CNN model, produces a nearly cost-free regional recommendation technique that greatly increases target detection speed. This method was used in [27] to identify PCB surface flaws, and a unique network that combined ShuffleNetV2, ResNet50, and GRAPN residual units was suggested. Furthermore, a cascaded RCNN structure for power line insulator defect identification is presented in literature [28], which essentially converts the issue into a two-level target detection problem, as illustrated in Figure.

Unsupervised Method

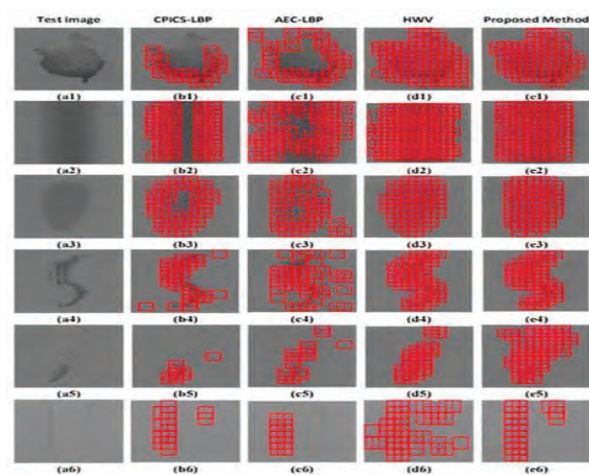


Fig. 6: Defect Sample using methods

In research, unsupervised approaches are becoming more popular as a way to overcome the shortcomings of supervised methods. Machines are capable of independently classifying data patterns by using intrinsic features that they have learned from input training data without label information. Reconstruction-based techniques such as autoencoders (AEs) and Generative Adversarial Networks (GANs) are widely used, while algorithms like PatchCore, PaDIM, and SPADE are frequently used. A DBN-based approach for solar cell defect identification was developed in [36], using reconstructed and training images for supervision. Furthermore, literature [37] presented a multi-scale convolutional denoising auto encoder that ensures great accuracy and robustness by synthesizing data from various pyramid levels. A two-step process including the detection of suspected defect regions and the independent inspection of each problem area was described in [38] as part of a Self-Organizing Map (SOM)-based method for differentiating between normal and defective wood. Similar to this, reference [39] suggested a GAN-based detection technique that is split into two phases: Frechet distance-based defect classification and generative network utilization. The accuracy of this approach on datasets of solar panels was 93.75%. In [40], a multiscale AE using fully convolutional neural networks was presented. Each subnetwork directly collected the original feature images and carried out feature clustering, merging residual images to create the defect image. PatchCore, as described in the literature [35], used memory banks and coreset subsampling to efficiently detect and localize image anomalies, even when there were only normal samples present. A GAN-based surface vision detection framework was reported in literature [41], which demonstrated excellent segmentation of fusion feature response maps utilizing OTSU and fused GAN discriminator layers' responses. The system was tested on datasets containing wood and road cracks. A GAN-based technique for identifying strip steel surface flaws was presented in Reference [42], whereby the generator made use of SVM classification and encoding. The accuracy test results showed good performance, especially in texture photos, but there is still potential for improvement.

Semi-Supervised Method

Semi-supervised methods leverage characteristics from together supervised and unsupervised approaches. These methods utilize simply normal models for training, learning and setting a defect-free boundary, considering any models outside this boundary as anomalies. Despite the scarcity of defective samples, semi-supervised methods are highly valuable, although tend to exhibit lower defect detection accuracy compared to supervised methods. Moreover, semi-supervised methods can automatically generate unlabelled sample data without manual involvement.

A methodology for detecting PCB solder joint faults was presented in the literature [43]. It uses self-training and active learning with a sample query recommendation algorithm for classification. This approach decreases the amount of manual annotations required while improving classification accuracy.

A semi-supervised model that combined generative adversarial networks (GAN) and convolutional autoencoders (CAE) was presented in [44]. The encoder network of the stacked CAE is kept and fed into the SoftMax layer as a GAN discriminator following training with unlabelled data. Using this method, fake pictures of steel surface flaws were produced for discriminator training. Furthermore, literature [45] created a weakly supervised learning (WSL) framework that integrated decision networks (DNets) and localization networks (LNets) for the purpose of detecting steel surface defects. Heat maps indicating possible flaws were created using LNets using image-level labels for training, which were then fed into DNets. The suggested approach proved effective on actual industrial datasets by using the RSAM algorithm to weight selected regions..

In [44], a semi-supervised model combining convolutional autoencoders (CAE) and generative adversarial networks (GAN) was introduced. After training with unlabelled input, the encoder network of the stacked CAE is retained and fed into the SoftMax layer as a GAN discriminator. This technique was used to create fictitious images of surface defects in steel in order to train discriminators. Moreover, research [45] developed a framework for weakly supervised learning (WSL) that combined localization networks (LNets) and decision networks (DNets) to identify surface defects in steel. Using image-level labels for training, LNets were used to build heat maps that showed potential defects, which were then input into DNets. The proposed method, which weighted certain regions using the RSAM algorithm, worked well on real industrial datasets.

Deep Learning Defect Detection Methods for X-ray Images for Industrial Products

In the engineering sector, non-destructive testing, or NDT, is frequently used to assess and find flaws in a variety of materials without causing harm. An essential NDT method is radiographic testing, which uses X-rays to identify and evaluate item faults like cracks or porosities. However, because of noise and poor contrast, flaws in X-ray pictures can vary widely in size and shape, making detection difficult.

Defects in industrial items are typically found via visual inspection by human operators or professionals using radiography. But this method is labour-intensive, subjective, and prone to mistakes, which could result in misunderstandings. Defect detection has undergone a revolution thanks to recent advances in deep learning, which provide more dependable and effective methods than those used in the past. An

overview of recent work on X-ray image-based defect identification in industrial products is given in this section, with a particular emphasis on deep learning methods like generative adversarial networks (GANs) and convolutional neural networks (CNNs). By precisely identifying flaws in radiography images, these deep learning techniques may lessen subjectivity and human error while expediting the inspection process. Furthermore, can get better over time with more data, increasing resilience and dependability. By analysing flaws in actual production samples, a method that was proposed in the literature [49] sought to automate the inspection and monitoring of machinery in the hard metal industry. Three models were created to analyse different kinds of data. combined and analysed the ultrasonic and micro profile meter model results using a random forest classifier and a stacked generalization ensemble approach. When compared to separate models, the fusion model performed better, with a higher classification accuracy of 88.24%. Furthermore, the ultrasound model scored better in classification scores than the VGG-19 model, and the shop floor model successfully detected malfunctions during the manufacturing process. A three-stage deep learning technique for identifying bubble patterns in engines was presented in a different paper [50]. Training an auto encoder with normal images, adjusting the encoder's coefficients, and training a fully-connected network with both normal and faulty photos were all part of the algorithm. The entire system was optimized to improve the performance of the network. A CNN model consisting of ten layers was created, according to [51], to identify flaws in X-ray welding pictures. With the ReLU activation function, the model's classification accuracy for X-ray welding picture identification was 98.8%. A Support Vector Machine (SVM)-based real-time X-ray image analysis technique was introduced in [52]. Using a background subtraction approach, the technique required segmenting possible flaws and collecting three features to feed into an SVM classifier. This method decreased false alarms and identified faults. In [53], a different SVM-based technique for identifying weld flaws was presented. Grey-level profile analysis was used to extract three feature vectors from possible weld faults. After that, the SVM was trained to distinguish between actual and possible flaws, resulting in a high detection accuracy rate. Yolov5-based DR image defect detection technique was proposed in ref. [54] for insert melding detection in automobile electronics. To improve flaw detection accuracy, the program made use of sophisticated network designs and pre-processing approaches. A lightweight semantic segmentation network for identifying bead toe mistakes was developed in Ref. [55]. By using feature extraction and fusion approaches, the methodology was able to decrease inference time and enhance segmentation accuracy. Deep learning with X-ray pictures was used in [56] to find flaws in aluminium casting

parts used in autos. Feature Pyramid Networks (FPNs) and RoIAlign were utilized to enhance the precision of bounding box positioning and defect identification. By modifying the feature extraction and classification components, literature [57] enhanced the precision and recall of tire flaw detection using the Faster R-CNN detection model. Using relief picture pre-processing and SVM classification, triplet deep neural networks were proposed in the literature [58] for the detection of numerous weld flaws. Tables give a thorough summary of recent work on deep learning for defect detection in X-ray pictures, summarizing papers and contrasting the advantages and disadvantages of various approaches.

Table 1: Recent publications on deep learning defects detection in Xray images

Reference	Method	Target	Performance
[50]	Three-Stage Deep Learning Algorithm	Engines	Accuracy rate: above 90%
[51]	Convolutional Neural Network (CNN)	Welding	Recognition accuracy can be more than 90%
[52]	Support Vector Machine (SVM)	Welding	Accuracy rate: 99.4%
[53]	Support Vector Machine (SVM)	Welding	Rate of detection is approximately 99.1%
[54]	Yolov5	Insert Molding	Recognition accuracy: 93.6%
[55]	Lightweight semantic segmentation network	Tire	Achieved 97.1% mIoU and 92.4% L-mIoU for 512×512 input images
[56]	Faster R-CNN	Automobile casting aluminium parts	RoIAlign showed a significant improvement in the accuracy of bounding box location compared to RoI pooling, resulting in an increase of 23.6% accuracy under Faster R-CNN
[57]	Faster R-CNN	Tire	Compared with other methods, this method is capable of achieving a higher level of detection accuracy
[58]	Triplet Deep Neural Network	Welding	Can be more effective than traditional methods.
[59]	Deep Convolution Neural Networks	Aluminium Conductor Composite Core (ACCC)	Can be effective in recognizing small and inconspicuous defects, with a 3.5% improvement in mean Average Precision compared to RetinaNet

[57]	Unsupervised Learning with Generative Adversarial Network	Tire	A tire X-ray dataset achieves 0.873 Area Under Curve (AUC)
[58]	R-CNN	Metal	Can eliminate time-consuming and inconsistent criteria while making judgments more efficient and accurate
[49]	Deep Neural Networks (DNNs)	Actual samples from the hard metal production industry	Indicates that the fusion model outperforms the separate models in terms of recall (100%), precision (60%), F-score (75%), and accuracy (88.24%)

CONCLUSION

Deep learning is especially helpful for detecting defects in engineering goods. Our research focused on cutting-edge strategies for recognizing surface faults and flaws in X-ray pictures. We conducted a thorough analysis of the numerous approaches and algorithms suggested in these sectors. In addition, we examined the major obstacles and restrictions associated with these approaches and proposed viable solutions. The goal of our appraisal is to provide researchers with a comprehensive understanding of the most recent breakthroughs in surface defect identification for engineering products, serving as a helpful resource for future study in this subject.

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Improving The Effectiveness and Efficiency of Technical Debt Management Automation

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ABSTRACT

Efficient Technical Debt Management Automation (TDMA) is crucial in software engineering to mitigate the detrimental effects of technical debt accumulation. This research addresses the challenges of integrated, comprehensive TDMA, aiming to enhance software development processes. The key challenges include the absence of detailed strategy implementation due to interdependencies between TDMA activities, maintenance of TD types in siloes, ambiguity in rules for TD activities, and integration issues among automation artifacts. By proposing a comprehensive approach, this study aims to establish a comprehensive strategy with context-aware decision support, leveraging ML/AI for further automation through establishment of digital thread between within the ecosystem. The anticipated outcomes include improved capabilities for identifying, prioritizing, and addressing technical debt, along with establishing an integrated framework for TDMA throughout the software development lifecycle. The implications of this study extend to advancing software engineering practices, fostering innovation, and enhancing the competitiveness of organizations in the dynamic technology landscape.

KEYWORDS: *Digital thread, Technical debt management, Generative AI, Software development Lifecycle, Automation framework.*

INTRODUCTION

In the dynamic landscape of software development, Technical Debt (TD) has emerged as a significant challenge impacting productivity, quality, and ultimately, business outcomes. Stemming from the analogy of financial debt, technical debt indicates the trade-off during software development where expedient solutions are chosen over optimal ones, leading to accrued inefficiencies and complexities over time. This phenomenon occurs across various dimensions of software development, including code quality, documentation, infrastructure, and versioning.

The ramifications of technical debt are far-reaching, affecting not only software development but also maintenance efforts. Studies indicate that developers spend a substantial portion of their time grappling with technical debt, significantly impeding productivity. Moreover, the maintenance phase of software projects becomes increasingly burdensome, with a

majority of efforts allocated to addressing issues stemming from technical debt.

Recognizing the pervasive impact of technical debt, effective management strategies are crucial to reduce its negative impact. Technical Debt Management (TDM) encompasses a proactive approach to identifying, measuring, prioritizing, and addressing technical debt throughout the Software Development Life Cycle (SDLC). However, despite the critical importance of TDM, several challenges hinder its automation and optimization.

This research aims to address the challenges surrounding the automation of Technical Debt Management (TDM), with a focus on enhancing efficiency and effectiveness in software development practices. By delving into the intricacies of TDM automation, the research endeavors to provide comprehensive solutions that streamline processes, facilitate informed decision-making, and minimize the accumulation of technical debt.

The outcomes of this study are anticipated to represent a significant advancement in the field of software engineering. By offering integrated, context-aware automation solutions for TDM, this study seeks to empower development teams to proactively manage technical debt, thereby enhancing software quality, reducing maintenance overhead, and ultimately improving organizational agility and competitiveness.

LITERATURE REVIEW

According to a literature survey, the TD concept 47% of practitioners possess practical experience with TD identification or management, compared to 22% of practitioners who simply have theoretical understanding. Research conducted by authors [5] highlights the varying levels of familiarity and practical experience with technical debt among software development practitioners. While a substantial portion (69%) of participants acknowledged awareness of the TD concept, a significant proportion (31%) had no prior exposure to it. Moreover, within the cohort familiar with technical debt, only 47% possessed practical experience in managing or addressing TD issues, underscoring the need for enhanced education and awareness initiatives in the software engineering community.

Recent research indicates that in software development organizations, TD-caused problems account for an average of 25% of development effort—that is, wasted work. Time pressure and deadlines emerge as primary drivers of technical debt, as indicated by numerous studies [5]. The imperative to deliver within constrained timeframes often compels developers to make trade-offs that prioritize short-term gains over long-term sustainability, thereby accumulating technical debt. Additionally, factors such as non-adoption of good practices, lack of experience, and insufficiently defined processes contribute to the proliferation of technical debt within software projects.

The effects of TD reverberate across various dimensions of software development, with delivery delays, reduced maintainability, and increased rework among the most frequently cited consequences [5]. These adverse effects not only impede project progress but also exacerbate the complexity and cost of software maintenance over time, underscoring the importance of proactive debt management strategies.

A comprehensive understanding of TD necessitates delineation across various dimensions, including design, test, code, architecture, documentation, and process debt [5]. Each type of TD manifests distinct challenges and implications for software development, ranging from violations of design principles to deficiencies in testing activities and

architectural shortcomings. By categorizing technical debt types, researchers aim to deliver a nuanced framework for identifying, prioritizing, and addressing debt accumulation throughout the software development lifecycle.

Requirements debt (8.80%) indicate the trade-off between accepted requirements and that are actually executed in a software product. For example, this can be manifested as partially implemented requirements or requirements that are implemented for some cases only [3].

Architecture debt (10.70%) highlights issues and problems with the system's architecture that impact the architectural requirements (e.g., performance, maintainability, robustness, etc.) [3]. For instance, violating the modularity principle or inadequately separating concerns can lead to significant problems with the system's ongoing development, maintenance, and growth.

Design debt (21.99%) describes transgressions of best practices and principles in design. Source code can be examined to find this kind of debt. For example, using code review techniques or static code analysis tools [1].

Code debt (14.66%) is the term used to describe issues with the source code that make it harder to comprehend and maintain. For instance, too complicated techniques or a lack of code standards. In order to remove code debt, code refactoring is needed [2].

Test debt (19.94%) describes any problems relating to testing operations (Guo and Seaman, 2011). For instance, low test coverage or scheduled testing which was not carried out.

Process debt (4.11%) describes to inefficient processes. For example, a process changed over time and the existing practices are not efficient any longer [6].

Infrastructure debt (2.93%) describes to issues that if present in an organization significantly reduce the teams' abilities to deliver quality products [6]. For example, using outdated tools or postponing regular software or system updates.

Defect debt (2.79%) describes to known defects that are discovered by testing activities, however the corrective actions are postponed or never implemented. Delays in corrective action decisions can result in a large build-up of TD inside the system [4].

People debt (1.32%) describes any issues related to people. For instance, deficiency in particular knowledge and abilities that would call for recruiting or further training (Alves et al., 2016). People related issues are much more multifaceted, they involve socio-organizational issues that directly affect output and people satisfaction [2].

Other debt types had less than 1% occurrences each: service (0.88%), automated test (0.88%), versioning (0.73%), usability (0.59%), and build (0.59%). Precise definitions for these TD types can be found in (Mandic et al., 2020).

A survey conducted by DXC Technology [8], a Fortune 500 company, underscores the widespread recognition of TD among industry practitioners. Drawing insights from 750 CxOs and technology executives, the survey revealed that 99% of respondents acknowledged technical debt as an integral component of their risk management processes (DXC Technology TD Survey). This high level of recognition underscores the significance of technical debt as a pervasive challenge faced by organizations across diverse sectors.

In agile software development, technical debt management automation (TDMA) promises substantial benefits across various roles and stages of the development lifecycle.

- Software developers and engineers can anticipate streamlined workflows and more focused development efforts as TDMA automates the identification and prioritization of technical debt, freeing up time for core tasks.
- Technical leads and architects stand to benefit from improved system reliability and scalability through proactive management of code quality and architectural integrity.
- Project managers will find TDMA invaluable for enhancing project predictability and risk management, providing clear visibility into technical debt resolution progress and its impact on timelines.
- Product managers and owners acquire essential understanding of how technical debt impacts product features and business goals, enabling them to prioritize development efforts effectively.
- Quality assurance teams can leverage TDMA to bolster product quality by integrating automated testing and bug prevention strategies, ensuring higher reliability and smoother release cycles.
- DevOps teams will appreciate the integration of TDMA into CI/CD pipelines, which streamlines deployment processes and minimizes operational disruptions.
- Executive leadership and stakeholders benefit from TDMA's ability to provide transparent metrics and insights into software quality and development efficiency, fostering confidence in project outcomes and alignment with strategic objectives.

- Finally, clients and end-users experience improved product stability, performance, and user experience as TDMA facilitates proactive maintenance and continuous improvement efforts throughout the development lifecycle.

Linkage with Digital Transformation

Furthermore, the survey findings highlight the interplay between TD and organizations' pursuit of digital initiatives. Notably, 46% of executives surveyed identified technical debt as a hindrance to their ability to embark on digital transformation journeys (DXC Technology TD Survey). In an era where digitalization is paramount for competitive advantage and business resilience, the presence of TD poses a formidable obstacle, impeding organizations' efforts to innovate and adapt to evolving market dynamics.

Anticipated Cost Savings and Desired Outcomes

Despite the challenges posed by TD, organizations recognize the opportunity for considerable cost savings through its reduction. According to the DXC Technology survey, respondents anticipated cost savings of up to 39% through effective management and reduction of technical debt (DXC Technology TD Survey). Moreover, the survey identified the mitigation of technical debt as the top desired outcome among executives, highlighting its critical role in enhancing operating margins and fostering organizational efficiency.

Analogy with Depreciation

Many industry leaders compare technical debt to depreciation, recognizing it as an inevitable aspect of software development & maintenance. Senior executives perceive technical debt as a challenge that necessitates proactive measures to mitigate and eliminate, akin to managing financial depreciation within their organizations. This acknowledgement underscores the necessity for strategic approaches to technical debt management that align with broader business objectives & financial considerations.

Types of Automation Artifacts for TDM

Managing technical debt involves two fundamental aspects: preventing its accumulation and repaying existing debt through prioritization, incentivization of quality work, and systematic refactoring. The process of technical debt management encompasses identification, measurement, documentation, prioritization, monitoring, repayment, communication, and prevention, with each step contributing to a holistic approach towards debt mitigation.

There are 8 steps in managing the debt and these steps are common irrespective of the TD types or where it happens.

- Identification: Recognize signs of TD in the software development process whether it is architecture, design, code or documentation.
- Measurement: Measure the time and resources needed to reduce the TD.
- Representation and Documentation: Document and represent the identified technical debt for better understanding and communication.
- Prioritization: involves evaluating and grouping the debt into categories, such as critical, important, low priority, or negligible, to make it easier to prioritize.
- Monitoring: Keep track of the TD to increase awareness among team members.
- Repayment: Dedicate time for intentional and systematic refactoring to reduce the debt. Repayment is a business decision that should be made based on the impact and urgency of the TD.
- Communication: Educate stakeholders on the true cost of technical debt to gain their support in addressing it.
- Prevention: Make managing technical debt a part of every conversation with developers to ensure it remains a priority.
- Automation artifacts for technical debt management encompass a diverse range of tools and processes tailored to the specific needs and difficulties encountered by software development teams. These artifacts include:
 - Tools: Independent, configurable software solutions providing interfaces such as GUI, command line, or APIs, examples of which include SonarQube and Arcan.
 - Plugins: Extensions installed within Integrated Development Environments (IDEs) or other software artifacts to enhance existing capabilities, exemplified by plugins like jDeodorant and Checkstyle.
 - Scripts: Context-specific code pieces executing tasks with less configurability, designed to automate specific aspects of technical debt management, such as debt free and piranha.
 - Bots: Background runners triggered automatically to automate tasks, offering potential applications in TD documentation and remediation, illustrated by examples like FixMe.

Technical Debt Management (TDM) encompasses a range of activities aimed at identifying, prioritizing, and addressing technical debt throughout the Software Development Life Cycle (SDLC). The process of TDM involves recognizing

the implications of expedient decisions made during development, which prioritize speed or release over optimal software quality. Without effective management, TD can accumulate, leading to increased costs, delayed time-to-market, and reduced customer satisfaction.

Challenges in Automation of TDM

Despite the growing recognition of the importance of automation in TDM, several challenges persist, hindering comprehensive strategy implementation and interoperability among automation artifacts. These challenges include:

- Interdependencies and Strategy Implementation: The absence of details on the interdependencies between TDM activities poses a significant challenge in devising comprehensive automation strategies. The order of activities is crucial for effective implementation, highlighting the necessity for a structured approach to managing TD throughout the SDLC.
- Fragmentation and Siloed Automation Artifacts: Current automation artifacts often focus on addressing specific types of TD in isolation, leading to fragmentation and siloed approaches. This limits the effectiveness of automation in managing the diverse range of technical debt types encountered in software development projects.
- Rule Setting and Quantifiability: Establishing clear and quantifiable rules for prioritizing and executing TDM activities presents another challenge. The absence of standardized rules and metrics complicates decision-making processes, making it difficult to determine when and how to proceed with addressing TD effectively.
- Interoperability and Integration: Integrating TDM automation artifacts poses significant challenges due to interoperability issues. Tools often operate in isolation, utilizing different formats and protocols, which hinders seamless integration and data exchange. Overcoming this challenge requires the development of interoperable tools capable of reading from multiple formats and facilitating seamless integration through standardized protocols.

The literature review highlights the critical importance of addressing the challenges in the automation of Technical Debt Management to enhance efficiency, reduce risk, and improve software quality. By understanding the interdependencies between TDM activities, addressing fragmentation in automation artifacts, establishing clear rules and metrics, and promoting interoperability, organizations can unlock the full potential of automation in managing technical debt effectively.

OBJECTIVES OF THE STUDY

The research aims to address the lack of integrated, comprehensive software engineering knowledge available for Efficient Technical Debt Management Automation (TDMA). This objective stems from the identified challenges in the State of the Art, which highlighted fragmentation, interoperability issues, and the absence of clear strategies in existing approaches to TDM automation.

Significance

Solving the challenge of TD management (TDM) in software engineering not only enhances organizational capabilities but also offers significant cost-effectiveness and return on investment (ROI).

Current statistics reveal that developers spend approximately 23% of their time dealing with technical debt, which directly impacts productivity and project timeline. Moreover, maintenance efforts often constitute a substantial portion (50-75%) of overall project efforts, with a focus on functionality enhancements, adaptability improvements, and error corrections being crucial.

- **Improved Capabilities:** By developing integrated and comprehensive software engineering knowledge for TDMA, the research seeks to enhance the capabilities of organizations in identifying, prioritizing, and addressing technical debt effectively. This would lead to improved software quality, reduced maintenance burden, and enhanced customer satisfaction.
- **Establishing Order and Integration:** The research aims to establish a structured approach for TDM activities throughout the software development lifecycle (SDLC). By elucidating the interdependencies between TDM activities and promoting integration among automation artifacts, the research seeks to streamline processes and improve overall efficiency in technical debt management.
- **Comprehensive Strategy and Decision Support:** The development of a comprehensive strategy and context-aware automated decision support for TDMA would empower organizations to make informed decisions regarding technical debt. This would enable stakeholders to prioritize and allocate resources effectively, leading to more efficient debt reduction efforts and optimized project outcomes.
- **ML/AI Enablement:** Furthermore, the research intends to explore the potential of Machine Learning (ML) and Artificial Intelligence (AI) in further automating TDM processes. By leveraging ML/AI techniques, the research seeks to enhance the automation capabilities of

TDM tools, enabling them to adapt to evolving project dynamics and facilitate proactive debt management.

RESEARCH METHODOLOGY

To achieve the research objectives, the following methodological approaches will be employed:

- **Literature Review and Synthesis:** Building on the State of the Art, a comprehensive review of existing literature in software engineering, technical debt management, and automation will be conducted. This review will identify gaps, challenges, and opportunities in current approaches to TDMA, serving as the foundation for further research.
- **Development of Integrated Framework:** Based on the insights gained from the literature review, an integrated framework for Efficient Technical Debt Management Automation (TDMA) will be developed. This framework will delineate the interdependencies between TDM activities, propose strategies for integration among automation artifacts, and outline clear guidelines for effective TDMA implementation.
- **Prototype Development:** A prototype TDMA system will be developed, incorporating the principles and strategies outlined in the integrated framework. The prototype will leverage existing automation artifacts and ML/AI techniques to demonstrate the feasibility and effectiveness of the proposed approach in addressing the identified challenges in TDM automation.
- **Evaluation and Validation:** The prototype TDMA system will be evaluated and validated through empirical studies, involving real-world software development projects and practitioners. The evaluation will assess the system's usability, effectiveness, and impact on technical debt reduction efforts, providing empirical evidence of its efficacy and practical utility.

FINDINGS AND SUGGESTIONS

Finding 1: Technical debt is not only about code and code quality. If it is not managed from the initial phase, it will continue to accumulate in the later phase and becomes difficult to repay.

For example, if technical debt is not managed in the requirements phase, it can lead to inefficient code, poor configuration control, and neglected documentation. This can further result in postponed bug fixes, failing to address security vulnerabilities, and other issues that can impact the performance, reliability, security, and maintainability of the software system.

Findings 2: The literature and industry survey findings underscore the pervasive nature of technical debt within organizations and its profound implications for digital transformation, cost management, and operational efficiency. As organizations grapple with the complexities of modern software development, addressing technical debt emerges as a strategic imperative to foster innovation, mitigate risks, and drive sustainable growth. By understanding the challenges posed by technical debt and leveraging effective management strategies, organizations can navigate the digital landscape with confidence and resilience.

SCOPE OF STUDY

Spotify's [7] development of Backstage represents a significant innovation in managing technical debt within complex micro services architectures. By integrating monitoring, documentation, and deployment tools into a unified digital thread, Spotify created a comprehensive view of their micro services landscape.

This approach not only reduced fragmentation and eliminated silos but also provided a single source of truth for developers, enhancing collaboration and efficiency across teams. Furthermore, leveraging generative AI allowed Spotify to analyze service dependencies, identify outdated components, and recommend proactive updates or refactoring strategies based on real-time data insights. This combination of integrated tools and AI-driven decision-making has enabled Spotify to continuously refine their technical operations and effectively manage ongoing technical debt challenges.

Guided by this case study, this research will address the challenges of managing technical debt (TD) in Agile software development by integrating TDM automation with digital threads and generative AI. It will explore how these technologies can tackle key TDM challenges effectively.

Firstly, the study will investigate how a digital thread can provide a comprehensive view of the software development lifecycle (SDLC), capturing and linking data from various stages and tools to track dependencies between TDM activities. Generative AI will be examined for its ability to analyze the digital thread, identify interdependencies, and suggest optimal sequences for TDM activities.

The research will also address the fragmentation and siloed nature of automation artifacts. It will explore how continuous data flow through digital threads can integrate information from different tools and stages of the SDLC, ensuring a holistic view of technical debt. AI will be used to synthesize data from fragmented sources, providing a unified understanding of TD and proposing unified management strategies.

Additionally, the study will focus on rule setting and quantifiability by examining how digital threads facilitate the collection and analysis of quantitative data across the SDLC, enabling the establishment of TDM metrics. AI will be used to define and refine rules for TDM by analyzing historical data and predicting future impacts.

The research will also investigate interoperability and integration, standardizing data formats and protocols to ensure seamless data exchange. AI will facilitate integration by mapping and translating data formats, enabling effective tool communication and automating data flows.

Furthermore, the research scope includes investigating the ethical implications of AI-driven TDM, ensuring that algorithms are designed and implemented ethically and responsibly. This involves examining issues such as fairness, transparency, and accountability in automated decision-making.

By leveraging digital threads and generative AI, this research aims to enhance visibility, proactive management, and decision-making in TDM, providing Agile teams with more effective tools for managing technical debt and improving software quality and development efficiency.

CONCLUSION

In essence, research goals and methods described aim to address the gap in software development knowledge related to TDMA., offering novel insights, methodologies, and tools to improve the efficiency and effectiveness of technical debt management in software development projects. Through a systematic and interdisciplinary approach, the research aims to contribute significantly to the advancement of TDMA practices and ultimately improve the quality and reliability of software systems.

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A Comparative Analysis of Urban and Rural Air Quality using an Internet of Things-based Monitoring System

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ABSTRACT

The Internet of Things is revolutionizing environmental monitoring by enabling devices to communicate with each other and collaborate, providing a solution to India's major air pollution problem. Air pollution in India kills about 1.5 million people every year and is the fifth leading cause of death. Traditional air quality monitoring systems face challenges such as low precision, delayed responsiveness, and reliance on laboratory analysis. This paper proposes an advanced IoT-based air quality monitoring system to solve these problems by providing real-time and accurate data to urban and rural areas. In urban settings, where air pollution is intensified by dense traffic, industrial activities, and construction, the system will be strategically deployed at traffic intersections, industrial zones, and residential areas. It will utilize multiple sensors to capture data on pollutants such as CO, CO₂, CH₄ and particulate matter, and will offer real-time alerts through an Website application when air quality deteriorates to hazardous levels. Additionally, the system will predict pollution levels for commonly traveled routes, aiding users in avoiding areas with high pollution. In rural areas, where pollution comes from agricultural activities and biomass burning, the system will be suitable for remote monitoring. Sensors are placed on farms and near incinerators to monitor emissions and air quality. Data is collected and sent to the cloud for analysis. The system provides real-time updates and predictive analysis of travel routes and local activities, helping users to make the decisions about air quality when pollution levels are low. This comprehensive approach aims to improve air quality management, enhance public health, and provide actionable insights across diverse geographic areas, addressing the limitations of traditional monitoring systems with innovative IoT technology.

KEYWORDS: *Internet of Things (IoT), Air quality monitoring, Real-time data, Urban air pollution, Rural air pollution, Environmental monitoring.*

INTRODUCTION

Air quality is a critical determinant of public health and environmental well-being. As urbanization accelerates and industrial activities expand, cities around the world are experiencing heightened levels of air pollution. Urban environments, characterized by high population densities, extensive vehicular traffic, and significant industrial output, are particularly vulnerable to the adverse effects of pollutants. Pollutants such as Carbon dioxide (CO₂), Methane (CH₄), carbon monoxide (CO), and particulate matter (PM_{2.5} and PM₁₀) are prevalent in these areas, leading to significant health risks. Chronic exposure to these pollutants is linked to respiratory and cardiovascular diseases, decreased lung

function, and increased mortality rates. The urban heat island effect, where concrete and asphalt trap heat, exacerbates these issues by concentrating pollutants and creating microclimates with elevated temperatures. This environment can further aggravate the health impacts of air pollution, leading to poorer overall air quality and increased public health burdens.

IoT Sensor Network: IoT technologies allow for the deployment of interconnected sensors to monitor air quality in real-time across various environments.

Technological advancements, especially in the areas of Internet of Things (IoT) and Wireless Networks (WSN), provide dynamic solutions for air quality monitoring in urban and rural areas. IoT technologies involve interconnected

devices that communicate data in real-time, enabling continuous monitoring of environmental conditions. In urban areas, these technologies can be deployed to create a dense network of sensors that provide detailed, granular data on air quality. This data helps to identify pollution hotspots, track temporal changes in air quality, and evaluate the effectiveness of pollution control measures.

Urban Air Pollution: High-density urban areas are often plagued by elevated levels of pollutants due to industrial activities and vehicular emissions.

Air quality is a critical determinant of public health and environmental well-being. As urbanization accelerates and industrial activities expand, cities around the world are experiencing heightened levels of air pollution. Urban environments, characterized by high population densities, extensive vehicular traffic, and significant industrial output, are particularly vulnerable to the adverse effects of pollutants. Pollutants such as Carbon dioxide (CO₂), Methane (CH₄), carbon monoxide (CO), and particulate matter (PM_{2.5} and PM₁₀) are prevalent in these areas, leading to significant health risks. Chronic exposure to these pollutants is linked to respiratory and cardiovascular diseases, decreased lung function, and increased mortality rates.

Urban Heat Island Effect: The heat retained by urban infrastructure can worsen air quality by trapping pollutants and creating microclimates with elevated temperatures.

The urban heat island effect, where concrete and asphalt trap heat, exacerbates these issues by concentrating pollutants and creating microclimates with elevated temperatures. This environment can further aggravate the health impacts of air pollution, leading to poorer overall air quality and increased public health burdens.

In rural areas, the sources of air pollution differ but remain significant. Agricultural activities such as farming and the use of fertilizers contribute to the release of ammonia and methane, which can affect the atmosphere and contribute to the accumulation of greenhouse gases. Additionally, rural areas often face problems such as seasonal burning of agricultural residues, which releases particulate matter into the air. The lack of robust monitoring infrastructure in these areas means that pollution levels can go unchecked, leading to undetected air quality issues that can still impact health.

Although rural areas generally experience lower levels of industrial pollution compared to urban centres, the cumulative effects of agricultural emissions and other local practices can still pose significant health risks to residents.

Rural Air Quality Monitoring: Affordable sensor networks can be deployed in rural areas to provide crucial data on

air quality, addressing challenges associated with limited monitoring infrastructure.

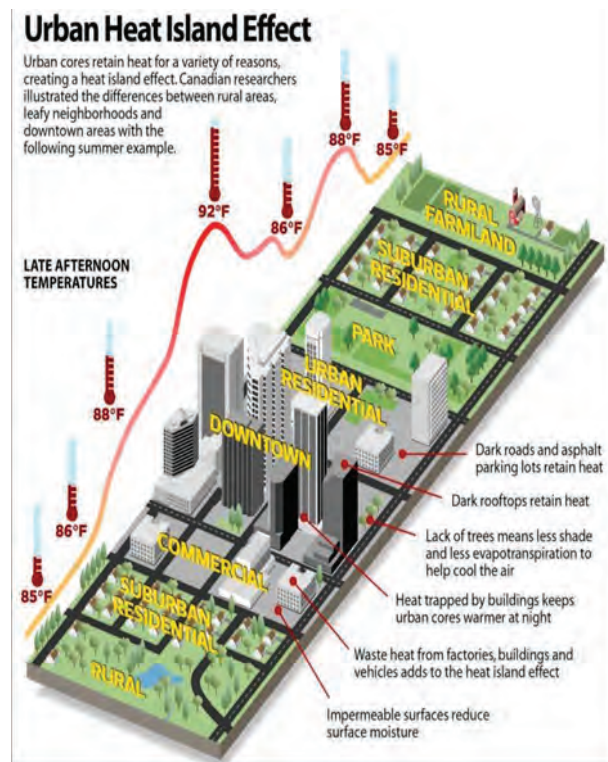


Fig. 1: Urban Heat Island Effect

For rural areas, IoT and WSNs offer a practical approach to overcoming the challenges associated with limited monitoring infrastructure. Affordable and adaptable sensor networks can be deployed in remote locations, providing essential data on air quality that was previously unavailable. This capability is crucial for developing localized strategies to address pollution from agricultural practices and other sources. Additionally, IoT platforms enable the collection and analysis of data without the need for extensive physical infrastructure, making it feasible to monitor air quality in areas with fewer resources.

PROPOSED METHOD AND DESIGN

IoT monitors air quality, air quality measurement, water and electricity management, and pollution control, including waste reduction. Such platforms provide users, especially businesses, with insight into issues such as toxic chemicals, oil spills, and improper waste disposal, while also strengthening environmental standards and regulations. This system includes the following areas: A global platform for monitoring and managing air quality index. Instant process views, control status, and results. Notifications are displayed when a violation occurs. Crime is prohibited. You can view

the application form using the form below,

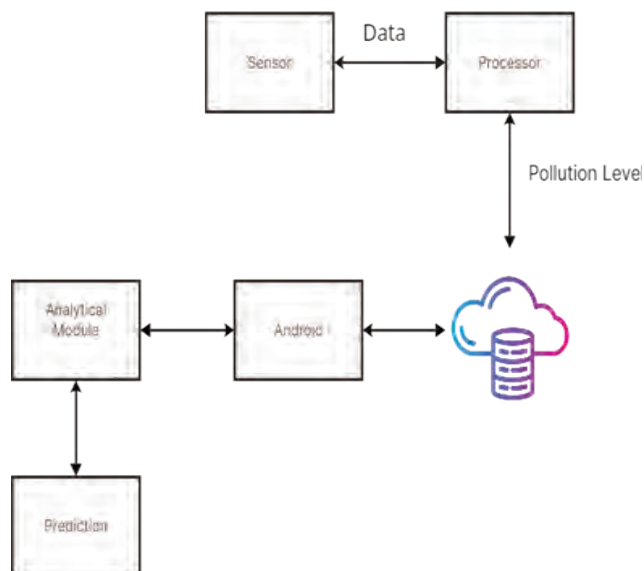


Fig. 2 Overview of the system

The completed data is continuously monitored on the IoT platform. This information is processed by the processor and stored in open storage in the cloud. The completed data is continuously monitored on the IoT Thing Viewer platform Android application for analysis and prediction. Smart sensors continuously collect information about the environment and transmit it wirelessly to the next step. Each wireless technology has its own advantages and disadvantages in terms of power, data transmission, and overall performance.

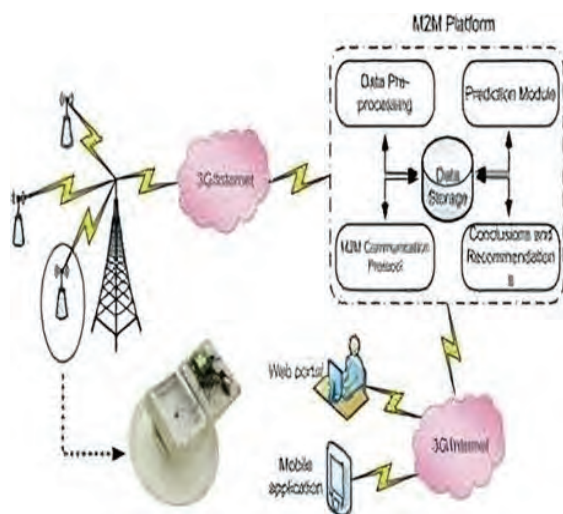


Fig. 3: Architecture of the System for Monitoring Air Quality through IoT Technology (Reference: Wireless Sensor Networks (WSNs) in Air Pollution Monitoring: A Review)

The air monitoring system consists of the following steps:

Step 1: Gather concentration data from the designated area using sensors.

Step 2: Link the data to the cloud following Arduino processing.

Step 3: Examine the data using an IoT platform.

The IoT Gateway is in charge of controlling two-way data flow across different networks and protocols. Moreover, it also serves to convert various network protocols and guarantee the safety of linked devices and sensors. Gateways can be set up to handle data preprocessing from many sensors before transmitting it to the next stage. In essence, the IoT cloud is an efficient network of networks designed for fast data processing on billions of devices, providing accurate analytics. This cloud system combines billions of devices, sensors, gateways, and data storage options with predictive analysis capabilities. Service providers can be ready for other tasks when they gather information promptly. It offers a system for handling to allow the transfer of the surrounding environment's image to the cloud and mobile devices. The table below displays the sensor data. Figure 2.3 displays the block diagram of the air pollution control system. The MQ-7, MQ-4 and MH-Z19 sensors provide air data for Arduino, detecting all gases and measuring pollution levels in parts per million (PPM).

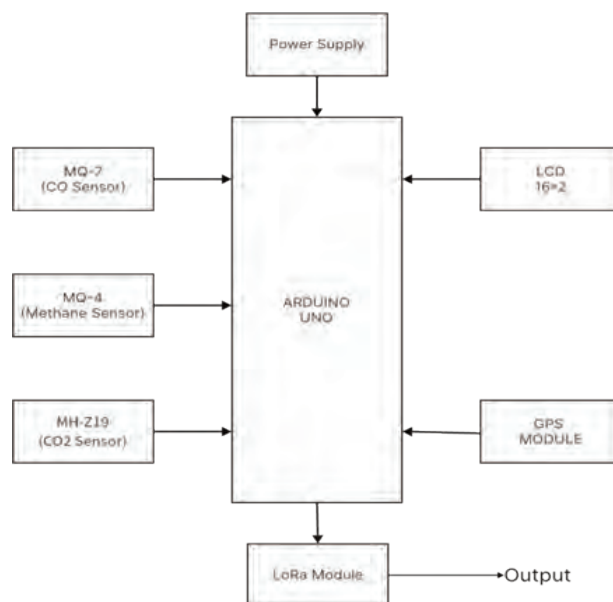


Fig. 4: Proposed System

The System for Monitoring Air Quality through IoT Technology utilizes various gas sensors, including MQ-7, MQ-4 and MH-Z19, to measure different gas concentrations.

These sensors output analog signals, which are converted into digital values using a gas sensor library. In this system, the Arduino Uno processes these sensor values and displays the results on an LCD screen as well as a web page. The system has predefined thresholds: when the air quality is ideal, with a CO₂ concentration close to 330 PPM, the LCD and web page will show “No Results” if the sensor values are below this threshold. If the sensor values exceed the threshold, indicating potential health hazards like headaches, insomnia, and shortness of breath, the system displays “DANGER” on both the LCD screen and the web page. Should the sensor values indicate very high levels, the system updates the server and displays “Very High” on both the LCD and web page, alerting users of the critical air quality condition. The ESP8266 WiFi module and the GPS module facilitate data transmission and location tagging, ensuring real-time updates and accurate monitoring.

Table 1 Limit Values

MQ4	MQ7	MH-Z19
Risky ; 370 - 800	Risky ; 370 - 800	Risky ; 1000 - 2000
Very Risky ; 810 - 2000	Very Risky ; 800 - 2000	Very Risky ; above 2000

Table 2 Details of the Sensor

Sensor	Gas	Description
MQ7	Carbon Monoxide	It can detect CO gas concentrations between 20 and 2000 ppm.
MQ4	Methane	It is able to identify LPG i- butane, alcohol, hydrogen, and smoke.
MH-Z19	Carbon Dioxide	To detect carbon dioxide (CO ₂) levels in the air

Requirement of the system

A web application is employed to oversee and manage air pollution in particular locations. In order to be alerted by the air pollution monitoring server, the GSM activates the SMS system. The information is transmitted to an online application server through IoT technology, Table III displays the overall system components.

Table 3 Necessary Components

Components	Description	Quantity
Power supply	Power supply of 5 volts for Arduino uno.	1
Arduino Uno	Micro controller board	1
LoRa Module	A LoRa module enables long-range, low-power wireless communication for IoT applications.	1
GPS module	In order to monitor the device's whereabouts.	1
MQ - 7 sensor	Sensor for detecting Carbon Monoxide gas	1
MQ - 4 sensor	Sensor designed to detect methane (CH ₄) gas.	1
MH-Z19 sensor	Carbon dioxide (CO ₂) concentration sensor	1

Design Requirement

An Arduino unit was chosen for the device due to its user-friendly programming and ability to quickly create prototypes. The software for monitoring the device was developed with the Arduino IDE. The detection module interacts with the LoRa module if the sensor value goes beyond each sensor's threshold value. The sensor values in the object call server and the object viewer application are continuously updated by the server. GPS monitors the device's location and transmits it to the manager's phone during high levels of harmful air pollution.

The system is designed to be robust and adaptable, allowing for easy calibration of sensor thresholds and integration of additional sensors if needed.

Algorithm Integration

The IoT-Based Air Quality Monitoring System employs a suite of advanced algorithms to deliver accurate and actionable air quality insights. It starts with data acquisition and preprocessing where moving average and median filters are applied to smooth sensor readings from MQ-7, MQ-4, and MH-Z19, reducing noise and ensuring reliable data. For real-time analysis, the system utilizes isolation forests and Statistical Process Control (SPC) to detect anomalies and unusual pollution patterns quickly. In the forecasting stage, ARIMA models are used for their strength in predicting future air quality based on linear time series data. Long Short- Term Memory (LSTM) networks complement this by capturing more complex temporal dependencies and nonlinear trends, providing a deeper understanding of future pollution levels. Additionally, regression models, including

linear and polynomial types, evaluate the impact of various environmental factors on pollution levels, enhancing predictive accuracy.

For visualization and data interpretation, the system employs heat maps to represent pollution intensity across different locations, making it easier to spot high pollution areas. Clustering algorithms like K-means and DBSCAN are used to group similar pollution patterns and identify hotspots. The user alert system classifies air quality into categories such as good, moderate, or unhealthy using decision trees,

which trigger appropriate notifications to users. Path-finding algorithms, including Dijkstra and A*, are used to suggest optimal travel routes based on real-time and predicted air quality data, helping users avoid highly polluted areas and minimize exposure. This comprehensive approach ensures both effective monitoring and actionable insights for improving air quality management. The user alert system used decision tree algorithms to classify air quality into different categories and trigger the corresponding alerts. Rule-based systems provided a robust mechanism for generating notifications based on certain circumstances.

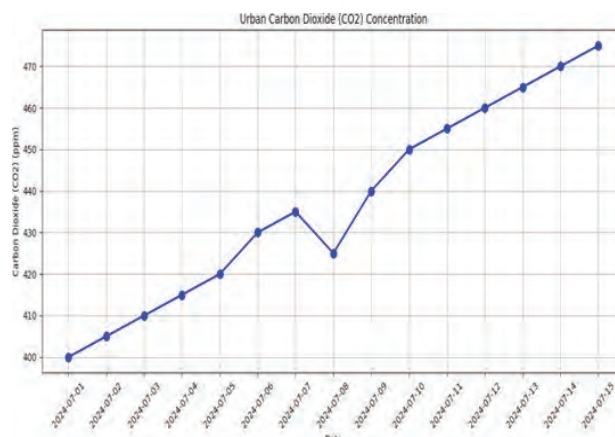
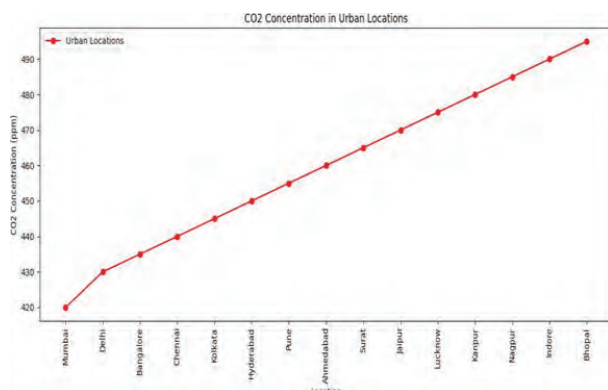
RESULTS AND DISCUSSION

Table 1. Sample dataset of air quality in the Urban places of India

Location	Date	Carbon Monoxide (CO) (ppm)	Methane (CH ₄) (ppm)	Carbon Dioxide (CO ₂) (ppm)
Mumbai	2024-07-01	0.70	1.3	420
Delhi	2024-07-02	0.75	1.4	430
Bangalore	2024-07-03	0.68	1.2	435
Chennai	2024-07-04	0.72	1.3	440
Kolkata	2024-07-05	0.74	1.4	445
Hyderabad	2024-07-06	0.78	1.5	450
Pune	2024-07-07	0.70	1.3	455
Ahmedabad	2024-07-08	0.76	1.4	460
Surat	2024-07-09	0.73	1.2	465
Jaipur	2024-07-10	0.77	1.3	470
Lucknow	2024-07-11	0.74	1.4	475
Kanpur	2024-07-12	0.72	1.3	480
Nagpur	2024-07-13	0.75	1.2	485
Indore	2024-07-14	0.78	1.3	490
Bhopal	2024-07-15	0.74	1.4	495

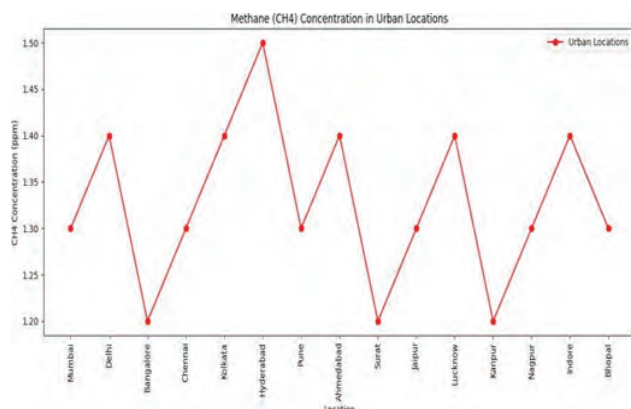
Air pollutant levels of Carbon dioxide (CO₂) concentration Carbon Dioxide (CO₂) (ppm) Vs. Date

Carbon Dioxide (CO₂) (ppm) Vs. Location

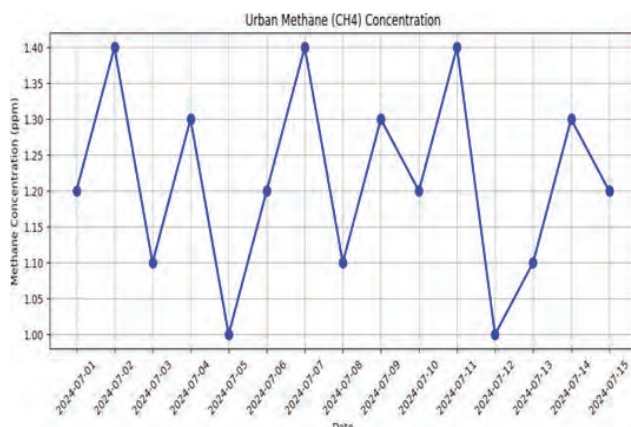


Air pollutant concentration of Methane (CH₄)

Methane (CH₄) (ppm) Vs. Location



Methane (CH₄) (ppm) Vs. Date



Urban Air Quality

Pollutants in Urban Areas

Carbon Dioxide (CO₂): Elevated due to combustion from vehicles and industrial processes. Methane (CH₄): Emissions from waste management, agriculture, and some industrial processes. Particulate Matter (PM): Generated from vehicle emissions, industrial activities, and construction.

Urban Data Example

CO₂ Concentration: Ranges from 420 to 495 ppm in various cities.

CH₄ Concentration: Ranges from 1.2 to 1.5 ppm in different urban locations.

Impact of Urban Pollution

Increased respiratory and cardiovascular diseases.

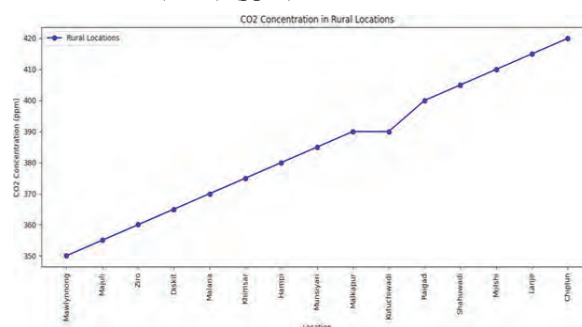
Elevated greenhouse gas levels contributing to climate change. Urban heat islands exacerbating heat effects.

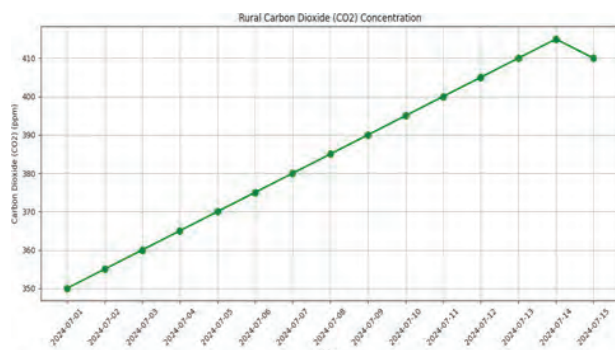
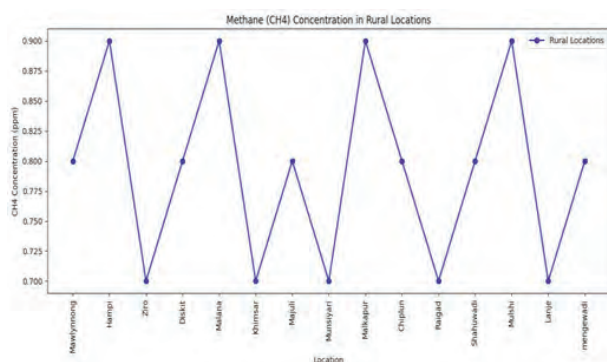
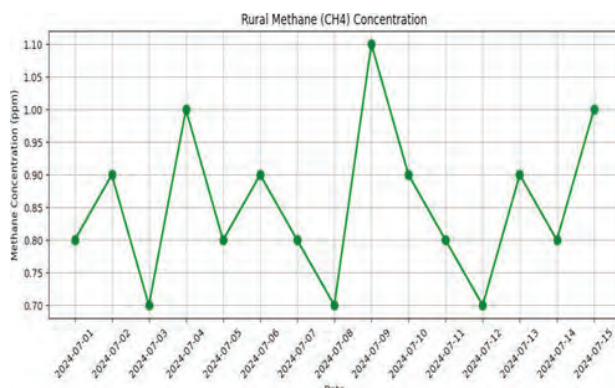
Table 2. Sample Dataset of air quality in the Rural places of India

Location	Date	Carbon Monoxide (CO) (ppm)	Methane (CH ₄) (ppm)	Carbon Dioxide (CO ₂) (ppm)
Mawlynnong	2024-07-01	0.40	0.8	350
Majuli	2024-07-02	0.38	0.9	355
Ziro	2024-07-03	0.35	0.7	360
Diskit	2024-07-04	0.37	0.8	365
Malana	2024-07-05	0.34	0.9	370
khimsar	2024-07-06	0.33	0.7	375
Hampi	2024-07-07	0.36	0.8	380
Munsiyari	2024-07-08	0.32	0.7	385
Malkapur	2024-07-09	0.35	0.9	390
Kutuchi-wadi	2024-07-10	0.37	0.8	395
Raigad	2024-07-11	0.34	0.7	400
Shahuwadi	2024-07-12	0.36	0.8	405
Mulshi	2024-07-13	0.33	0.7	410
Lanje	2024-07-14	0.37	0.8	415
Chiplun	2024-07-15	0.34	0.9	420

Air pollutant levels of Carbon dioxide (CO₂) concentration

Carbon Dioxide (CO₂) (ppm) Vs. Location



Carbon Dioxide (CO₂) (ppm) Vs. DateAir pollutant concentration of Methane (CH₄)Methane (CH₄) (ppm) Vs. LocationMethane (CH₄) (ppm) Vs. Date

Rural Air Quality

Pollutants in Rural Areas

Carbon Dioxide (CO₂): Generally lower due to less industrial activity and fewer vehicles.

Methane (CH₄): Lower, but can still be notable due to agricultural activities and waste decomposition. **Particulate Matter (PM):** Typically lower, though dust from agricultural activities can contribute.

Rural Data Example

CO₂ Concentration: Ranges from 350 to 420 ppm in various villages.

CH₄ Concentration: Ranges from 0.7 to 0.9 ppm in different rural locations.

Impact of Rural Pollution

Lower overall health impacts compared to urban areas, but still significant in areas with intensive agriculture or waste management.

Less contribution to global warming compared to urban areas.

CONCLUSION

In conclusion, the System for Monitoring Air Quality through IoT Technology has effectively demonstrated its capability to enhance air quality management and public health through the integration of cutting-edge technologies. The project achieved its primary objective of providing real-time, accurate air quality measurements by leveraging a combination of MQ-7, MQ-4, and MH-Z19 sensors. These sensors were instrumental in capturing diverse pollutant data, which was then processed and analyzed using advanced algorithms to ensure reliable results.

The system's real-time monitoring capabilities, coupled with sophisticated anomaly detection, allowed for immediate identification of hazardous pollution levels, thereby offering timely alerts to users. This proactive approach is crucial in mitigating the impact of air pollution on health. The predictive analytics component, utilizing time series and regression models, further enriched the system by forecasting air quality trends, allowing users to anticipate and prepare for potential changes in pollution levels.

User engagement was significantly enhanced through intuitive visualizations and a responsive alert system. Heatmaps, graphs, and charts provided clear and actionable insights into air quality conditions, while the alert system ensured users received real-time notifications of significant pollution events. The integration of route optimization algorithms also added a valuable dimension to the system, enabling users to plan their travels to avoid high pollution areas, thus reducing their exposure to harmful air pollutants.

Throughout the project, several challenges were addressed, including sensor accuracy and data processing efficiency. Variability in sensor readings and the need for real-time data handling were notable obstacles. Moving forward, efforts will be directed towards refining sensor calibration techniques, optimizing data processing algorithms, and scaling the system for broader deployment. Future enhancements will also focus on incorporating additional data sources and

user feedback to improve the system's functionality and user experience.

The successful implementation of this System for Monitoring Air Quality through IoT Technology highlights the transformative potential of technology in environmental monitoring. By providing comprehensive, real-time insights and actionable alerts, the system not only advances the field of air quality management but also contributes to the broader goal of improving public health. The project serves as a foundation for future innovations in environmental technology, underscoring the importance of integrating IoT and data analytics to address critical health and environmental challenges.

Overall, this project represents a significant milestone in leveraging technology to tackle air quality issues, offering a scalable and impactful solution that can be adapted and expanded to meet evolving environmental needs.

FUTURE WORK

The successful implementation of the System for Monitoring Air Quality through IoT Technology sets the stage for significant enhancements and expansions. Future improvements will focus on refining sensor accuracy through advanced calibration techniques and exploring new sensor technologies to capture a wider range of pollutants. Data processing will be scaled to handle increased volumes, incorporating sophisticated analytics such as machine learning for better predictive accuracy and anomaly detection. Geographic expansion will extend the system's reach, and integration with other environmental and public health systems will enhance its impact.

Additionally, user experience will be optimized through continuous feedback and interface enhancements. Predictive and prescriptive analytics will be advanced to offer actionable recommendations and better forecast air quality trends. Educational campaigns and public engagement initiatives will raise awareness and involve the community in monitoring efforts. Regulatory compliance will be ensured, with system data used to inform policy recommendations and advocate for measures to improve air quality.

ACKNOWLEDGMENT

I express my deepest gratitude to my mentors and professors at AISSMS College of Engineering, Pune, for their unwavering support and guidance.

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Enhanced Leaf Disease Detection Using Multi-Stage Segmentation and GAN-Based Classification Techniques

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ABSTRACT

This paper explores a framework for enhancing leaf disease detection using advanced image processing and machine learning techniques. The proposed approach begins with the scanning of leaf images, followed by data augmentation to increase dataset diversity. Image enhancement and edge detection techniques are then applied to improve the clarity and accuracy of the images.

To identify the most effective method for disease segmentation, multiple segmentation techniques will be implemented and evaluated. The framework integrates Generative Adversarial Networks (GANs) to further refine segmentation results and improve classification accuracy. The model will classify segmented regions to determine the presence and type of disease, offering a robust and scalable solution adaptable to various plant species.

The research emphasizes the importance of data integrity, model interpretability, and accuracy in the detection process. By systematically evaluating and refining these techniques, the framework aims to provide precise, reliable disease identification, ultimately contributing to more efficient agricultural management. This paper sets the stage for future practical implementations, with the goal of enhancing plant disease monitoring and treatment strategies.

KEYWORDS: Leaf disease detection, Image processing, Machine learning, Data augmentation, Image enhancement, Edge detection, Segmentation techniques, Generative adversarial networks (GANs), Classification, Agricultural management.

INTRODUCTION

Effective detection of leaf diseases is crucial for maintaining crop health and agricultural productivity. Traditional methods are often labor-intensive and prone to errors, highlighting the need for automated solutions. This paper introduces a machine learning-based approach for leaf disease detection that combines image processing with advanced algorithms. The approach starts with capturing high-resolution leaf images, which are augmented to enhance dataset diversity. Image enhancement and edge detection techniques are then applied to improve clarity and detail. Multiple segmentation methods are used to accurately identify diseased areas, with Generative Adversarial Networks (GANs) employed to refine these results and enhance classification accuracy. This framework aims to provide precise, actionable insights for disease identification and management, ultimately supporting more effective agricultural practices. The following sections outline the methodology, expected outcomes, and future directions for practical implementation of this approach.

LITERATURE REVIEW

Radhika et al. (2023) explored the application of Convolutional Neural Networks (CNNs) for detecting potato leaf diseases, including Late Blight, Early Blight, and Healthy states. Their study demonstrated the effectiveness of CNNs in achieving high accuracy in disease identification. The model's integration into existing systems was evaluated, with positive feedback from stakeholders, emphasizing its practical utility in reducing crop losses and enhancing agricultural health.

International Journal of Research Publication and Reviews (2022) focused on developing an automated disease detection system for potato leaves using CNNs. This research aimed to address challenges posed by Early Blight and Late Blight through image processing and machine learning. The system processed over 2000 leaf images, achieving a classification accuracy of 91.41%. The study highlighted CNNs' effectiveness in automating disease detection and classification, supporting increased potato production through digitization.

IOP Conference Series: Earth and Environmental Science (2022) examined rice leaf disease classification using CNNs, addressing the impact of diseases like Brown Spot, Leaf Blast, and Hispa on crop yield and quality. The study compared various deep learning models, finding that a 5-layer convolution model achieved the highest accuracy of 78.2%, outperforming models like VGG16 with an accuracy of 58.4%. This research underscores the importance of deep learning in disease detection for improved crop management and food security.

IJEAST (2023) investigated an automated system for potato leaf disease detection using CNNs. The study aimed to enhance potato production and digitize the detection system by analyzing leaf images. Over 2000 leaf pictures from Kaggle were used, achieving an impressive accuracy of 91.41%. The research highlights the effectiveness of CNNs and image processing in identifying and classifying potato diseases, with a focus on increasing crop yield and system efficiency.

EPRA IJRD (2023) addressed the need for rapid and reliable potato leaf disease detection using CNNs. The study demonstrated a significant breakthrough with an accuracy rate of 98.8%, facilitated by data augmentation techniques. This research emphasizes CNNs' potential in automating disease identification, improving flexibility to environmental variations, and contributing to global food security through early disease intervention.

These studies collectively highlight the advancements in using CNNs and other deep learning models for plant disease detection. They demonstrate the potential of these technologies to enhance accuracy and efficiency in identifying and managing agricultural diseases, ultimately contributing to improved crop health and increased productivity.

METHODOLOGY

Overview

The proposed methodology for leaf disease detection aims to create a comprehensive and effective system that combines advanced image processing techniques with cutting-edge machine learning algorithms. The approach involves several critical steps, including image acquisition, data augmentation, image enhancement, edge detection, segmentation, classification, and the application of Generative Adversarial Networks (GANs). This multi-step methodology is designed to enhance the accuracy and reliability of disease detection, supporting better agricultural practices and crop management.

Image Acquisition

The initial step involves capturing high-quality images of leaf samples, which serve as the foundation for the entire

detection process. These images will be collected using high-resolution digital cameras or scanners to ensure that they capture fine details of the leaf structures. The dataset will include images of both healthy and diseased leaves from various plant species to provide a diverse and representative sample. Special attention will be given to ensure that images are captured under consistent lighting conditions to minimize variability. Additionally, the dataset will be organized into categories corresponding to different disease states and healthy conditions to facilitate subsequent analysis and processing.

Image ID	File Name	Disease Type	Leaf Age	Days Since Born	Image Quality
1	this	Early	Young	10	High
2	this	Late Blight	M	30	Medium
3	the	Good	Old	60	Low
4	leaf_004.jpg	Early	Young	12	High
5	leaf_005.jp	The	Mature	35	Me
6	leaf_006.jpg	Good	Old	50	Hig
7	leaf_007.	Early Blight	One	8	Low
8	leaf_	Late Bligh	Along with	2	Medium
9	leaf_	Healthy	Old	55	High
10	leaf_010.jpg	Early Blight	AND	14	environment

Data Augmentation

To address the challenges of data scarcity and imbalance, data augmentation techniques will be employed to enhance the diversity of the dataset. This process involves applying various transformations to the original images to create new, synthetic images that represent different variations of the data. Techniques such as rotations, translations, scaling, flipping, and color adjustments will be used to simulate different conditions and scenarios. For instance, rotating images can help the model learn to recognize diseases from different angles, while color adjustments can simulate varying lighting conditions. By expanding the dataset through augmentation, the model's ability to generalize to new, unseen data is improved, thereby reducing the risk of overfitting and enhancing overall model robustness.

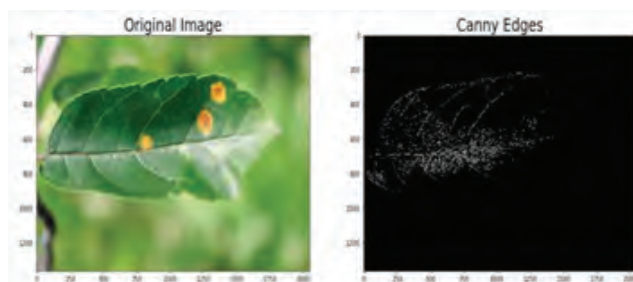
Image Enhancement

Image enhancement is crucial for improving the quality and clarity of leaf images, which directly impacts the accuracy of subsequent analysis. This step involves applying techniques to adjust and improve the visual quality of the images, making it easier to identify and analyze disease symptoms. Methods such as contrast adjustment, histogram equalization, and

noise reduction will be used to enhance the visibility of important features. For example, contrast adjustment can make the boundaries of diseased areas more distinct, while histogram equalization can improve the overall brightness and contrast of the images. These enhancements help in highlighting subtle disease symptoms and reducing the impact of noise and artifacts, thereby improving the performance of edge detection and segmentation algorithms.

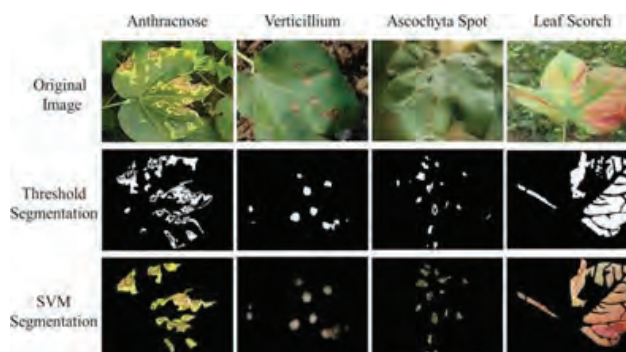
Edge Detection

Edge detection is a critical step for identifying the boundaries of leaf structures and disease symptoms, which is essential for accurate segmentation. This process involves applying algorithms that detect changes in intensity or color gradients in the images to outline the edges of different regions. Several edge detection techniques will be explored, including Canny, Sobel, and Laplacian operators. The Canny edge detector is known for its ability to detect edges with high precision and low error rate, while the Sobel operator emphasizes edges in specific directions. The Laplacian operator detects edges based on second-order derivatives and can be useful for detecting more subtle edges. The choice of edge detection algorithm will be based on performance evaluations to ensure that the most effective method is selected for accurate boundary identification.



Segmentation

Segmentation involves dividing the enhanced and edge-detected images into distinct regions corresponding to different areas of interest, such as healthy and diseased leaf parts. This step is crucial for isolating the regions that need to be analyzed and classified. Various segmentation techniques will be applied and compared to determine the most effective method for this task. Techniques such as thresholding, clustering (e.g., K-means), and region-based methods will be used. Thresholding involves segmenting the image based on pixel intensity values, while clustering methods group similar pixels into clusters. Region-based methods, such as watershed transformation, partition the image based on regions with similar characteristics. The selected segmentation method will be chosen based on its accuracy and ability to effectively differentiate between healthy and diseased regions.



Classification

Classification is the process of categorizing the segmented regions into specific disease types or healthy conditions. Convolutional Neural Networks (CNNs) will be used for this purpose, leveraging their ability to learn complex patterns and features from the images. The CNN will be trained on the segmented images to recognize and classify different disease types. The training process will involve feeding the model with labeled data, where each segmented region is associated with a specific disease label. The model will learn to identify patterns and features that distinguish between healthy and diseased leaves. The performance of the classification model will be evaluated using metrics such as accuracy, precision, recall, and F1-score to ensure that it provides reliable and accurate results.

Application of Generative Adversarial Networks (GANs)

Generative Adversarial Networks (GANs) will be employed to enhance the quality of segmentation results and improve classification accuracy. GANs consist of two neural networks—a generator and a discriminator—that work together to generate synthetic images. The generator creates new images, while the discriminator evaluates their authenticity. By generating additional variations of leaf images, including simulated diseased and healthy states, GANs help to augment the training data and improve the performance of the segmentation and classification models. This approach is particularly useful for addressing issues related to dataset imbalance and underrepresented disease types, leading to more accurate and robust disease detection.

Integration and Evaluation

The final step involves integrating the developed components into a unified system for leaf disease detection. The system will combine image enhancement, edge detection, segmentation, classification, and GAN-generated data to provide a comprehensive solution. The integrated system will be tested using a separate validation dataset to assess its overall performance. Evaluation metrics such as accuracy, precision,

recall, F1- score, and processing time will be used to measure the system's effectiveness. The results will be analyzed to identify strengths and areas for improvement, ensuring that the system meets the desired performance standards and provides actionable insights for disease management.

RESULTS

The proposed methodology, implemented through a mobile app, is expected to achieve several key outcomes. The Convolutional Neural Network (CNN) model, running on the mobile platform, is anticipated to deliver high accuracy in detecting and classifying leaf diseases, with accuracy rates projected to exceed 90%. This performance will be supported by advanced image processing techniques, effective segmentation methods, and data augmentation.

The mobile app will leverage multiple segmentation techniques to precisely identify diseased areas on leaf images, enhancing disease detection accuracy. Image enhancement features within the app will improve image quality and visibility, aiding in accurate edge detection and segmentation.

Generative Adversarial Networks (GANs) will be integrated into the app to generate synthetic data, addressing dataset imbalances and improving the model's robustness. The final integrated system within the mobile app is designed to provide reliable and accurate disease detection in real-time, directly accessible to users in agricultural settings.



The impact of deploying this system through a mobile app is expected to be significant. The app will enable on-the-go disease detection, allowing farmers and agricultural professionals to make timely decisions and manage crops effectively. Enhanced disease detection accuracy will contribute to better crop management, reduced losses, and improved food security. The app's practicality and accessibility will support precision agriculture and sustainable farming practices by providing real-time, actionable insights while minimizing the need for excessive chemical treatments. Additionally, the mobile app will facilitate broader adoption of advanced disease detection technology in agriculture, making it accessible to a wider audience.

CONCLUSION

The development of a mobile app for leaf disease detection, utilizing Convolutional Neural Networks (CNNs), advanced image processing, and Generative Adversarial Networks (GANs), promises to revolutionize agricultural practices. The app is expected to deliver high accuracy in identifying and classifying leaf diseases, thereby providing farmers with real-time, actionable insights. This capability will enable timely intervention, reduce crop losses, and enhance overall productivity and sustainability in agriculture. By making sophisticated disease detection technology accessible and user-friendly, the mobile app will significantly improve crop management and support food security, representing a substantial advancement in plant disease management.

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The Potential of Demand Response Management in Shaping the Future of Energy Systems: A Study on Empowering the Grid

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ABSTRACT

Demand Response Management (DRM) is an important component of the smart grid modernization process. DRM empowers utilities and consumers to actively manage energy consumption patterns by optimizing grid operations, increasing system dependability, and encouraging sustainability. The paper investigates the revolutionary potential of DRM by conducting an in-depth analysis of its concepts, methods, and applications. The focus of this paper is to study the challenges and opportunities that are linked with the incorporation of DRM, which includes the advancement of technology, legislative frameworks, and the participation of stakeholders. In addition to higher grid resilience, decreased operational costs, and increased utilization of renewable energy sources (RES), the adoption of DRM offers a variety of other benefits. It is possible for stakeholders to increase energy efficiency, demand flexibility, and grid optimization through the usage of DRM techniques, so paving the way for a future energy system that is more resilient and sustainable. In addition, a comparative evaluation of DRM implementation in Europe, the United States of America, and India is addressed in the paper.

KEYWORDS: Demand response management (DRM), Smart grids, Renewable energy sources (RES), Grid optimization.

INTRODUCTION

The transformation of conventional power grids into intelligent power grids is a notable advancement in the field of energy management and distribution. The integration of digital communication technologies and advanced metering infrastructure (AMI) into conventional electrical infrastructure is what makes smart grids possible. This integration enables real-time monitoring, analysis, and management of energy production and consumption. The imperative to improve energy distribution systems in terms of efficiency, dependability, and sustainability is the driving force behind this dramatic transition. One of the most important mechanisms for optimizing energy consumption and achieving a balance between supply and demand dynamics is the notion of DRM, which is at the heart of smart grid technology. End-users are responsible for the strategic modulation of their patterns of electricity use as part of DRM. This is done in reaction to fluctuating energy costs, grid congestion, or supply constraints.

Demand response efforts give customers the ability to modify their patterns of electricity consumption by means of dynamic pricing signals and automated control systems. This helps to alleviate the strain that is placed on the grid during

times of peak demand and reduces the amount of expensive infrastructure upgrades that are required.

The objective of this study is to examine and analyze the significance of DRM within the context of the implementation of smart grids. Our goal is to shed light on the critical role that demand response (DR) plays in determining the future of energy management and sustainability by conducting an investigation into its fundamentals, applications, problems, and potential effect. Stakeholders have the ability to pave the path for an energy ecosystem that is more robust, responsive, and efficient if they take use of the synergies that exist between smart grid technologies and DR tactics.

FUNDAMENTALS OF DRM

- The structure of the Smart Grid includes a crucial component known as DRM, which is required for the Smart Grid's efficient operation and optimization for optimal performance. It covers a collection of techniques and actions that are developed with the intention of modifying the use of electricity in response to fluctuations in demand, conditions on the grid, and pricing signals.

The Significance of DRM in the Smart Grid

- **Peak Load Mitigation:** The major purpose of DRM is to mitigate peak loads that occur during periods of increased electrical demand. By promoting the reduction of power use among consumers during periods of high demand, the electrical grid can function with greater efficiency and cost-effectiveness.
- **Enhanced Grid Flexibility:** DRM improves the flexibility of the grid by allowing it to quickly adjust to shifting demand patterns. The grid can ensure stability and resilience by dynamically altering electricity use in response to market signals or pricing.
- **Integration of Renewable Energy:** DRM is an essential component that can facilitate the smooth incorporation of RES into the electrical grid. DRM facilitates the optimal utilization of clean energy resources by aligning power usage with the availability of renewable energy.
- **Financial Benefits:** DRM efforts offer consumers the opportunity to achieve financial benefits by strategically adjusting their energy consumption to off-peak periods, so taking advantage of lower electricity costs. This not only leads to a decrease in individual utility expenses but also enhances the overall efficiency of the grid.

DRM is essential for maximizing electricity usage, guaranteeing the stability of the power grid, and promoting the shift towards a sustainable and efficient Smart Grid system. According to the Figure 1, the DR programs can be categorized into two distinct groups: those that are based on prices and those that are based on incentives.

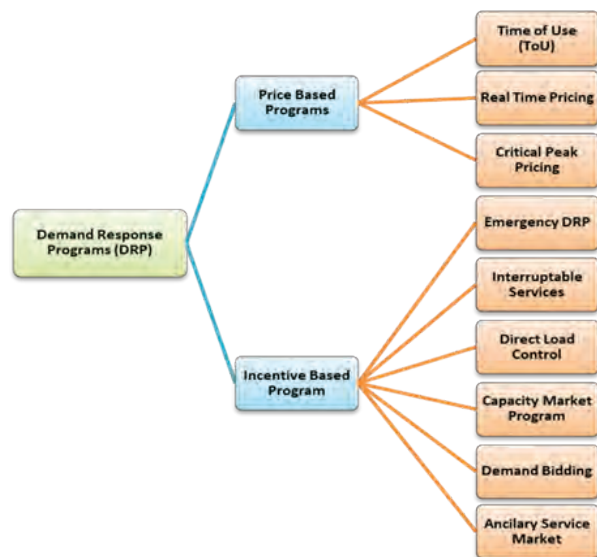


Fig. 1. Categories of DR programmes

DR Programs

DR programs are strategic measures aimed at incentivizing consumers to adjust their power consumption habits, especially during times of increased demand. These programs are essential to preserve harmony among the supply and demand of power and guaranteeing the dependability of the grid. DR programs can be classified into two primary categories: price-based and incentive-based.

Price-based DR Programs: These programs utilize fluctuating power costs over different time intervals as a means to motivate consumers to transition their electricity consumption from peak hours to off-peak hours, when electricity is more affordable. There exist three fundamental categories of price-based programs:

- **Time-of-Use (TOU) Pricing:** The rates of electricity are predetermined and subject to variation depending on the time of day, which is indicative of fluctuations in wholesale pricing. Peak hours are associated with higher rates, while off-peak hours are associated with lower rates [1].
- **Real-Time Pricing (RTP):** The prices of electricity exhibit hourly or more frequent fluctuations, which are indicative of the prevailing wholesale market pricing. Consumers have the ability to modify their consumption patterns in accordance with these fluctuating prices [2].
- **Critical Peak Pricing (CPP):** This is a combination of TOU and RTP. During important peak periods, which are normally advertised one day in advance, a predetermined higher rate is imposed [2].

Incentive-based DR programs are designed to offer monetary incentives or prizes to consumers as a means of encouraging them to decrease their power use during times of heightened demand or system problems. This paper examines the two primary categories of incentive-based programs.

Direct Load Control (DLC): During moments of high demand, utilities or third-party aggregators have a capacity to manage from a faraway location and reduce the usage of individual appliances or equipment, such as air conditioners or water heaters. Incentives or bill credits are provided to consumers as a result of their participation in the programme [3].

- **Interruptible/Curtailable Rates:** During emergencies or periods of high demand, large industrial or commercial clients willingly consent to decrease their electricity consumption upon receiving a request from the utility. As part of the agreement, individuals are provided with reduced electricity rates or incentive payments [4].
- DR programs, whether based on price or incentives,

are essential components in the management of power demand and the preservation of grid stability. In order to accomplish their targeted DR objectives, utilities and system operators utilize a variety of programs, taking into account elements like as consumer preferences, regulatory obligations, and market circumstances [3].

Advantages of DR Programs

DRM offers several key benefits for utilities, consumers, and the overall power grid:

For Utilities:

- **Grid Stabilization:** DR assists utilities in achieving equilibrium between the power supply and demand of the grid by decreasing the load during periods of high demand. The integration of variable RES such as wind and solar is particularly advantageous [5].
- **Cost Savings:** The mitigation of peak demand allows utilities to circumvent the need for costly peaking power facilities, resulting in a reduction of overall generation expenses [1].
- **Improved Asset Utilization:** The concept of DR involves the postponement or prevention of new infrastructure investments through the optimization of current generation assets [6].

For Consumers

- **Lower Energy Bills:** Incentives, rebates, or reduced rates are provided to consumers who engage in DR programs, resulting in a reduction of their overall energy expenses.
- **Increased Grid Reliability:** Minimizing the burden on the power system during periods of high demand improves dependability and decreases the likelihood of brownouts or blackouts that impact consumers [7].

For the Grid

- **Enhanced Flexibility:** DR enhances the grid's adaptability by enabling prompt adjustments to oscillations resulting from fluctuating renewable generation [3].
- **Reduced Emissions:** DR reduces the grid's reliance on fossil fuel power and decreases greenhouse gas emissions by avoiding peak plant utilization [8].
- **Deferred Infrastructure Investments:** The requirement for new power plants and modifications to transmission and distribution systems can be delayed or reduced if peak demand is brought under control.

At the same time, it improves the general stability and flexibility of the grid, the DR program is an efficient and

affordable method for balancing the supply and demand of the grid, integrating RES, lowering emissions, and providing financial incentives to both utilities and customers.

Algorithms used for DR Management

DRM is a strategic approach that aims to optimize energy use in order to effectively respond to fluctuations in supply and demand. Numerous algorithms are of paramount importance in facilitating this procedure. The following are often employed algorithms for the management of DR:

- **Reinforcement Learning (RL):** Reinforcement learning (RL) is a machine learning paradigm in which agents acquire the ability to make consecutive decisions by means of trial and error. RL algorithms play a important role in DR by facilitating the optimization of energy use through the utilization of feedback from past actions. This enables the implementation of dynamic and adaptive responses to accommodate fluctuating energy demands [9], [10].
- **Predictive Modelling Algorithms:** Predictive algorithms, such as regression analysis, time series forecasting, and machine learning models, utilize previous data and external factors to estimate future energy consumption. The utilization of these algorithms facilitates proactive energy management, enabling utilities to forecast peak demands and make appropriate adjustments to energy consumption.
- **Rule-Based Algorithms:** Predefined logical rules are employed by rule-based algorithms in order to ascertain patterns of energy consumption. These algorithms rely on if-then logic statements and demonstrate efficacy in straightforward DR tasks, wherein a well-defined set of rules can inform judgements on energy use.
- **Optimization Algorithms:** Algorithms for optimization, such as linear programming and evolutionary algorithms, are designed to save energy expenses while simultaneously satisfying demand limitations. The optimization of energy consumption plans is achieved by these algorithms through the real- time balancing of supply and demand or by employing predictive modelling techniques.
- **Machine Learning Algorithms:** In the field of machine learning, several techniques such as clustering, classification, and regression are employed to examine extensive datasets with the aim of detecting patterns and correlations in energy consumption. By utilizing past data, these algorithms can generate precise predictions of demand and suggest the most effective techniques for managing energy.

- **Metaheuristic Algorithms:** The complex mixed-integer non-linear DR scheduling problem has been solved using techniques such as grey wolf optimization (GWO) [11], particle swarm optimization, and genetic algorithms. These algorithms have the capability to identify schedules that are close to optimal for deferrable loads, taking into account user preferences and restrictions.
- **Hybrid algorithms:** These algorithms utilize a combination of two or more of the aforementioned techniques to exploit their advantages and surpass their constraints. One example of enhancing performance is the integration of a rule-based system with either an optimization method or a machine learning programme [4].
- **Convex Optimization:** DR scheduling has been conceptualized by researchers as a convex optimization problem, which can be effectively addressed through the utilization of techniques such as interior point approaches. The utilization of continuous variables to represent appliance operation hours circumvents the intricacies associated with mixed-integer programming.
- **Uncertainty-Aware Optimization:** The incorporation of uncertainties in renewable energy and consumer behaviour into stochastic/robust optimization models [12] enables the derivation of reliable DR plans in the presence of uncertainties.
- **Distributed Optimization:** Centralized scheduling is not feasible for large systems that have a high number of consumers. In order to find a solution the DR optimization in a decentralized manner, distributed algorithms utilizing the alternate direction method of multipliers (ADMM) [13] and other decomposition strategies have been suggested.
- **Load Aggregation and Thermal Inertia:** For the purpose of DR oriented scheduling, methods have been developed that aggregate flexible air conditioning loads by taking advantage of the thermal inertia of buildings [14].

The algorithm selection is contingent upon variables such as the problem's magnitude, accessible data, computer capabilities, and the desired balance between optimality and computational intricacy. Hybrid algorithms, which integrate various techniques, are frequently employed in practical applications to attain a harmonious equilibrium between performance and efficiency. The contemporary optimization methodologies utilize progress in optimization theory, parallel computing, and machine learning to achieve efficient, dependable, and user-friendly DR plans for the smart grid. [3]

COMMUNICATION PROTOCOLS AND INFRASTRUCTURE FOR DRM

The emphasis in recent times has been on improving the efficiency and effectiveness of smart grids' energy distribution networks through the development of communication protocols and infrastructure for DRM. In the period following 2020, there have been advancements in the incorporation of state-of-the-art technologies such as 5G, Internet of Things (IoT), and machine learning. These advancements aim to enhance energy efficiency and enhance the ability to respond to demand [15].

After 2020, various communication technologies and protocols have been created and implemented for managing DR in smart grids. These include 5G, LoRaWAN, NB-IoT, as well as updates to protocols such as OpenADR, IEC 61968, and IEEE 2030.5.

- **5G Cellular Networks:** The implementation of 5G networks has facilitated the provision of communications with reduced latency and increased capacity for smart grid applications, such as DR. The 5G network has the capability to facilitate extensive machine-type communications (mMTC) for Internet of Things (IoT) devices and provide highly dependable low-latency communications (URLLC) for essential smart grid services [16].
- **LoRaWAN (Long Range Wide Area Network):** The LoRaWAN protocol is designed to cater to the needs of IoT and smart city applications, such as smart metering and DR, by offering a low-power and long-range wireless communication solution. It offers extensive connectivity for Internet of Things (IoT) devices that are powered by batteries and have modest bandwidth requirements.
- **NB-IoT (Narrowband IoT):** NB-IoT is a wireless communication system that facilitates effective communication between Internet of Things (IoT) devices and the smart grid using pre-existing cellular infrastructure. It provides support for a significant quantity of low-throughput devices, such as smart meters [17].
- **OpenADR (Open Automated Demand Response)** OpenADR is a widely accepted and standardized communication data type designed for DR. It enables utility companies to transmit event signals related to DR to customers in the commercial and industrial sectors. The introduction of Version 2.0b in 2020 introduced the inclusion of distributed energy resource support.

- IEC 61968 Update [18] The IEC 61968 series establishes a set of standards that govern interfaces utilized in utility operations, encompassing DR aspects. New interfaces for DER management and DR have been introduced in recent releases.
 - IEEE 2030.5: The smart grid communications protocol known as IEEE 2030.5 was initially granted approval in 2013. The latest revisions have improved the functionality of DR signaling to facilitate communication between utilities and energy service providers [19].
- Emerging technologies have the potential to enhance the resilience, security, and scalability of communication networks utilized in smart grid DR programmes. This enables the effective dissemination of information to a wide range of residential, commercial, and industrial consumers, while also facilitating the management of distributed energy resources (DERs).

Table 1. Comparison of Demand Response Protocols: Functionality And Limitations

Protocol	Description	Usefulness in DRM	Limitations
Open ADR	Open Automated Demand Response (OpenADR) is a standardized protocol facilitating communication between utilities and end-users for Automated DR signaling.	It enables automated and interoperable DR signaling, allowing utilities to send load control signals to commercial and industrial customers during peak demand periods.	Implementation complexity may arise, along with dependencies on standardized equipment and software.
IEC 61968/61970	IEC 61968/61970 are integration standards for operations and information exchange within electric utilities.	These standards facilitate the integration of DRM systems with other utility systems, enabling efficient data exchange and coordination.	The adoption of these standards may necessitate significant investment in system upgrades, and interoperability challenges might arise with legacy systems.
ZigBee Smart Energy Profile	ZigBee Smart Energy Profile is a wireless communication protocol designed for energy management and DR in residential and commercial buildings.	It enables utilities to control and monitor smart meters, thermostats, and other energy-consuming devices for DR purposes.	Limitations include its limited range and susceptibility to interference from other wireless devices. Vulnerabilities to cybersecurity threats and limited support for newer communication technologies may
DNP3	Distributed Network Protocol (DNP3) is a standard for communication between control systems and field devices in the electric utility industry.	It allows utilities to monitor and control DERs, such as energy storage systems and renewable generation, for DRM.	Vulnerabilities to cybersecurity threats and limited support for newer communication technologies may be encountered.
MQTT	Message Queuing Telemetry Transport (MQTT) is a lightweight publish-subscribe protocol for machine-to-machine communication.	It facilitates efficient data exchange between smart meters, sensors, and DRM systems, enabling real-time monitoring and control.	Limitations include limited support for Quality of Service (QoS) guarantees and potential increases in network traffic and latency

CHALLENGES AND ISSUES

Emerging technologies have the potential to enhance the resilience, security, and scalability of communication networks utilized in smart grid DR programs. This enables the effective dissemination of information to a wide range of residential, commercial, and industrial consumers, while also facilitating the management of distributed energy resources (DERs).

- Consumer Participation: Encouraging customers to engage in DRM programs can be difficult due to apprehensions regarding comfort, convenience, and the apparent relinquishment of control over energy consumption. It is essential to promote voluntary participation by implementing effective engagement, education, and reward programs.
- Privacy and Security: DRM systems encompass the collection and analysis of customer energy consumption data, hence giving rise to privacy problems. To address these concerns and establish consumer trust, it is crucial to have strong data protection safeguards and transparent rules.
- Integration with Renewable Energy: The intermittent nature of RES such as solar and wind necessitates the adaptation of DRM systems to meet their growing usage. The use of energy storage technology and intelligent grid management is of paramount importance in achieving optimal demand-supply equilibrium.
- Regulatory Challenges: The successful implementation of DRM necessitates the presence of regulatory and legislative frameworks that provide incentives for

utilities, consumers, and other stakeholders to actively participate.

Well defined protocols, criteria, and market mechanisms are essential for the effective implementation of DRM projects.

CASE STUDY

The objective in India is to achieve a 15% reduction in energy demand during peak hours by the year 2025 by implementing DR programs. Nevertheless, the level of consumer engagement remains comparatively low as a result of insufficient awareness.

India encounters various problems in the successful implementation of DR programs, including legislative barriers and sluggish infrastructural development. Potential solutions encompass enhancing consumer awareness, optimizing regulatory processes, and expediting the implementation of infrastructure. In contrast, the United States has successfully decreased total power consumption in the commercial and industrial sectors by 5% in 2019 through DR programs. This achievement may be attributed to the implementation of incentives and awareness campaigns, which have encouraged greater consumer engagement. The nation derives advantages from a robust regulatory framework and sophisticated infrastructure that facilitates the execution of DR. DR efforts implemented by European governments have resulted in a 6% decrease in overall electricity usage within the European Union in 2019. They tackle obstacles by providing regulatory assistance, offering incentives, and fostering collaboration, utilizing EU rules to guarantee adherence and encourage acceptance. Every region acknowledges the significance of incorporating DG with RES to improve the stability and efficiency of the power grid, however there may be differences in the level of progress in infrastructure and regulatory frameworks.

FUTURE TRENDS

The incorporation of smart home technology, such as smart meters, smart appliances, and home energy management systems, facilitates the ability to monitor and regulate energy consumption in real-time within a household setting. By incorporating these technologies into DR programmes, residential consumers can achieve enhanced flexibility and responsiveness. As an illustration, intelligent thermostats possess the capability to autonomously regulate temperatures during moments of high demand by utilizing utility signals or dynamic pricing mechanisms [4] [20].

- DERs and microgrids: DERs such as rooftop solar panels, battery storage, and electric cars, offer homes and communities the ability to generate and store energy

in a localized manner. Microgrids refer to localized energy grids that possess the capability to detach from the conventional grid and function independently. The incorporation of DERs and microgrids into DR systems has the potential to bolster grid resilience and facilitate community engagement in grid services such as peak shaving and frequency management [1] [2][3].

- In relation to recent statistical data in India, a survey conducted in 2021 by the India Smart Grid Forum revealed that a mere 3% of utility DR initiatives in India were specifically aimed at residential consumers. This finding underscores the considerable untapped opportunities within this particular sector [21]. The government has established a lofty objective to achieve a valuation of \$4.6 billion for the Indian smart meter sector by 2025, perhaps stimulating residential DR [22]. Nevertheless, it is imperative to acknowledge and tackle obstacles such as limited consumer knowledge and inadequate regulatory structures.

CONCLUSION

DRM plays a vital role in India's pursuit of a more intelligent and environmentally friendly energy future. According to statistics, only approximately 3% of utility DR programmes in India specifically focus on residential clients. This suggests that there is a substantial amount of untapped potential in this sector. By using cutting-edge technologies such as 5G and IoT, and taking proactive steps to tackle regulatory obstacles and improve consumer knowledge, DRM presents a hopeful route towards optimizing the grid and promoting sustainability. Through harnessing these technological breakthroughs and promoting cooperative endeavors, India has the potential to unlock untapped opportunities in energy management, thereby crafting a more promising and robust future for everyone. It is recommended that future study places emphasis on comprehending consumer behavior and incorporating renewable energy into DR strategies, while concurrently establishing regulatory frameworks and cybersecurity measures that are conducive to this objective. In order to foster innovation and ensure sustainability in DRM, it is imperative to engage in interdisciplinary collaboration and conduct comprehensive long-term effect assessments.

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State of the Art Review on Maximum Power Point Tracking, Power Quality and Control Strategies for Solar Photovoltaic Systems

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ABSTRACT

Integrating renewable energy resources into power distribution systems diversifies the energy supply market while reducing the load of centralized power plants and global emissions. Solar photovoltaic is a type of renewable energy resource that delivers peak capacity for short period of time which is also unpredictable and intermittent in nature. In this review, advanced Maximum Power Point Tracking (MPPT) algorithms are used to reduce power quality issues, and the possibilities of solar photovoltaic system energy enhancement by converter/inverter technology, energy management and scheduling strategies, dependability, energy policies, and control systems, among other factors, are investigated with cutting-edge control techniques. Also looks on measures to reduce the effects of a high renewable energy penetration rate on power quality. Different category-based evaluation exercises are expected to benefit both researchers and business specialists by giving information about present power quality concerns, methods to improve, and prospective paths for future solar photovoltaic technology development.

KEYWORDS: *PV module, Power quality, MPPT controller, Optimization algorithm, Energy efficiency.*

INTRODUCTION

Global concerns about the need for universal access to electricity are driving many researchers to explore for cleaner, more efficient ways to generate power as well as strategies to optimize the cost and generation efficiency of existing techniques [1]. The limited supply of fossil fuels utilized in traditional power plants to generate electricity has also prompted a move toward greener power supply [2]. The power industry is eyeing Renewable Energy (RE) technologies as an alternative for the sustainable energy transition because of the detrimental environmental effects in regular coal and thermal power plants [3]. Furthermore, the electricity supply is made even more dependable by hybridizing these RE resources to meet an equivalent load [4]. Nevertheless, the nature of RE resources is unpredictable even with its viability. For instance, the continual fluctuation of radiation from the sun and the speed of wind makes solar and wind energy unstable [5]. As illustrated in Fig. 1, the increasing number of articles published each year reflects researcher's interest in solar PV's MPPT technique and the author's ongoing involvement in the RE-incorporated power system.

Furthermore, solar modules are used in PV systems to harvest solar energy; however, due to the modest conversion

effectiveness of these modules, the amount of solar energy harvest is restricted [6]. These factors have led to the current use of various control strategies to track these energy system's maximum power. The Maximum Power Point (MPP), which is constantly shifting in relation to temperature and solar radiation intensity when PV system power output maximizes. Because the systems are made to produce a specific amount of power before installation, this has an impact on the size of the PV output power for a particular system [7]. A point on the PV curve that indicates the maximum power production at a given time period is called as optimal operational point and it must be at MPP in order to track the highest power output of the PV generator [8,9]. As a result, MPPT methods require continuous tracking of MPP [10] which optimizing the amount of energy extracted from PV modules. The goal of all MPPT controllers is to ensure that power change with respect to voltage is always zero on the P-V characteristic curve. The PV module's output current and voltage are measured, and the source impedance is matched to the load by suitably varying the rate of duty period of the converter in use. The MPP is tracked when the impedance matches correctly [11, 12]. Making use of solar tracking strategies is beneficial since it raises the output power and efficiency of PV systems [13,14]. Voltage tracking and determining the right duty ratio variation to maximize the PV system's output power provide an important challenge for MPPT systems [15,16].

MODELLING AND CHALLENGES OF GRID INTEGRATED RES

Grid integration of RE systems is crucial to reduce fossil fuel-based power generation and satisfy the growing demand for power more effectively as shown in Fig. 1. This grid integration raises challenges according to the identifications from IEEE Standard 929-2000, are voltage, frequency, voltage flicker, and current harmonic distortion [21]. This section addresses these PQ difficulties based on the grid integrated performance of the PV array.

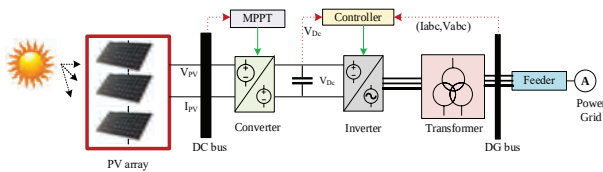


Fig. 1: Grid integrated PV module array energy management

Modelling of PV module

Solar cells use a P-N junction consisting of a thin plate or semiconductor layer. Exposure to light generates a photocurrent which is proportional to solar irradiation when photon energy exceeds the bandgap [22]. A solar cell's I-V output follows an exponential pattern, comparable to a diode. Fig. 2 depicts single diode model of the PV module.

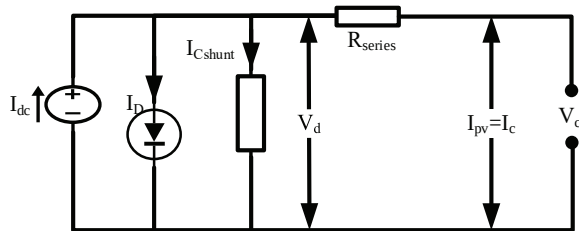


Fig. 2: Single diode model of PV module

According to the light energy (photons), the current passing through the load is expressed as,

$$I_{p\text{cell}} = I_{po} - I_o \left[\exp \left\{ \frac{q(V_{pv} + I_p S_r)}{\eta_k T} \right\} - 1 \right] - \frac{V_{pv} + I_p S_r}{S_r} \quad (1)$$

where, V_{pv} is PV voltage, I_p current, series resistance S_r , shunt resistance S_r , 'q' is the electron charge (1.6022×10^{-19} C). The PV array has been modified depending upon the load requirement by varying the Eq (1), which is works by Eq (2), and u,v are assigned as the indices.

$$I_{p(u,v)} = mI_p - mI_o \left[\exp \left\{ \frac{q(V_{p(u,v)} + I_{p(u,v)} S_r(u/v))}{\eta_k T} \right\} - 1 \right] - \frac{V_{p(u,v)} + I_{p(u,v)} S_r(u/v)}{S_r(u/v)} \quad (2)$$

The PV output current I_{po} depends on the factors such as outside temperature H and sun lights irradiation (I_m), miscellaneous loss factor .

$$I_{po} = I_{sc} \frac{I_m}{I_m^*} \left[1 + (H - H_R) \times l_i \right] \quad (3)$$

Using these parameters adjustments, MPPT achieved better in partial shading and uniform insolation conditions of the grid-integrated PV system operation [23-25]. The next sections cover the challenges and other significant threads which restricts the system in harvesting high PV efficiency.

PQ Difficulties in Incorporating Renewable Energy into The System

Some important factors affecting the grid integrated operation of PV are discussed in this section according to [26] are as follows,

Variations in the weather have a major impact on the oscillation of electricity produced by RE sources like wind and solar energy. These variations lead to excess voltage fluctuations and changes in the frequency of the grid. These variations include shifts in the distribution line peak and RMS voltage and affects the proper operation of many residential appliances.

One of the greatest problems with PQ in the electrical and commercial sectors is voltage sag. In the electricity network, voltage sags have an effect on grid stability. A voltage drop occurs in the network when solar PV is connected to the grid because it injects a lot of current into it. Industries are most affected by voltage sag because it reduces the lifespan of electrical equipment and resulting in large financial losses. Instability, decreased system efficiency, and system shutdown are possible additional consequences of voltage sag.

PQ IMPROVEMENT METHODS

This section discusses several MPPT approaches for operating PV modules with the grid. Some important contributions to PQ improvements in grid integrated operations via various strategies and its developments are explored in detail.

MPPT

An MPPT controller coordinates the activities of each linked power optimizer and forcing them to function in a certain mode. A larger version of a solar PV system connected to the grid requires a constant power source from the grid or batteries to work properly. MPPT is based on PV module, and its varying responses for different voltage, current, and temperature characteristics under normal condition in Fig. 3 (a-c) and Partial Shading Condition (PSC) is given in Fig.3 (d).

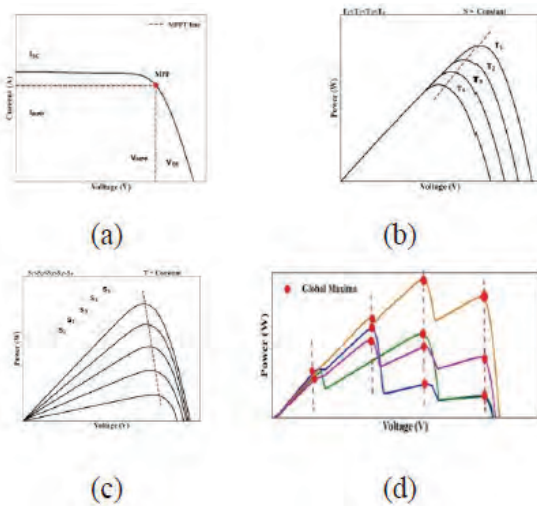


Fig. 3: Characteristics of voltage, current and power of the PV module (a) MPP of PV module (b) MPPT-varying response of temperature (c) MPPT-varying response of insolation (d) PV module with partial shading condition-MPPT (global maxima)

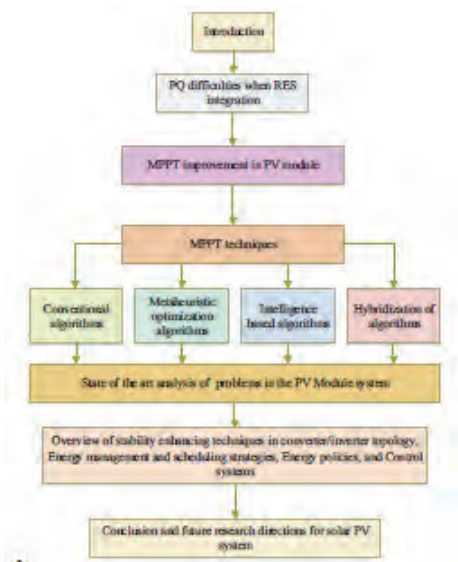


Fig. 4: Structure of the proposed article

The difficult aspect of solar energy is its dynamic ability to generate varying voltage and power based on the surrounding environment. These characteristics include wind speed, shade, and sun insolation angle. Consequently, there is no assurance that the maximum power is generated at any electrical loads [29]. With the right controllers, MPPT approaches maximize the power that extracted from PV installations.

There are numerous MPPT approaches for running PV modules at maximum power. Nonetheless, the technique

efficacy is determined by its capacity to follow changing meteorological conditions in real time. So, depending on the nature of the tracking under PSC [30-36], these strategies are grouped into four categories based on algorithms that increased MPPT control of PV modules to improve efficiency such as conventional, metaheuristic, intelligence, and hybrid optimization.

Conventional Algorithms

This section incorporates the analysis of conventional algorithms to track MPP. PV array terminal voltage is always updated based on the MPP voltage, and the duty cycle is immediately adjusted in the Perturb and Observe (P&O) algorithm and also MPPT may effectively reduce the total PV system cost while requiring less implementation costs [37].

A modified P&O MPPT system lowered convergence durations to 0.16 s and oscillation of steady-state at 1 W, with a response of step load change at 1.8 sec [38, 39]. The usage of variable step size in a MPPT scheme with P&O is required to get the best results in terms of short convergence time and minimal steady state oscillation [40]. The Incremental Conductance (IC) method was chosen because it is simpler and has better steady-state performance than the P&O approach [41]. The Sliding Mode Control (SMC)-based open circuit voltage MPPT approach is utilized to overcome the nonlinearity of the I-V characteristics-based problem, which is dependent on the temperature and irradiation circumstances [42]. It is employed with a buck converter to generate an ideal PV array output voltage [43].

Metaheuristic algorithms

This section incorporates the analysing of metaheuristic optimization algorithms to enhance the tracking of MPP by the MPPT Controllers and Table 1 provides different optimization algorithm-based control strategies.

BAT algorithm-based Proportional Integral (PI) controller's MPPT optimization provides excellent performance and is characterized by stability in operation [48]. With the Grey Wolf Optimization (GWO)-based MPPT approach, the challenge of tracking the Global Peak (GP) of a PV array under PSCs is attempted [49]. By using an active electronic circuit known as smart bypass with a two-step tracking MPPT algorithm, it is possible to reduce the conduction loss linked to the bypass diode's resistance under partial shading condition while extracting 35% more power compared with the traditional P&O approach [50]. Teaching Learning Based Optimization (TLBO) boosted tracking speed. In all tested distinct partial shade patterns, the average tracking time of global MPP is lowered by more than 23.8% compared with Particle Swarm Optimization (PSO) [51, 52].

Table 1: Control strategies of conventional nature inspired metaheuristic algorithms

Author and Citation	MPPT Algorithms	Control strategy	Input parameters	Output parameters	Cost	Operation	Converter
Mohanty, S. et al. [49]	GWO	Bio-inspired	Volt, Current	Duty cycle	High	Standalone, Grid -tied	DC/ DC
Nusaif, A.I. et al. [68]	ACO	Probabilistic algorithm	Volt, Current	Duty cycle	Low	Standalone, Grid -tied	DC/ DC
	ABCO	Bio-inspired	Volt	Duty cycle	High	Standalone, Grid -tied	DC/ DC
	Deterministic -PSO	Modified PSO	Volt, Current	Duty cycle	Low	Standalone, Grid -tied	DC/ DC
Pradhan, C., et al. [72]	RIO	Bio-inspired	Volt	Duty cycle	Low	Standalone, Grid -tied	DC/ DC
Basha, C.H. et al. [97]	SAOA	Metal annealing technique	Temperature	Max. Power	High	Standalone, Grid -tied	DC/ DC
	Cuckoo search	Bio-inspired	Volt	Duty cycle	Low	Standalone, Grid -tied	DC/ DC
	FFA	Bio-inspired	Volt, Current	Duty cycle	Low	Standalone, Grid -tied	DC/ DC

Other metaheuristic techniques that track global MPP [53] under PSC [54], dynamic conditions [55, 56] with battery storage facility [57] to improve PV efficiency [58] precisely with appropriate MPPT technique [59-61] also have single or multi MPPT structures [62] to improve solar PV module array performance.

A novel reduced sensor approach for single-phase two-stage grid connected solar PV systems was improved in a study conducted under PSC in variable temperature and irradiation conditions, which was found to be less expensive, more reliable, and easier to maintain even in the absence of a Direct Current (DC) link sensor [63]. The highest PV panel power extraction and a simpler implementation with the advantage of a higher convergence velocity are provided by the modified sine-cosine algorithm [64].

Also Fig. 5 illustrate the flowchart of the HBA algorithm [65] and Fig.6 showing the flowchart of the Sand Cat Optimization (SCO) algorithm.

The most studied domain is the optimization of MPPT controllers under partial shading circumstances, using a variety of optimization techniques such as PSO [68, 69], musical chair, and modified seagull [70]. The Roach

Infestation Optimization (RIO) method outperforms the PSO, P&O, and IC-based MPPT schemes under PSC in tracking, yielding a greater efficiency of 99.19% in constant shadowing and 99.86% during high accuracy.

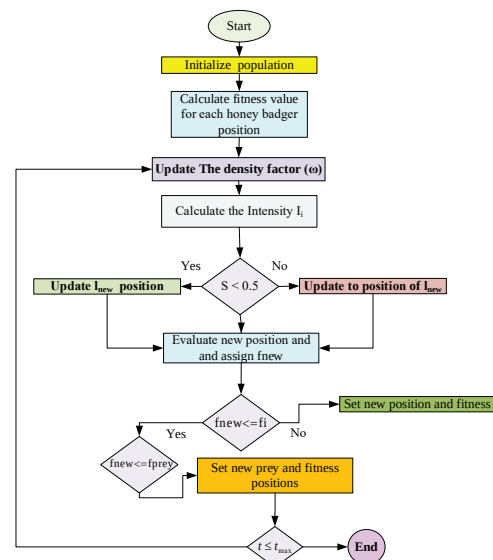


Fig. 5: Flowchart of the HBA Algorithm

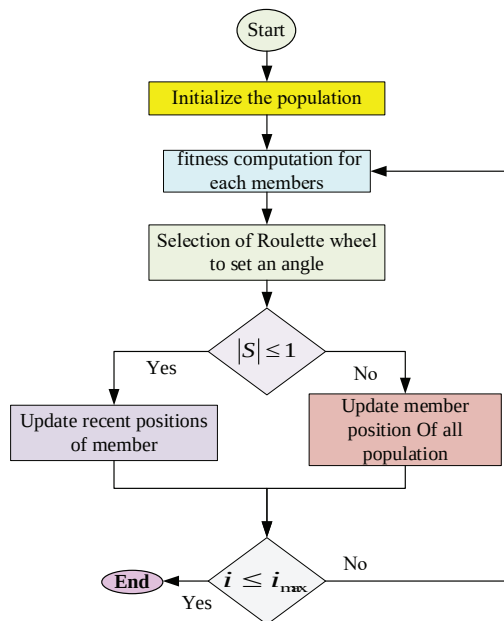


Fig. 6: Flowchart of the Sand Cat Optimization Algorithm

Intelligence Algorithms

The best gain values are set using the Fractional Order Transfer Function (FOTF) toolbox, and the system's dynamic responsiveness is enhanced by Fractional Order PID (FOPID) controller. It is discovered that the response obtained by the FOPID controller has shorter rising and settling times than the response obtained by the Proportional Integral Controller (PID). Under varying irradiance and temperature, the Fuzzy Logic Controller (FLC) based MPPT technique applies a boost converter with PI control that functions as a charge controller as depicted in Fig. 7. Using a DC-DC buck converter, a nonlinear Backstepping Controller (BC) may extract the most power possible from PV array. By using Lyapunov stability criteria, the system's asymptotic stability is enhanced. The DC gain of a single-stage PV fed buck converter, which functions as a battery charge controller, is controlled by the load resistance, which is usually significantly more than the series resistances in the circuit.

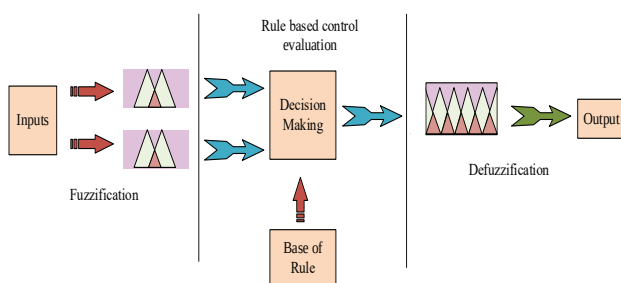


Fig. 7: Fuzzy logic based MPPT control

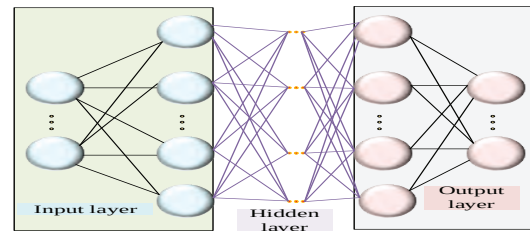


Fig. 8: Convolutional Neural Network

Even under changing temperatures and irradiances, the PV system operates in steady-state, the Multivariate Linear Regression (MLR) machine learning method yields a mean efficiency of more than 96% . In order to follow the rapidly changing MPP, a unique MPPT controller for standalone PV systems is based on a Neural Network (NN) as illustrated in Fig.8 and a Gain Scheduled Proportional Integral (GSPI) integrated controller is used for tracking MPP.

Hybrid Algorithms

An effective and reliable MPPT algorithm that tracks the MPP quickly and precisely with the combination of IC and Fractional-Order Control (FOC) methods Integral Regulator (IR) and IC algorithm provide excellent tracking accuracy and productivity at steady state under rapidly changing atmospheric conditions, which is utilized to get MPPT in PV systems . When the performance of the two-step size approach for IR in the solar PV system is examined, it is discovered that the variable step size method outperforms the fixed step size method and increases promising efficiency to 95.23% .

CONCLUSION

This review study covered numerous issues of RES integration, such as PV systems into the grid, as well as cutting-edge MPPT techniques in four categorized optimization approaches using controllers and algorithms. It also examined sophisticated control strategies for improving tracking speed in a PV integrated energy management system, as well as efficient PV power scheduling systems. The utilization of different converter technologies to successfully mitigate a number of operational and technical challenges related to grid integration of solar PV plants is also covered in this study. Some of the key energy policies and standards used to support bulk RER integrated power generation is also provided. Also, comprehensive grid integrated solar PV control strategies are discussed elaborately and concludes with the necessity of advanced control methods in future.

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A Comprehensive Review of Virtual Inertia Control Strategies for Highly Penetrated Renewable Energy Sources

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ABSTRACT

The incorporation of renewable energy sources (RES) into the electrical grid presents distinct obstacles concerning grid stability and resilience as a result of their intrinsic variability and intermittency. In response, virtual inertia control strategies have emerged as promising solutions to replicate the stabilizing effect of traditional synchronous generators and enhance the power system stability with extensive renewable energy penetration. This review study comprehensively explores the recent advancements in virtual inertia control strategies for highly penetrated renewable energy integration, synthesizing findings from a wide range of research efforts and methodologies. Through an in-depth analysis of control algorithms, optimization models, and case studies, this review elucidates the effectiveness, challenges, and opportunities associated with virtual inertia control strategies. Various control techniques, including Two-Layer Multiple Model Predictive Control (TLMMP), Load Frequency Control (LFC), and Fuzzy Adaptive Virtual Inertia Control, are evaluated in terms of their ability to improve grid stability, frequency response, and energy management in the presence of RES. The future scope for advancements in virtual inertia control strategies for renewable energy integration lies in further enhancing the adaptability and scalability of control algorithms, exploring innovative approaches for integrating multiple RES and promoting real-time implementation and validation in large-scale power systems.

KEYWORDS: Virtual inertia control strategies, Renewable energy integration, Wind farms, Solar PV systems, Battery energy storage systems (ESSs), Conventional grid operation.

INTRODUCTION

The emergence of virtual inertia (VI) from RES represents a transformative advancement in the quest for grid stability within the context of a rapidly evolving energy landscape. Traditionally, grid stability has relied heavily on synchronous generators, which inherently possess inertia a property that stabilizes the grid by resisting changes in frequency. However, the increasing integration of RES, characterized by their variable and non-dispatchable nature, challenges this paradigm[1]. Virtual inertia offers a solution by replicating the stabilising influence of inertia sophisticated control algorithms embedded within power-electronics-based devices, such as inverters connected to renewable energy systems. By dynamically modifying power output in reaction to variations in grid frequency, virtual inertia contributes to grid stability without relying on traditional synchronous generators, thereby enabling increased grid integration of green energy sources while preserving reliability[2]. Furthermore, the application of VI has the potential to

enhance power systems stability and flexibility in the face of changing energy dynamics and new grid difficulties. As renewable energy penetration continues to grow, the ability to effectively manage grid stability becomes paramount [3]. Virtual inertia not only provides a way to address frequency disturbances but also enables grid operators to optimize energy flows, mitigate voltage fluctuations, and enhance overall system resilience. Furthermore, by decentralizing grid control and leveraging distributed energy resources, virtual inertia promotes a more decentralized and modular approach to grid management, fostering a more robust and sustainable energy infrastructure. As such, the integration of simulated inertia derived from RES represents a judicious step towards achieving a cleaner, more reliable, and resilient energy future.

The current controller serves as an important component in regulating the flow of electric current within the VSG system, ensuring stability and accuracy in grid-connected operations [4].

Voltage source converter tied to weak grid

The integration of 3-phase voltage source converters (VSCs) tied to weak grids presents a unique set of challenges and opportunities in modern power systems. Weak grids are identified by low short-circuit capacity and high impedance, struggle to maintain stable voltage and frequency levels, particularly when exposed to disruptions such as sudden load changes or faults [5]. Three-phase VSCs, equipped with advanced control algorithms and power electronics, offer a hopeful solution to enhance grid stability and power quality in such challenging environments. By dynamically adjusting the output voltage and current waveform, VSCs can inject reactive power and provide voltage support, effectively compensating for the deficiencies of weak grids and improving system performance [6]. However, the integration of VSCs into weak grids requires meticulous consideration of control approaches and coordination mechanisms to ensure seamless operation and grid stability. Problems such as variations in voltage and distortion caused by harmonics, and interaction with existing grid components must be addressed through robust control algorithms and grid synchronization techniques[7]. Moreover, the optimal sizing and placement of VSCs within the grid network play a critical role in maximizing their effectiveness while minimizing costs. Despite these challenges, the deployment of three-phase VSCs represents an encouraging avenue for improving the resilience and reliability of weak grids, facilitating the development of a more environmentally friendly and effective electricity infrastructure[8]. linked to weak power grids, 3-phase grid-tied power converters with VI control may experience instability. As a result, 3-phase grid-tied to power converters can successfully offer virtual inertia to weak power grids, as demonstrated by experimental data.

Efficient Management of Intelligent Hybrid Power Systems

Efficient management of intelligent hybrid power systems is paramount for optimizing the integration of diverse energy sources while ensuring stability and reliability of grid. Smart hybrid power systems typically comprise a mix of RES, ESSs, and conventional generators, each with varying characteristics and operational requirements [9]. Healthy control strategies are essential to dynamically manage the generation, storage, and distribution of energy within the system, considering factors such as weather conditions, demand fluctuations, and grid constraints [10].

Fig.1 presents a simplified closed-loop system block diagram for a Standalone Hybrid Power System (SHPS). Such systems typically integrate multiple RES and backup generators, delivering consistent and sustainable power supply to remote or isolated areas. The closed-loop control system depicted in the diagram encompasses various components, including

sensors for monitoring renewable energy generation, battery state-of-charge, and load demand. These sensor signals are fed into a control unit, which implements algorithms for power management, energy storage control, and load balancing. The control unit then generates control signals to regulate the operation of RE converters, ESSs, and backup generators, ensuring optimal system performance and stability.

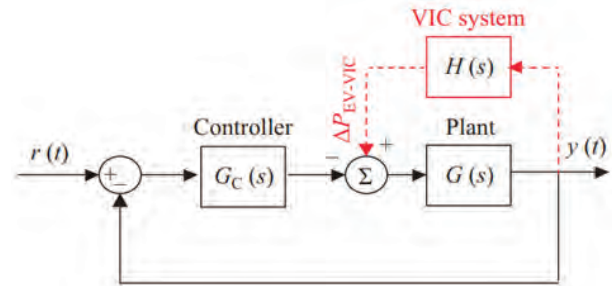


Fig. 1. Simplified SHPS Closed-Loop System Block Diagram

Virtual Inertia Emulation and RoCoF Control of a Microgrid

Rate of Change of Frequency (RoCoF) and Virtual inertia emulation control are crucial aspects of managing microgrids, especially in scenarios where RES dominate the generation mix. As distributed energy resources like wind and solar become more integrated, which lack inherent rotational mass, the grid's stability during disturbances becomes challenging [11]. Virtual inertia emulation techniques, typically implemented through advanced control algorithms, mimic the characteristic of traditional synchronous generators by dynamically adjusting power output in response to frequency deviations, thereby providing stability to the system. [12] examined a GA-optimized PI controller, and for RoCoF and frequency control of the previously mentioned low-inertia MG, an ESD-based VI simulation method that takes into account both inertia and damping has been proposed. The findings indicate that the suggested strategy manages the MG's frequency and RoCoF significantly better than various preexisting VI control methods. [13] introduced a novel application of virtual inertia simulation that utilizes ESSs to imitate inertia power, hence enhancing stability frequency and performance. Derivative control is utilized to attain sophisticated control of inertia emulation.

Fig. 2 shows the system under study's frequency response under "Electric Vehicles" uncertainties, focusing on conventional Load Frequency Control (LFC) with a ROCOF of 0.056 Hz/s. This frequency response characterization is crucial for understanding how the system behaves in uncertainties associated with EVs, which can significantly impact grid stability due to their variable charging and discharging patterns [14]. The frequency response curve

provides insights into how the system's frequency deviation evolves in response to disturbances, helping to evaluate the LFC scheme's effectiveness in mitigating frequency deviations and ensuring grid stability.

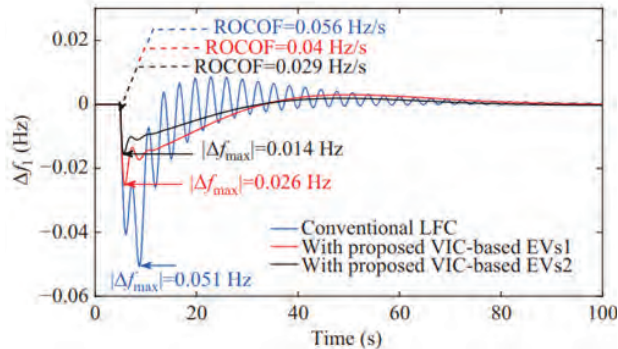


Fig. 2. Analysis of frequency response in the presence of uncertainties related to electric vehicles (EVs) [16]

Fundamental of Virtual Inertia

The fundamentals of virtual inertia lie in replicating the stabilizing effect conventionally provided by synchronous generators in power systems within an environment dominated by RES and power electronics [15]. In essence, virtual inertia involves the application of control strategies that mimic rotating machines' inertial reaction by modulating power generation or consumption in response to frequency deviations [16]. This emulation is typically achieved through advanced control algorithms that continuously monitor system frequency and adjust the output of inverters or ESSs accordingly. By effectively simulating inertia, virtual inertia techniques contribute to the stability of contemporary power grids, enabling the integration of RES while maintaining grid reliability and performance. An analytical approach to the equivalent inertia constant (H_e) for a converter-based RE system with a dc-link capacitor in MJ per MVA as the ESS to provide synthetic or virtual inertia for grid frequency management.

Definitaion and Conceptual Framework

Definition and conceptual framework refer to the establishment of clear definitions and the development of theoretical frameworks to guide research or analysis within a specific field or study. This process involves defining key concepts, outlining their relationships, and establishing theoretical constructs that provide a foundation for understanding phenomena and guiding empirical investigations.[17] To achieve virtual inertial response (VIR) not in need for high-power energy storage devices like supercapacitors, the suggested VIC uses active power control of PVA. The use of an adaptive virtual inertia gain facilitates dynamic power sharing among PVAs that offer VIR. The usefulness of the

recommended approach in enhancing the DC MG's dynamic performance, damping it down, and lowering the battery's high-current stress is demonstrated by the simulation results that are provided. [18] recommended A novel adaptive control method for real-time adjustment of the integral controllers' gains for plug-in electric vehicle (EV) power charging and discharging suggested using Harris Hawk's optimization (HHO) based Balloon Effect (BE), backed using a virtual momentum controller that considers the widespread integration of RESs in both isolated and interconnected microgrids (μ Gs). The control method proposed outperforms alternative powerful controller, the correlation illustration method (CDM), in terms of frequency regulation and μ G stability in the presence or lack of the control loop for virtual inertia.

Importance in Power System

Power systems are the lifeblood of modern society, underpinning everything from household appliances to industrial machinery. Their importance lies in their ability to efficiently generate, transmit, and distribute electricity, ensuring a reliable supply to meet the demands of consumers. With increasing reliance on electrification for transportation, heating, and more, the stability and resilience of power systems have grown paramount.[19] investigated power system stability using sync converters. A synchronverter is a voltage source converter control method that mimics synchronous machines to introduce virtual inertia. The findings highlight the advantages of sync converters over alternative control systems. The system using sync converters has a greater minimal damping ratio, as evidenced by numerical simulations. [20] suggested an improved FOI controller with virtual inertia control enabled for the LFC of a modern, two-area interconnected power system. Compared to the integral controller and the FOI controller, the finding from every scenario demonstrate that the suggested FOI provides the best overall response for the interconnected system.

Restrictions in the Integration of Renewable Energy

There are various obstacles to integrate RES into traditional power systems. One significant challenge is the inconsistency of renewable generation, particularly from sources like wind and solar. In contrast to thermal power plants, RESs highly dependent on weather situations, leading to instabilities in output that can destabilize the grid and compromise reliability. To address this challenge, advanced forecasting techniques and grid-scale ESSs are being developed to better predict and manage renewable generation variability, smoothing out fluctuations and ensuring a more reliable power supply. Another challenge in RE integration is the need for grid infrastructure upgrades to accommodate distributed generation and bidirectional power flow. Traditional fossil fuel-based power plants were planned for centralized

generation and power flow from generation power plants to consumers in unidirectional mode. [21] explored the problems, opportunities, and enabling ways for incorporating renewable technologies into mining operations. The mining industry is increasingly relying on renewable energy to power its operations, in part to fight its potentially rising greenhouse gas emissions. [22] discussed the effects of integrating large-scale RE facilities, such as wind and PV solar power plants, to Jordan's national grid. We evaluate potential locations that have optimal wind speeds, solar irradiation, and ample space. The load flow modelling results indicate that in order to control congestion, the peak power generation of the Regional Electricity Provider should not exceed 10% of Jordan's yearly peak demand, based on the limits of line flow capacity.

Impact on Conventional Grid Operation

The incorporation of sustainable energy sources has a noteworthy influence on conventional grid operation, necessitating adaptations to accommodate the variability and intermittency of renewables. Traditional power systems, built around dispatchable fossil fuel generators, relied on predictable generation patterns to maintain grid stability and balance supply and demand. However, the increasing penetration of renewables introduces greater variability into the system, challenging grid operators to manage fluctuations in real-time. This requires the implementation of sophisticated grid management techniques, such as advanced forecasting, flexible grid infrastructure, and innovative control strategies, to maintain grid stability while maximizing the utilization of RES. [23] discussed the significant issues in power system dependability that arise from the RESs integration with power grids. This is particularly remarkable because multiple power networks are already conducting research on the feasibility of power grids that are powered exclusively by PEC-interfaced renewable energy sources.

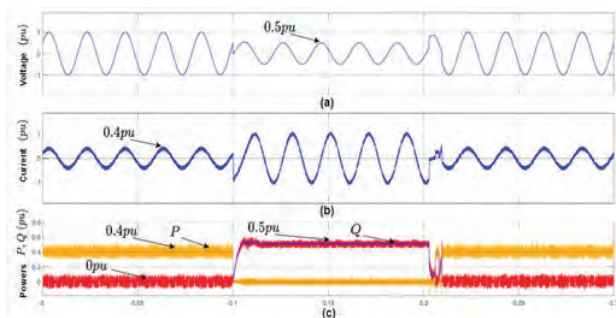


Fig. 3. The solar-PV system is injected reactive power when there is a voltage sag. The parameters being measured are voltage, current, and power. [24]

Fig. 3 showcases the behaviour of a PV Solar system is injecting reactive power at the event of voltage sag. The

subplots within the figure illustrate key parameters including voltage, current, and power. During a voltage sag, which represents a temporary reduction in voltage magnitude in the grid, the PV solar system exhibits a response where it gives the system reactive power. This reactive power injection helps to mitigate the sag voltage and stabilize the grid, ensuring uninterrupted power supply to connected loads. Subplot (a) displays the voltage profile, showing the reduction during the sag event, while subplot (b) represents the corresponding current response from the Solar PV system.

Virtual Inertia Control Strategies

Virtual inertia control solutions seek to replicate the stabilizing impact of synchronous generators in power systems that are primarily influenced by RES and power electronics. These solutions entail the utilization of sophisticated control algorithms to dynamically modify power generation or consumption in reaction to frequency variations, imitating the inertia response of rotating machinery. One approach is to utilize ESSs or grid-connected inverters equipped with VI algorithms that monitor system frequency and modulate their output accordingly. Another strategy involves incorporating grid-forming inverters that actively regulate voltage and frequency, effectively acting as virtual machines. These control systems are essential for improving the stability and robustness of contemporary power grids. They allow for the smooth integration of RES while confirming grid reliability and performance.

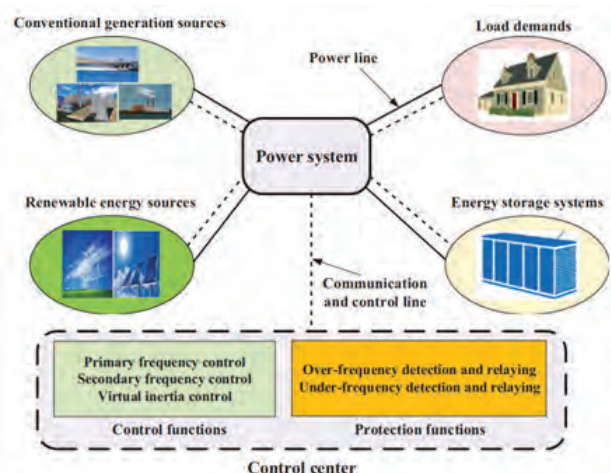


Fig. 4. Architecture of Power System

[25] studied on improving the ability of an isolated microgrid to maintain a stable frequency by executing the concept of virtual inertia frequency regulation. The virtual inertial control paradigm utilizes optimal model predictive control (MPC) as well. The African Vultures Optimization method (AVOA) is a very effective optimization method specifically designed to produce the best possible design for the Model

Predictive Control (MPC) system. The simulation results illustrate the usefulness of AVOA-based MPC in enhancing the frequency resilience of the microgrid.[33] examined the issue of frequency performance in microgrids (MGs) connected to RE sources. They proposed a solution by incorporating an ESS with virtual inertial control (VIC) assistance. According to other methods, the TLMMPCC strategy yields the most efficient ESS and significantly enhances the response of system frequency settling time, peak overshoot and undershoot. In their study, [26] presented the adaptive Variable Inertia Control System with adjustable moment of inertia (J) and damping factor (DP). They demonstrated that this system is effective in achieving faster recovery of frequency, minimizing overshooting, and maintaining stable operation even in the presence of grid faults and dynamic weather conditions. The results of the simulation are confirmed and authenticated by the use of Typhoon® Hardware-In-Loop 402 real-time simulations.

Power Electronics-Based Approaches

Power electronics-based approaches are important in enabling the integration of RES and improving grid stability. These approaches involve the use of advanced converters, inverters, and controllers to efficiently manage power flow, voltage regulation, and frequency control within the grid. Grid-forming inverters can produce steady voltage and frequency signals, enabling them to operate independently or in coordination with the grid. Additionally, power electronic devices such as VSCs offer enhanced flexibility and control capabilities, allowing for seamless RES integration and enabling grid support functionalities such as reactive power injection and voltage regulation. Furthermore, advanced control algorithms and communication systems enable coordination between distributed energy resources and centralized grid control, facilitating optimal power management and grid stability of intermittent renewable generation. These power electronics-based approaches are essential components of modern grid infrastructure, permitting the transition towards a more strong and sustainable power system.[27] suggested shipboard DC systems face issues in primary distribution, protection, and power scaling. The findings from that work should be used to inform a structured decision-making process for adequately defining protection and coordination needs in shipboard DC systems in light of the end user.

Comparative Analysis of Different Strategies

Comparative evaluation of various tactics entails evaluating multiple approaches or methodologies within a specific context to determine their respective strengths, weaknesses, and overall effectiveness. This analysis typically considers various criteria such as performance metrics, cost-effectiveness, scalability, and sustainability. By systematically comparing the strategies, researchers or decision-makers

can identify the most suitable option for a given problem or objective. For instance, in renewable energy integration, different strategies may include grid-scale energy storage, demand response programs, or grid strengthening measures. Through a comparative analysis, stakeholders can assess which strategy offers the best balance between efficiency, reliability, and economic viability, thus informing decision-making processes and guiding the implementation of sustainable solutions in energy systems.

In the study by[28] the authors conducted a comparative analysis of battery power management strategies within a given case scenario. The table provided outlines different cases characterized by various parameters such as

k_d , K , F_{min} , F_{max} , df/dt , and the range of battery power for charging and discharging operations

Table 1. Comparative Analysis of Battery Power Management Strategies[28]

Case						Battery Power (pu)	
k_d	K	F_{min}	F_{max}	df/dt	Charge	Discharge	Range
	20	59.65	60.5	0.26	0.57	0.63	1.2
400	40	59.7	60.4	0.25	0.50	0.52	1.02
	20	58.5	61.5	0.57	0.51	0.74	1.25
0	40	59.0	60.8	0.40	0.47	0.64	0.93

For instance, in the first case where k_d is 20 and K is 59.65, the battery power ranges from 0.63 to 1.2 per unit (pu) for charging and discharging, respectively. Similarly, the other cases are defined by distinct sets of parameters influencing the behaviour of the battery power system. The study likely investigated how these parameters affect the performance and efficiency of battery power management in the given context, providing insights into optimal strategies for enhancing the utilization and reliability of battery ESSs. Through such analyses, researchers contribute to the advancement of battery management techniques, enabling the integration of RES and promoting sustainable energy practices in power systems.

Table 2. Comparative Performance Analysis of Grid-Forming Converter Technologies

Parameter	No VI	Synchronverter	Ice Lab	VSG
Min. Frequency	57.3Hz	58.1Hz	58.6Hz	58.3Hz
Max. ROCOF	1.9Hz/s	1.5Hz/s	1.6Hz/s	1.7Hz/s
Settling Time	11.3S	13.2S	17.7S	17.9S
Peak Power Delivered	0W	1825W	1800W	1929W
Energy Exchanged	0Wh	0.8Wh	3.8Wh	4.9Wh

In TABLE II compared the performance of different grid-forming converter technologies, including No Virtual Inertia

(No VI), Synchronverter, Ise Lab, and Voltage Source Grid (VSG). The table provided presents various parameters such as min. frequency, max. ROCOF, settling time, peak power delivered, and energy exchanged for each technology. For instance, the Synchronverter demonstrated a min. frequency of 58.1 Hz, a max. ROCOF of 1.5 Hz/s, and a settling time of 13.2 seconds, delivering a peak power of 1825 W and exchanging 0.8 Wh of energy. Conversely, the No VI system had different performance characteristics, including a min. frequency of 57.3 Hz, a max. ROCOF of 1.9 Hz/s, a settling time of 11.3 seconds, and no power delivered or energy exchanged.

In recent years, virtual inertia control strategies have emerged as effective mechanisms for improving the stability of the power grid and making it easier to incorporate RES into power systems. [29] proposed Droop Control, which mimics the behaviour of traditional synchronous generators, providing stability. However, it may lead to frequency deviations during transient conditions. [30] introduced a Virtual Synchronous Generator (VSG), offering rapid response to frequency disturbances, thereby improving grid stability. Yet, its implementation necessitates an accurate estimation of virtual inertia parameters. Synthetic Inertia, as suggested by [31], enhances transient stability and grid resilience without the need for physical inertia. Nevertheless, its implementation complexity may increase due to real-time parameter tuning.

CASE STUDIES AND IMPLEMENTATION EXAMPLES

Several case studies showcase the successful implementation of grid-forming converter-based virtual inertia control strategies in RE systems. For example, in a wind farm or solar photovoltaic (PV) plant, grid-forming converters can emulate the behaviour of traditional synchronous generators by dynamically regulating voltage and frequency. Case studies demonstrate how grid-forming converters effectively stabilize the grid during transient events and improve system resilience to fluctuations in renewable energy output [31]. Case studies highlight the integration of ESSs with virtual inertia control strategies to enhance grid stability and manage renewable energy variability.

Virtual Inertia Deployment in Wind Farms

The dynamic frequency restrictions are determined for systems that include full-converter wind turbines. It is possible to provide virtual inertia to these wind turbines through the use of virtual synchronous generators (VSG) or synthetic inertia control. [32] devised a method to incorporate dynamic frequency constraints into the stochastic unit commitment of a system with an extensive integration of full converter wind turbines. This method takes into account the fluctuations in the rotor speed of the wind turbines, ensuring that they

remain coordinated with the system frequency. The findings suggest that decreasing wind power curtailment and raising the maximum credible contingency size would come from including the VSG control concept for wind turbines into the stochastic unit commitment model, notwithstanding the need for faster PFR services. Virtual Power Plants, also known as VPPs, are an innovative energy management structure that addresses the limitations of traditional wind power grids, which rely heavily on synchronous machines. VPPs achieve this by effectively coordinating a mix of renewable and non-renewable generating systems in real-time, resulting in synergistic benefits. [33] primarily focused on the dynamic nature of the system at shorter time scales, specifically sub-hourly intervals.

To simulate droop and inertia characteristics in microgrids simultaneously, [34] presented a novel design and study of VIC. By using simulation, a comparative analysis is conducted between the dynamic frequency response with and without RES penetration. To quantify the ROCOF slope during inertia emulation, the suggested virtual inertia control uses a derivative technique. To closely examine how it affects dynamic frequency response, sensitivity mapping is done. In conclusion, the University of Cuenca microgrid's operational battery storage system is utilized as a case study.

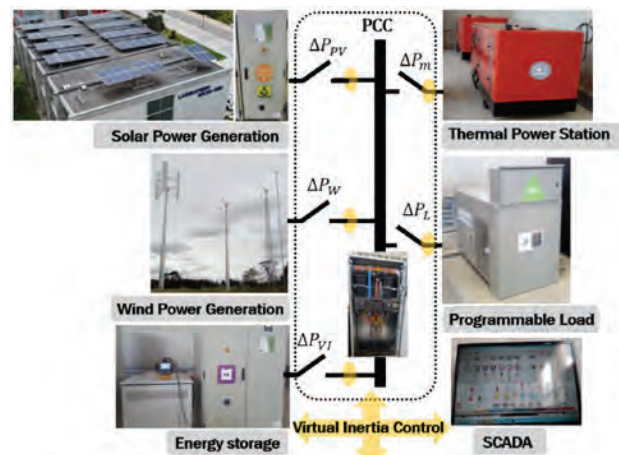


Fig. 5. Micro-grid laboratory-Case Study (CCTI-B) [35]

The case study presents an in-depth examination of a solar-wind-diesel system with the inclusion of energy storage equipment operated in island mode. The study specifically focuses on the influence of RE perturbations. The analysis primarily focuses on two perspectives regarding the system's response, comparing scenarios with and without RES penetration. Fig. 5 illustrates the parameters in VIC and mathematical modelling, developed based on features from CCTI-B at the University of Cuenca. The laboratory comprises a 35kW photovoltaic generating system, a 15kW mini wind farm, a 40 kVA diesel generator, storage systems

with a 15 kWh Valve-Regulated Lead-Acid known as VRLA a bank of gel batteries and a programmable electrical load that can generate step scenarios every 5 kW are included. The findings indicate that the ESS -based virtual inertia control effectively supplies power with the necessary inertia within 1–5 s, overlapping with the onset of disturbance produced by integrating RES in the electrical system.

Application in Solar PV Systems

The virtual inertia control application of strategies in solar PV systems represents a promising avenue for enhancing grid stability and resilience within increasing RE integration. By matching the inertial response of traditional synchronous generators, VI control techniques can effectively mitigate frequency fluctuations and voltage variations caused by the intermittent nature of solar PV generation. This enables solar PV systems to contribute more reliably to grid stability, eventually, enabling the smooth incorporation of renewable energy into modern power systems.[36] created a virtual laboratory and described its primary attributes and essential characteristics.

The dynamic feature of active power at a given capacity is intended to be enhanced by the adaptive VSG regulation. The electromechanical transient model of BESS based on VSG control. Next, the impact of inertia during grid disturbance is examined using the transfer function, and the critical factors that affect dynamic stability are determined. The suggested adaptive VSG control is finally validated in a real power grid example and the modified IEEE 4-machine 2-area system.

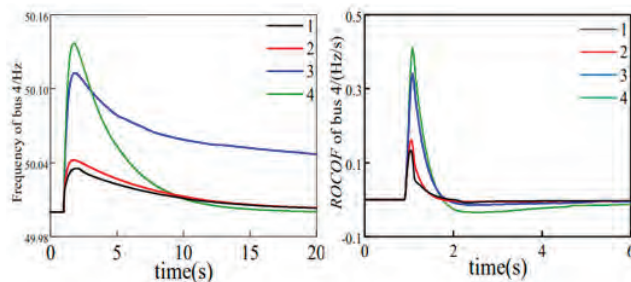


Fig. 6. Results for Bus 4's Step Response Frequency Response and df/dt [37]

In Fig. 6(a), the frequency is 0.137 Hz higher than the nominal value when the peak period of 1.02 s is attained. By using BESS, this emerging instability can be resolved. Three integrated BESS simulation results show that BESS can efficiently supply power backing to lower rate of change of frequency and hasten stability recovery. The df/dt in Figure 6(b), which represents the frequency response metrics, is calculated using simulated data. PI control falls short of providing adequate dampening and stabilised system response because the system's post-failure reactions took a long time to recover. Even with the considerable overshoot and extremely

long recovery time, BESS with PI control reaches its peak time at 1.11 s. However, the greatest frequency variation of the PI control is 0.113 Hz; in contrast, the VSG control has a deviation of 0.042 Hz, which significantly lessens fluctuation in frequency. Like droop control, the VSG control distributes the steady-state power among SGs based on the droop coefficient. The outcomes of the simulation demonstrate this model's efficacy and enormous potential for enhancing frequency stability.

CONCLUSION

To summarize, this review study has presented a comprehensive overview of advancements in virtual inertia control strategies for RE integration. Through an analysis of recent research efforts, various methodologies, and outcomes, key insights into the effectiveness, challenges, and opportunities in virtual inertia control strategies are elucidated. From the investigation of control algorithms like Two-Layer Multiple Model Predictive Control known as TLMMP and Load Frequency Control (LFC) to the exploration of optimization models and off-grid energy community scenarios, diverse approaches have been explored to improve grid resilience and stability despite the growing utilization of RES. Subsequent investigations in this field should prioritize the resolution of the recognized constraints and deficiencies in existing virtual inertia control systems. Further investigation into the impact of uncertainties, such as load variations and renewable energy generation fluctuations, on control algorithm effectiveness is essential for refining predictive models and improving performance under dynamic operating conditions. Additionally, efforts should be directed towards developing more robust and scalable control strategies that can accommodate the evolving complexity of modern power systems. Collaborative interdisciplinary research endeavours involving experts from the fields of power engineering, control theory, and renewable energy technologies will be crucial for advancing state-of-the-art virtual inertia control strategies and facilitating the smooth grid integration of renewable energy, correspondingly.

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Comparison of Total Harmonics Distortion for Grid Connected and Solar/Inverter Based Induction Motor Using Power Quality Analyzer

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ABSTRACT

Harmonic distortion is one of the disturbances that mostly affects the quality of the electrical system. The widespread use of power electronic systems, especially power converters, has increased harmonics and inter harmonic emission. Also, the use of renewable energy sources such as Solar PV Systems is increased in a wide range. As most of the industries uses induction motors as loads, there is a need of observing the harmonics produced in the machine when run based on Solar PV Systems and converters.

The main aim of this research work is to determine one of the major power quality issues i.e. the amount Total Harmonic Distortion (THD) present in an induction motor. In this work a case study for the effective estimation of THD is performed using a power quality analyzer. An induction motor is operated without power electronic converters through grid and the corresponding THD value is measured. Further, the same machine is run based on power obtained from solar PV system and inverter and corresponding THD is measured. A comparison of THD for both case studies is discussed.

KEYWORDS: Power quality indices, Total harmonic distortion rates, Harmonic analysis, Inter harmonics, High-frequency spectral components.

INTRODUCTION

Out of all issues the presence of harmonics will play a major role in electrical Machines. Harmonics are unwanted frequencies along supply frequencies[1]. The impact of harmonics present in the system is to produce excessive heat in the motor winding thereby the life of the motor gets reduce due the harmonic currents which in turn to damage in windings and insulation of the electric motors [2]. The total harmonic distortion (THD) is a measurement of the harmonic distortion present in a signal and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. Usage of power electronic converters increases harmonics in the waveforms which leads to the increased THD in the motors [3-5]. In this work an analysis is carried out to calculate the THD for a 0.5

HP single phase induction motor when run on grid connected mode and powered by solar PV system.

METHODOLOGY

Power Quality Analyzer

A Power Quality Analyser (PQA) is a device to measure the quality of the electrical power network. Beside of the basic values like voltage, current and power, a PQA can measure also values like harmonics, dips, swells, peaks, transients etc. In an installation without a proper power quality, an electrical device/load may malfunction, fail prematurely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power. To avoid a situation where devices and installations are faced with poor power quality, a PQA is required. A

measurement, the information and also a reaction to protect installation is very useful and helps to extend machine lifetime. The power quality analyzer used in this work is PQ3198 model of HIOKI. This is shown in figure 1.



Fig. 1. Power Quality Analyzer PQ3198 HIOKI

This power quality analyzer had the following measuring and analysis capabilities:

MEASUREMENT

1. 3ph and neutral measurement.
2. Active, reactive and apparent power/energy.
3. Power factor for all phases.
4. Angles between phases.
5. Voltage and current harmonics on all phases (up to 40th) Period measurements.
6. Voltage and current peaks Phase sequence detection.

Analysis capabilities

1. Voltage and current THD and current TDD on all phases
2. Voltage and current harmonics on all phases (up to the 40th)
3. Voltage and current peaks, Voltage SAG
4. Over-voltages and over-currents
5. Phase sequence detection (and correction)
6. Transients >125usec
7. Temperature monitor (internal and external)

Grid Connected Single Phase Induction Motor

To set up a 0.5 HP split-phase induction motor connected to a power quality analyser with a direct supply from the grid, you will need to follow the wiring connections carefully. Here's an explanation of the setup:

Motor Wiring

The split-phase induction motor consists of two windings, the main winding (also known as the running winding) and the auxiliary winding (also known as the start winding).

- Connect one end of the main winding to one of the supply voltage lines (usually the Line or L1 terminal).
- Connect the other end of the main winding to one end of the power quality analyser (specific terminal depends on the analyser).
- Connect one end of the auxiliary winding to the other supply voltage line (usually the Neutral or L2 terminal).
- Connect the other end of the auxiliary winding to the other end of the power quality analyser, completing the motor connection to the analyser.

This connection diagram is displayed on the screen of power quality analyzer as shown in figure 2.

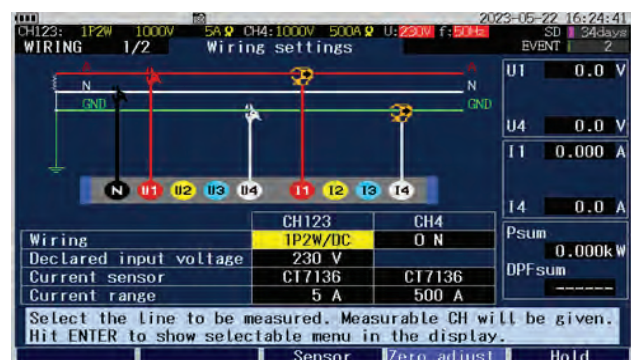


Fig. 2. Connection diagram of single phase 2 wire system

Power Quality Analyzer Wiring

- The power quality analyzer typically has terminals or connectors for connecting to the motor and the power supply.
- Connect the Line or L1 terminal of the analyzer to the end of the main winding connected to the supply voltage line.
- Connect the other terminal of the analyzer to the end of the auxiliary winding connected to the supply voltage line.
- Make sure the analyzer is properly grounded according to the manufacturer's instructions.

Power Supply Wiring

- Connect the supply voltage lines (Line or L1 and Neutral or L2) to the appropriate terminals of the motor and the power quality analyzer as explained above.

- Ensure proper fusing or circuit breaker protection for the motor and the analyzer based on their respective ratings.
- The power supply should be stable and within the required voltage range for the motor and analyzer to operate correctly.

Once the wiring connections are made, the split-phase induction motor will receive power from the grid through the power quality analyzer. The analyzer will monitor and analyze the quality of the power supplied to the motor, measuring parameters such as voltage, current, harmonics, and other electrical characteristics.

The setup of single phase induction motor with power quality analyzer when connected to grid is shown in figure 3.



Fig. 3. Grid connected single phase induction motor through power quality analyzer.

Solar Connected Single Phase Induction Motor

To connect a split-phase induction motor to a power quality analyzer using a direct supply of solar DC output power, you would need to set up the wiring appropriately. Here's an explanation of the wiring setup:

1. Solar DC Output: The solar panel array generates DC power.
2. Electrical Distribution Panel: The distribution panel acts as a central point for electrical connections. It distributes power to various devices, including the motor and the power quality analyzer.
3. Motor Wiring: The split-phase induction motor requires two power supply lines, often referred to as the "hot" and "neutral" lines. The hot line provides the power, while the neutral line completes the circuit. Connect these two lines from the distribution panel to the motor terminals.
4. Power Quality Analyzer: The power quality analyzer monitors and analyzes the electrical parameters of the

system. It typically requires a power supply to operate. Connect the power supply of the analyzer to an available power source, such as a wall outlet or a dedicated circuit from the distribution panel.

5. Measurement Connections: The power quality analyzer needs to measure the voltage and current of the motor. Connect the voltage measurement probes of the analyzer to the appropriate motor terminals, ensuring proper polarity. Similarly, connect the current measurement probes to measure the current flowing through the motor.

Grounding: Ensure proper grounding throughout the system for safety and to prevent electrical faults. Connect the grounding wire from the motor, power quality analyzer, solar inverter, and distribution panel to a common grounding point.

The setup of single phase induction motor with power quality analyzer when connected to the output of PV array is shown in figure 4.



Fig. 4. Solar connected single phase induction motor through power quality analyzer.

RESULTS AND DISCUSSION

Grid Connected Single Phase Induction Motor

In this case when we connect 0.5 HP split phase induction motor to the grid supply we observed on power quality analyser display it shows the voltage is 241.36V and the current shows 4.04 amp , frequency is as it is (50Hz) and the power shows 463KW and the power factor is 0.47. This is shown in figure 5.



Fig. 5. Power consumption of the motor when connected to grid

In the case of a split-phase induction motor, harmonics can impact its performance and efficiency. In this case due to ac supply the voltage harmonics V(THD) is 1.84 and the same case current (THD) is 1.76. due to these values of THD they effect on the sinusoidal waveform. The voltage and current THD readings of the machine are shown in figures 6 and 7 respectively.



Fig. 6. Voltage THD under grid connected mode



Fig. 7. Current under grid connected mode

Solar Connected Single Phase Induction Motor

In this analysis we connect the induction motor to direct output of solar then the waveforms shown on the power quality analyser are shown in figure 8. The values of the voltage is 250.02 V and current is 4.28 amp.

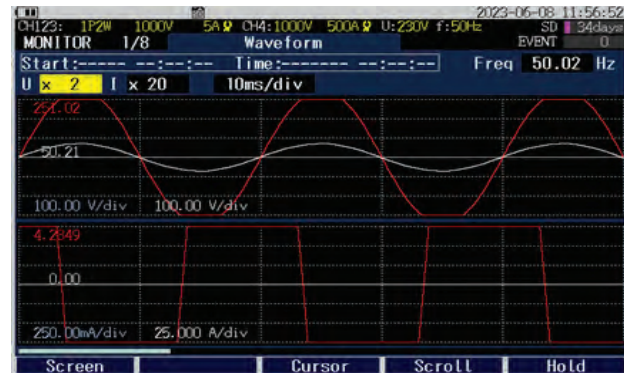


Fig. 8. Waveforms of voltage and current under solar connected mode.

The voltage THD and current THD of the machine when connected to the output of solar PV system are shown in figures 9 and 10 respectively.



Fig. 9. Voltage THD under solar connected mode

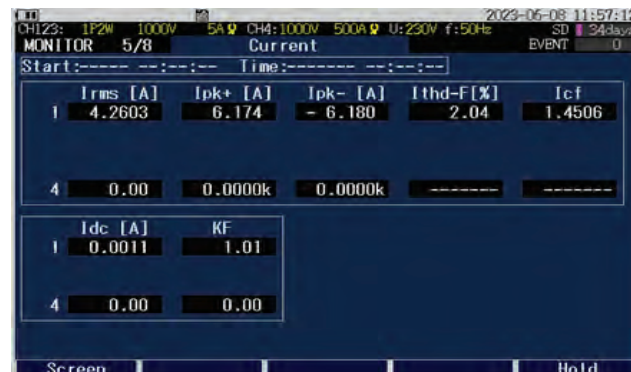


Fig. 10. Current THD under solar connected mode

In this case we connect induction motor on solar and these analysis shows that the voltage THD 1.34V are reduce than grid connected motor but the current THD is 2.04 amp increased twice.

CONCLUSION

In this paper an analysis is carried out to read the THD for a single phase induction motor using a power quality analyzer. The analysis majorly concentrates on the observation of THD under two modes of operation, grid connected mode and solar connected mode. The paper discussed the connections of power quality analyzer and results obtained in each mode of operation. The results conclude that, current THD is increased by twice under solar connected mode when compare to the grid connected mode.

FUTURE WORK

Future work includes the solution for the above problem identified with increased current THD in an induction motor when run on solar PV system.

ACKNOWLEDGMENT

Authors are thankful to the Management, Principal and Head of the Department, Electrical Engineering, SVKMs

Institute of Technology Dhule for allowing us to utilize the infrastructure to conduct the above work.

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Voltage Profile Optimization in Power System using PID Driven Automatic Voltage Regulator

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ABSTRACT

The accuracy with which an Automatic Voltage Regulator (AVR) operates determines the electrical system's power quality and voltage stability. AVR design technology is currently being dramatically enhanced. Nonlinearities and parametric uncertainties are unavoidable concerns in control. When working alone or with others, the gain voltage of a synchronous generator fluctuates. Voltage instability is induced by system transients from excessive load switching. Regular occurrences might disrupt the body's homeostasis. Unstable energy also refers to restrictions in electrical equipment. Because electrical stability is the capacity of electrical power to sustain each voltage's acceptable range bus within the system's permissible limits, in accordance with procedure, and once faults emerge, gradually, as the faults appear, there will be a declining trend, and the energy will reach zero. The condition of the automatic voltage regulator (AVR). The PID controller, which is a proportional-integral-derivative controller, regulates the AVR. To attain a steady voltage, the variable equation is adjusted with utilizing an Artificial Neural Network (ANN).

KEYWORDS: Proportional-integral-derivative controller, AVR, ANN, Voltage improvement.

INTRODUCTION

The optimization of voltage profiles has emerged as a crucial aspect within the realm of electrical power systems. The exciter, which provides electrical power to a generator's field winding and is in charge of the AVR, is extremely efficient in steady-state operation. However, the study discovered that abrupt disruptions may have an adverse effect on the dampening of the power swing. It could be reduced or eliminated entirely by incorporating a second linear controller, the PID controller, which can recompense for voltage fluctuations by adding more signal to the AVR control loop. Three-mode controllers with proportional, integral, and derivative (PID) actions became popular and commercially available in the mid-20th century. Several linear control algorithms have recently been developed. PID-type controllers account for 90% of industrial controllers, making them the most common control strategy in use. This is because its high performance, flexible tuning capabilities, and straightforward design. The researchers discovered

that sudden disturbances can reduce the damping of power fluctuations. By incorporating a Supplementary linear can be reduced or eliminated. This can be reduced or eliminated by incorporating a PID controller, which can inject additional signals into the AVR control loop to compensate for voltage oscillations. By the middle of the twentieth century, three ways of controllers with proportional, integral, and derivative (PID) actions were widely used and commercially available. Furthermore, a number of linear control methods have been grown recently. However, PID controllers are the most widely utilized control approach in reality, constituting up 90% of all industrial controllers. This is due to its straightforward design and useful functionality.

LITERATURE REVIEW

Shamik Chatterjee [1] presents a new quadruple controller named PIDD2 for improvement of voltage profile system. This controller integrates proportional, integral, and derivative terms along with a second-order derivative system. Saptarshi

Rakshit [2] presents a model for a Dual Conversion Type AVR using SIM Power Systems inner parts. Their proposed control scheme includes Fuzzy Logic operated.

Changyou Feng [3] addresses the difficulty of automatic generation control (AGC) in a dual-area microgrid escorted by multiple energy sources and storage, considering the stochastic nature of renewable energies and loads. It introduces a load frequency control (LFC) model that includes discrete Markov processes for wind power, PV output, and load fluctuations. Juga Jyoti Sahu [4] deals with choosing the best parameters for an AVR and PID controller and proposes a new approach using the sine-cosine algorithm (SCA) technique. Gitanjali Chadar [5] proposes a method to mitigate voltage instability in power systems caused by factors such as sudden load changes. In his work, Davut Izci [6] presents a new approach utilize an arithmetic optimization algorithm to tune the parameters of a second-order derivative (PIDD) plus real inversely related integral derivative (PIDD)2controller for automatic voltage regulator (AVR) control. Xinghai Zhang [7] proposes a new approach to solve the prevalent minimum voltage in rural power grids which is an issue, by introducing a 10kV remunerate voltage regulator specially formulated for carbon brush current reduction.

S. Kongtripopl [8] investigates the influence of a distribution generator (DG) on voltage fluctuations in a large- scale distribution line with multiple voltage regulators. Naira Jeelani [9] suggests using a single-phase AC-AC converter with voltage step-up and step-down to create an AC chopper- based voltage regulator. Mazabuka [10] provides an explanation on how to use MPC to enhance AVR's dynamic performance.

SYSTEM ANALYSIS

Automatic Voltage Regulator

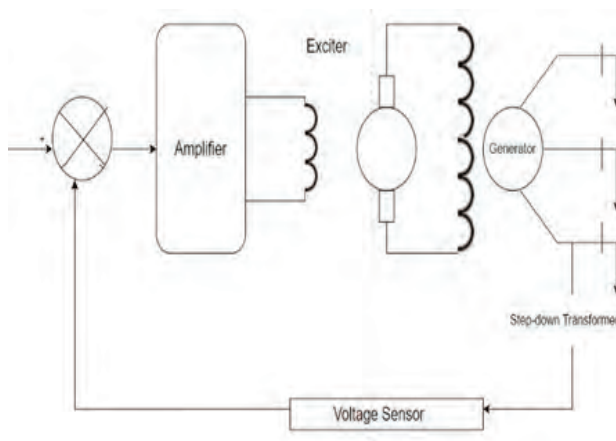


Fig. 1. General model of AVR

The Basic purpose of an Automatic Voltage Regulator regards to maintain consistent voltage output from a generating plant, ensuring a stable and reliable power supply. Changes in loads, temperature, speed can lead to fluctuation in voltage profile. The AVR plays an important role in maintaining constant voltage within defined limits, enhancing the overall power supply by managing continuous power output.

Amplifier model

A gain with a K_a sign and a time constant escorted by T_a symbol represents the amplifier model. The transfer function is given by:

$$\frac{V_r(s)}{V_e(s)} = \frac{K_a}{1 + T_a s}$$

Exciter Model

The gain with the K_e sign and the single time constant with the T_e symbol is able to express the transfer function of a modern exciter, which is as follows:

$$\frac{V_f(s)}{V_r(s)} = \frac{K_e}{1 + T_e s}$$

Generator Model

Gain (K_g) and time constant (T_g) is able to determine a line changing position of the electrical side of the generator with the voltage source.

The transfer function is

$$\frac{V_t(s)}{V_r(s)} = \frac{K_e}{1 + T_e s}$$

Where T_r is the sensor's time constant and K_r is the sensor gain.

PID is utilized with the AVR system to alleviate the observed poor reaction and time delay due to the AVR without PID.

A Proportional -Integral-Derivative Controller coupled with an AVR

PID control stands out as a widely employed method across various industries for industrial control applications. It has received notice on global scale because of its robustness, user-friendly nature, and effectiveness in diverse operational scenarios. In the realm of electric power systems, PID controllers prove particularly valuable for managing sudden and substantial load fluctuations [11]-[16]. The PID algorithm, as the name implies, relies on three key elements: proportional, integral, and derivative. These coefficients

undergo adjustments to achieve the optimal response. The classical PID concept and its influence on tuning a closed-loop control system are explored concerning closed-loop systems.

This widely accepted control approach plays a pivotal role in electric power systems, particularly when confronted with dynamic load changes. The versatility, ease of implementation, and adaptability of PID controllers make them instrumental in maintaining stability and efficiency within various operational contexts [17]-[22].

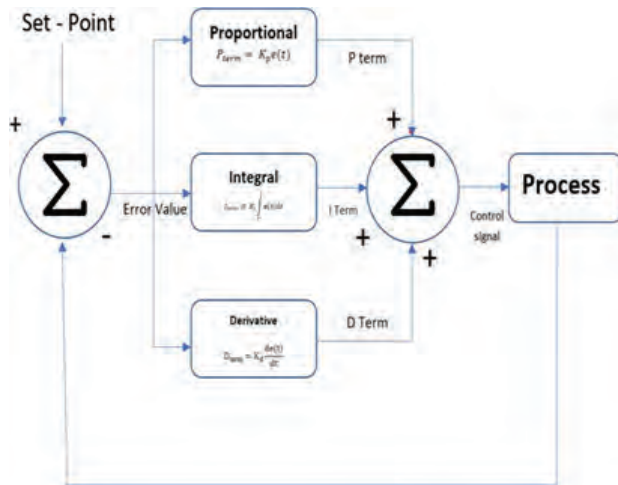


Fig. 2. Schematic diagram of PID

This Schematic diagram of PID explains about the overall process of improving voltage profile in power plants and maintaining stable efficiency as well as reducing steady state error. The efficiency of Power plants can be increased by using the combination of PID Controller in AVR.

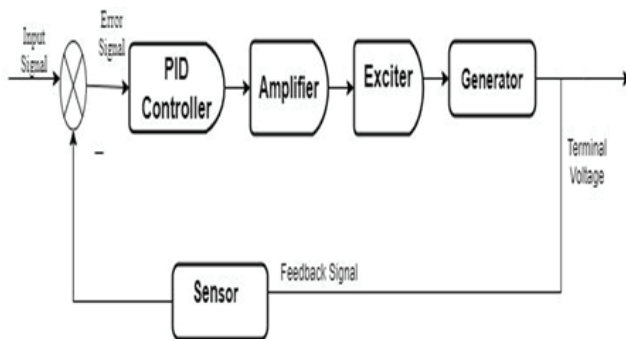


Fig.3. Block diagram representation of AVR with PID controller

The above block diagram representation shows the steps of improving voltage profile in power plant. PID Controller is used at very first block it increases the stability and reduces steady state error (SSE). Amplifier is used to magnify the

strength of the signal. The third block contains of an exciter it is a device that, after the machine voltage reaches a certain point, forces the DC machine-held excitement to build up during startup. Generator transform mechanical energy into electrical energy form. Sensor is used to sense or detect the steady state error. In this way PID Controller works in AVR.

Table 1 Values of Gain and Constants of AVR

Parameter	Gain	Time Constant
Amplifier	Ka	Ia = 0.1
Exciter	Kc	Ie = 0.4
Generator	Kg	Ig = 1.0
Sensor	Kr	Ir = 0.5

PERFORMANCE ANALYSIS

Estimation of an automatic voltage regulator involves measuring its ability to maintain constant output power under varying load conditions and power supply changes. Performance evaluation of an AVR is usually done through a combination of tests, simulations, and fields tests. Regular maintenance and testing is also important to ensure AVR continues to perform at its best.

Steady state response is given below:

$$V(t) = A \sin(2\pi ft + \theta) \text{ Terminal steady state voltage (Vt's)}$$

Actual Steady state voltage (Va's) Here base voltage is set at 11 KV Amplifier,

Gain Ka = 10

The transfer function of AVR technique as G(s) and the transfer function of PID controller as H(s) can be given as :

$$TF = G(s) * H(s)$$

The PID controller transfer outcome is usually expressed as: $H(s) = K_p + K_i/s + K_d * s$

Here,

Kp is constant of proportional

Kd is constant of derivative

i is constant of integral

And s is the Laplace variable

Table 2 Parameters of PID Control

Quality	Gain
Proportional controller	Kp = 1%
Integral controller	Ki = 0.25%
Derivative controller	Kd = 0.28%

The above table shows the quality and gain of each controller. The gain of Proportional controller is high while the gain of Integral controller is low and the gain of Derivative controller is in medium.

PID control synthesized artificial neural network in automatic voltage regulator

Power analysts are the primary users of ANNs. In management, ANN are frequently utilized. The more sophisticated and complex methods used in the design of energy management systems have been superseded by . ANN arrangement can be trained to meet the demands of the final operation in change of scenarios can also remove information from offline simulation data. The application of ANN's to enhance the response phase even more. The ANN block that was trained in equivalent with the guidelines provides the value for the PID constant. PID adjustment is necessary because the desired response rate curve is the decision input.

The generator needs to be operating with an appropriate generator in order for the ANN to receive the required training data. In this article, an AVR is operated by a PID controller. In order to get response results that are consequently used as training data for artificial neural networks, offline simulations are used to determine how to control the generator appropriately under various operating conditions. ANN are trained using a variety of output responses. This neural network is a feed-forward multilayer neural network with ten layers. After the ANN is trained with some input, it produces a function-adaptive neural network block that gives the required features for a given range of input of the PID controller is regulated by the output of the block. P (peak time), O (overflow), R (hold time) and S (off time) are the inputs of the ANN module, and the PID gain is the output of the change of inputs.

The consequent simulation diagram is of AVR in the trauancy of the controller as shown in fig.4.

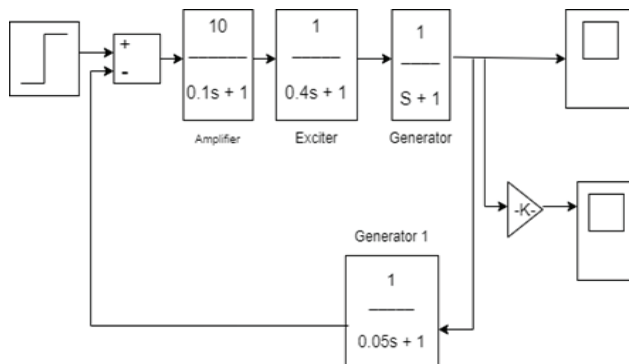


Fig. 4. Simulation Block diagram of AVR without PID system

Above is a simulation diagram that AVR devoid of a PID controller. The step response of transients is larger than that of succeeding simulations. This block diagram illustrates the basic closed-loop control of an AVR system; it lacks the sophistication of a PID controller. The actuator adjusts the generating field voltage in response to the error signal. it receives from the comparator in an effort to decrease the diversity between the reference voltage and the actual value. The absence of proportional, integral, and derivative actions means the system might have problem to correct errors quickly and accurately, potentially leading to greater fluctuations and a higher steady-state error. While simpler and less costly to implement, such AVRs are generally better suited to less demanding applications where control of voltage regulation is not critical.

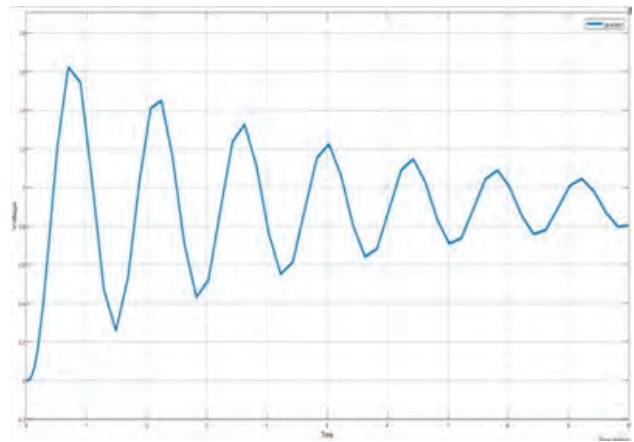


Fig. 5. Results of AVR without PID

The above waveform shows the simulation of automatic voltage regulator waveforms including modelling the AVR control loop in a simulation software, such as MATLAB/Simulink or PSpice. This includes generating input signals representing varying load conditions and disturbances, and analysing the resulting output voltage waveforms to validate the AVR system's performance in maintaining stable voltage levels under different time conditions.

A PID controller coupled accompanied by AVR

In order to find solution of large distortion caused by sudden electric current in the generator in the system, a PID controller needs to be increased to the AVR model. This PID controller reduces the overshoot and correction time and keeps the voltage constant. Before using PID, the output expression is intermittent; but after a while, this response becomes better and the waveform stabilizes and reaches the constant value of

1. In this case, the overshoot is 27.1% and the settling time will be 4.37 seconds.

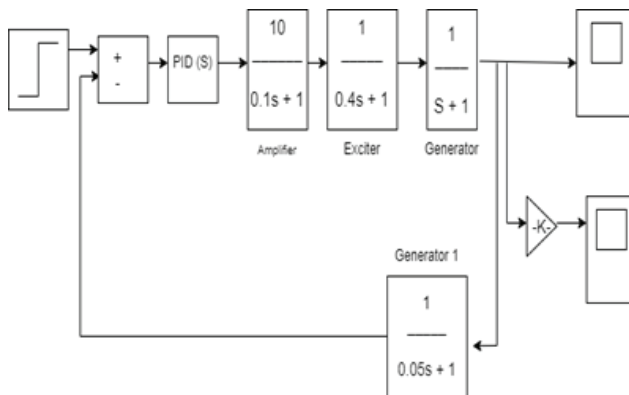


Fig. 6. Results of AVR with PID

The following reconstruction modelling diagram shows the simulation of AVR waveforms involves modelling the AVR control loop in a simulation software, such as MATLAB/Simulink or PSpice. This includes generating input signals representing varying load conditions and disturbances, and analysing the resulting output voltage waveforms to validate the AVR system's performance in maintaining stable voltage levels under different time conditions.

This diagram is based on time vs voltage it explains about the stability of voltage. The voltage shoots up and it takes time to come back to its normal position. The modelling results of AVR with PID controller shows the constant voltage in given time. PID with AVR requires less time to stabilize the voltage after it shoots up. Hence, it also saves the time delay and gives the output in less input also reduces the transient effect. Transients in AVR when it is combined with PID is reduced and stability of voltage is increased whereas, the steady state error is also reduced. Therefore, PID controller is very important in AVR to improve voltage profile.

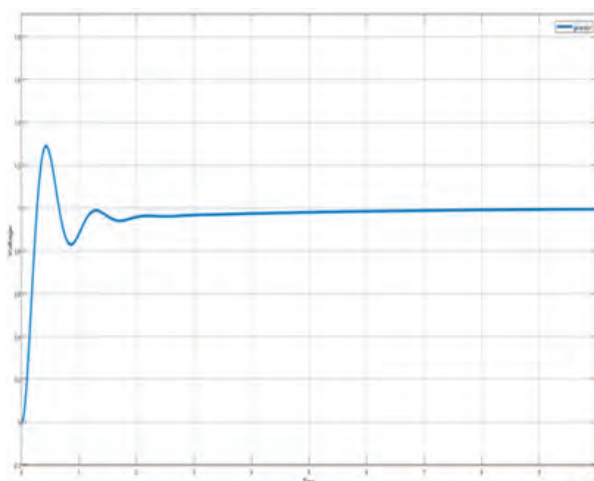


Fig.7. Results of AVR with PID system

An ANN applied to calibrate an AVR with a PID controller

It constructs of electronic components with an automatic electronic controller tuned by an electronic neural network. By combining control theory and machine learning and automatic electrical control with PID controller tuned using an ANN has been created. This complex process requires a deep understanding of control theory, neural network and properties of system you are controlling. Additionally, adequate testing and validation is needed to ensure the reliability and performance of AVR system. ANN must be trained to adjust the proportional input controller of an AVR while also optimizing the PID controller based on system response. Instead of the process, a well-learned ANN supports the adoption and adjustment of the PID gain, improving the AVR's ability to control the voltage.

This integrated approach improves the AVR's stability and responsiveness in a range of operating scenarios. The results from the simulation of the model with the controller are shown in the waveform. After some time, the voltage becomes constant, there is a decline in the peak time, a percentage of overshoot, and a decline in the settling time. for Below is a block diagram that manifest the AVR simulation replica with PID adjusted by ANN.

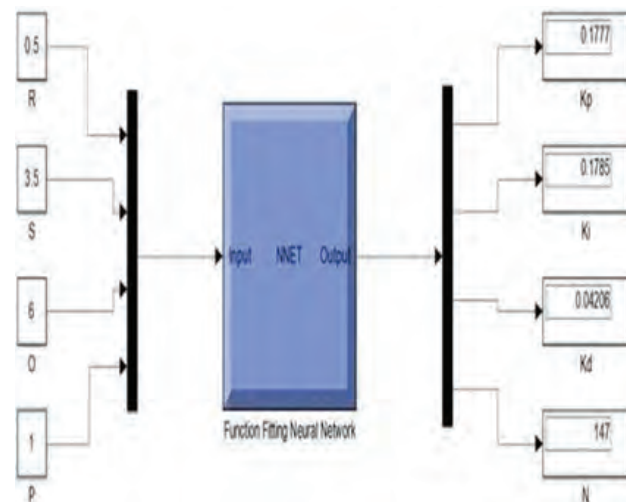


Fig. 8. ANN block diagram with PID gains

The AVR model's waveform findings from PID simulation and ANN-based PID fine-tuning are shown. After some adjustments, the voltage is stabilized and the correction time, peak time, overshoot percentage and transients are reduced. The response steps of the AVR are shown below after adjusting the PID using ANN to achieve the desired result. They show a decrease in overshoot, peak and correction times. Add a block neural network to adjust the PID to minimize changes.

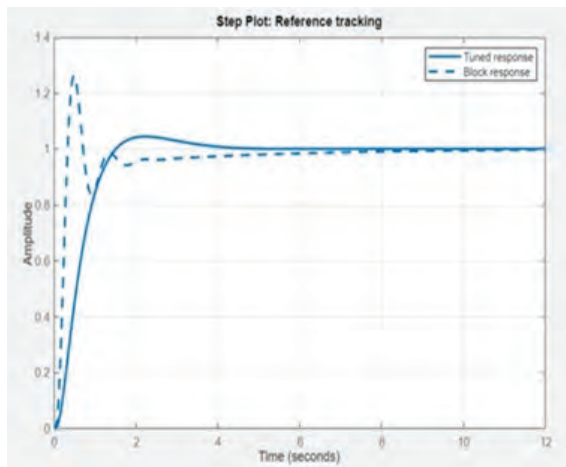


Fig. 9. Results of AVR tuning with PID

Figure (9) shows the results of simulation of AVR when it is tuned with PID. The above waveform is based on time vs amplitude.

Table 3 Performance and Robustness

Parameters	Tuned	Block
Rise Time	0.928 sec	0.196 sec
Settling Time	3.33 sec	5.13 sec
Overshoot	4.42%	26.3%
Peak	1.04	1.26
Gain margin (in dB)	13.13	Infinite
Gain crossover frequency (rad/sec)	12.92	6
Phase margin (deg).	34	50
Phase crossover frequency (rad/sec)	4	Infinite
Closed- loop stability	Stable	Stable

The above table shows the evolution of the performance Robustness. The various variable similar to rise time, setting time, overshoot, peak, gain margin, phase margin, closed – loop strength are considered for the analysis. The comparison is shown between the Tuned and Block.

The above waveform shows the plot reference tracking of an AVR. The waveform of an AVR with a PID controller typically demonstrate faster response, reduced overshoot, and minimal steady-state error compared to a system without PID

control. The specific characteristics depend on the dynamics of the PID controller, increasing with the system dynamics. In general working state of AVR, the proportional-integral-derivative controller provides powerful and precise voltage control under different operating conditions, improving the performance of the AVR system.

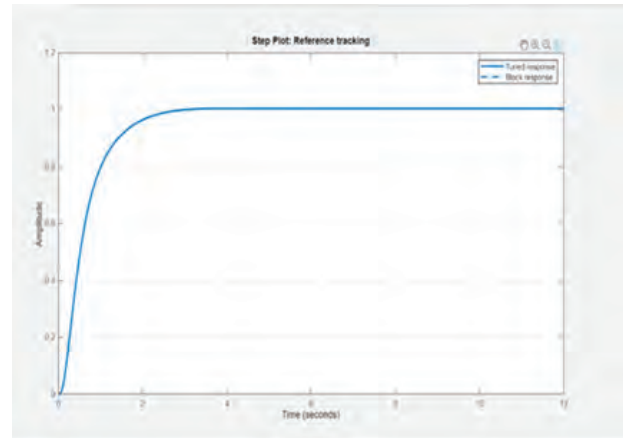


Fig. 10. Plot reference tracking of AVR

Steady State: Initially the voltage is stable and generator output voltage is good with less error than voltage. The proportional (P) term of the PID controller helps in increasing the starting response and thus reduces the fixed error.

Reference Voltage Change: When the power consumption changes, the PID controller considers the equation, one and variable points to calculate the derive signal. The generator's output voltage is automatically adjusted to the new value

Transient Response: The integral (I) phrase helps eliminate any steady-state error, and the derivative (D) term contributes to damping oscillations. As a result, the transient response is smoother compared to a system without a PID controller.

Adjustment Period: The PID controller's integral term continues to act over time, reducing any persistent error. The derivative term helps to prevent overshooting, contributing to a more controlled adjustment period.

Settling to New Steady State: After the transient period, the generator output voltage stabilizes and approaches the new reference voltage. The PID controller actively maintains the desired voltage level, balancing the trade-off between reducing error and avoiding excessive control effort.

CONCLUSION

In this process, the combination of PID controller within the AVR system significantly enhances voltage profile stability and performance. When the PID controller properly tuned in a way to improves the system's progressive response by

reducing settling time, rise time, peak overshoot and thereby ensuring a more robust and reliable power system. This modelling and simulation lead to a more stable and reliable voltage control mechanism, ensuring that the generator can maintain voltage levels within permissible limits. The solution advancement underscores the PID controller's pivotal role in bolstering the reliability and efficiency of electrical grids, aligning with the IEEE's objective of fostering technological innovation in sustainable computing and excellence.

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An IoT Enabled Health Monitoring System for Construction Workers

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ABSTRACT

Ensuring the safety and well-being of construction workers is of paramount importance in hazardous work environments. This abstract outlines the development of a novel Wearable Safety Device designed to enhance the safety and protection of construction workers across various sectors. The Wearable Safety Device integrates advanced sensor technologies, real-time data analysis, and user-friendly design to provide comprehensive safety features and early warning systems. The Wearable Safety Device consists of several key components, including a ruggedized wearable module, a variety of environmental sensors (such as gas detectors, temperature sensors, and air quality monitors), motion and posture sensors, and wireless communication capabilities. These components work together to monitor the worker's immediate surroundings, physiological state, and movements. The real-time data gathered by the Wearable Safety Devices is transmitted to a central monitoring system, which employs machine learning algorithms to analyse the data and detect potential safety hazards. The system can identify factors such as toxic gas leaks, abnormal temperature fluctuations, dangerous posture or movement patterns, and signs of worker fatigue. The system can identify factors such as toxic gas leaks, abnormal temperature fluctuations, dangerous posture or movement patterns, and signs of worker fatigue. The Wearable Safety Device also collects valuable data over time, enabling employers to analyze trends and patterns in worker behavior and environmental conditions.

KEYWORDS: Workers, Construction, IoT, Health, Monitoring

INTRODUCTION

The evolving nature of construction environments presents challenges that demand innovative solutions. Enter the era of wearable safety devices – a groundbreaking approach to enhance the protection of construction workers. Imagine a workplace where every employee is equipped with cutting-edge wearable safety technology, seamlessly integrated into their daily routines. These devices go beyond traditional safety measures, providing real-time monitoring, instant alerts, and invaluable data insights to create a safer and more efficient work environment. The proposed wearable safety device is designed to revolutionize the way we prioritize and safeguard the individuals powering our industries. It is for Improving worker safety and health performance which is a major issue that is of interest to share in the construction worldwide. This is because of the fame of the construction industry in terms of

the number of fatal and nonfatal injuries recorded annually. Owing to the hard and hazardous nature of construction work sites such as falling from a height, musculoskeletal diseases, and being struck or hurt by machine or equipment's result in relatively high incidence of injuries, illnesses, and fatalities[2]. The primarily passive character of current safety procedures has not produced the ideal outcomes. Wearable technology has the ability to improve worker safety and health, and further advancements are required to foster construction safety through the application of creative techniques.

The "Wearable Safety Device for Construction Workers" emerges as a transformative solution, seamlessly melding technological prowess with ergonomic ingenuity to comprehensively enhance the protection of construction laborers[1]. This cutting-edge gadget serves as a sentinel, constantly on the lookout for the variety of risks present

in construction environment and offering a channel for communication and health tracking. The gadget also takes on the job of a watchful health companion, thanks to its sensors, which are skilled at keeping an eye on body temperature, heart rate, and oxygen saturation levels[4]. The safety and well-being of workers are of paramount importance. The evolving landscape of technology has paved the way for innovative solutions to enhance workplace safety. One such advancement is the development of wearable safety devices designed specifically for construction workers. These devices are engineered to mitigate risks, monitor environmental conditions, and provide real-time data to ensure a secure working environment. The primary purpose of wearable safety devices for construction workers is to proactively address and prevent potential hazards, accidents, and health risks. These devices are equipped with advanced sensors, communication capabilities, and data processing features to continuously monitor various aspects of the work environment and the wearer's health[3]. This article aims to systematize knowledge in the field of construction wearable safety in order to evaluate the applicability of their use in businesses as a means of ensuring occupational safety, to correlate the costs and benefits of their implementation, and, by pointing out areas in which research is still lacking, to suggest promising avenues for further investigation. To better comprehend the potential role of wearable technology in maintaining workplace safety, we classify construction wearable functions into four classes (monitoring, supporting, training, and tracking) and present a classification of the metrics collected by wearables. We also go over the main localization strategies and communication technologies used in wearable-based work safety solutions. With the growing popularity of wearable devices for things like fitness, medical monitoring and tracking things like keys, their use in occupational health and safety seems like a given. Wearable devices with the right combination of sensors can be used to monitor not only the surrounding conditions of a work environment, but also bodily vital signs that may be affected, as well as any effects of hazards or stress on the wearer.

LITERATURE SURVEY

The 4.0 industrial paradigms has also let to the spread of wearable devices in work contexts[1]. Devices first developed in the medical field and then disseminated for tracking daily life and physical well-being data for personal use, present different functionalities suitable for industrial environments, especially for monitoring of psychological and physiological factors of employees and promoting the health and safety of the worker. However, few studies have focused on this specific application through wearable devices, such as smart watches, wristbands, wearable IMU devices, or EEG devices. [2] Compared to other industries, construction is fundamentally less safe since workers are

exposed to hazardous and demanding conditions. Because of the nature of the construction sector, falling from a height, musculoskeletal diseases, and being struck by objects are among the common causes of significant injuries and fatalities. In order to address this issue in the future, a novel idea is presented in this study. The main idea of this research is that if we relocate the human construction worker off-site and remotely connect his or her movements to a Robotic Construction Worker (RCW) on-site, we can potentially eliminate injuries. [3] Using creative ideas and putting them into practice is a good way to raise building safety standards. Over the past 20 years, there has been a significant increase in interest in the use of technology as a preventive measure to reduce the construction industry's reported disproportionate rate of worker injuries and fatalities when compared to other industrial sectors. Prior research has emphasized the need to increase our understanding of the variables that restrict and prohibit the use of technology in the construction industry, as well as the value and usability of technologies for safety and health management in the sector. The literature survey summarizes that, recent research from 2019 has focused on using wearable devices in production systems to monitor operators' health and safety, indicating growing recognition of their potential. Studies have proposed concepts like a robotic construction worker operated remotely using human motion tracking to eliminate on-site construction injuries. This highlights innovative thinking underway. Adoption of modern technologies for construction safety management has been limited historically despite evident benefits. Barriers like cost and lack of customization have restricted uptake. Wearable devices present a promising avenue to overcome limitations of traditional safety practices in construction sites and enhance risk mitigation through real-time data. Specific capabilities like early injury and fatigue detection, illness prevention through health tracking, and enabling timely responses make construction industry a highly relevant application area for wearables. In summary, the literature survey establishes strong conceptual evidence regarding the value of leveraging wearable devices and sensors to improve health, safety and performance monitoring of workers in hazardous environments like construction sites. Integration of wearable technology for occupational wellbeing and risk mitigation is an emerging concept that needs robust prototypes and implementations to validate and realize its potential benefits.

PROPOSED METHODOLOGY.

Wearable devices with the right combination of sensors can be used to monitor not only the surrounding conditions of a work environment, but also bodily vital signs that may be affected, as well as any effects of hazards or stress on the wearer. Fig 1 represents the proposed methodology. The integrated sensor system consists of two microcontrollers,

the ESP8266 and ESP32, to monitor various environmental and physiological parameters, transmit data to the Thing-Speak cloud for real-time visualization, and send SMS alerts for critical conditions. The microcontroller used in fig.1 is ESP8266, it has MAX30100 pulse oximeter which measures heart rate and SpO2 levels and sends this data to WiFi through GPS module which has Thing-Speak. The other components connected are, GPS module, DHT22 and MPU6050 accelerometer. The GSM module will send SMS alerts to the manager's phone. The ESP32 interacts with the MAX30100 pulse oximeter. The sensor data is sent through wifi and GSM module and can be verified through thing-Speak. Alert SMS for high temperature, low heart rate, and high impact conditions are sent to the manager's phone. The thing-Speak cloud stores and receives the data from both the microcontrollers. It also provides real-time monitoring and analysis of sensor data. The manager's phone receives SMS alerts from the GSM module when specific conditions are detected by the sensors.

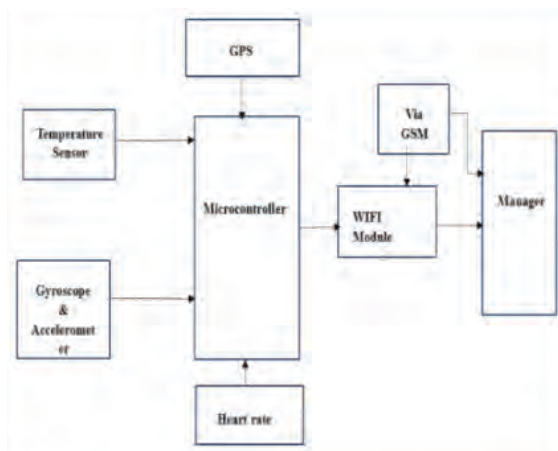


Fig. 1: Proposed Methodology



Fig. 2: Model for proposed Methodology

IMPLEMENTATION

The implementation is development of the methodology as shown in fig1. The ESP processor, the sensors the GPS module are integrated for health monitoring of the workers. The device can be worn in the jacket or can be placed on the safety cap. Fig 2 shows the actual system developed.

The implementation is began with initialization and activating WiFi connection. Both the controllers ESP8266 and ESP32 are powered on and initialized. The initialization process involves setting up the necessary pins, configuring the serial communication, and preparing the sensors and modules for data collection. The ESP8266 and ESP32 attempt to connect to the predefined WiFi network using the provided SSID and password. This step is crucial as it enables the microcontrollers to transmit data to the Thing-Speak cloud. Next is sensor initialization. ESP8266 initializes the MAX30100 pulse oximeter to start reading heart rate (BPM) and blood oxygen saturation (SpO2) levels. The MAX30100 sensor is configured to operate in its optimal mode for accurate readings. ESP32 initializes the GPS module to obtain the latitude and longitude coordinates. MPU6050 accelerometer to measure the g-force experienced along the X, Y, and Z axes. GSM module is initialized to be ready to send SMS alerts when necessary. ESP8266 continuously reads the heart rate and SpO2 data from the MAX30100 sensor. These readings are taken at regular intervals to ensure up-to-date information is collected. ESP32 continuously reads data from its connected sensors. GPS Module: Reads the current latitude and longitude coordinates, ensuring that the location data is accurate and up-to-date. DHT11 Sensor measures the current temperature, providing essential environmental data. MPU050 accelerometer measures the g-force along different axes, which is crucial for detecting high-impact events. ESP8266 converts the heart rate and SpO2 readings into the appropriate format and transmits this data to the Thing-Speak cloud. Thing-Speak stores and visualizes this data, allowing for real time monitoring and historical analysis. ESP32 combines the GPS location, temperature, and g-force data into a single data packet. This combined data is then sent to Thing-Speak, ensuring that all monitored parameters are available for analysis. Threshold checks and SMS alerts are executed by ESP8266. It checks if the heart rate is below a predefined threshold. If the heart rate is critically low, it indicates a potential health issue, and an SMS alert is sent using the GSM module on the ESP32. This alert system ensures that immediate action can be taken. If the temperature exceeds a predefined threshold, indicating a potential overheating or environmental issue, an SMS alert is sent. G-Force Check: If the g-force reading exceeds a predefined threshold, indicating a high impact event (e.g.,

a fall or collision), an SMS alert is sent. This helps in prompt response to accidents or impacts. The SMS alerts are sent to a manager's phone number predefined in the system, ensuring that the responsible person is notified immediately.

Both the ESP8266 and ESP32 operate in a continuous loop. This loop ensures that data collection, processing, and transmission are ongoing processes. Delays are introduced in the loop to prevent overwhelming the WiFi network and the Thing-Speak cloud with too many requests in a short period. This ensures stable and reliable operation of the system.

RESULT AND ANALYSIS

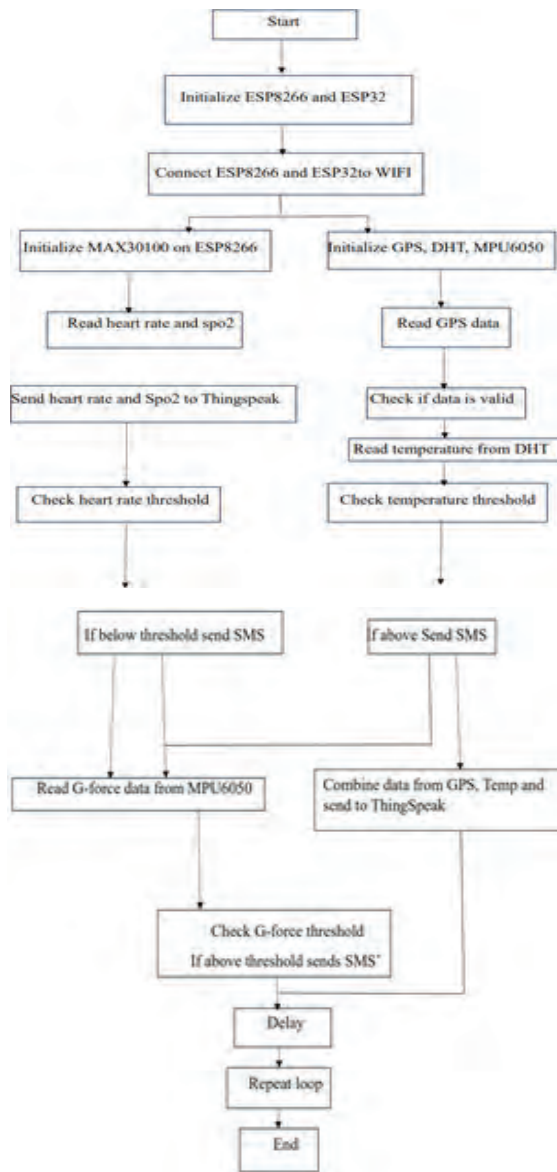


Fig. 3: The flow of the model

The flowchart outlines a comprehensive and integrated system using ESP8266 and ESP32 microcontrollers for collecting, processing, and transmitting sensor data to the Thing-Speak cloud, with real-time SMS alerts. The process begins with initializing the microcontrollers and establishing a WIFI connection, essential for data transmission to the cloud. The ESP8266 reads heart rate and SpO2 data from the MAX30100 pulse oximeter, while the ESP32 collects data from the GPS module, DHT22 temperature sensor, and MPU6050 accelerometer. This multi-sensor approach enables thorough monitoring of environmental and physiological parameters. Collected data is processed to check for thresholds indicating abnormal conditions such as low heart rate, high temperature, and high g-force impacts. The processed data is sent to Thing-Speak for real-time monitoring and historical analysis. The GSM module connected to the ESP32 sends SMS alerts to a manager's phone when specific thresholds are crossed, ensuring immediate communication for prompt response. The system operates in a continuous loop with delays to avoid network flooding, providing continuous monitoring and timely updates. This integrated system facilitates real-time data visualization, immediate alerts, comprehensive environmental and physiological monitoring, and scalability, making it ideal for applications like healthcare monitoring, environmental sensing, and safety systems. The parameters measured are presented as below: Heart rate :The heart rate is number of times the heart beats per minute. A normal beating rate of adults ranges from 60 to 100bpm. The result shows 77 bpm, which is within the normal beating range, a healthy rate. SpO2: It represents percentage of oxygen saturated hemoglobin relative to total hemoglobin in the blood. It shows a measured value of 98% which is within normal range i.e. healthy level of blood oxygen Temperature: It refers to the ambient temperature around the sensor. It is measured as 28.88 °C about normal body temperature and it's indicating a warm environment. Impact: It is likely measured by an accelerometer to detect falls and sudden movements. From fig 4 & 5 indicates the GPS tracking of the worker. GPS Tracking latitude and longitude shows a relatively constant value over a time. This indicates the worker being monitored has remained in a fixed or limited geographical area. The integrated sensor system is a robust and efficient solution for monitoring various environmental and physiological parameters using the ESP8266 and ESP32 microcontrollers. The ESP8266 handles heart rate and SpO2 data collection from the MAX30100 pulse oximeter and sends this data to ThingSpeak for real-time visualization. The ESP32 collects data from the GPS module, DHT11 temperature sensor, and MPU6050 accelerometer, combining these readings and sending them to ThingSpeak. The system includes a critical alert mechanism using a GSM module

that sends SMS notifications to a manager's phone based on predefined thresholds for heart rate, temperature, and g-force



Fig. 4: The GPS location of the worker

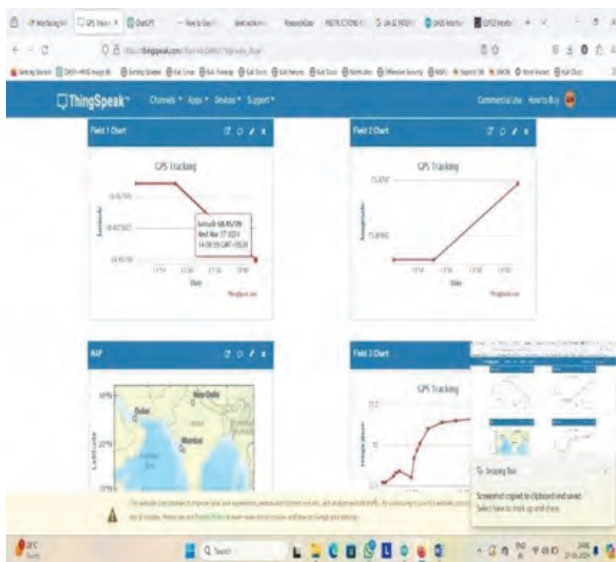


Fig. 5: Result showing the location of the worker

This ensures immediate awareness and response to potential health issues, environmental hazards, or high-impact events. Overall, this integrated system is ideal for applications requiring continuous and comprehensive monitoring, such as healthcare monitoring, environmental sensing, and safety systems, providing real-time data and prompt alerts for effective management and response.

CONCLUSION

This health monitoring system for construction workers represents a significant advancement in occupational safety

and health management. By leveraging modern technologies such as the ESP32 and ESP8266 microcontrollers, along with sensors like the MAX30100 for heart rate and SpO2, MPU6050, for impact detection, GPS for location, and GSM for communication, this system provides comprehensive, real-time monitoring of workers. The GPS data shows stable latitude and longitude readings, indicating reliable location tracking. The latitude was consistently recorded at approximately 18.457395, and the longitude at around 73.87065. This precise tracking ensures accurate monitoring of the individual's movements and location. The temperature readings indicate a significant increase over time, with a peak temperature of around 40°C. The system effectively detected and alerted for high temperature, ensuring timely interventions to prevent heat-related health issues. The heart rate data displayed critical fluctuations, with readings dropping to 0 bpm around 12:30 and spiking around 13:30. These anomalies triggered low heart rate alerts, indicating the system's capability to detect potential cardiac events or sensor errors promptly. The impact data showed fluctuations, with values dropping from 1.05 to around 0.98, suggesting an impact event. The system's ability to detect and alert for high impact is crucial for identifying accidents or physical shocks. The system generated real-time SMS alerts for detected anomalies, including multiple notifications for high temperature, low heart rate, and high impact. These alerts ensure immediate attention and response to potential health risks, enhancing overall safety.

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Mobile Charging Using Piezoelectric Material

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ABSTRACT

Our increasing reliance on mobile devices in our daily lives has raised concerns about effective and sustainable charging methods. This research investigates the use of piezoelectric materials as a novel solution for mobile charging. Known for their ability to generate electricity when mechanical pressure is applied, piezoelectric materials are combined in mobile devices. This combination allows mechanical energy from everyday interactions, such as tapping and swiping, to be converted into electricity energetically for charging. The working principles of piezoelectric charging, design and integration of piezoelectric elements in mobile devices, the potential benefits of this technology, including durability, extended battery life and environmental reduction Movable of the root and convenient Is to contribute to the development of charging solutions Our increasing reliance on mobile devices in our daily lives has raised concerns about effective and sustainable methods of charging.

KEYWORDS: Footstep body, Mobile charging module, Piezoelectric sensor.

INTRODUCTION

The energy demand has been expanding at an alarming rate in recent years, and the availability of energy supplies has decreased. More efficient, pollution-free, and renewable energy supplies must be developed to fulfil the ever-increasing needs for sustainable development. The depletion of fossil fuels has had an impact on global economics. Electrical energy has become a basic necessity in our day-to-day activities. The advent of the Industrial Revolution has drastically changed the way of life. In the past few decades, power consumption has drastically increased as electricity has been used in new industries. Conventional energy sources include power generation from coal, petroleum, LPG, etc., which involves the emission of green gasses [1]. The rapid proliferation of mobile devices in our daily lives has changed how we communicate, work and access information. As these devices have become inevitable, they pose a fundamental challenge to management. Mobile phone users are keenly aware of the need to recharge their devices, often looking for power outlets or relying on power banks. Mobile charging is no exception as the world looks for sustainable and environmentally friendly solutions to everyday challenges. This research begins a journey to find an innovative solution:

mobile charging using piezoelectric materials. At the core of this new approach are piezoelectric materials [2]. These materials can convert mechanical energy, such as pressure or vibration, into electrical energy. They are commonly used in various applications, from sensors to energy harvesting. However, the addition of piezoelectric materials to mobile devices offers new possibilities. It can power mobile devices and reclaim energy from mechanical energy generated during regular device interactions, such as screen taps and button presses. This promises a consistent and intuitive approach to connecting potential touches to how we use and charge our mobile devices more.

LITERATURE REVIEW

The work proposed in the literature [1] states that The project proposes an innovative method to harvest electrical energy from piezoelectric elements, aiming to provide a renewable and sustainable energy source amid the depletion of fossil fuels. The approach involves converting pressure from human and vehicle activities into electrical energy using piezoelectric sensors. The team has developed a unique methodology and efficient circuitry to maximize power output, storing it in a rechargeable Lithium-Ion battery. The module stands out for

its charging efficiency, utilizing a prototype with numerous sensors and well- designed components. This innovation is particularly relevant for remote areas where traditional electricity transmission is economically challenging, such as powering cellular phone towers.

The work proposed in the literature [2] states that When an individual walks, the pressure exerted on the ground can be harnessed to generate electrical energy, which, in turn, can be utilized to power electronic devices. This paper introduces a mobile charging system design that incorporates a piezoelectric generator embedded in the shoe. The generated power from the piezoelectric generator, activated during walking, is then transferred to the device through a mid-range wireless power transfer (WPT) system, specifically employing a resonance coupling technique.

The work proposed in the literature [3] states the challenge of sustainably powering wire-free sensors (WFSs) in structure health monitoring (SHM) applications, particularly in scenarios where battery replacement is impractical. The

focus is on remotely charging WFS devices using external power sources. The proposed approach involves a novel stress wave-based optimization method for wirelessly charging piezoelectric sensors. This method incorporates a unique waveform optimization scheme, a multi-actuator system, and a multi-channel wire-free charging strategy to maximize energy transmission efficiency. Four different waveform design algorithms are successfully implemented based on measured channel characteristics in a tightly insulated environment. The effectiveness of the optimized wire-free charging method is demonstrated through simulations, showcasing the advantages of multi-channel wire-free charging in reducing input power loss and improving energy transmission efficiency.

The work proposed in the literature [4] states that The Internet of Things (IoT) is a transformative technology aiming to create a connected ecosystem of devices, including sensors and actuators. The deployment of these devices, enabled by advancements in miniaturization and low-power communication, necessitates fundamental changes in hardware, software, networks, data analytics, storage, and power sources. Many IoT devices cannot rely solely on batteries, especially in hard-to-reach areas where regular maintenance is impractical. The survey advocates for energy harvesting techniques to address this, emphasizing the need to scavenge and harvest energy from the environment. The objective is to extend the device's lifespan and eliminate battery dependency. The survey delves into the energy and power design challenges for IoT devices, offering considerations for successful self-powered implementations.

It focuses on piezoelectric energy harvesting as a promising solution and discusses challenges and research directions.

The work proposed in the literature [5] states that Piezoelectric Energy Harvesters (PEH) is gaining attention for prolonging the battery life of wearable devices by generating electricity from stress or vibrations. Recent research explores their dual role as power-free sensors for gait recognition, leveraging their sensitivity to gait-induced stress or vibrations. However, challenges arise in achieving high accuracy, especially when PEHs simultaneously store generated electricity. This work proposes a preprocessing algorithm to mitigate the impact of energy storage on PEH signals and introduces Long Short-Term Memory (LSTM) network-based classifiers to capture temporal information for precise gait recognition. Implemented in an insole form factor, the proposed architecture shows improved gait recognition with a 12% higher recall and enhanced energy harvesting performance—127% more energy harvested while consuming 38% less power—compared to the state-of-the-art.

The work proposed in the literature [6] states that this paper discusses the generation and storage of electrical energy from piezoelectric materials, emphasizing their ability to directly convert mechanical energy into electrical energy. The focus is on energy harvesting techniques and circuits, exploring the conversion of ambient vibration into electrical power—a current and compelling research area. Piezoelectric materials are highlighted for compatibility with electronics and microsystems, making them popular for low-power consumption applications like wireless devices and sensors. The paper addresses explicitly energy extraction from piezoelectric materials for storage in devices such as batteries, intending to supply power to electronic equipment. The simulation in MATLAB Simulink and experimental results presented in the paper validate the effectiveness of energy extraction, positioning this work as practical for supplying energy to low-power devices.

The work proposed in the literature [7] states that energy harvesting involves deriving energy from external sources like solar power, thermal energy, wind energy, salinity gradients, and kinetic energy. This harvested energy is captured and stored for small, wireless autonomous devices, such as those found in wearable electronics and wireless sensor networks. The focus of this work is on utilizing piezoelectric materials for energy harvesting. While various methods exist for energy harvesting, mechanical energy harvesting, particularly based on piezoelectric components, is highlighted as a prominent technique. This approach involves converting deformation generated by different means directly into electrical charge through the piezoelectric effect. The

proposed innovative method in this work involves utilizing freewheel and reciprocating motion for enhanced mechanical energy harvesting.

The work proposed in literature [8] states that this paper explores the potential of Acoustic Energy Harvesters (AEH) in generating electricity to reduce overall energy consumption. AEHs utilize piezoelectric materials to convert mechanical stress induced by stimuli like pressure or sound, into electrical energy. The study focuses on the impact of a commercial passive piezoelectric transducer on an energy harvesting circuit, with the generated energy intended for low-power charging applications, such as mobile electronic devices. The methodology involves employing a Piezoelectric Acoustic Energy Harvester (PEAEH) circuit. The paper advocates for the use of renewable acoustic energy to support eco-friendly applications, emphasizing the system's resilience in noisy environments like industrial areas and busy transportation hubs. The proposed system not only contributes to the minimization of electrical waste but also offers a convenient public service for mobile device charging.

The work proposed in literature [9] states the paper addresses the increasing interest among electrical engineers in developing oceanic wave energy conversion technologies using piezoelectric materials. Piezoelectric Oceanic Wave Energy Converters (OWECs) are highlighted for their advantages, including small size, lightweight nature, independence from intermediate devices, and minimal negative impacts on the oceanic environment. While existing literature discusses piezoelectric devices for oceanic energy conversion, this review distinguishes itself by providing a comprehensive scheme covering various piezoelectric device-based power generation aspects. The paper explores prospects, historical development, classification, operating principles, configurations, arrangements, models, processing, post-processing, and test setups related to piezoelectric device-based oceanic wave energy conversion technology. Additionally, the review addresses technical challenges, outlines future research directions, and offers a critical assessment, aiming to contribute significantly to advancing piezoelectric OWECs and assisting researchers in this field.

The work proposed in literature [10] states that This paper introduces a novel wearable energy harvester integrating a PVDF piezoelectric charge generator and an a-Si:H dual-gate thin-film transistor as a rectifier. An analytical model and equivalent circuit explain the device's working principle and physics. Initial experimental results confirm the viability of the concept, showcasing the device's ability to generate microwatt-range power through a simple 90° finger bending action. The combination of low-cost and large-area

fabrication processes suggests the potential for creating a pixelated energy-harvesting array, positioning it as a promising alternative energy source for wearable electronics.

The work proposed in the literature [11] states that This paper introduces an innovative self-powered CMOS interface circuit tailored for piezoelectric harvesters. The design aims to conserve backup or pre-charged power by employing self-powered peak detection (PKD) and switch circuits to minimize quiescent current. A novel low phase lag (LPL) PKD circuit enhances synchronous extraction efficiency, utilizing a single detection capacitor for positive and negative PKD. The circuit offers both general mode (G-mode) and LPL mode (LPL-mode), with LPL-mode reducing phase lag by approximately 50%. Achieving a synchronous extraction efficiency of up to 94%, the circuit yields an output power of 659 μW when the piezoelectric transducer's original open-circuit voltage is 5 V, surpassing full-bridge rectifier standard energy harvesting circuits by 3.56 times at the maximum power point. The minimum harvesting startup voltage is 1.7 V, independent of the energy storage capacitor voltage (VDC). Even at $V_{oc,org} = 5\text{ V}$, the harvesting efficiency remains at 71.3%. Implemented in a 0.18- μm CMOS technology with a 0.5 mm² active area, the circuit holds promise as a functional block for energy-autonomous wireless sensor network nodes within the Internet of Things.

The work proposed in literature [12] states that This study investigates the utilization of piezoelectric elements for harvesting energy from ambient vibration and human motion. The research quantifies the energy generated by the piezoelectric device in both scenarios. A nickel metal hydride rechargeable battery is employed to store the harvested energy. In resonant vibration environments, the discharged 40mAh rechargeable battery can be rapidly charged to its cell voltage within 10 minutes. In the case of human motion energy harvesting, with a subject running at a speed of 5km/h, the same battery can reach its cell voltage within one hour. These findings highlight the efficiency of piezoelectric energy harvesting, showcasing its potential for quick charging in resonant vibrations and feasible energy generation from human motion.

The work proposed in the literature [13] states that This paper compares three ac-dc converter circuits designed for energy harvesting from piezoelectric sources, specifically focusing on periodic mechanical vibrations of a piezomaterial cantilever beam. The circuits are intended to supply voltage to charge Li-ion battery energy storage devices. The study investigates the impact of incorporating third and fifth harmonics, in addition to the fundamental input, on output voltage, current, and power delivered to the load. The

comparison is conducted on an even basis, with all circuits operating in an open-loop configuration and sharing the same input parameters and load characteristics, including the battery model. Simulations performed using PSIM software showcase the output voltage ranging between 3.5 V and 4.2 V. The study contributes to understanding the voltage and current responses to different AC-DC conversion circuitry approaches, providing insights into optimizing the energy storage produced by piezoelectricity.

The work proposed in the literature [14] states that This paper addresses the challenge of limited energy storage space in miniaturized systems, such as biomedical implants, by proposing a 2- μm bi-complementary metal-oxide semiconductor switched-inductor piezoelectric harvester prototype. Unlike traditional rectifiers, this prototype directly channels 30 μW from a periodic 72- μW piezoelectric source into a battery, eliminating operational restrictions. The circuit enhances the system's electrical damping force to extract more power from the transducer and increases mechanical-electrical efficiency by up to 78%. Additionally, the system captures up to 659 nJ from nonperiodic mechanical vibrations prevalent in the environment, with an observed mechanical-electrical efficiency ranging from 6.1% to 8.8%. This innovation holds promise for overcoming energy storage limitations in small-scale systems, providing a more efficient and sustainable energy harvesting solution.

The work proposed in the literature [15] states that This paper emphasizes the crucial role of ecological security within the broader human security framework, tracing environmental challenges back to the Industrial Revolution's impact on pollution and ecosystem degradation. The study introduces a method to generate environmentally friendly electricity using piezoelectric materials, aiming to mitigate the effects of global warming. The proposed model utilizes piezo materials to convert scavenged mechanical energy from vibrations and rotations into electrical energy. This generated power is employed to sustain the "Eco secured Piezoelectric Road" and "Ecosecured Piezoelectric Waterfall," turning the material into a medium for power harvesting. The significance lies in leveraging natural resources for electricity generation in hilly areas and rural locations, mainly through tube-well water pressure. Additionally, the research addresses challenges faced by individuals living below the poverty line, presenting a sustainable solution to overcome critical problems in these communities.

METHODOLOGY

The proposed system works on converting mechanical energy to electrical energy, as shown in Figure 1.

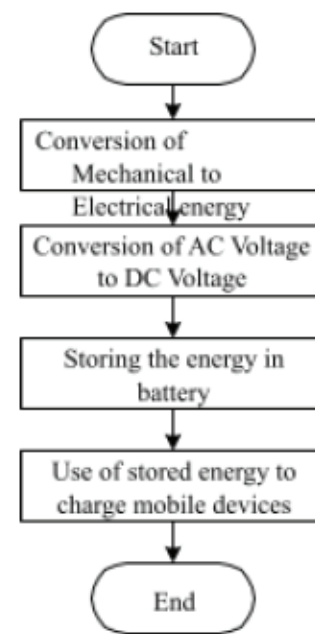


Fig. 1: Process flow of the system

Energy Conversion (Mechanical to Electric): Piezoelectric material converts mechanical energy (such as pressure or vibrations) into electrical energy when subjected to mechanical stress or deformation.

AC to DC Conversion: The electrical energy generated by the piezoelectric material may be in the form of alternating current (AC). This needs to be converted into direct current (DC), which is suitable for charging batteries.

Energy Storage (Battery): The converted DC electrical energy is then stored in a battery for later use. The battery serves as an energy reservoir to ensure continuous power supply for charging the mobile device.

Use of Stored Energy to Charge Mobile Device: When the mobile device needs to be charged, the stored energy in the battery is utilized to supply power to the device, charging its battery or powering its operation directly.

The proposed system has successfully tackled these challenges head-on. Our solution boasts a significantly reduced form factor, effectively eliminating the bulkiness associated with previous systems. We've dramatically lowered production costs by leveraging cutting-edge materials and design approaches, making our technology more accessible to a broader audience. Furthermore, our system is engineered with scalability in mind, ensuring it can be easily expanded to meet the growing demands of mobile charging. The key principle behind the energy- generating floor is the piezoelectric effect shown by metals. When a person walks, he puts pressure on

the floor due to his weight and muscle power. The electricity-generating floor uses this force to generate electricity by utilizing this force to bend the piezoelectric material.

RESULT AND TESTING

Conversion of Mechanical to Electric Energy:- Stepping on the footstep body containing piezoelectric sensors helps convert mechanical energy to electrical energy. It gives AC voltage as an output, which then converts to DC for further use. Output AC voltage also depends on the weight of the Person. **2. Conversion of AC Voltage to DC Voltage:-** The output voltage from the piezoelectric sensor is AC, which is converted to DC voltage with the help of a bridge rectifier made using diodes. **3. Storing the Energy in the battery:-** The output of the bridge rectifier is a DC voltage. This DC voltage is stored in the rechargeable battery, which will charge for further use. **4. Use of stored energy to charge mobile devices:-** The stored energy in a rechargeable battery is used for many purposes in our research. This system uses this energy to charge the mobile.



Fig. 2: Piezoelectric material connection

The developed working model produces power by applying pressure and imitating walking situations; this can also be done by physically walking on the setup of piezoelectric sensors. This model effectively demonstrates the use of power, which was previously neglected. The developed model is straightforward and highly useful. This system can output a good amount of power, which can further be used to provide huge areas with electricity.



Fig. 3: Hardware Setup



Fig. 4: Working of Mobile Charging

In Figure 3, the mobile device remains uncharged due to the absence of any pressure applied to the piezoelectric material. However, in Figure 4, the mobile successfully charges, illustrating the direct result of exerted pressure on the piezoelectric element. The research on “Mobile Charging Using Piezoelectric Material” has uncovered the potential of harnessing mechanical energy for sustainable mobile device charging. Piezoelectric materials offer a promising avenue to convert user interactions into electrical power, reducing the reliance on traditional charging methods. While in its early stages, this technology addresses sustainability concerns and reduces environmental impact. Technical challenges like limited energy output are being researched and refined to enhance efficiency.

CONCLUSION

The developed working model generates electricity by applying pressure and simulating walking situations; this can also be accomplished by walking on the piezoelectric sensor setup. This model successfully illustrates the application of power, an aspect that was previously neglected. The formulated model is simple and extremely practical. This system can produce a substantial quantity of electricity, which can then be expanded to provide huge areas with electricity.

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Automatic Clothes Segregator

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ABSTRACT

— In today's era, washing machines are used mainly for cloth washing. Both coloured and white clothes, if washed together there, are possible to mix colours. Colour segregation is needed for washing machines to avoid such situations. The proposed system introduces an Automatic Clothes Segregator that employs the TCS3200 colour sensor and Arduino Uno microcontroller as fundamental components. The Automatic clothes segregator operates on the TCS3200 sensor and detects the colour of incoming garments, converting light intensity into digital signals processed by the Arduino Uno controller. Upon analysis, the controller initiates segregation, directing garments to designated compartments based on colour. Rigorous testing validates the system's reliability and accuracy, showcasing high precision in colour detection and segregation while accommodating a broad spectrum of colours. The proposed system holds significant promise for industries reliant on efficient sorting processes, including laundry services, garment manufacturing, and retail. Integrating advanced sensor technology and microcontroller systems is a transformative step towards automation, promising heightened productivity and resource optimization across diverse operational contexts.

KEYWORDS: *Arduino nano, Automation, Color detection, Segregation, TCS3200.*

INTRODUCTION

This project presents a novel solution called the Automatic Clothes Segregator (ACS), which is aimed at optimizing the sorting process of garments based on their colours. Utilizing the precision of the TCS3200 colour sensor alongside the flexibility of the Arduino Uno microcontroller, the ACS automates the identification and separation of clothes based on their distinct colours. Adhering strictly to IEEE standards, the system ensures the dependability and precision of its functions. The ACS holds significant promise for transforming industries reliant on efficient sorting methods, including laundry services, garment manufacturing, and retail, offering enhanced productivity and resource utilization through integrating advanced sensor technology and microcontroller platforms.

LITERATURE SURVEY

The Automatic Clothes Segregator (ACS) employs a TCS3200 colour sensor and Arduino Uno microcontroller to segregate clothes based on their colour [1]. Numerous

studies have demonstrated the viability of using Arduino and the TCS3200 for colour sorting in diverse applications, such as sorting industrial parts, tomatoes, and educational aids [1- 16]. The potential applications of the ACS span across several industries, including laundry services, garment manufacturing, and retail [1, 14, 16]. Automatic sorting can significantly enhance efficiency, reduce human error, and potentially mitigate damages caused by color bleeding during washing [1, 18]. This versatility suggests that the ACS could be a valuable tool in streamlining processes and improving the quality of services in these sectors. The project utilizes established components and presents a novel application focusing on clothes segregation [13, 14, 17]. Existing studies often address sorting in broader contexts, such as object recognition or industrial automation. This targeted approach towards clothes segregation adds a distinctive dimension to the project's contribution to the field of automated sorting systems. Recognizing the limitations like sensitivity to ambient light and the necessity for regular sensor calibration [17-20], future studies could explore integrating advanced sensor technologies and machine learning algorithms. These

enhancements could significantly improve colour detection and classification accuracy, thereby boosting the overall effectiveness of the ACS [1, 13, 17].

METHODOLOGY

The process flow of the proposed system is shown in Fig.1. This figure explains the working flow of the model and the work of all components to carry the mechanism of clothes segregation.

This automated system commences by identifying incoming clothes and employing a TCS3200 colour sensor interfaced with an Arduino Uno microcontroller to analyze their colour. The servo motor 1 places the clothes below the colour sensor. The clothes are then directed to a designated bin for white clothes or coloured clothes using the servo motor 2. The segregation process is coordinated by Arduino Uno, which operates two servo motors. A battery regulated to 5V via a voltage regulator is used to power this system. This battery supplies energy to Arduino Uno, the color sensor and the servo motors. This setup ensures efficient clothes segregation based on colour, enhancing workflow automation across diverse applications.

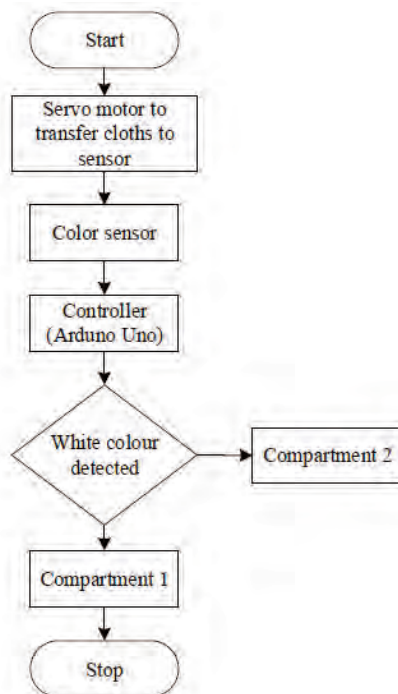


Fig. 1: Process flow of Automated Clothes Segregator

By integrating precise colour detection with servo-controlled segregation, the system offers a reliable and adaptable solution for industries reliant on efficient sorting processes, such as laundry services and retail.

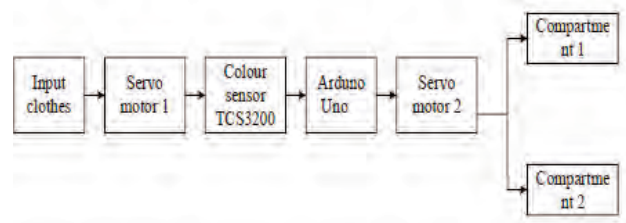


Fig. 2: Block diagram of Automated Clothes Segregator

Moreover, its reliance on battery power provides flexibility in deployment, making it suitable for various operational environments where reliable and efficient clothes segregation is essential. The proposed system includes two servo motors, a TCS3200 Colour sensor, and Arduino Uno, two compartments for white and coloured cloths, as shown in Fig.2.

IMPLEMENTATION

Fig 3 shows the interfacing of stepper motors and TCS3200 colour sensor with Arduino nano.

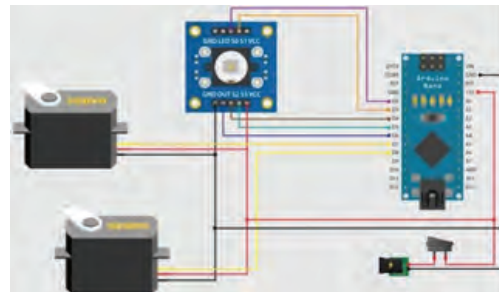


Fig. 3: Circuit Diagram of Automated Clothes Segregator

Fig. 4 shows the working prototype model of the Automatic Clothes Segregator.



Fig. 4: Working prototype model of Automated Clothes Segregator

The servo motor is seamlessly integrated into the system to ensure optimal functionality, with specific connections to the Arduino Nano. Its VCC pin is linked to the 5V pin on the Arduino Nano, providing a consistent power supply. Meanwhile, the GND pin is connected to the ground pin for proper grounding. The servo motor's control signal is intricately tied to a PWM (Pulse Width Modulation) pin, typically designated as pin 9 on the Arduino Nano. This arrangement allows for precise control over the motor's movements. During operation, the Arduino Nano receives input signals from sensors, often indicating the type of clothing detected. Based on this input, the Arduino Nano sends a corresponding signal to the servo motor through the control pin. As a result, the servo motor rotates to a predefined position, activating a mechanism configured for sorting clothing items. This streamlined and automated setup enhances efficiency and accuracy in various sorting applications. The system demonstrates effective colour-based clothing classification. Accurately identifying colours mitigates issues like colour bleeding and fading in textiles. The proposed system also addressed sensitivity to ambient light and the need for regular sensor calibration. Future research can explore advanced sensor technologies and machine learning algorithms to enhance colour detection and classification accuracy, overcoming existing limitations.

CONCLUSION

This project presents a comprehensive solution for automating clothing sorting based on predefined criteria. By integrating servo motors controlled by an Arduino Nano microcontroller, we achieve precise sorting operations in response to input signals. The meticulous connections between the servo motor and the Arduino Nano ensure reliable functionality, with optimized power supply and signal transmission for seamless operation. The project's significance lies in its potential to streamline sorting processes across various industries, including logistics, retail, and manufacturing. With the Arduino Nano as the central controller, the system demonstrates adaptability and scalability, making it suitable for diverse operational settings. By harnessing servo motor technology and microcontroller capabilities, our project underscores the power of automation in enhancing workflow efficiency and precision. Future refinements and enhancements could further expand the project's functionalities, solidifying its role as a valuable asset in modern automation and sorting systems.

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Dynamic Solar Orientation System for Sustainable Energy Synthesis

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ABSTRACT

Nowadays, everyone worldwide talks about global warming. It is a huge issue. To reduce this issue, people are moving towards renewable energy. There is an urgent need to switch to non-traditional energy sources because traditional energy sources are becoming more scarce due to the rising energy demand. Solar energy is a limitless resource that can be readily captured worldwide and transformed into electrical energy via gadgets like solar panels. However, the Sun's east-west motion and changes in its angle of incidence with the seasons and time of day cause the output power of these photovoltaic panels to fluctuate. A dual-axis solar tracker is required to turn the solar panel around its vertical and horizontal axes to maximize energy output. This method ensures optimal energy efficiency and successful solar tracking. This research covers using the Internet of Things to remotely monitor and adjust the solar panel's position from any place. Solar energy is a renewable energy, plentiful, clean, and environmentally benign.

KEYWORDS: Dual axis solar tracker, IoT, LDR, Motor driver, Solar panel.

INTRODUCTION

Over the last ten years, there has been a rise in the need for consistent and plentiful electrical energy from renewable sources. In the nation's energy dilemma, renewable energy is crucial. As it became less dependent on fossil fuels, the government began to encourage the development of renewable energy, such as solar and hydropower. Solar energy is a renewable energy. One enormous, limitless source of energy is solar energy. A solar tracker focuses a solar reflector or lens toward the Sun or aligns a photovoltaic array solar panel. There are two categories in this project: software and hardware. Light-dependent resistors (LDRs) have been utilized in hardware components to trace the synchronization of sunlight. The power results may be viewed via the IOT-enabled Think Talk app and displayed on the LCD panel. The microcontroller is programmed with embedded C code to execute the software component. This project is intended for portable and low-power use. Therefore, using it in rural regions is suitable. Furthermore, the output power generated by solar radiation is more effective.

Consequently, a dual-axis solar tracker outperforms a single-axis one in terms of effectiveness when using a dual-axis solar system. There are numerous ways to follow the Sun. Finding the Sun's location using an LDR is simple. An LDR is a photoresistor that responds to light intensity by altering its resistance. This method allows for a $\pm 4\%$ degree precision for tracking the Sun. The solar panel has four LDRs on each side, and when the LDR output on that side is low, the panel spins in that direction [1]. By utilizing cameras, the precise angle of solar radiation may be improved by positioning the PV panel vertically to the Sun's rays throughout the day.

LITERATURE SURVEY

On Earth's surface, we receive around 1.2×10^{15} TW of solar energy. Because solar radiation is a free, plentiful, clean energy source, it has the most tremendous potential for utilization in green technologies. India's solar capacity of 22 GW is eight times greater than 2.63 GW between 2014 and 2018. It is anticipated that India will produce 227 gigawatts of renewable energy. Nevertheless, the benefits of solar energy

are limited to the daytime. Technology has improved solar system efficiency by employing single- and dual-axis solar tracking devices that continually observe the Sun's location despite the widespread usage of static or permanent solar systems [3].

Direct beam radiation carries about 90% of the Sun's energy on a clear summer day, while diffuse radiation carries only 10%. A further strategy for making the most of this incoming energy is to combine a solar tracker and concentrator. Solar trackers can boost system efficiency by 30–40% compared to fixed systems, while solar concentrators can increase solar energy density, reducing the surface required for installation [4]. Photovoltaic effects are the mechanism by which solar cells convert sunlight into direct electricity. Sunlight beams must be vertical to the solar panels' orientation to maximize energy output throughout the day. The Sun moves and changes positions all the time. Many factors vary, such as the type and size of solar cells, temperature, angle, and intensity of sunshine [5].

METHODOLOGY

Two LDR sensors are fixed to the photovoltaic panel's surface to track solar radiation. By combining it in different ways, users of the smart tracker system may tailor it to their tastes and environment. The network operates at night in "sleep" mode to conserve energy. The photo voltaic panel spins on its own throughout the daytime according to the Sun's intensity. The solar tracker comprises lead-acid batteries, charge controllers, and photovoltaic cells [6]. Additional components included a target board with a PIC1 8F4520 microcontroller, LDR sensors, and a voltage regulator.

The LDR sensors send a signal to the microcontroller instructing it to spin the photo voltaic panel using the servo motor. The necessary components are then powered by the electrical energy that has been stored in a lead-acid battery. Because it only uses one tracking axis, it is less sophisticated and expensive to retain. The tracker system combines light- sensor tracking technology with time-based tracking technology. However, tracking is less effective than dual-axis tracking since it requires the microcontroller to provide Pulse Width Modulated waves as input [7].

A novel control approach that enhances distributed maximum power point tracking systems' dynamic performance. These architectural solutions assist systems in collecting extra solar power in situations when there is partial shade and irradiance mismatch. It might be challenging to assess if a system operates at peak efficiency when distributed DC/DC power electronics and control are used without centralized intervention [8]. The innovative control process provided in

this work operates on the control sequence under changing irradiance circumstances to reduce the output terminal voltage stresses of the DC/DC converter. Utilizing vectorial multi-variable perturb observe logic [9]. Additionally, matching the DC bus voltage control, which offers centralized control over the whole system, is investigated, a topic that is rarely covered.

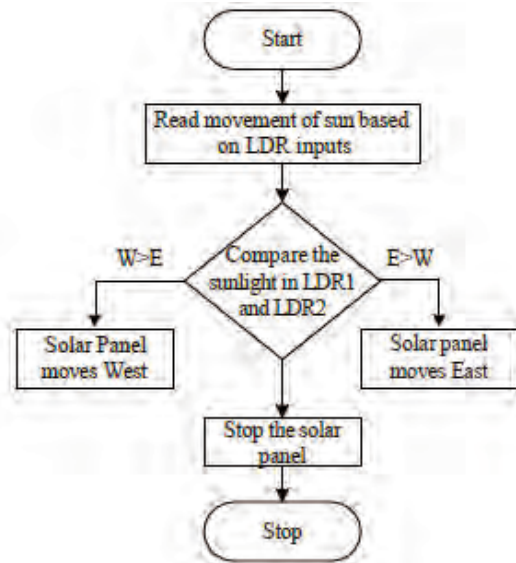


Fig. 1: Flowchart of the proposed system

The concurrent modifications are shown in Figure 1. Adding VDC control into the MV control sequence makes it possible to reference numerous variables and synchronize the procedure of distributed and central MPPT functions [10]. HMPV control is an additional choice for DMPPT systems with various converter topologies in their modules. The PV panels' MPPTs may be off, and the MV algorithms may not function optimally due to nonhomogeneous irradiance changes among the modules. Furthermore, the TMS320F28069 M DSP converters and other components add to the system's complexity and cost.

The mechanical framework and electrical systems comprise this suggested solar tracker configuration. Based on the angle data gathered from a website, the mechanical structure is utilized to operate the solar tracker's azimuth and elevation motor [11]. The electrical system is utilized to read sensor data and drive the motors. The Internet of Things is an interconnected network of mechanical and computer equipment. It can transmit data via the Internet, fully automating the system and doing away with human-system interaction requirements [12].

The Sun's elevation angle and azimuth for the solar tracker location are found on the suncalc.org website. They monitor

the location of the Sun all day long. These statistics are gathered from morning (8:00) to evening (5:00) at intervals of every five minutes [13]. The Arduino utilizes the position data it gets every five minutes to drive the motor that circulates the solar tracker, enabling the solar panel to be oriented vertically.

The solar tracker's proper positioning at the given angle is assessed using accelerometer and gyroscope sensors. The accelerometer sensor determines the solar tracker's tilt (altitude) angle, and the gyroscope sensor determines its azimuth angle. These online and sensor data are uploaded to the Internet so that anyone, wherever at any time, may keep an eye on them. According to a thorough literature review, optimization approaches include high-volume equations whose solution creates a heavy computational load on the processor [14]. There is no need for calibration if the sun tracker moves. Long-term efficiency gains are feasible, which might be highly beneficial, particularly for off-grid applications. Using a Wheatstone bridge, one approach to using a DAST is to measure the Sun's brightness at two separate ends.

Creating a dual-axis solar tracker is the primary goal of this proposed part, which aims to increase solar panel efficiency. To guarantee that the solar panel is often in the best possible location to absorb most solar energy, the DAST is made to rotate it in the horizontal and vertical axes. Using a microcontroller, the panel's position is automatically changed based on the Sun's location in the sky. Additionally, this system is linked to the Internet of Things to track and ensure that the output power is constantly at its highest level.

This method offers a practical and efficient means of producing renewable energy. This section aims to provide a detailed overview of every piece of hardware that comprises our recommended system. The limit switch, voltage regulator, potentiometer, solar panel, motor driver, LDR, and adapter will all be covered in detail. Sunlight is captured by the solar panel and transformed into renewable electrical energy. The system is adjusted based on the ambient light conditions detected by the LDR.

Algorithm that elucidates the research paper's overall concept:

Step 1: Gather data on the Sun's angle of incidence concerning Earth during the day and throughout the seasons.

Step 2: Construct a dual-axis solar tracker that revolves the panel along its vertical and horizontal axes to produce the most energy.

Step 3: Using the data acquired in Step 1, a microcontroller controls the solar panel's position.

Step 4: To monitor the outcomes, link a Wi-Fi system to the solar panel.

Step 5: Use the Internet of Things to monitor the solar panel's maximum power production and adjust the dual-axis solar tracker system as needed.

Step 6: Monitor the solar panel's efficiency and reposition it as necessary.

According to the suggested method's operating theory, the Dual-Axis Solar Tracker is a tool used to maximize the angle of incidence between the Sun and the solar panel to maximize the efficiency of solar energy conversion. In order to optimize the solar panel's energy output, the system is made to follow the Sun's passage across the sky and rotate the panel concerning it.

The controller and the motor are the two primary parts of the DAST. The solar panel may be moved horizontally and vertically with the motor's assistance. The controller, which is usually a microcontroller, is in charge of directing the motor's motion. The microcontroller uses the Sun's location in the sky to calculate the movement of the solar panel's direction and angle. The sensors that measure the Sun's location and angle of incidence concerning the solar panel are connected to the microcontroller. The motor receives instructions from the microprocessor to spin the panel at the proper angle and direction. The microcontroller receives information from the sensors.

Evaluate and select appropriate control algorithms to process sensor data and calculate precise angles for solar panel orientation. Explore closed-loop control methods such as PID control, fuzzy logic control, or model predictive control for real-time adjustment. Sensors for tracking solar irradiation and sun position accurately. Consider accuracy, sensitivity, response time, and environmental resilience. Choose suitable actuators for monitoring the motion of solar panels along both azimuth and elevation axes. Evaluate different actuation mechanisms and select the most suitable option based on system requirements. Integrate selected sensors, actuators, and control systems into a prototype solar tracking system. Conduct thorough testing and fine-tuning to optimize performance. Test the solar tracking system under various environmental conditions to assess tracking accuracy, energy yield improvement, and overall efficiency. Optimize system parameters and calibration settings to maximize energy capture while minimizing power consumption and mechanical wear. Implement calibration routines to compensate for sensor drift and inaccuracies. Document the solar tracking system's design, construction, and operation, including installation instructions for deployment in the intended location.

IMPLEMENTATION

Figure 2 shows the model's front view, which shows the east-to-west direction.



Fig. 2: Front view of model

In this model, all electronic components are assembled correctly and accurately maintained to give proper results. In this model, these kinds of electronic components are situated in the solar panel, motor driver, DC motor, battery, Arduino uno, LCD, LDR sensors, DHT11 sensor, L293D sensor, and 8266 Wi-Fi module. Figure 3 shows the side view of the model.

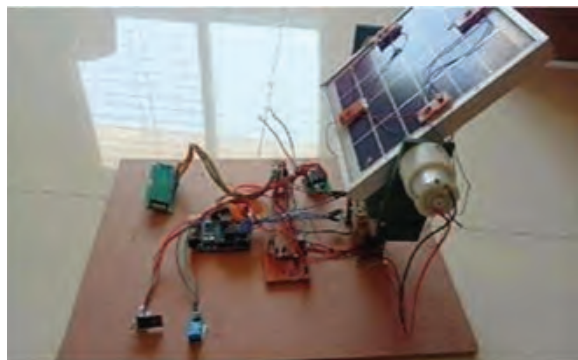


Fig. 3: Side view of model

As discussed above, the same electronic components are situated in this model. The side view shows the direction of the north and south.

RESULTS

A “Humidity vs Date” plot for a dual-axis solar tracker shown in Figure 4 gives how humidity levels vary over time, with dates on the horizontal axis and humidity readings on the vertical axis. This plot helps monitor changes in atmospheric moisture levels, which can impact the performance and efficiency of solar panels and the overall operation of the solar tracking system. Understanding these variations can inform

adjustments to the system's settings or provide insights into environmental conditions affecting solar energy generation.



(a)



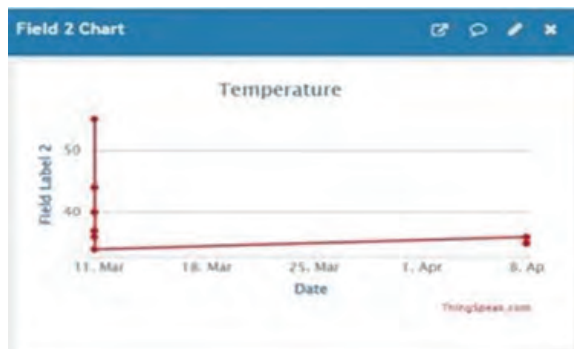
(b)

Fig. 4: Humidity Plot (a), (b)

A “Temperature vs Date” plot taken for a dual-axis solar tracker would display how temperatures fluctuate over time, with dates on the horizontal axis and temperatures on one vertical axis shown in Figure 5. This visualization helps understand how environmental conditions impact solar panel efficiency and tracking performance.



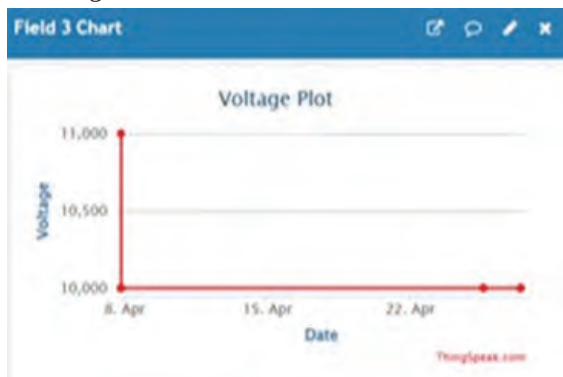
(a)



(b)

Fig 5. Temperature Plot (a), (b)

A dual-axis solar tracker's "Voltage vs. Date" display, which shows voltage readings on the vertical axis and dates on the horizontal, shows the link between voltage output and time. This graphic can be used to track variations in voltage levels over time in the context of a dual-axis solar tracker, which may indicate adjustments to tracking angles or solar panel orientation. These differences are essential for maximizing the solar tracking system's effectiveness and performance, as shown in Figure 6.



(a)



(b)

Fig 6. Voltage Plot (a), (b)

Table 1, generated by comparing the output power of static and dynamic solar systems, displays the power generated by each system at different times of the day.

Table 1. Comparison between static and dual-axis solar tracker systems

Time	Static solar system's output power (W)	Dual-axis solar tracker system output power (W)
7:00 a.m.	14.57	38
8:00 a.m.	23.98	49.72
9:00 a.m.	43.94	52.70
10:00 a.m.	47.94	54.95
11:00 a.m.	52	52.97
12:00 Noon	57.66	59.61
13:00 p.m.	57.96	58.04
14:00 p.m.	56.41	56.56
15:00 p.m.	54.69	55.31
16:00 p.m.	48	54
17:00 p.m.	37	52
18:00 p.m.	27.72	52.66
19:00 p.m.	13	33

The "Time" column would indicate the specific times when the power output was measured, while the "Output Power" column would show the amount of power generated by each system at those times. This comparison helps illustrate how dynamic solar systems adjust their orientation to track the Sun, potentially generating more power than static systems, which remain fixed. When light is incident at a 90-degree angle to the surface of the solar panels in a Dual Axis Solar Tracker, the output power generated is typically greater than when light is incident at other angles. This phenomenon is a result of optimising the angle of incidence, which maximises the effective area of the solar panels that are exposed to sunlight.

CONCLUSION

A dual-axis solar tracker is a helpful device that can raise solar panel efficiency. It is cheap and straightforward to assemble gadgets. The solar panel may be positioned optimally for maximum energy output by the system, which can track the movement of the Sun. The system's use of IOT enables it to track the PV panels' output power and notify the user when adjustment is necessary. DAST can be implemented to decrease dependence on conventional energy sources and increase the quantity of energy harvested from solar panels. Using a 24-hour data collection allowed for a more efficient system implementation. The recommended solution will turn on the tracker in less than 0.2 seconds, guaranteeing

that electricity is generated continually. Additionally, this work will be intended to be implemented using artificial intelligence- based control approaches and more excellent power ratings.

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Utilizing a Naive Bayes Classifier to Forecast Heart Disease

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ABSTRACT

Globally, among the greatest reasons for mortality is cardiac arrest. Making a heart disease diagnosis is a laborious process. Making a wise choice is necessary. Support system for the forecasting of diseases. When determining if a patient has coronary artery disease or is average, Machine learning techniques are frequently employed. A data mining approach called Hidden Naïve Bayes modifies the conventional Naïve Bayes conditional autonomy requirement. The framework asserts the cardiac disease category (prediction) can be achieved by using the Hidden Naïve Bayes (HNB). The results of our study on the cardiac sickness information set demonstrate that the HNB surpasses naïve bayes and captures 100% of the information accurately.

KEYWORDS: *Heart illness, Categorization, Machine learning (ML), Hidden naïve bayes (HNB), UCI data set.*

INTRODUCTION

A medical issue that impacts heart function is cardiac arrest. Heartburn and heartburn can result from “cardiovascular artery narrowing,” which slows or stops the circulation to the cardiac muscle [1]. Experts with extensive training and expertise are needed to diagnose cardiac disease [2]. The goal of statistical mining, which combines a number of fields, is to glean expert knowledge from massive volumes of data. Information mining can be used to create hypotheses from vast amounts of scientific data and extract information about health for clinical decision making [3]. The challenge of categorisation is ubiquitous and is used to identify unidentified samples in a variety of contexts. The goal of research is to create effective methods for classification for enormous quantities of data [1]. Comparing Hidden Nave Bayes with various traditional categorization algorithms, its efficacy is astounding. A precise categorization is necessary for data analysis applications, particularly for health information mining.

The cost of misdiagnosis must be considered into account while extracting medical data. For operations that are sensitive to cost, classification chance estimate is necessary [6]. Our goal is to forecast cardiac disease with HNB categorisation that is reliable and fast. This is how the remainder of the paper is structured. The second component presents related research on cardiac disease. Section 3 discusses the research under assessment. During section 4, we'll discuss our new classifying algorithm. Instructions on installation are provided in Section 5. We discuss conclusion in section 6.

RELATED WORK

A few CHD-related publications are examined in this section. In [2], The authors used random forest classification with choosing attribute to create a method for categorising cardiac disease. Chi square measurement is employed in picking characteristics to eliminate superfluous features, yielding an 83.70% correctness rate.

M.A. Jabbar et al. [7], proposed an effort to improve cardiovascular illness accuracy. They employed genetic algorithms on naïve bayes classifier and separation pre- treatment approaches. A proposal for association identification and GA-based forecasting of heart disease is made in [1]. A system for decision-making was created by the authors to determine the likelihood of cardiovascular disease. The Gini index and Z statistics measurements are employed in associated methods of classification to filter a multitude of rules.

A proposal for disease classification utilising ANN and FSS may be found in [3]. With PCA as an attribute choice tool, the amount of factors included in cardiac ailment registry is reduced. Their technology effectively classifies cardiac disease by removing irrelevant and distorted data.

S. Sreejith et al. suggested a real-time medical tracking system that uses random forests to foresee diseases [8]. Their suggested solution offers an outline for evaluating multiple safety variables with a wearable device, and it transmits the measured values to an Android device.

M.A. Jabbar et al. presented the idea of utilising GA and closest neighbour to predict cardiac events in [9]. GA is used as a characteristic assessment criterion. The characteristics with the highest rankings are chosen to construct the classifier. Their technique outperformed other methods in terms of reliability. In contrast to previous work on categorization of coronary illness, we suggest a novel method that improves the reliability of our system by efficiently classifying cardiac prognosis with hidden naïve bayes.

PROPOSED METHODOLOGY

The terms utilised in the approach we suggest is covered in this subsection. Because of its robust features, data extraction has garnered a lot of interest [1]. In the process of data mining, segmentation is the most crucial activity. A lot of academics are working on creating the most precise and effective classifiers possible for newly developing fields like language recognition, categorization of images, bio-medical, etc. Every instance in a collection of information is mapped to a unique class by a categorization process. In medical care, a binary classifier determines if someone has a cardiac condition or not.

Naive Bayes(NB)

The naïve Bayesian algorithm, a stochastic classifications methodology built around Bayes' hypothesis and its guiding concepts and procedures are collectively referred to as Naive Bayes knowledge. Finding retrieved patterns is the foundation for segmentation in data analysis, which divides the population into cardiovascular sufferers and those who are healthy. The naïve bayes learner is a basic type of Posterior networked extractor that relies on the solid interdependence of features premise and the application of the Bayes hypothesis. A Bayesian classifier uses database D, which contains instances E, to allocate attributes F1, F2, F3... to Categories C1, C2, C3...

$$a(E) = \arg \max_c P(a) P\left(\frac{F_1, F_2, F_3 \dots F_n}{c}\right) \quad (1)$$

Given the supposition of variable liberty, naïve Bayes classifications can be described as

$$P\left(\frac{E}{c}\right) = P(F_1, F_2 \dots F_n | c) = \prod P(F_i | a) \quad (2)$$

The most widely used model is the naïve bayes (NB) classification because of its ease of use, effectiveness, and strong collection of data effectiveness. NB fails to work well for collections of data including complicated property relations. For big data packages, NB classier won't yield reliable results [10]. There is a correlation between characteristics and health issues in medical circles. NB's drawbacks can be addressed with hidden naïve bayes classification algorithms.

Hidden Naive bayes (HNB)

When it comes to classifying connections, naïve bayes prediction is inferior to hidden Bayes identification. The HNB is comparable to a Bayes classifier in that it avoids unmanageable intricacy and considers the influence of every attribute. A parent attribute that incorporates the effects of other features is built for each element in hidden naïve bayes. Figure 1 depicts the HNB design.

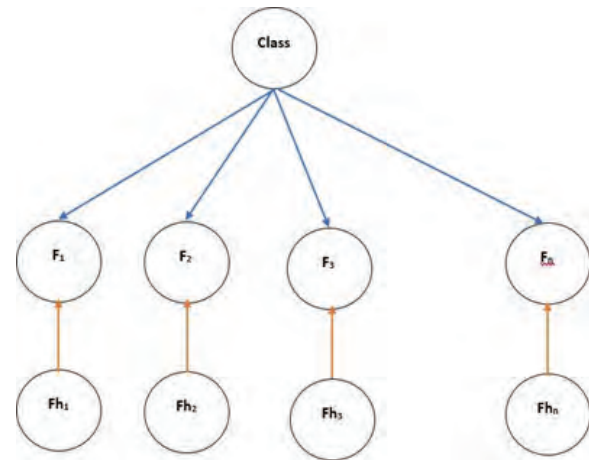


Fig. 1 Hidden Naive bayes Classifier

The weighed impact of every other trait is combined to form the hidden parent in HNB. Figure 1 illustrates the class node. The node that serves as the parent for each feature is the class node. There are hidden parents Ah1, Ah2, Ahn for every characteristic Fi.

The structure-extension-based algorithm Hidden Naïve Bayes requires extra learning period. It is possible to think of Hidden Parent in Hidden Naïve Bayes as collecting the impacts for any additional characteristics that have greater weights and more influences. Given the growing demand for health analysis approaches, we implemented Hidden Naïve Bayes on a cardiac condition database containing independent characteristics.

We outline our suggested algorithm here.

Hidden naïve bayes cardiac arrest detection algorithms dataset set on heart conditions as inputs. Determining a person's cardiac condition or level of wellbeing in order to forecast an outcome.

We obtained the cardiac stalogs set of data in ARFF to conduct our investigation using the UCI dataset [11]. To conduct the research, we used the preliminary processing methods listed below. To substitute every empty attribute value, we employed the repair values that were absent filter. Fig 2 shows the average and mode form the training set of data

are used by this filter to fill in the values that are absent. Using unsupervised 10-bin separation, separation filters were used for separating numerical features. Filtering by their interquartile range (IQR) One way to quantify volatility is with the interquartile range, or IQR. It divides the information given into halves. In a rank-ordered collecting of data, Q1 is the smallest value in the main half, and Q2 is the median element of a data subset.

In the latter half of this information set, Q3 represents the “centre” value.

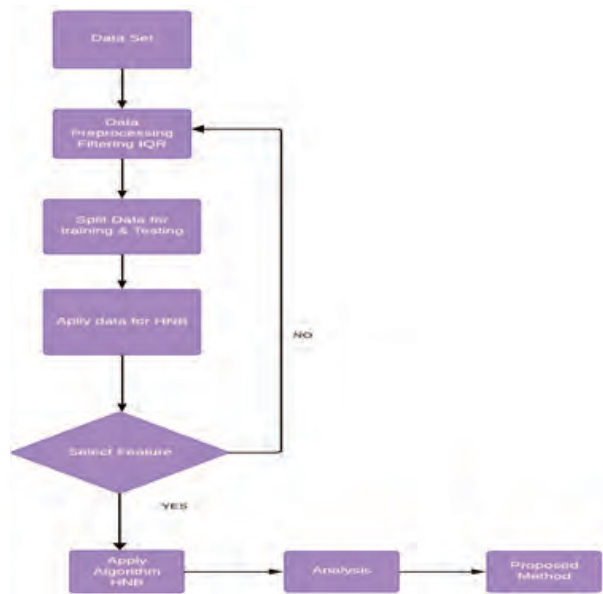


Fig. 2. Work flow of research

EXPERIMENT ANALYSIS

We utilized WEKA 6.4 to apply a hidden naïve bayes algorithm. We used cardiac data that we acquired from UCI [11] to conduct our studies. There are 270 entries and 14 characteristics in the heart stalog information set. Tenfold cross-validating is used to evaluate HNB. Table 1 displays details from the Cardiac survey. Table 2 provides characteristics for this information set.

Ten cross-fold validation was employed. Here, we divided the data into 27 and 243 for training and testing, respectively.

To conduct the research, we used the Exploratory Data Analysis (EDA) methods listed below.

Table 1 UCI Dataset

Sr No.	Code	Description
1	age	Age of Patient
2	sex	Men & Female (1 & 0)

3	cp	Chest pain kind 0,1,2,3
4	trestbps	Resting BP
5	chol	Cholesterol Level
6	fbbs	Fasting Blood Sugar Test
7	restecg	ECG
8	thalach	Heart Bits
9	exang	Exercise Induced Angina
10	oldpeak	ST Depression
11	slope	The peak on the hill of the workout.
12	ca	The quantity of main vessels
13	thal	Stress from Thallium

Substitute any null numbers

To substitute every missing attribute value, we employed the substitute null values filter. The mode and mean from the initial set of data are used by this sort of filter to fill in the values that are missing.

Configuration

Applying unsupervised 10-bin splitting, division filters were used to separate numerical characteristics.

Inter-Quartile range filter (IQR)

The interquartile range, or IQR, is a variation measurement. The data set is split into quarters by it.

Q1 represents the average figure in the initial half of a rank-ordered data collection; Q2 represents the information set's median figure. In the latter portion of the data set, Q3 represents the “centre” figure.

$$IQR = Q3 - Q1 \quad (3)$$

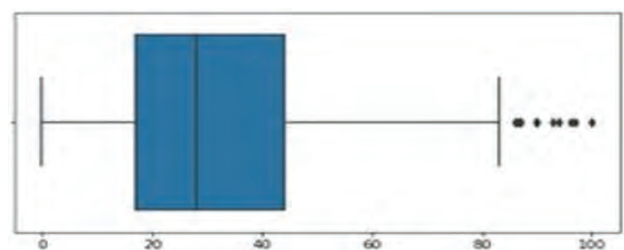


Fig. 3. Boxplot before EDA

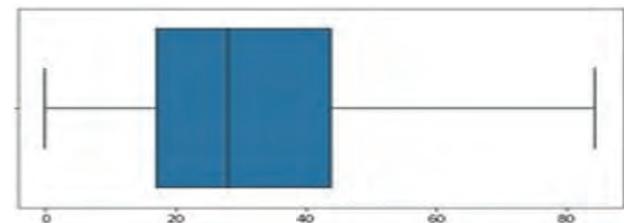


Fig. 4. Boxplot after EDA

Figure 3 and Figure 4 display boxplots utilized for exploratory data analysis (EDA). In Figure 3, we observe outlier factors emerging after the age of 80 years, whereas in the range of 20-40 years, we find a higher likelihood of data points exhibiting strong correlation. Figure 4 illustrates the refined data set achieved by removing outliers using EDA techniques. In the research we conducted, we assessed the effectiveness of HNB using metrics such as positive predictive value, sensitivity, specificity, and accuracy. Such metrics for performance, which come from a matrix of confusion, are especially significant in the health care sector. The efficacy of a technique can be seen using a confusion matrix. It is employed to gauge how accurate and inaccurate the classifier's predictions were. Table 2 displays the matrix of confusion.

Confusion matrix :
[[707 93]
[123 677]]
Accuracy score :
0.865
Classification report :

```

              precision    recall  f1-score   support

     0       0.85        0.88        0.87        800
     1       0.88        0.85        0.86        800

 accuracy          0.86        1600
 macro avg         0.87        0.86        0.86        1600
 weighted avg      0.87        0.86        0.86        1600

```

Fig. 5. Confusion Matrix

Fig 5 indicates that the F1-score is 87%, recall is 88%, and precision is 85%. That gave us an accuracy of 86.50%.

Table 2. Report of various aspect

Report	HNB		NB	
	Cross Validation	Full Training	Cross Validation	Full Training
Sensitivity	89.56	91.5	79.16	79
Specificity	85	95	85.6	86.85
Accuracy	82.3	93.4	83.7	84.18
PPV	81	93.8	83	84
NPV	80	93.1	88	83
TRP	79	91.5	79	79.83
FPR	13	3	14	11.1

Table 3 Comparison of research

Sr no	Authors	Methodology	Accuracy
1	Our Methodology	HNB + IQR	86.50
2	Peter john et al [12]	CFS ,NB	85.18

3	Maishouman et al. [13]	NB	84.50
4	Rupali [14]	NB	78

Whenever the test score is positive, PPV (Positive Predicted Value) determines the chance of the illness being present, while NPV (Negative Predicted Value) determines the chance that an illness is missing.

We found that Peter John et al. [12] used the CFS, NB technique to construct a heart disease prediction model by comparing our findings with previous research. Using that strategy, the author's accuracy was 85.18%. Maishouman et al. [13] obtained 84.50% accuracy in their research using solely NB. Rupali et al. [14] achieved a 78% accuracy rate with the use of the NB algorithm. After analysing all approaches, the HNB with IQR filtering method produced the best accuracy, at 86.50%.

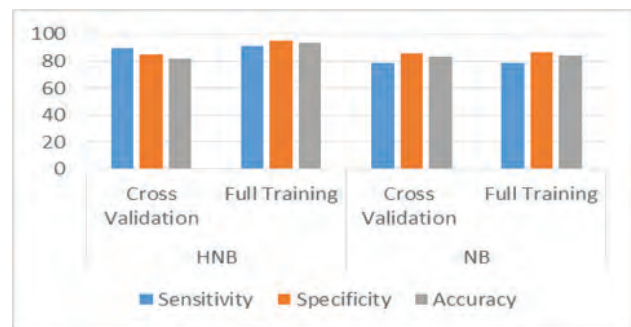


Fig 6. Comaparitive Chart for Sensitivity , Specificity & Accuracy

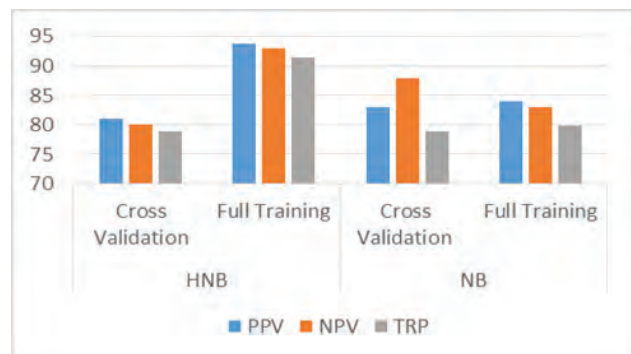


Fig 7. Comparative Chart for PPV, NPV & TRP

CONCLUSION

Further study is necessary to address the root cause of technical challenges. For example, we must consider all EDA variables, including the removal of null values, outliers, and correlation, as these might improve any algorithm's reliability. Cross-validation involves folding (or partitioning)

the data a predefined number of times, analysing each fold, and averaging the total error calculation. The 10 cross fold method produced higher accuracy in this case, up to 86.50%.

Below is a summary of the suggested model's salient features.

- a) The algorithm we used yielded an accuracy of 86.50%. At the greatest extent of our ability, each of the systems shown in the comparative table have achieved the highest accuracy.
- b) Compared to other approaches, the HNB-based model achieved greater accuracy without choosing features.
- c) The suggested model classifies heart illness by addressing the shortcomings of the NB classifier.
- d) The suggested model has a far higher sensibility than NB.
- e) The suggested model's actual positive rate is significantly greater than NB's.

When compared to other theories, the suggested model performs best generally, making it the most appropriate intelligent DSS for diagnosing cardiovascular disease. The problem of under fitting in machine learning algorithms was successfully resolved.

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Design of Sierpinski Fractal Antenna for Multiband

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ABSTRACT

Wireless communications is a rapidly growing segment of the communications industry, with the potential to provide high-speed high-quality information exchange between portable devices located anywhere in the world. For wireless communication system, antenna is one of the most critical components. Antennas enable wireless communications between two or more stations by directing signals toward the stations. A good design of the antenna can thus improve overall system performance. The objective of this research paper is to propose a design for a fractal antenna that caters to the requirements of multi band applications by employing a circular patch. The proposed design incorporates the employment of the Sierpinski gasket geometry, which entails the utilization of triangular and circular geometric forms that possess dimensions as diminutive as 25 by 24 mm and 8 mm, respectively. The implementation of a fractal antenna affords the advantages of reduced size, broad frequency coverage, and the capability to operate across multiple frequency bands, rendering it highly suitable for applications such as WLAN and Wi Max. The antenna is fabricated using an FR4 substrate, which possesses a dielectric constant of 4.4, and it is fed through a 50 ohms microstrip line. The design is optimized to function effectively within a frequency range spanning from 1 to 10 GHz.

KEYWORDS: Fractal antenna, Sierpinski gasket, Circular patch, Microstrip feed line.

INTRODUCTION

Wireless communications is a rapidly growing segment of the communications industry, with the potential to provide high-speed high-quality information exchange between portable devices located anywhere in the world. For wireless communication system, antenna is one of the most critical components. Antennas enable wireless communications between two or more stations by directing signals toward the stations. A good design of the antenna can thus improve overall system performance.

There has been increasing need for innovative antennas on both mobile terminal and base stations in wireless communication including the increasingly popular wireless local area network (WLAN) system. The IEEE 802.11 WLAN standard allocates the license-free spectrum of 2.4 GHz (2.40-2.48 GHz), 5.2 GHz (5.15-5.35 GHz), 5.8 GHz (5.47-5.725), 5.8 GHz (5.725-5.825 GHz). The Wi MAX forum has published three license spectrum profiles, namely

the 2.3 (2.3-2.4 GHz), 2.5 GHz (2.495-2.69 GHz) and 3.7 GHz (3.6-3.8 GHz) varying country to country [1].

In modern wireless communication systems and increasing of other wireless applications, wider bandwidth, multi band and low profile antennas are in great demand for both commercial and military applications. This has initiated antenna research in various directions, one of them is using fractal shaped antenna elements. Traditionally, each antenna operates at a single or dual frequency bands, where different antenna is needed for different applications. This will cause a limited space and place problem. In order to overcome this problem, multi band antenna can be used where a single antenna can operate at many frequency bands. One technique to construct a multi-band antenna is by applying fractal shape into antenna geometry. The geometry of fractals is significant because the physical length of the fractal antennas can be enlarged while keeping the total area the same.

Some unique geometries are useful in developing new and innovative designs for antennas. These geometries are the

Sierpinski gasket, Sierpinski carpet, and Koch curves. In this project, a Sierpinski gasket is used, and the antenna was designed for wireless application. This design is based on a 50Ω CPW-fed structure operating in WLAN communications and also 2.4, 5.2, 5.8GHz bands and 3.4GHz WIMAX applications. Adjustable strips were used to enhance the bandwidth, and consequently, a wide-band operation was obtained in the higher frequency band [13].

The proposed multiband antenna design was based on a methodology that utilizes the self-transformation principle of fractal-like rectangular profiles to generate multiband operation. The proposed monopole-type antenna is built on a partial ground plane and fed through a microstrip feed line. In this paper, the triple-band and the quad-band structures have been realized [14]. A triangular patch with a microstrip feed line structure is invented on the Teflon substrate. This antenna is useful for portable communication systems. For operational frequencies of 2.25 GHz, 4.15 GHz, and 6.25 GHz, a VSWR bandwidth of nearly 2.4 and return loss bandwidth up to -15.85db has been obtained [15]. In the [16] paper, a multiband microstrip antenna based on a fractal configuration with a modified ground integrating optimized slots has been proposed and optimized for GPS and Wi-MAX applications—the antenna design based on the Sierpinski configuration with substrate FR4.

As compared to classical antenna fractal antenna provides better input impedance matching, wideband and multiband, minituration. Self-similarity in the geometry creates effective antennas of different scales. This can lead to multiband characteristic antennas, which is displayed when an antenna operates with a similar performance at various frequencies. As compared to square monopole antenna circular monopole antenna provides wide bandwidth.

FRactal ANTENNA

In modern wireless communication systems and increasing of other wireless applications, wider bandwidth, multiband and low profile antennas are in great demand for both commercial and military applications. This has initiated antenna research in various directions, one of them is using fractal shaped antenna elements. Traditionally, each antenna operates at a single or dual frequency bands, where different antenna is needed for different applications.

The term “Fractal” means linguistically “broken” or “fractured” from the Latin “fractus.” Benoit Mandelbrot, a French mathematician, introduced the term about 20 years ago in his book “The fractal geometry of Nature”. Fractal geometry has unique geometrical features occurring in nature. It is defined as “A fractal is a shape made of parts similar to the whole in some way”.

Most fractals have infinite complexity and detail that can be used to reduce antenna size and develop low profile antennas. For most fractals, self-similarity concept can achieve multiple frequency bands because of different parts of the antenna are similar to each other at different scales. The combination of infinite complexity and detail and self-similarity makes it possible to design antennas with very wideband performances.

Fractal came into two major variations

1. Deterministic Fractal
2. Random Fractal

The first category consists of those fractals that are composed of several scales down and rotate copies of it, such as Koch curves. The second category (Random fractals) includes those fractals which have and attach to the original triangle. This process can be done in numbers of times, n being the order of fractal iteration. There is much fractals geometry that has been found to be useful in developing new and innovative design for antennas.

In this proposed antenna Sierpinski gasket geometry is implemented. Sierpinski gasket geometry is the most widely studied fractal geometry for antenna applications. Sierpinski gaskets have been investigated extensively for monopole and dipole antenna configurations [27]. The self-similar current distribution on these antennas is expected to cause its multi-band characteristics. It has been found that by perturbing the geometry the multi-band nature of these antennas can be controlled [28]. Variations of the flare angle of these geometries have also been explored to change the band characteristics of the antenna. Antennas using this geometry have their performance closely linked to conventional bow-tie antennas. However some minor differences can be noticed in their performance characteristics. It has been found that the multi-band nature of the antenna can be transformed into wideband characteristics by using a very high dielectric constant substrate and suitable absorbing materials. Explanation of its generation is in two ways:

1. The multiple copy approach.
2. Decomposition approach.

For the first generation, start with a small triangle. Two more copies of these triangles (same size) are generated and attach to the original triangle. This process can be done in numbers of times, n being the order of fractal iteration. In the decomposition approach, first start with a large triangle. The midpoints of the sides are joined together and a hollow space in the middle is created. This process divides the original triangle to the three scales down version of a large triangle.

The same division process can be done on each of the copies. After n such division, the geometry shown in Fig. is obtained.



Fig. 1. Multiple Copy Approach



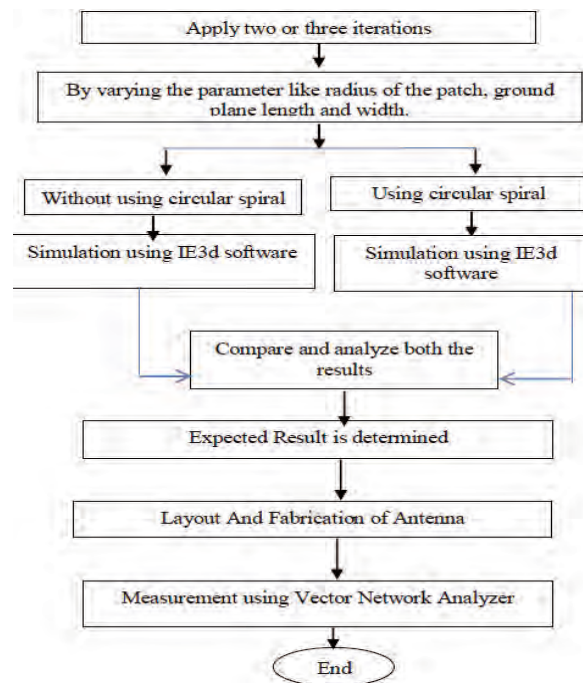
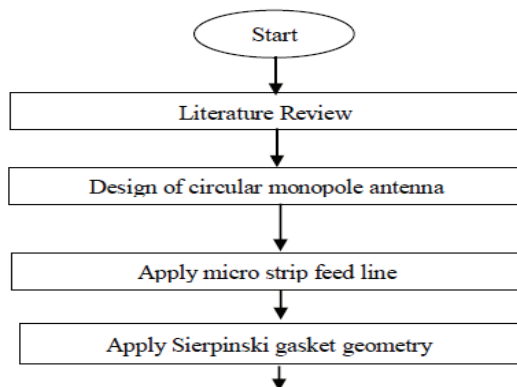
Fig. 2. Decomposition Approach

METHODOLOGY

The methodology used to carry out the proposed antenna performance will be utilized by using IE3D software.

The design of the circular monopole antenna using Sierpinski gasket starts with an equilateral triangle. In this design micro strip feed line technique is used because of their simplicity and ease of fabrication. After that apply two or three iterations to the circular monopole antenna. Then vary the antenna parameters of the design like radius of the patch, length and width of ground plane. By taking several variation circular spiral is applied to the antenna to improve the performance of the antenna. Two antennas are designed one is modified CM antenna and another is modified CM antenna with circular spiral.

Then these two designs are simulated using IE3D software and compare these results. The antennas are tested and measured by using VNA analyzer. Figure No.3 shows flowchart of proposed antenna design.



ANTENNA DESIGN

The generation of Sierpinski Gasket starts with a large triangle. After that the midpoints of the sides are joined together, and a hollow space in the middle is created. This process divides the original triangle to three scaled down (half sized) versions of the larger triangle. The same division process can be done on each of the copies. This process is called "Decomposition".

$$Radius(r) = \frac{F}{\left\{1 + \frac{2h}{\pi \epsilon_r F} \left[\ln \left(\frac{\pi F}{2h} \right) + 1.7726 \right] \right\}^{1/2}} \quad (1)$$

$$Effective\ Radius\ (r_e) = r \left\{ 1 + \frac{2h}{\pi \epsilon_r r} \left[\ln \left(\frac{\pi r}{2h} \right) + 1.7726 \right] \right\}^{1/2} \quad (2)$$

The design starts with circular patch with R= 12mm, h= 1.6mm, $\epsilon_r = 4.4$ and loss tangent= 0.019 with ground plane Lg x Wg= 24 mm x 15 mm. In this design two iteration are applied to the antenna. The design dimension are shown in the table below.

Table 1 Design dimension of radius R= 12mm

No. of Iterations	Side length of triangle 'a' in mm	Height of the triangle 'h' in mm
First iteration	20.8	18
Second iteration	10.4	9
Third iteration	5.2	4.5
Fourth iteration	2.6	2.25

The monopole antennas are convenient to match to 50 ohms, and are unbalanced. This eliminates the need for a balun, which may have a limited bandwidth (BW). But the bandwidth of the CM is larger than all the monopole antennas. So due to that reason circular monopole antenna is used in this design.

Radius of the patch is calculated using equation (3) considering LF as 3.1 GHz.[19]

$$LF = 7.2 / [(2.25 * R) + g] \quad (3)$$

Where L.F = Lower resonant frequency in GHz, R = Radius of a circular patch in centimeters, g = gap in centimeters between patch and ground plane.

If there are n such copies of the original geometry scaled down by a fraction f, the similarity dimension D is defined as:[7]

$$D = \log n / \log[(1/f)] \quad (4)$$

There are some steps to construct Sierpinski gasket geometry.

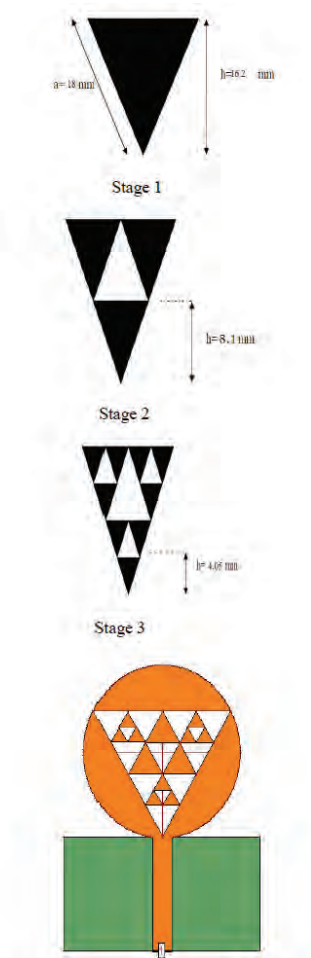


Fig. 5. Modified CM antenna

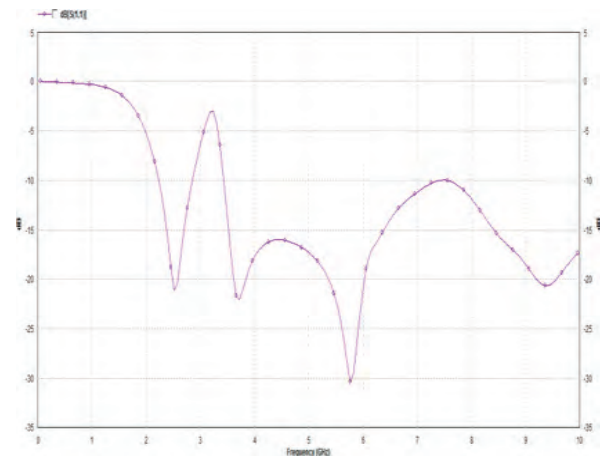


Fig. 6: S11 Parameter Modified CM antenna using circular spiral

For the modified geometry, new resonance frequencies appear at 2.4GHz with return loss -18.91 dB, 3.6 GHz with return loss -21.68dB, and 5.7 GHz with return loss -30.04dB. From these results it can conclude that all these frequency bands are below -10dB. As compared to previous design at R=10.32mm this design gives better output. This design can be used for band 3.7 GHz Mobile Wi-MAX IEEE 802.16 2005.

By taking several variations here circular spiral is used. In this research with circular spiral and without circular spiral is designed for comparison.

By implementing circular spiral design is as shown below. R= 12mm, h= 1.6mm, $\epsilon_r = 4.4$ and loss tangent= 0.019 with ground plane Lg x Wg = 30mm x 16 mm. The micro strip feed line is used. Radius of circular spiral is 2mm and the strip width= 1mm. The design structure and simulation result is as shown below.



Fig. 7: Modified CM antenna using circular spiral

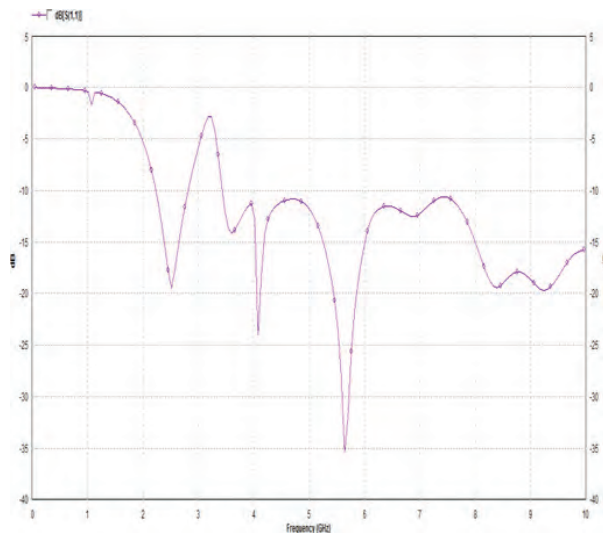


Fig. 8: S11 Parameter Modified CM antenna using circular spiral

From this result frequency resonate at 2.4 GHz with return loss -17.79dB, 3.6GHz with return loss -13.85 dB, 4GHz to 4.2 GHz with return loss -13.09 dB, 5.4GHz to 5.7GHz with return loss -25dB. The narrow band is 4GHz to 4.2 GHz and 5.4 GHz to 5.7 GHz. The return loss of the band from 5.4 to 5.7 GHz is quite good. This band can be used for Wi-Fi IEEE 802.11. By using circular spiral it gives better result than previous design.

The simulated radiation pattern for above two designs are as shown in figure. E-plane is where the plane cut theta at 90° and varying the parameter of phi. Meanwhile, the H-plane is when the plane cut at $\phi = 0^\circ$. These two antennas exhibits omnidirectional pattern for H-plane at 3.6 GHz.

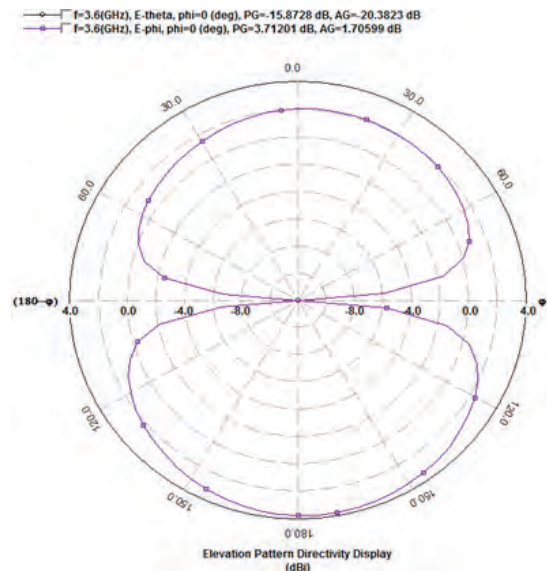
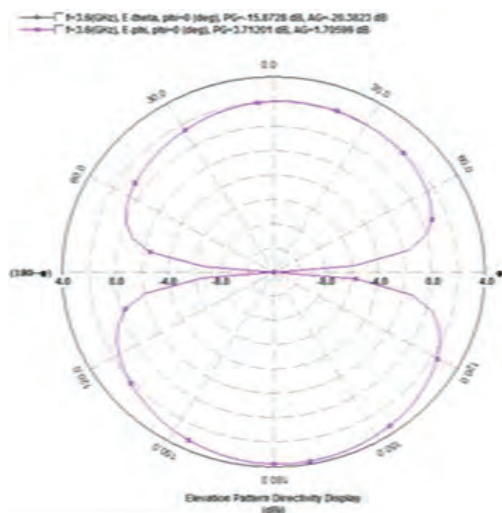


Fig. 9: Radiation pattern for modified design of CM with circular spiral at 3.6GHz

ANTENNA PROTOTYPE AND ITS MEASURED RESULTS

The proposed antennas have been fabricated and the results is been measured. Figure below shows the figure of the fabricated prototype of antennas.

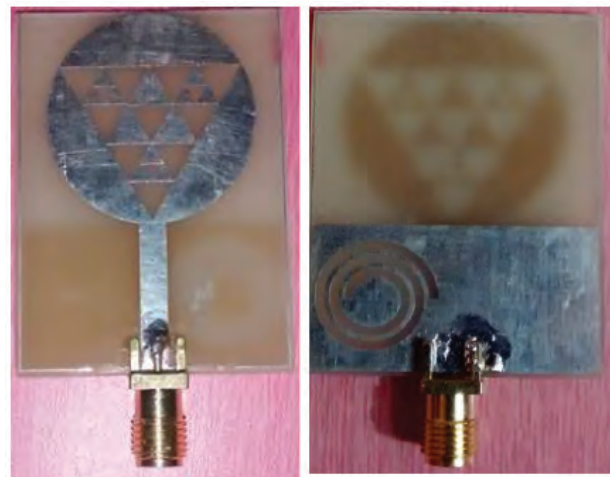


Fig. 10: Front and Back view Proposed Antenna

The measured results of this proposed antenna are as shown in fig. 11. The proposed antennas are measured and analyzed by using VNA (Vector Network Analyzer).

with return loss -9.66dB. From this result it clearly see that the frequency band at 2.43GHz and 5.63GHz gives return loss below -10dB. But as compared to simulated results only two

bands are below -10dB. As compared to measured results of modified CM antenna the frequency shifts to the lower side.

CONCLUSION

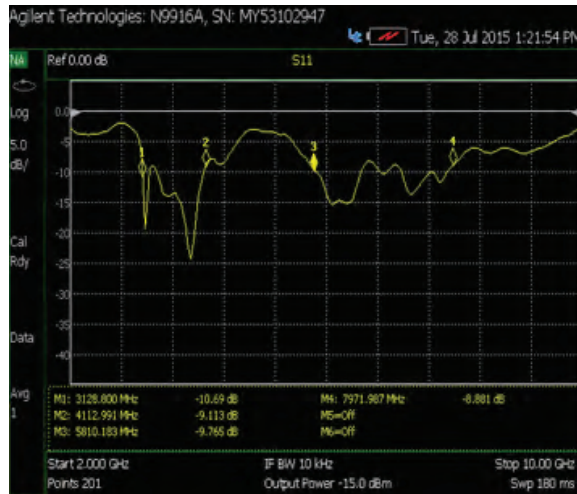


Fig. 11: Measured result of Modified CM antenna

The measured result of modified CM appears the frequency at 3.12GHz with return loss -10.69dB, 4.12GHz with return loss -9.11dB, 5.81 GHz with return loss -9.76dB, -7.97 GHz with return loss -8.81dB. only the band 3.12GHz is below -10dB.

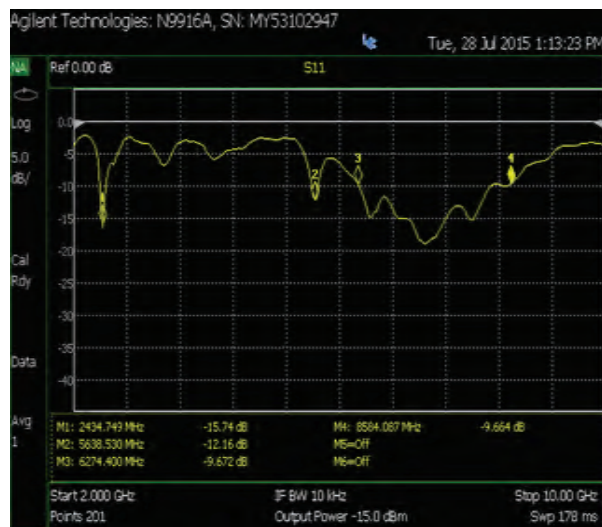


Fig. 12: Measured result of Modified CM antenna with Circular Spiral

The figure 12 shows the measured result of Modified CM antenna with circular spiral. The frequency appear at

2.43GHz with return loss -15.74dB, 5.63GHz with return loss -12.96dB, 6.27GHz with return loss -9.67dB, 8.58GHz

This proposed design for a fractal antenna that addresses the challenges posed by the contemporary era of 5G and the increasing demand for versatile mobile device applications. The primary objective of this research was to create a Circular monopole antenna which is capable of operating effectively across a wide range of frequencies, particularly within the 1 to 10 GHz range using Sierpinski gasket geometry. By increasing the values of the parameters like radius of the patch, ground plane length and width the resonance frequency shifts to the lower side. Also by using circular spiral the frequency shifts to the lower side. The modified CM antenna with circular spiral can be used for the band from 5.4GHz to 5.7GHz. Wi-Fi (IEEE 802.11) and the band 3.7GHz of modified CM antenna can be used for Mobile WiMAX IEEE 802.16 2005.

It offers a compact and multifunctional solution to address the limitations of spatial and locational resources in the 5G era, making it a promising contribution to the field of antenna technology. Further experimentation and testing are needed to confirm the design's practicality and performance in real-world scenarios, but the presented concept shows promise for future advancements in wireless communication technology.

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A Systematic Performance Analysis of Machine Learning based Solar Power Forecasting

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ABSTRACT

In recent year, there have been more PV panel installations due to the solar PV panels expanding effectiveness as a source of renewable energy. As various renewable sources like, Bio-fuel, Geothermal, Biomass, wind and solar etc. but wind and solar are highly intermittent, as well it is challenging to insist system stability while using an excessive amount of renewable energy. A photovoltaic (PV) system may produce solar energy as an alternative energy source. The PV system is dependent on the current climatic circumstances, including the humidity level, the PV system surface temperature, and the wind speed. Solar power is one of the most usable renewable energies in this world and utilization of this energy for particular application is also challengeable. Solar power forecasting could be used to increase system stability by offering system control specialists an estimation of future power generation and by supporting the allocation of hydro power plants with in best possible manner. Forecasting of solar power is essential for an electric grid balancing of supply and demand. Assuming that solar power generation is dependent on weather and unpredictable nature, this is very difficult and complex for the prediction. In this study, a hybrid model that combines statistical and machine learning techniques is proposed for forecasting future solar power generation. Time series models and machine learning can be used to forecast solar PV energy output, which is vital for many participants in the energy sector. In this study, an ensemble of machine learning algorithms is used to increase the suggested model accuracy. In this review paper it has been surveyed about solar power forecasting using machine learning and also entitled that which machine learning algorithm is best suitable for forecasting solar power.

KEYWORDS: Solar forecasting, Solar power, Time series, Machine learning algorithms.

INTRODUCTION

The renewable source of energy is defined as energy that is both sustainable and limitless, such as the sun. Renewable energy sources are commonly referred to as “alternative energy.” It refers to energy sources other than the most commonly utilized non-sustainable sources, such as coal. These renewable energy sources consist of solar energy, biomass energy, wind energy, hydroelectric power, and geothermal energy. Green energy and clean energy are frequently associated with renewable sources, although there are some significant differences in between three energy categories. The Renewable sources of energy approaches from recyclable sources, clean energy emits from sources that not generate pollutants i.e. carbon dioxide, & Green energy comes from natural sources. While there is significant overlap between different energy types, not all renewable energy is truly clean or environmentally sustainable. Some hydropower sources, for example, can affect natural habitats as well as lead to deforestation. Renewable power energy

is expanding, due to technological advancements that are lowering costs and providing on the goal of a clean energy future. Wind and solar power generation are setting records and it is being incorporated into the electric grid without affecting reliability.

Photovoltaic (PV) systems are used to generate solar energy around the world. Solar power sources are unpredictable in nature because their output power is alternating and largely dependent on environmental factors. Solar Irradiance, Relative humidity, PV surface temperature, wind direction & velocity are only some of these environmental parameters. Due to the unpredictability in photovoltaic (PV) electric power generation, it's essential for making plan for solar electricity formation as in prediction of solar power has important for the electric power grid.

The forecast of Solar power is also necessary for planning, estimating resources, dealing with generated electrical power, discovering the functionality power grid, decreasing the cost of formatted electrical energy, and also crucial for

managing congestion. Due to the previous power system problems, forecast the solar power becomes more decisive for the penetration of solar photovoltaic in the electric grid expands. Now days, the demand for renewable energy sources has exponentially due to their environmental benefits and potential to mitigate climate change. Solar power forecasting plays a vital role in the effective management of solar energy resources. Accurate forecasts enable grid operators, energy traders, and solar power plant operators to optimize their operations, improve grid stability, and plan ahead for electricity generation. Over the years, many forecasting methods have been developed, and among them, machine learning algorithms have proven to be highly effective due to their ability to handle complex nonlinear relationships within the data.

In this research mainly focuses on the application of different machine algorithm that is k- Nearest Neighbors (kNN) and Random Forest, and Ensemble stacking for prediction of solar power. The kNN algorithm is a non-parametric method that predicts a output variables based on the similarity of its neighboring data points. And other hands, Random Forest (RF) used ensemble learning concept that construct many decision trees and aggregates their predictions to generate accurate forecasts.

In this progress presentation we have implemented various machine learning algorithms as per given dataset downloaded from Kaggle website. This dataset taken historical power plant of past years like 2008 and 2009 dataset with providing near about 2920 samples and 11 features. In the given data set independent features and target features are provided with the entries like day of year, Is Daylight, first hour of period, Average Barometric Pressure (Period), Average temperature, distance to solar noon, Average wind direction, Average wind speed (Day), Visibility, Power generated, Relative Humidity, sky cover, Average wind speed (Period). From this dataset we have selected as target variable is power generated.

As per given dataset we have apply workflow of kNN, RF algorithm and Ensemble stacking algorithm for preprocessing the data, validating the models with metrics, and build the models. Our main objective is to compare the performance analysis of kNN, Random Forest models. For this purpose, it is required to confirm the types of data that are included in the dataset and to omit the columns that have the least bearing on the projection of solar energy production. The describe function is then invoked to display some key information about the data frame, like the mean, maximum, minimum, standard deviation, and others. Furthermore, we will investigate our data using descriptive and graphical statistics to characterize and summarize our variables once it has been cleaned. In this step, we'll figure out the distribution of each

feature individually, the correlation between the target feature and the other features in the dataset, and the normalization of the data. A table with the actual and anticipated values was used as the final comparison. The final comparisons provided better accuracy for Ensemble stacking model than the other model.

PROPOSED METHODOLOGY

There are several methods for solar power forecasting that forecasts future power generation for a long term and short-term using historical power generation data. In this research proposal ML approaches are being utilized to map power generation using future meteorological parameters as inputs in this study. Forecasted weather parameters are essential for this purpose to anticipate future power output.

Input Variable

Output Variable (Solar Power Forecast)

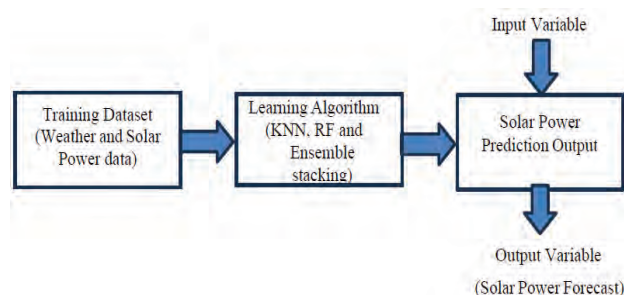


Fig. 1: Block Diagram of Proposed Methodology

These progress presentation we have implemented two types of machine learning methods for forecasting solar power such as:

1. KNN algorithm
2. Random Forest (RF) algorithm
3. Ensemble stacking.

k-NN Algorithm

This is a type of supervised learning being used for finding both regression as well as classification problem. k- Nearest Neighbor is similar like “Lazy Learner” algorithm for saves the dataset will training instead of learning from it rapidly. Instead, it uses the dataset to perform an action when classifying data. The k-NN method simply saves the information during the training phase, and when it receives new data, it categorizes it into a category that is quite similar to the new data. In this algorithm ‘k’ refers to the number of nearest neighbors and normally the value of ‘k’ for the forecasting model is kept as low value in given calculation. This can lead to the effect of outliers in the model. This

algorithm the most important to finding the Euclidean distance by using the below formula.

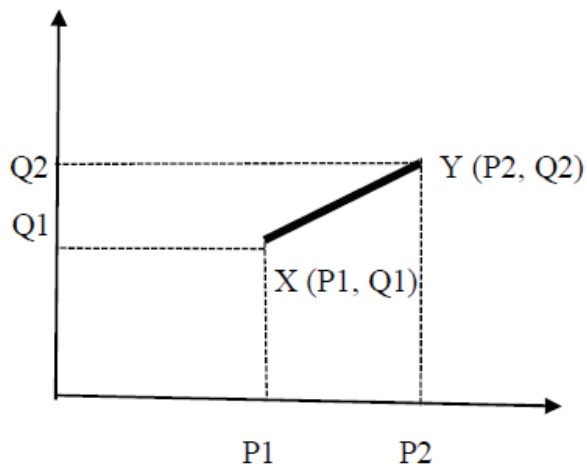


Fig 2: Calculation of Euclidean Distance

Euclidean Distance of two point = $\sqrt{(P2 - P1)^2 + (Q2 - Q1)^2}$

In this equation where P and Q represents the coordinators of the datapoints. And the concept of calculation Euclidean distance can easily understand with the help of above figure. After calculating the distance between two point and the new data point taken for regression/ classification. The KNN method uses the full training dataset as a reference throughout the training phase. When producing predictions, it uses a selected distance metric, such as Euclidean distance, to calculating the distance between every input data point and every training dataset example.

Random Forest (RF) Algorithm

An extremely similar supervised learning approach utilized for Regression and classification challenges in machine learning the name suggest that Random Forest method. In this the word forest is prepared by various types of trees, also have more trees, it will help to strong forest. This relation is common for the complex task solving and more accuracy of a Random Forest Algorithm enlarge with the number of network trees in this algorithm. To expansion of the dataset's required predictive accuracy, for this purpose a classifier required that is known as Random Forest that utilizes various decision trees on many subfields of the input data. And is correlation of ensemble learning, which is the exercise of combining different classifiers to determine a challenging problem and improve the performance of the models.

The Random Forest (RF) algorithm is used in this because it eliminates the problem of overfitting which is present in various machine learning algorithm. A versatile, easily operated machine learning approach called random forest

usually yields excellent results even without hyper- parameter adjustment. Due to its simplicity and versatility (it is utilized in both regression and classification challenges), it is also among the most often used algorithms.

We will now use Python programming for creating the Random Forest algorithm as based on tree. The common "user_data.csv" dataset used for reading data for classification models will be used for the same. We may compare the Random Forest classifier to various types of classification models like KNN, Decision tree classifier, Logistic Regression, SVM, etc. by utilizing the common dataset. For this we required step by step procedure for building the random forest model with the help of given dataset. When dataset is getting the first step, we have to done data preprocessing. Then next step fitting random forest algorithm for the training dataset. After that forecasting the test results. And as per the results creation of confusion matrix for testing accuracy of the result. Finally, visualization and performance analysis the test result has done.

Assuming that it can manage missing values, random forest is an excellent option for anyone who wishes to create the model quickly and effectively. It is one of the best strategies with excellent performance, and because of its effectiveness, it is extensively utilized in many industries. It can handle category, continuous, and binary data. Overall, random forest is a quick, straightforward, adaptable, and reliable model with certain drawbacks.

Ensemble stacking Algorithm

In the machine learning ensemble techniques called Stacking is an ensemble method in machine learning that combines predictions from learner models and meta-models to create a final model. It's also known as stacked generalization. In stacking, a set of training data is used to develop algorithms that use machine learning, and these models can then be utilized to build a new dataset. To build a final model with exact forecasts, the fundamental concept is to understand how to integrate forecasts from learning models and meta-models.

A subset of machine learning is ensemble learning. It is employed to integrate the results of several models in order to maximize a model's performance. Additionally, ensemble learning increases the model's accuracy. In machine learning, stacking is an ensemble approach applied to prediction models that yield effective results.

Figure 3 shows the structure of ensemble stacking in this we can integrate various machine learning model for prediction of solar power output.

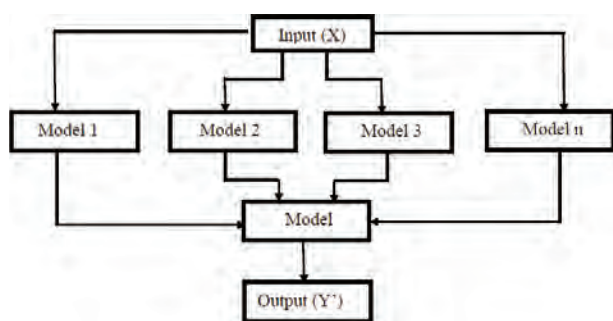


Fig. 3: Structure of Ensemble model

Flowchart of Proposed system

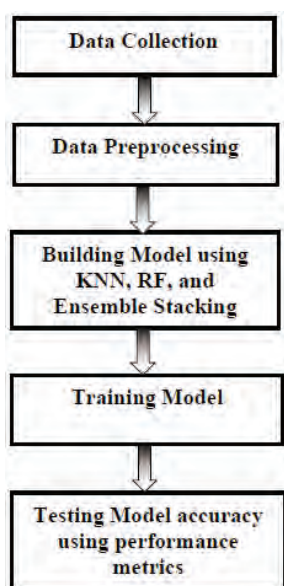


Fig. 4 : Flowchart of the methodology adopted

Dataset

In this progress presentation we have implemented some machine learning algorithms that is k-NN, Random Forest and Ensemble stacking algorithm with the help of downloaded dataset from Kaggle website. This is a historical dataset of two years like 2008 and 2009 by providing us near about 2920 number of instance (rows) and 11 features. In the given data set independent features and target features are provided with the entries like day of year, Is Daylight, first hour of period, Average Barometric Pressure (Period), Average temperature, distance to solar noon, Average wind direction, Average wind speed (Day), Visibility, Power generated, Relative Humidity, sky cover, Average wind speed (Period). By using this variable Our target variable will be the power-generated and others variables are the independent features.

Performance parameter and Results

Performance parameters

The following performance parameters are considered for solar power generation

- i) Explained Variance Score (EVS)
- ii) Max Error (Max Error)
- iii) Mean Squared Error (MSE)
- iv) r^2 _score (R2)
- v) Mean Squared Log Error (root - RMSLE)

Results

The study's primary findings are presented and discussed in this section. Depending on the performance analysis and accuracy we get the result RF model, k-NN and Ensemble stacking model for solar power forecasting using the dataset. Basically, our both the model is well trained the dataset and splitting the data in terms of 70% training and 30% testing to get the desired result. Finally, as from given dataset we found that the maximum R^2 score by using hyperparameters tuning in the given below table 1.

Table 1: Result of k-NN, RF and Ensemble stacking Algorithm

Model	Performance Metrics					Accuracy	Interpretation
	EVS	ME	MSE	R^2	RMSLE		
KNN	0.9058	0.7770	0.0075	0.9055	0.0636	90.55%	The accuracy and performance metrics indicate Ensemble stacking algorithm is more effective for solar power prediction.
RF	0.9201	0.5869	0.0063	0.9201	0.0591	92.01%	
Ensemble Stacking	0.9233	0.6041	0.0060	0.9233	0.0654	92.33%	

```

In [7]: subdata = df.groupby('Year').sum()['Power Generated']
subdata.plot(kind='pie', legend = True, subplots=True)

Out[7]: array([<AxesSubplot:ylabel='Power Generated'>], dtype=object)
  
```

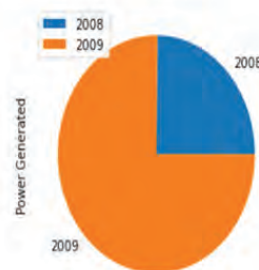
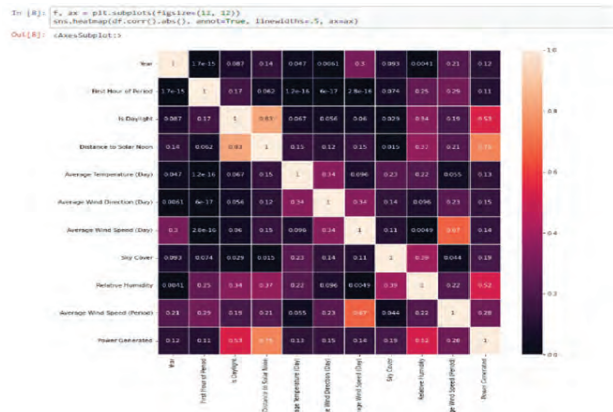


Image 1: Pie Chart for Power Generated and Year



Images 2: Heat Map



Image 3: Histogram graph of independent and dependent variable.

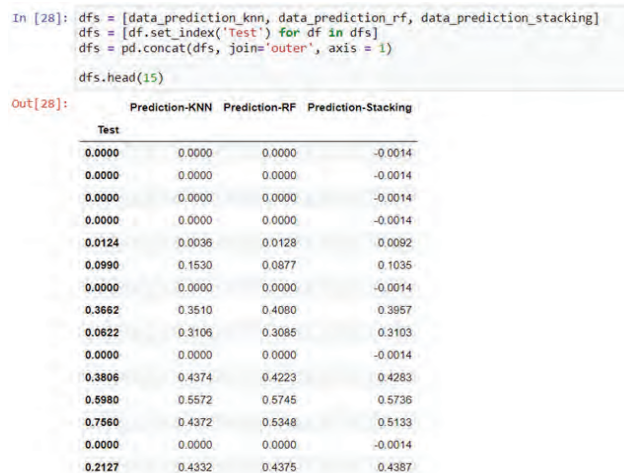


Image 4: Prediction of KNN, RF and Ensemble learning model.

CONCLUSION

There are several machine learning methods are used for solar power forecasting. In this we used some important machine learning algorithms such as k-Nearest Means (KNN), Random Forest and ensemble learning. The main goal was to create accurate models that could predict solar power output based on meteorological variables. In this we conducted a comprehensive analysis and evaluation of given ML algorithms. The results indicated that kNN, Random Forest and ensemble learning exhibited promising performance in solar power forecasting.

The kNN algorithm demonstrated simplicity and effectiveness in capturing patterns in the given dataset. By determining distance between data points and classifying new instances based on the majority of their k nearest neighbors, this algorithm provided reasonably accurate prediction. However, it is worth nothing that kNN may suffer from higher computational complexity and sensitivity to noise in the dataset. On other side, Random Forest proved to be a powerful ensemble learning techniques for solar power forecasting. By creating multiple decision trees and aggregating their predictions, the Random Forest Algorithm has better accuracy than kNN algorithm.

In this specific outcome of the models were encouraging, there are still areas for improvement and future research. Basically, both models are used for solar power forecasting and finally we concluded that the ensemble model is best performance and better accuracy as compare with the other model.

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Design & Development of a Smart Safety System to Improve Risk Mitigation in Mining Operations

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ABSTRACT

Mining is an industry where safety needs to be top priority for the all the time. Safety in mining refers to all measures taken to ensure the health and safety of a mining team for their efficient, safe and responsible work. Mining Safety is designed to prevent injuries in the mining industry and promote a safe workplace for miners. There is a need of real-time monitoring of all the critical problems faced by miners. We are presenting solution through which Mine Supervisor will be able to track and monitor parameters like presence of hazardous gases, temperature of surrounding area, ground vibrations, miners' health & position, etc. with the help of sensors and RF technology. Chemical hazards due to harmful gases will be detected using Gas Detection Sensors. Ground & Body Vibrations will be detected by vibrations sensors while, miners' health will be monitor by body temperature and pulse sensors. We will be able to trace miners' positions with the help of location tracking devices. With the help of controller, sensors will send data to RF module and it will be monitored continuously at Supervisor's system. If any problem is detected by system, alarm will be raised automatically to alert control unit to take preventive actions. Thus, problem of unavailability of network can be overcome by the RF based wireless communication system. The presented approach will provide smart, effective and efficient Mining Safety System.

KEYWORDS: Mining safety, RF technology, Wireless sensor networks, Wireless communication.

INTRODUCTION

The mining industry is known worldwide for its highly risky and hazardous working environment. Studies in the area of mining safety have shown that the majority of incidents occur due to human error, the prevention of which would greatly enhance the safety of working conditions [1]. Mining workers are affected by many hazards like ventilation problems, mine flooding, gas explosions, ceiling collapsing, mine haulage, sudden inrushes and mine inundation, spontaneous combustion, to un-optimized evacuation routes [2]. The mine operators have been working for decades to ensure no fatal accident results in death, injury, or poor health of miners [3]. Our objective is to improve the overall safety of the mine & workers by designing a smart system that has sensors embedded in it that will detect hazardous conditions

inside the mine and to analyze the physical conditions of the workers to trigger an alarm in case of emergency [4]. Using RF based wireless communication, system will send sensors data to control unit and raised an alert if problem is detected. Such private networks allow real-time monitoring through connected sensors, which produce troves of data about mine conditions, equipment status and worker location, enabling operators to understand present conditions inside the mine [5]. Hence, this safety system will efficiently solve the problems faced by mines.

METHODOLOGY

The methodology presented in this paper involves a technical solution through which Mining Supervisors will be able to track and monitor parameters like the presence of hazardous

gases, temperature and humidity of the surrounding area, ground vibrations, miners' health, etc. The proposed system comprises RF communication Module NRF24L01 along with sensors like MQ2, MQ135, SW420, DHT11, DS18B20 and MAX30100. A MQ2 sensor, which detects gases like CO, methane and smoke along with a MQ135 sensor, which is used for measuring air quality are installed in the system to detect harmful gases. A DHT 11 sensor senses the temperature and humidity around the mining area. A SW420 sensor detects the unusual movements or vibrations of the mining area which may lead to fatal injuries. A DS18B20 is a programmable temperature sensor measures temperature of mining area as well as miner. A MAX30100 sensor measures the pulse, oxygen level and heart rate of miner. All these sensors are interconnected with each other and forms a sensor network which is controlled by ATmega328P controller (installed in Arduino Uno). The sensors will send data microcontroller which will further communicate with a RF communication medium i.e. NRF24L01+PA/LNA Trans receiver Module. It is a wireless transceiver module that can send and receive data at a radio frequency of 2.4 to 2.5 GHz in the ISM band [6]. The sensors data will be stored at supervisor's system in specific intervals for each miner. If any data crosses threshold value, system will blow buzzer at supervisor's desk as well as at miner system. Miner will be able to press alarm of his/her system if he/she gets caught in trouble [7]. In both the cases, supervisor will respond to the situation to mitigate the problem as soon as possible. The proposed system keeps connected to miner and supervisor with each other through dedicated radio frequencies. Thus, it will be helpful for mining authorities to track and monitor mining conditions in real time.

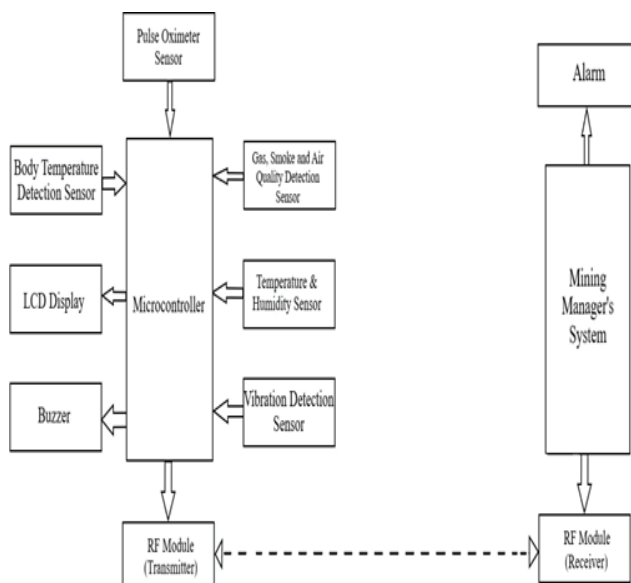


Fig 1: Block Diagram

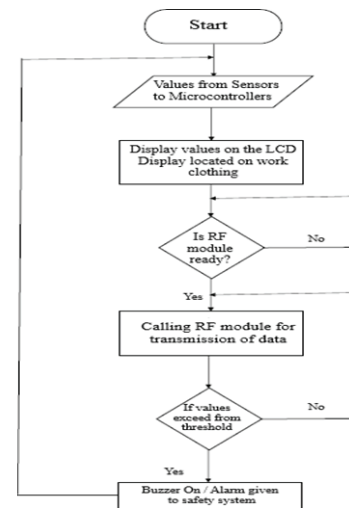


Fig. 2: Flow Chart

EXPERIMENTAL SETUP

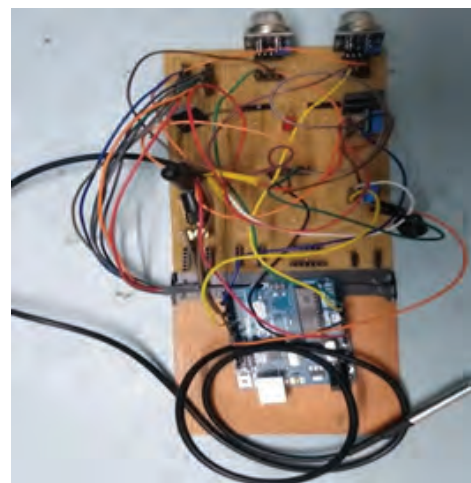


Fig. 3: Transmitter Circuit (Placed in Miners' Clothing)

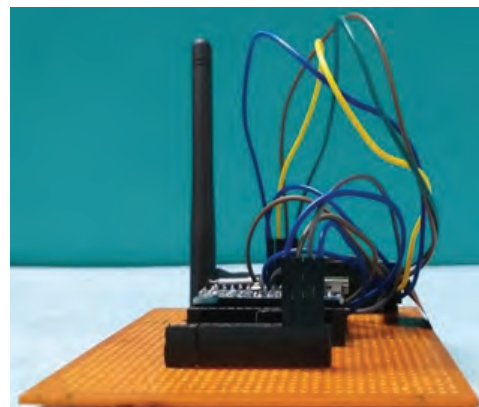


Fig. 4: Receiver Circuit (Placed at Manager's Desk)

The transmitter circuit should be placed in Miners' Clothing (as shown in Fig.3). Sensors will collect, measure and transmit data to the microcontroller. With help of NRF24L01, the data will be transmitted through wireless medium to the receiver Circuit. Receiver Circuit (as shown in Fig.4) is placed at supervisor's desk. It will receive the transmitted data and raise an alarm if any problem is detected by transmitter circuit or by miner itself. The supervisor will report to the control room to take preventive actions.

RESULT AND DISCUSSION

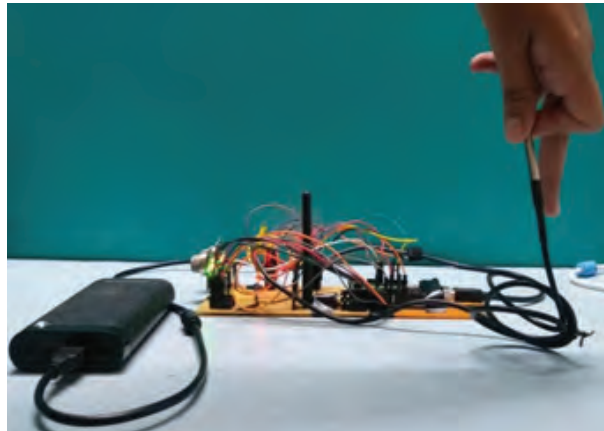


Fig. 5: System's Result when the problem is detected

As shown in Fig.5, If the value of any of the sensors exceed the threshold level, then the microcontroller will detect it as the problem and send the corresponding message to the supervisor's desk to raise an alarm to take preventive action.

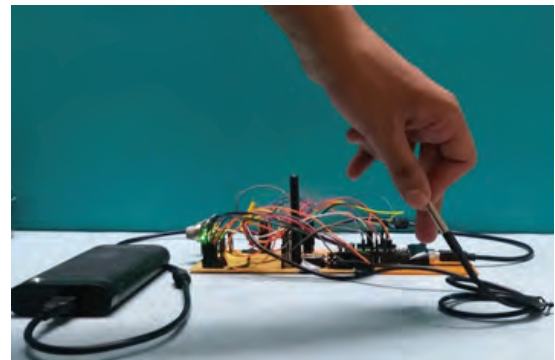


Fig. 6: System's Result when the problem is not detected

As shown in Fig.6, If the value of any of the sensors does not exceed the threshold level, then the microcontroller will detect it as the normal condition and send the corresponding message to the supervisor's desk to ensure that everything is in good condition.

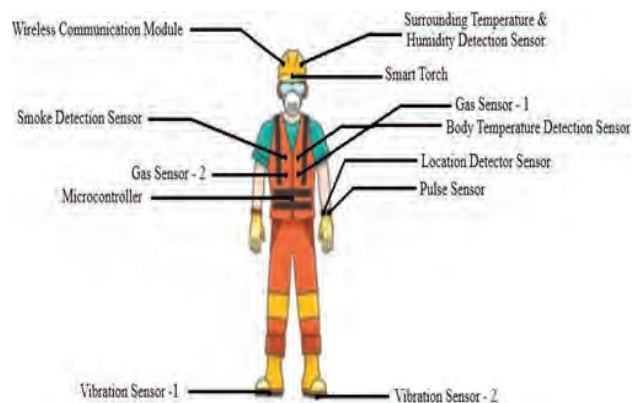


Fig. 7: Expected Product Design

Our expected product design will be Miner's Work Clothing including transmitter circuit and sensor network. (As shown in Fig.7). It is designed in a way to keep miner protected from mining environment as well as to place the transmitter circuit effectively for the smooth operation. This clothing will help to add more efficiency to the current mining safety system.

CONCLUSION

The proposed solution will help to add more efficiency to existing Mining Safety System. System will be able to track the data like presence of hazardous gases, temperature and humidity of surrounding area along with health monitoring of workers. It will assist mine supervisor to take instant actions for prevention of accidents. Due to use of RF technology, this system can work in all types of mines where majority of problem is of unavailability dedicated system for transmission of data.

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System for Detecting Diseases in Pomegranate using Deep Learning and IoT

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ABSTRACT

This article gives literature review of efficient and effective system for detecting diseases in pomegranate using deep learning. Pomegranate is a fruit which grows with a very high yield in many states of India and one of the most profits gaining fruit in the market. But due to various conditions, the plants are infected by various diseases which destroy the entire crop leaving very less product yield. So, the work proposes Deep learning model deal with the main issues of detection and classification of disease in pomegranate.

The classical method is very much time consuming and needs too much efforts. In this paper 4 different Deep Learning algorithm, a. Neural Network (NN) b. Convolution Neural Network (CNN) c. Supervise Vector Machine (SVM) and Deep CNN, are executed for the detection and classification of the Bacterial blight. Here, the accuracy of the training and validation data is carried out.

The results in this paper show the loss and accuracy of the training and validation data by all the 4 algorithms mentioned in this paper, with CNN showing highest accuracy.

KEYWORDS: *Bacterial blight, DNN, CNN, SVM and NN.*

INTRODUCTION

Pomegranate is a highly established fruit in Asian countries and earns high profits. It is one of the fruits that have elevated healing and beneficial value. This fruit is the most antiquated crop in India. Contemporary farmers are facing enormous problems in the premature stages of pomegranate production. Due to this, pomegranate plants get microorganisms, which cause fruit contamination, resulting in reduced yield. The major maladies caused by pomegranate fruit are Anthracnose, Bacterial blight, Aspergillus fruit rot, and Alternaria fruit rot. This infects the entire plant and diminishes the yield.[1]

Pomegranate is a fruit with the highest yield and the most significant geographic distribution in Asia. On the other hand, the plants are susceptible to a diverse range of illnesses due to several factors, which lead to the destruction of the plants and a significantly reduced harvest. To avoid reductions in agricultural output, diagnosing plant diseases as quickly as possible is necessary.[2]

Pomegranate fruits and leaves are plagued by various diseases exacerbated by plant life, microorganisms, and, as a result, climatic circumstances. Bacterial rot, fruit spot, fruit rot, and leaf spot are examples of these illnesses.[3]

In a nutshell, Bacteria and fungi are the most important bacterial diseases of pomegranates. Significant yield losses due to pomegranate bacterial blight have been reported in different areas in India where environmental conditions, like relative humidity, precipitation, and temperature, are favorable for disease development. Symptoms on fruits start with water-soaked lesions on the fruit surface that later turn to dark brown spots. Formation of cracks on necrotic fruit spots and splitting of fruits is prevalent. Also, Anthracnose in pomegranates appears on leaves as small circular leaf spots with yellow halos and on fruit as brown lesions that progress through the fruit, causing external and internal rot.

LITERATURE REVIEW

Survey of the work done in the research area:

In [1], the author reviews various techniques for detecting

plant disorders. The work of researchers considerably made progress in detecting and recognizing plant maladies, aiming at the issues that exist in pomegranates such as *Alternaria* fruit rot, *Aspergillus* fruit rot, Bacterial blight, and Anthracnose. This review concludes that machine learning algorithms provide the best outcome in detecting and identifying plant diseases.

Deep Learning (DL) is utilized to diagnose diseases affecting pomegranate trees [2]. An algorithm for automatically diagnosing diseases affecting pomegranate plants based on images of the plant's leaf structures is presented in this paper. Two different DL models, AlexNet and VGG-16, are used to classify diseases.

The two major diseases, bacterial blight, and *Alternaria*, are presented in the article using the AlexNet algorithm [3]. The dataset of pomegranate leaf images, with a total of 1245 images, which were unavailable for these diseases, was created. 80% of the dataset is used for the training part, and another 20% is used for the testing part. The model includes techniques including image pre-processing, image segmentation, and image classification.

In [4], the system makes use of the Internet of Things, which uses a Raspberry Pi to monitor and regulate several parameters such as temperature and humidity and uses AI techniques to classify diseases for early detection and prevention. The K-Nearest Neighbor KNN classifier is employed in the final phase of image detection. (KNN) is an exceedingly simple yet widely used classification method.

The authors [5] detected and classified these two diseases by extracting knowledge from custom-trained models using Deep Learning. To overcome the traditional methods, Faster-RCNN helps us to do better object detection. Faster R-CNN is a Convolutional Neural Network-based object recognition architecture that uses a Region Proposal Network (RPN). It is commonly used in Deep Learning and Computer Vision and is considered one of the most effective object detection architectures. They proposed a system for detecting pomegranate diseases like Anthracnose and bacterial blight via Tensor Flow for object detection on a Faster R-CNN.

Image processing is used to recognize ailments of pomegranate plants and classify them into individual classes using the machine learning approach [6]. The Ada-boost classifier is utilized for the classification of ailments in multi-class. Initially, feature optimization is performed using the PSO algorithm, and multi-class classification is executed. So, testing accuracy using the Ada-boost algorithm was achieved at 92.9%.

The model in [7] was trained using standard parameters like a number of filters, activation functions, and several epochs, and the Convolutional Neural Network algorithm was used

for improved performance. The evaluation used standard metrics such as accuracy, precision, recall, and F1 score. The authors collected a dedicated dataset of real pomegranate leaves containing four diseases and healthy leaves. They developed a deep learning model based on CNN architecture and trained it on this dataset to classify the images into their disease categories.

In [8], the system uses numerous parameters, including temperature and humidity, a GSM module for wireless digital communication, and the Hidden Markov Model and sensor network, which can offer alerts to the farmer and the professional.

The author in [9] examines the efficiency of the electronic nose (E-nose) system as a fast, non-destructive, and low-cost method in the diagnosis of the amount of *Alternaria* fungi in the Pomegranate. Linear Discriminant Analysis (LDA), Back Propagation Neural Network (BPNN), and Support Vector Machine (SVM) methods were applied and compared as linear and non-linear analysis methods for detection.

The methods in [10] used in the implementation of leaf disease detection for pomegranates using leaf images are the K-Means algorithm and multi-class SVM, and image processing techniques like image enhancement and segmentation.

In [11], CNN is applied for deep feature extraction, and LSTM is used to detect class using the extracted features of the pomegranate fruit.

In [12], the system provides insight into newly developed Internet of Things (IoT) applications in the agricultural sector, focusing on sensor data collection and early detection of diseases. It seeks to utilize the Internet of Things and Machine Learning technologies to detect fungal diseases. Crop field environmental conditions are monitored using the Internet of Things.

The system in [13] is IoT deployment, which aims to use an array of sensor networks in conjunction with Cloud enablement for real-time monitoring of environmental factors such as light intensity, temperature, soil moisture, etc. It is used to detect diseases in their plants by capturing an image and loading them into the module, which uses a CNN model to predict the plant's diseases, if any.

Despite advances in machine learning and deep learning applications in the agriculture domain, there remains a significant gap in the development of comprehensive models explicitly designed for the early detection of disease. This research will build deep learning algorithms trained on datasets to enhance the detection of diseases in pomegranates and also implement a real-time monitoring and controlling system.

Table 1: Model Accuracy Comparison

Methodology Used	Ref. No	Performance Metrics
NN	[7]	94%
SVM classifier	[10]	99.55%
CNN with full-color model	[11]	99.84%
Deep CNN with VGG model	[13]	99.53%
R-CNN with ResNet- 101 model	[5]	99.64%

Summary of literature survey

From the survey, we conclude that CNN methods were mostly used for plant fruit and leaf disease detection. The detection rate was boosted in Deep CNN techniques and with Object Detection models, the classification process was significantly fast. These implementations indicate that CNN requires an additional model to improve overall accuracy and increase the performance of the model.

DATASET

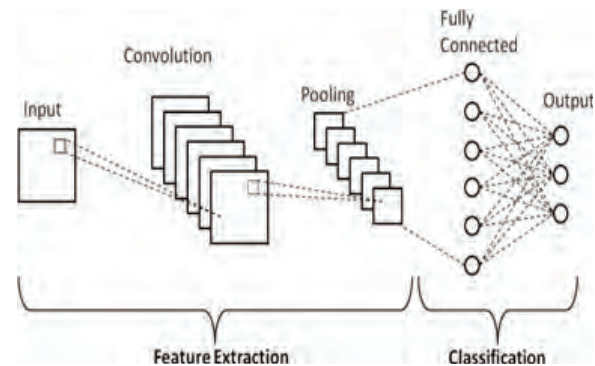
The UCI Machine Learning Repository, Bacterial Blight Database dataset is primarily used for research and experimentation in the field of plant data analysis and pattern recognition. It allows developing and evaluating machine learning/deep learning algorithms for the categorization of Bacterial blight using information in.csv file.

This dataset consists of 279 different attributes out of these 279 attributes, 206 of are linear valued and remaining are nominal.

PROPOSED RESEARCH METHODOLOGY

Various neural network models were studied which includes deep learning and non-deep learning algorithms that are mentioned in the literature survey. Out of all the models, 4 different models are used in this paper, which are deep learning models. The four deep learning models includes CNN, NN, SVM and Deep CNN. From the results obtained from various training and testing of the dataset using all four different methods, it was found that CNN gives the best results.

CNN is the neural network. In this, there is a network of neurons connected to each other, and there are various layers for the performance of the task. The input is given to the input layer and then every input is received to all the neuron in each layer, performs a dot product and follow non-linearity. The whole network takes an image as the input, and it determines certain properties (such as in this paper, it can be the duration of the RR part of the wave) into the architecture and outputs classes depending on the dataset. Figure1. shows the fundamental structure of CNN.

**Fig. 1: Basic CNN Architecture**

The CNN network is made up of many layers, which includes convolutional, pooling and fully connected layers.

Convolutional layers are the core building blocks of CNNs. They consist of filters called kernels that process over the input data to detect patterns and features.

The layer which is Pooling layer is to down sample the spatial proportions of the data, reducing computational complexity while preserving important features.

Fully connected layers are traditional neural network layers that process the flattened output of previous layers to make predictions.

Convolution layer

- Convolution operations convolution of the input data using the filter. Many filters can be used in such layers to get different features at different location of the process. Pooling layer
- Although significant information is lost, it is used to reduce the spatial proportions of the feature maps that are acquired from the convolution layer. Max Pooling is the most common method used.

Activation Function

- Function such as ReLU (Rectified Linear Unit) are used once the convolution and pooling layers is implemented which enables to learn complex patterns.

Layers Stacking

- It consists of multiple convolution and pooling layers, which are stacked on one another.

Dropout and Batch Normalization

- These techniques are generally used to improve CNN training and generalization.

Training

- Method used for the training in CNN is backpropagation and gradient descent. It helps to update network weights.

Transfer Learning.

- Transfer learning approach is helpful in the approach of transfer helps on smaller datasets.

Algorithm

In this algorithm CSV data file is loaded into the program. After loading of the .csv file, the pre-processing of the data is been carried out. For the pre-processing, the data is split into training and validation datasets. Eighty percentage of the data is utilized for validation, while twenty percentage of the data is used for training. After pre-processing, normalization / standardization is carried out. In this implemented CNN model, normalization is carried out along the column, i.e., sample-wise normalization.

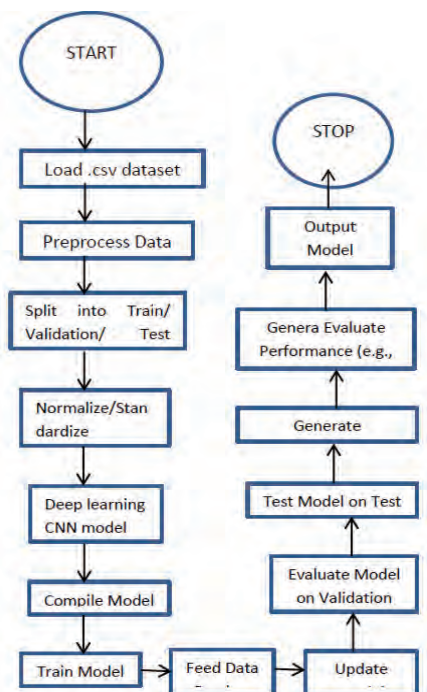


Fig. 2. Flowchart of CNN model implemented in this paper.

After the process of pre-processing and normalization of the dataset, CNN architecture is built. Here to work of the .csv file, 1D convolutional neural network model is built. To build the CNN model input layer has input shape as conv_input_shape. 2 1D convolution layer and 2 MaxPooling 1D layer is been built in the CNN architecture. A flattened layer is added, which flattens the input. A dense class is added with 129 units and activation filter used is 'ReLU'. The same activation filter is used in the 1D convolution layer and the 1D MaxPooling layer. In another dense class activation filter SoftMax is been used. For the compilation of the model optimizer used is „adam“, loss is set as cross entropy and accuracy is also compiled. Train and validation of the data is been carried out

in this suggested model. Iteratively feeding the model with the training data allows the model's weights to be updated. Additionally, the model-based data validation is done.

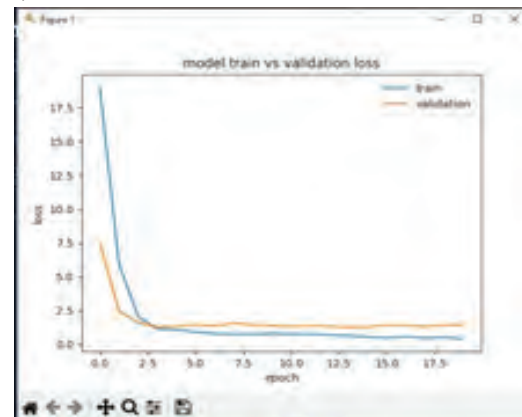
Finally, the results obtained is nothing but the plot of trained and validated loss and accuracy

RESULT

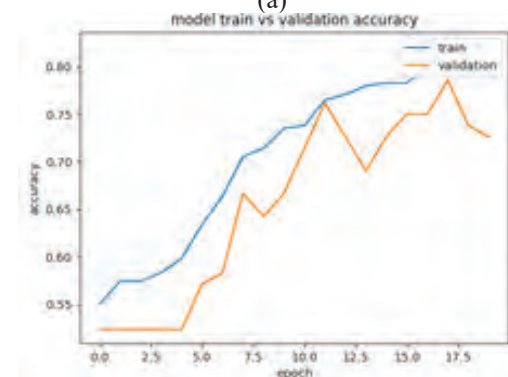
In this paper the testing and validation of the UCI Machine Learning Repository Bacterial blight Database is been carried out. According to [26] the CNN deep learning algorithm is used and an accuracy of 72.05% is achieved on the same dataset that is used in this paper.

CNN

The first algorithm used in this paper has achieved training loss = 0.6045, training accuracy = 0.8155, whereas validation loss = 0.8936 and validation accuracy = 0.7857. In this algorithm, the convolution kernel size used is 2. Here, the CNN algorithm makes use of softmax and ReLUs. Eighty percent of the dataset is utilized for class validation and twenty percent of the dataset is used for training. (16 different classes)



(a)

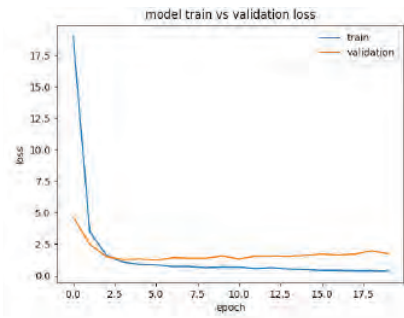


(b)

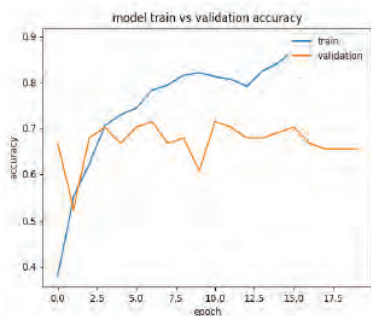
Fig. 3: CNN results for training and validation for (a) Epoches vs Loss (b) Epoches vs Accuracy

NN

The second algorithm used is the implementation of Neural Network where the results obtained are for the training loss = 0.6619 and training accuracy = 0.8125 where as validation loss = 1.3237 and validation accuracy: 0.7143. This result gives less validation accuracy as compared to the CNN algorithm.



(a)

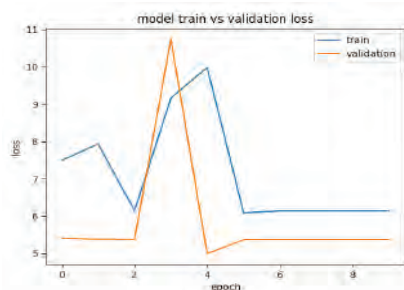


(b)

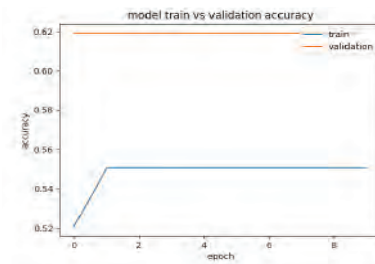
Fig. 4: DNN results for training and validation for (a) Epoches vs Loss (b) Epoches vs Accuracy

SVM

The GRU algorithm used for the testing and validation of the datasets had the results as testing loss = 6.1402 and accuracy = 0.5506 whereas validation loss = 5.3727 and validation accuracy = 0.6190.



(a)

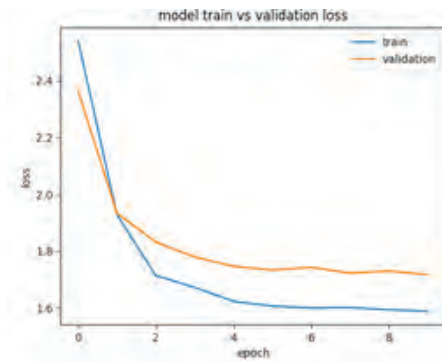


(b)

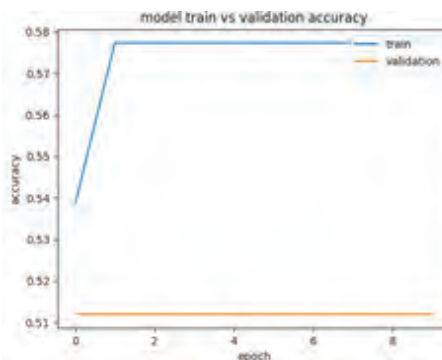
Fig. 5: NN results for training and validation for (a) Epoches vs Loss (b) Epoches vs Accuracy

Deep CNN

In the results obtained in this algorithm, the training loss obtained is = 1.6354 and training accuracy = 0.5565 where as validation loss = 1.5273 and validation accuracy = 0.5952.



(a)



(b)

Fig. 6: NN results for training and validation for (a) Epoches vs Loss (b) Epoches vs Accuracy

DISCUSSION

Among various papers evaluated and studied, the main research work is been carried out by using the Kaggle dataset. In the dataset that is currently used in this paper have some

missing parameters. Also, the study indicated that the sensors used vary between 1-12 leads, as the sensor has low cost, can be used for various research purposes, and can give different solutions to the problem related to the creation of the datasets. Kaggle is the most accessed dataset and various studies shows classification of diseases. With the results obtained in this particular paper, it is seen that the CNN model processing the used dataset gives the best results as compared to other models used in this paper.

CONCLUSION

Observing the various results after discussion and observing 4 different models in this paper we can say that CNN is the most efficient model for the testing and validation of the dataset with the training loss = 0.6045 training accuracy = 81.55% whereas validation loss = 0.8936 and validation accuracy = 78.57%. The result here can be improved as the accuracy is not up to the mark and there is always the scope of improvement. Preventing these diseases is always not possible, but by using better methods, we can always get some better solution, or at least we can get around the situation.

As future work, our own dataset can be created, and a hybrid model can be built so that we get better accuracy and fewer losses with very good classification results for the prevention of death of plant due to various diseases

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A Novel Approach to Write of Self Customized Text Using 2D CNC Plotter

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ABSTRACT

This paper introduces an innovative framework for the generation of self-customized text and imagery via a 2D CNC plotter, meticulously orchestrated through a Raspberry Pi. This system is a leap towards personalization in the domain of digital fabrication, enabling users to input data through various formats such as images, PDFs, and direct text entries. A notable feature of this research is the utilization of Inkscape for processing input data into G-code, which commands the plotter in delineating the desired outputs on a 2D plane. The amalgamation of hardware and software, inclusive of a self-developed Android application, offers a streamlined, user-friendly interface for customization. This integration not only fosters font personalization and single-stroke text printing but also introduces a novel method for text and image creation. The methodology employed encapsulates a comprehensive approach, from the design and development of the plotter to the execution of G-code through Universal G-code Sender, highlighting the system's potential in educational, healthcare, finance, legal, and retail sectors. The results demonstrate the system's capability in producing tangible, personalized outputs, underscoring its versatility and efficiency. Through this work, we underscore the plotter's potential for learning and adaptation, paving the way for advancements in personalized printing and cutting tools for commercial applications. Furthermore, the system is enhanced with a self-developed Android application that facilitates user input through a user-friendly interface. The potential applications of this technology span educational, healthcare, financial, legal, and retail sectors, promising enhancements in information processing, personalization, and efficiency.

KEYWORDS: 2D CNC plotter, G-code, Inkscape, Raspberry Pi, Smart handwriting.

INTRODUCTION

Traditional handwriting recognition systems often have limitations in accurately recognizing and interpreting handwriting due to differences in typefaces, languages, and the presence of noise and distortions in the text (1).

One way to use AI and machine learning to address these challenges is to use deep learning algorithms to train handwriting recognition models on large datasets of handwritten text. By analyzing handwriting patterns and features, these models can learn to recognize and classify different handwriting styles with high accuracy. The following features and abilities can be added to a smart handwriting machine to enhance its performance and usability (1, 2).

- Support for multiple languages: To expand its user base, the machine should be able to read and translate handwriting in a variety of languages.
- Accurate recognition: The machine should be very accurate at reading handwriting, including various handwriting variations and styles.
- User-friendly interface: The device ought to have a simple, intuitive user interface that is simple to use and comprehend, even for those who are not particularly tech-savvy.
- Real-time feedback: To help users write better, the machine should give them immediate feedback on how accurately they entered their handwriting (3-4).
- Intelligent correction: The system should be able to identify mistakes in handwriting recognition and suggest ways to improve the writer's handwriting.
- Integration with other applications: To enable efficient and seamless workflows, the machine should be able

to integrate with other programs like word processing, email, and note-taking.

- Continuous learning: To increase accuracy and recognition, the machine should be able to pick up on user input and modify to their handwriting style over time. There are a number of potential uses and advantages for a smart handwriting machine in various industries, such as
- Education: The device can be utilized in classrooms to digitize handwritten notes and give students immediate feedback. Additionally, it can be used to grade tests and assignments automatically, saving teachers' time.
- Healthcare: By digitizing patient records and prescriptions, the device will make it simpler for healthcare professionals to access and share information. Additionally, it can be used to keep an eye on patients' handwriting in order to spot neurological or motor disorders early on.
- Finance: The device can digitize financial documents like checks, invoices, and receipts to make the processing and storing of data easier. In order to avoid fraud, it can also be used to validate signatures.
- Legal: The device can be used to digitize contracts and legal paperwork, making it simpler to look up specific clauses and terms. Additionally, it can be used to validate signatures and guarantee the legitimacy of documents.
- Retail: The device can be used to digitize customer signatures for transactions and returns, reducing paper waste and increasing efficiency. For customers, it can also be used to personalize handwritten notes and messages.

Overall, a smart handwriting machine can increase the effectiveness, accuracy, and accessibility of information in a variety of industries, resulting in cost savings, improved client experiences, and better outcomes (3,4). The project for printing self-customized text using a 2D CNC plotter provides users with a creative and personalized means of expressing themselves. Enabling customization through inputs such as Microsoft Font Maker, Word/PDF, or images, the system, controlled by a Raspberry Pi, processes user preferences and generates G-code using Inkscape. The Universal G-code Sender communicates with the 2D CNC plotter, orchestrating precise movements of the pen to bring the user's text to life on a 2D plane. Whether users choose to design their own fonts or utilize existing images, this project seamlessly combines hardware and software, offering a user-friendly and versatile platform for unique text designs (5-7).

METHODOLOGY

A smart handwriting machine should, in general, have features and functionalities that make it simple to use, accurate, safe, and accessible, while also offering the tools needed for effective document processing and collaboration. The use of computer numerical control (CNC) to automate the process of cutting, drawing, and writing is one of the core tenets of CNC plotter technology. Typically, a CNC plotter is made up of a number of essential parts, such as a computer, software, controller, motors, a driving system, and a tool head (6-10). The design that will be plotted is created on a computer and then converted into a digital file format that the software can read. The controller is then given G-code, a language used to drive CNC machines, by the software. The drive system and tool head are moved to the proper spot by the motors after the controller analyses the G-code (11).

As shown in figure 1 shows the workflow of a system designed to convert digital text into handwritten text using a 2D-CNC plotter. Here's the working explained point wise:

- 1) Input Sources: The system accepts text input from two sources:
 - a) Images: Handwriting can be captured as images, which are then processed.
 - b) PDF/Word Documents: Text from PDF or Word documents is used as input for handwriting generation.
- 2) Font Generation:
 - a) The system uses a font generation tool, such as Microsoft Font Maker, to create a custom font that matches the user's handwriting or desired text style.
 - b) This font generation is based on the user's requirements and can be tailored to replicate specific handwriting styles.
- 3) Application/PC Interface:
 - a) The user interacts with the system through an application on a mobile device or software on a PC.
 - b) This interface is used to input the text, select the desired font style, and initiate the conversion process.
- 4) Bluetooth Module:
 - a) The system includes a Bluetooth module for wireless communication.

- b) This module is used to send the converted text and font data from the application/PC to the Raspberry Pi controller.

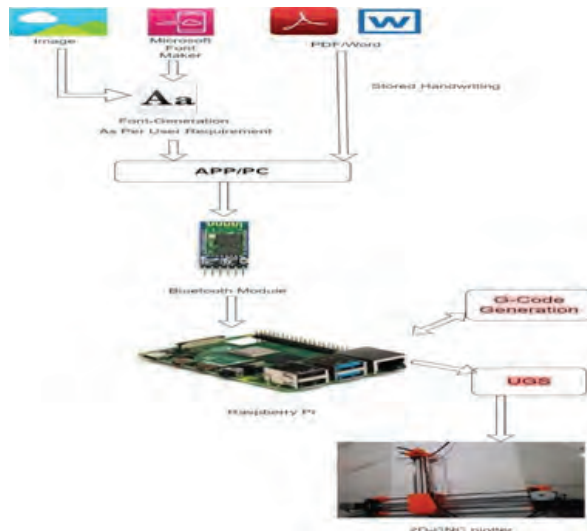


Fig. 1: Methodology of Machine

- 5) Raspberry Pi:
- The Raspberry Pi is the central processing unit of this system.
 - It receives the text and font data and is responsible for generating the G-code.
- 6) G-Code Generation:
- G-code is a language used to tell a machine how to move. In this case, it converts the text into commands that dictate the movements of the 2D-CNC plotter's pen.
 - The Raspberry Pi processes the text and font data to create this G-code.
- 7) Universal G-code Sender (UGS):
- UGS is a software that sends G-code to the machine (the 2D-CNC plotter).
 - The Raspberry Pi uses UGS to send the generated G-code to the plotter.
- 8) 2D-CNC Plotter:
- The final component is the 2D-CNC plotter itself, which physically moves a pen or other writing implement across a surface to 'write' the text.
 - It follows the G-code instructions to replicate the handwriting style on the chosen material.

- c) The tool head is typically moved along the X, Y, and Z axes using a drive system made of belts or threaded rods.

Numerous tools, such as a cutting blade, pen, or writing implement, can be mounted on the tool head. The tool acts as intended on the material being plotted while the motor mechanism moves the tool head. The overall process involves taking digital text, converting it into a specific font that replicates handwriting, generating G-code to represent the movements needed to recreate this font, and then sending these commands to a CNC plotter which physically produces the handwriting-like text (6-9).

Stepwise Execution

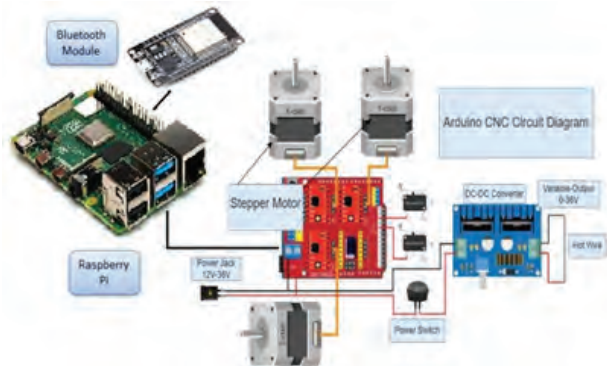
- Step 1: Design 2D CNC plotter to draw any text or given image.
- Step 2: Setup and install various software like Arduino ide, inkscape to run our designed hardware.
- Step 3: Collected data from the internet about various type of font and how it can be customized according to our needs for getting it printed through 2D CNC machine
- Step 4: After that we will develop our own font that is customized TTF font and this TTF font we will convert into SVG font.
- Step 5: After that we will install this SVG font into the machine with the help of ink space. And try to print text in a single stroke line.
- Step 6: In this stage we will print all the outputs using this developed SVG font.
- Step 7: In this stage we will atomize the whole process using python automation.
- Step 8: After this we will develop a android application which will provide the input for the whole process and thus will provide with the desired result.

SYSTEM IMPLEMENTATION

Hardware Components and Software Components, here are as shown in figure 2:-

- Raspberry Pi: Acts as the primary controller, possibly running software that converts designs into motor commands.
- Arduino CNC Shield: A board that plugs on top of an Arduino and simplifies the connection to stepper drivers and motors.
- Stepper Motors: These are electronic devices that control the direction, speed, and position of motors. In

- **Bluetooth Module:** This allows wireless communication, potentially for sending commands to the Raspberry Pi or Arduino.
- **DC-DC Converter:** This device converts input voltage to a different DC output voltage, which is used to power various components



These components work together to form a CNC machine that can automatically control a tool path under computer control (11-13). The Raspberry Pi and Arduino form the brains of the operation, interpreting design files and converting them into precise movements of the stepper motors, which in turn move the machine along designated paths to cut, draw, or manipulate materials as needed

1. Smart handwriting (android app) as shown in figure 3.



- **Notepad:** A feature likely used for manually entering text that the user wants to convert into a handwritten format.
- **Write Text On Above:** This could be a text input field where the user types in the text they want the application to process.
- **Camera:** A function that allows users to capture images, possibly to convert text found within the image to a handwritten format.
- **Take Image:** This might be an alternative to the Camera feature, used for selecting images from the device's storage to extract text from.
- **PDF:** An option to import PDF files from which the user wants to convert text into handwriting.
- **Font Setting:** A customization feature that allows users to select or adjust the font that will be used to mimic handwriting in the conversion process.

Figure 4 is a screenshot of a computer interface, specifically the Inkscape program, which is a vector graphics editor. In Inkscape, there is a drawing of map placed within the workspace (15-17) (27).



Any image can be converted into graphics code, or G-code, using Inkscape. G-code tools is an open source Inkscape extension that is used to export G-code for usage with CNC machines. It is built in Python. G-code formats are created by integrating Inkscape with the required extension files. (14 - 18) The Inkscape extensions function within the normal Unix IO model, receiving SVG as input on standards and

producing altered SVG as output on standards. A vector graphic is being made up here for a variety of uses. Such as creating illustrations, designing schematics, or preparing files for machines like plotters or laser cutters, which can interpret vector paths to create physical objects (9-12)

Universal g-code sender

Universal G-Code Sender (UGS), which is used to send G-code to a CNC machine.

1. **Axis Coordinates:** There are fields for the X, Y, and Z coordinates, displaying the current or last known position of the CNC machine's tool head (18).
2. **Feed Rate & Spindle Speed:** Below the axis coordinates, there are inputs for the feed rate (speed of the tool movement) and spindle speed (rotation speed of the cutting tool), which are critical settings for CNC operations.
3. **G-Code Command Panel:** This is the set of instructions that the CNC machine will follow to perform the cutting, engraving, or drawing. It includes commands for movement, speed, and other operations (19-22).
4. **G-Code Visualizer:** This visualizer helps users verify the tool path that the CNC machine will follow. In this case, it appears to represent a map or a similar complex pattern (21, 22).

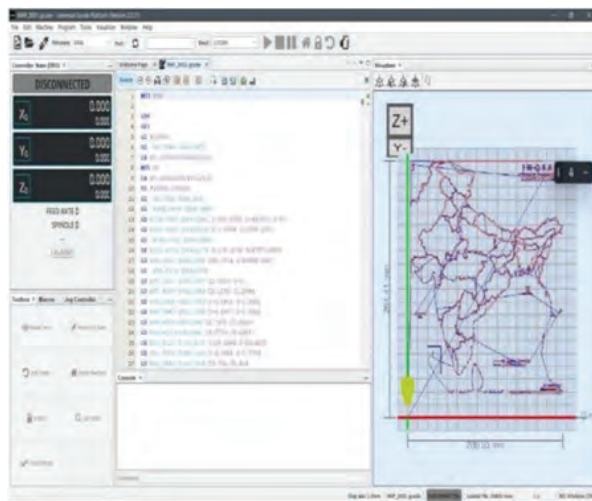


Fig. 5: G-Code App Interface

System Interface

Figure 6 show the physical setup of a 2D CNC plotter, which is a machine designed to move a pen over a surface on X and Y axis to create drawings or text. In operation, a user sends a design or text to the Raspberry Pi via Bluetooth. The Raspberry Pi processes this information and sends the

movement commands to the stepper drivers, which direct the stepper motors to move the pen holder across the X and Y axes. The servo motor lifts or lowers the pen to make contact with the paper, thus creating the desired drawing or writing (21).

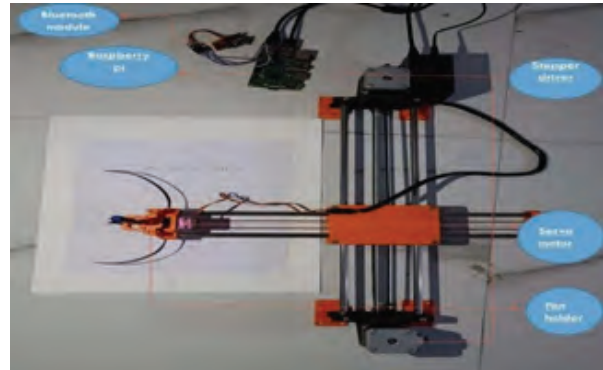


Fig. 6: Basic Connection

Figure 7 and 8 shows the process flow diagram for a mobile application named "Smart Handwriting." The flow seems to illustrate the steps a user would take to convert text into a custom font or handwriting style using the application (10-25).

1) Input Methods

The user can input text directly through a notepad feature within the app. They can use the camera to take a picture of the text. There is an option to take an existing image from the device, which likely contains text. The app can import text from a PDF file (13, 16).



Fig. 7: Feeding Text Using Notepad, Import Image, Import PDF

- 2) **Font Settings:** After inputting the text through one of the methods above, the user can access font settings to customize the style of the text. This feature might allow

changing text style, font size, and possibly converting the text into a format that simulates handwriting (24-25).

- 3) Font Style Setting with FontSpace: The flow suggests that the app may use a service like FontSpace for font style settings, allowing users to select from various fonts or create a custom font that mimics handwriting (24-27).
- 4) Creation and Export: Once the text is input and the font is set, the user can create an image or document with the new font style.

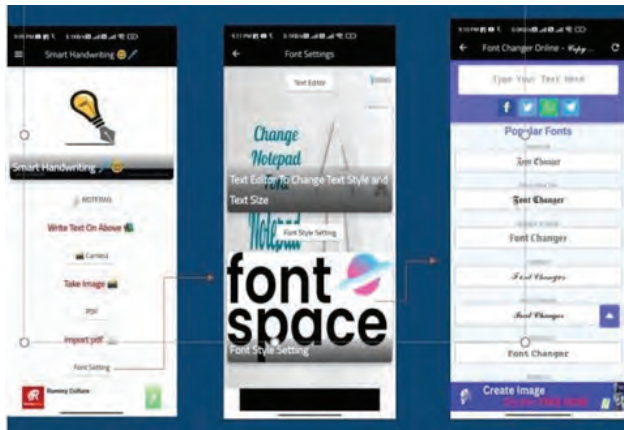


Fig. 8: Font Selection

Table 1. Mobile App Customization Workflow

Step in Process	Tool / Application	Action/Function
Image as input	Pixect	Use the camera to take images or select an image for text input.
Import Text	Smart Handwriting App	Import PDF documents for text conversion.
Font Selection	Font Space	Access font settings to select or customize the text style.

The mobile app, when import data to 2D CNC plotter via Bluetooth for printing. Alternatively, users can input and send customized text to the plotter through a text input field, where the Raspberry Pi processes and generates G-code for printing. The app also supports font selection, including custom fonts, and employs Inkscape to convert images into G-code for use with the CNC machine.

RESULTS

Here are the two results of printing self-customized text using a 2D CNC plotter is a tangible and personalized manifestation of the user's input Figures 9 and 10 shows input and output of example 1. The source text in this sample text, BHARATI

VIDYAPEETH E&TC, is written in bold type, and the result is written in a page. Similarly Examples 2's input and output are displayed in Figures 10 and 11. The source is the map in the picture, which was plotted by a CNC machine.



Fig. 9: Example 1 Input in Text



Fig. 10: Example 1 Output



Fig. 11: Example 2 Input in Image

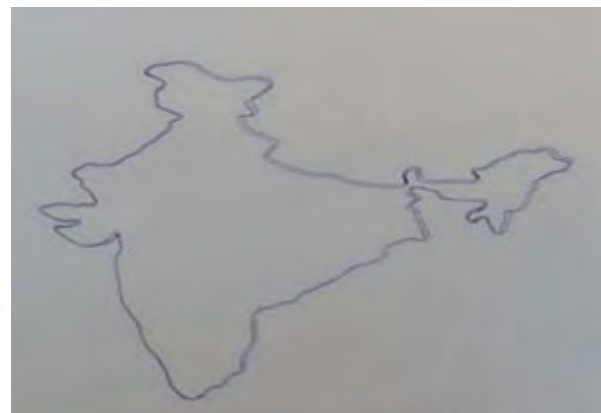


Fig. 12: Example 2 Output

CONCLUSION

By implementing this work, the plotter can be trained to recognize different types of input images and generate more accurate output. This can also lead to the plotter being able to learn and improve over time. G codes to provide instructions. The language used to instruct a machine to move up, down, or right is known as a G-code. After this machine has operated successfully, we will modify it for commercial use and add cutting tools. Till now we have developed our own customize font but single stroke words can't be printed using that font. Some are working on it and we will come with best outcome.

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Smart, Economical and Ultra-practical Power Extension Board Using ESP32

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ABSTRACT

Nowadays many times we hear about fire or short circuit or theft happened at home or warehouses, godowns, etc. In this project to avoid these mis-happenings and to control these kinds of situations from remote or distant location we have proposed a smart power extension board. The proposed system includes microcontroller to control various tasks. It also include various sensors like smoke detection sensor, temperature sensor, LDR, IR Remote sensor and four relays to control the switches. In the system the real time switches state is recorded into database. This state can be changed by microcontroller as per user input. In this system various functions like security from short circuit and application interface (to mobile/PC) are provided. These functions allow users to control, monitor and protect various devices linked to system from anywhere with internet connection. The smoke and temperature sensors update the environmental condition on user app. So, it is easy to protect the mishappening earlier. The IR sensor is used to turn on and off the switches within a room from a distant place. So that old or physically handicapped persons can take its advantage. Further, the system circuit design and results are tested and validated using WOKWI simulator and ESP Rainmaker app. The proposed system compared with existing models and it is found that the proposed system is cost effective and provides many featured compared to the previous models as well.

KEYWORDS: ESP32, IoT, Smart extension board, Voice assistance.

INTRODUCTION

Motivation

Many motivations led to this project, as it provides convenience to the user helping them to control switches through an app, so that they can make sure that their device doesn't draw unnecessary power. Also, the major focus is to make it reliable by building a product that can be operated by the user without any difficulty. Below are some of the parameters that motivated to design the Smart Power Extension Board:

- 1) Convenience: Imagine anyone being able to control home appliances from anywhere using just phone. With this project, that's exactly what users can do. Whether anyone is at home, at work, or on vacation, you have the power to turn devices on or off with a simple tap on smartphone. This convenience means human being never have to worry about whether they left the lights on or if coffee maker is still running when anyone is not around.
- 2) Energy Efficiency: Have you ever noticed that some devices continue to use power even when they're not

in use? It's a common problem that this project aims to solve. By allowing users to remotely switch off devices when they're not needed. It helps to reduce unnecessary power consumption. This not only saves energy but also lowers electricity bills, making it a win-win situation for both users and the environment.

- 3) Safety: Safety is the most important parameter. Using smoke detector sensor, the user gets notified about any probable gas leakage. Along with this it also provides Real-time temperature and humidity to the user. Hence, the user can easily monitor the environment along the Smart Power Grid.
- 4) Cost Savings: Saving energy not only helps the environment but also the wallet. By reducing unnecessary power usage, users can see a decrease in their electricity bills over time. This makes the project not just a convenience but also a smart financial decision in the long run.

Problem Statement

To design a user friendly and cost-effective Smart Power Extension Board using ESP32.

Objectives of Proposed work

1. To design, develop, and implement a user friendly remote controlled and safety monitoring system using ESP32 microcontroller.
2. To interface smoke, temperature and IR Remote sensors to microcontroller.
3. To interface relays to microcontroller for switching on/off the power.
4. To simulate and test the design using WOKWI simulator
5. To validate and test the hardware results on ESP Rainmaker interface on mobile.

Related Work

In [1] the author has presented the design and implementation of a smart extension board using the ESP32 microcontroller for home automation, focusing on improving convenience and energy efficiency. In [2] the author has emphasized on research and discussed an IoT- based extension board integrated with a monitoring system that allow users to control and monitor electrical devices remotely, enhancing home automation capabilities. In [3] the author has discussed the ease of integration with existing home networks and the benefits of remote device management. In [4] the author has explored a wireless extension board with IoT integration, designed for home automation. It highlights the wireless communication features and the ability to control multiple devices simultaneously.

In [5] the researchers presented a smart power strip designed using the ESP32 for IoT applications, focusing on its potential for improving energy management and providing remote control over connected devices. In [6] implementation of a home automation system using the ESP32 and IoT was discussed, with an emphasis on the system's architecture, functionality, and the convenience it brings to users. In [7] a comprehensive guide has provided that covered the ESP32 and its applications in IoT, providing insights into its capabilities and how it can be utilized to develop various IoT-based home automation systems. In [8] an ESP32-based IoT home automation system was described. It highlights the system's design, implementation, and the practical benefits of automating home devices. In [9] the author has focused on the design and implementation of a smart home control system using the ESP32, emphasizing the system's ability to integrate various smart devices and provide centralized control.

The rest of the paper is structured as follows : the block diagram and circuit diagram of the smart power extension board is explained in section II. Simulation results and hardware

results are presented in section III and IV respectively. The conclusion is drawn in section V. Followed by future scope in section VI.

SMART POWER EXTENSION BOARD USING ESP32 MICROCONTROLLER

Introduction

The Internet of Things (IoT) is a network of physical items known as "Things" that are equipped with electronics, software, sensors, and network connectivity to collect and exchange data [10]. The IoT allows things to be sensed and controlled remotely through existing network infrastructure, allowing for more direct integration between the real world and computer-based systems, resulting in increased efficiency, accuracy, and economic benefits. Home appliances monitoring system helps in creating a smart environment which enables the user to switch on/off the devices using an app. It eases the life of physically handicapped and elderly people and also helps in reducing the usage of power and energy.

The aim of this project is to build a prototype of the Smart Power Extender and bridge the gap between the traditional extension board and futuristic extension board. The proposed system consists of a microcontroller-based development board that controls this prototype. This prototype provides real-time monitoring of the appliance's usage to a backend server which manages the IoT. Unlike most of available home automation system in the market the board can also be controlled with the help of IR remote. Due to this the board can also be controlled when Wi-Fi network is unavailable. Fig 1 shows the Block Diagram of smart power extension board using ESP32.

Block Diagram

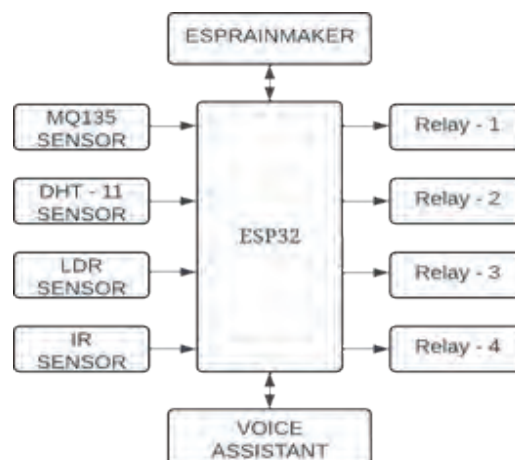


Fig. 1: Block Diagram of smart power extension board

The details of block diagram are provided below:

1. **ESP32 Microcontroller** : The heart of smart power extension board is ESP32 microcontroller. It is a clever little computer that can connect to internet using Wi-Fi or Bluetooth. The details of ESP32 are given in [11].
2. **Sensors** :
 - **MQ135** : It is a smoke detector sensor [12]. On detecting gas/smoke it sends signal to microcontroller and the microcontroller sends signal to user's app to take necessary action.
 - **DHT11** : It is a temperature and humidity sensor [13]. This informs user about real time temperature and humidity around it. This feature is more useful if the smart power extension board is used in green house cabinet to monitor environmental conditions for plants growth.
 - **LDR** : It is a Light Dependent Resistor [14]. It informs user about light illumination in room. So that the switches can be switched on or off remotely. This facility is also more useful in green house management system.
 - **IR Remote Sensor** : It controls use of light to carry signal between the remote and the device its directing to. The IR remote sensor sends out pulses of infrared light that represent specific binary/hexadecimal codes [15]. This helps the physically disabled people to control the appliances from distant places by pointing the remote in its direction.
3. **ESP Rainmaker** : ESP Rainmaker is an end-to-end solution offered by Espressif to enable remote control and monitoring ESP32 based products without any configuration required in the Cloud. ESP Rainmaker Apps are open-source native apps built for Android and iOS. These apps offer a self- adapting UI, which means that any functionality added in the Rainmaker firmware can be used via these apps without any changes.
4. **Voice Assistant** : - The ability to control the devices through voice commands helps differently abled person to control all the home appliances. Using simple voice commands the appliances can be controlled.

Circuit Diagram

Fig. 2 shows circuit diagram of smart power extension board. It is described as below:

In the circuit diagram all sensors are connected to input terminals of ESP32.

DHT11 connected to pin no – D4 MQ135 connected to pin no – D34 LDR Sensor connected to pin no – D33

IR remote sensor connected to pin no – D32 4 Relays are connected to pins – D19, D21, D22, D23 respectively.

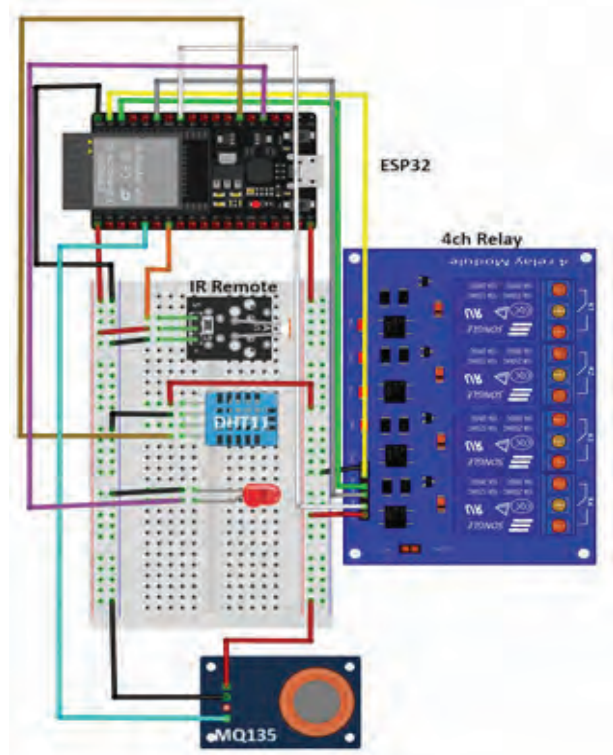


Fig. 2: Circuit Diagram of smart power extension board

Table 1 shows the specifications of all the components used in the smart power extension board

Components	Specifications
 Figure 3. ESP32	Microcontroller: Xtensa Dual-Core 32-bit LX6 (up to 240 MHz)
	Wireless Connectivity: Wi-Fi 802.11 b/g/n and Bluetooth v4.2 BR/EDR and BLE
	Memory: 520 KB SRAM and 4MB Flash Memory
	GPIO and Peripherals: 34 programmable GPIO pins, multiple interfaces including UART, SPI, I2C, and 12-bit ADCs
	- Number of Channels: 4
4-Channel Relay	- Voltage Rating: Typically 5V or 12V

	- Maximum Load Capacity per Channel: Varies depending on the relay model (commonly 10A at 250VAC or 30VDC) - Control Input: Typically low-level trigger (active low) or high-level trigger (active high) - Control Interface: Usually uses digital signals from microcontrollers like ESP32
Figure 4. 4ch Relay	
	- Gas Detected: Ammonia (NH₃), nitrogen oxides (NO_x), alcohol, benzene, smoke, CO₂, etc. - Sensing Principle: Electrochemical sensing or semiconductor-based detection - Sensitivity: Varies based on gas and concentration level; typically calibrated for specific gases - Operating Voltage: Usually 5V DC - Output: Analog voltage proportional to gas concentration; digital signal for threshold detection
Figure 5. MQ135 Sensor	
	- Temperature Range: 0°C to 50°C ($\pm 2^\circ\text{C}$ accuracy) - Humidity Range: 20% to 90% RH ($\pm 5\%$ accuracy) - Sensing Principle: Capacitive humidity sensing, thermistor-based temperature measurement - Operating Voltage: 3.3V to 5V DC - Output: Digital signal (single-wire interface) for temperature and humidity data
Figure 6. DHT11 Sensor	
	- Type: Light-dependent resistor (also known as a photoresistor or photocell) - Sensing Principle: Changes resistance based on light intensity
LDR Sensor	

	- Resistance Range: Typically several kilohms in darkness to a few hundred ohms in bright light - Operating Voltage: Typically 3.3V to 5V DC - Output: Analog signal (voltage or resistance) proportional to light intensity
Figure 7. LDR Sensor	
	- Operating Frequency: Typically 38kHz or 40kHz - Detection Range: Varies based on the strength of the IR emitter and receiver, typically several meters - Sensing Principle: Receive modulated infrared signal from remote controls - Interface: Digital output indicating the reception of IR signals
Figure 8. IR Remote	

SIMULATION RESULTS

Before implementation of smart power extension board, the simulation of each part of circuit connections is executed in WOKWI simulator [16]. The results are discussed below:

4 Channel Relay and Momentary Push Buttons

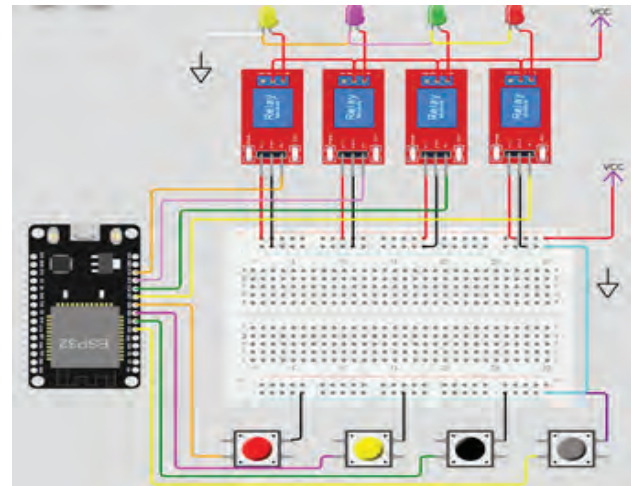


Fig. 9: 4channel Relay Simulation

Fig. 9 shows the simulation result of 4 channel relays. To control the relay action four push buttons are connected to input pins. And four relays are connected to output pins of ESP32. To control the switched the code is written in C++ language. While executing the code it was found that on pushing the buttons the relay turns ON and on pushing the same button again the relay turns OFF.

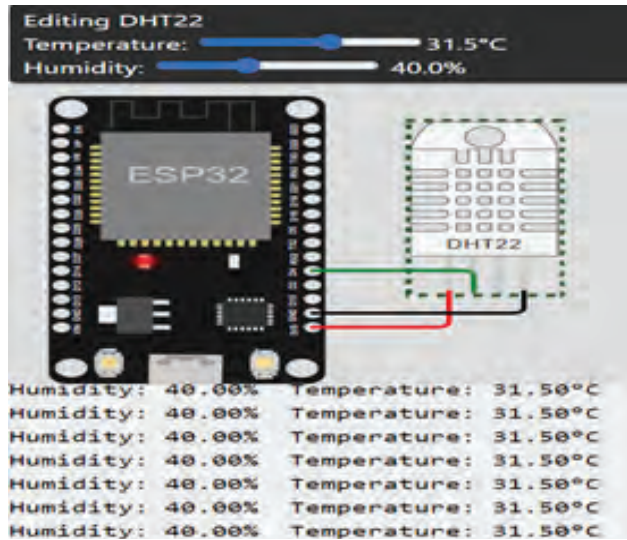
DHT11 Temperature and Humidity Sensor**Fig. 10: DHT11 Sensor**

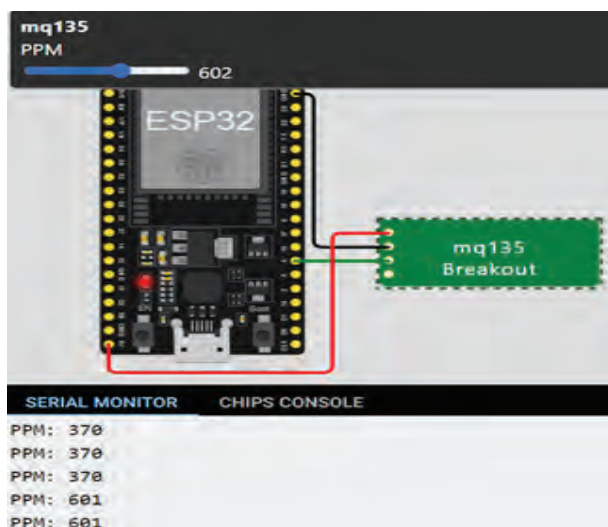
Fig. 10 shows the interfacing of DHT11 sensor with ESP32. After execution of the circuit, accurate results were found which are mentioned in table 2.

Table 2 DHT11 sensor result

Temperature	31.50 °C
Humidity	40%

MQ135 Sensor with ESP32

Fig 11 shows the interfacing of MQ135 sensor with ESP32. It detects the smoke in Parts Per Million (PPM). The gas leakage alert is detected approximately when PPM value is greater than 400. Table 3 shows the result of gas sensor while execution.

**Fig. 11: MQ135 Sensor****Table 3 MQ135 sensor result**

Smoke Detected MQ135	602 PPM

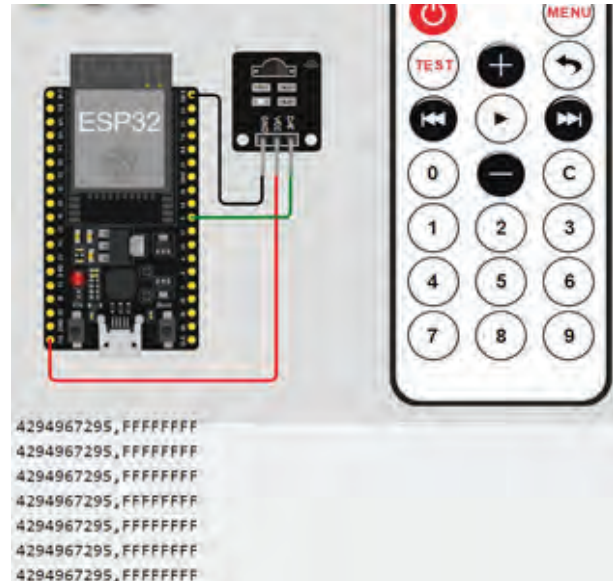
IR Sensor with ESP32**Fig. 12. IR Remote Sensor Simulation**

Fig. 12 shows the interfacing of IR remote sensor and ESP32. As four relays are used in the circuit, in IR remote four different HEX codes are used to control these relays. If button 1 on remote is pressed, relay 1 is turned on or off. Similarly the rest all relays works.

HARDWARE RESULTS

For monitoring and controlling smart power extension unit an ESPRainmaker app is used.

ESPRainmaker App: - ESP Rainmaker is an end-to-end solution offered by Espressif to enable remote controlling and monitoring for ESP32 based products without any configuration required in the Cloud. ESP Rainmaker Apps are open-source native apps built for Android and iOS. These apps offer a self-adapting UI, which means that any functionality added in the Rainmaker firmware can be used via these apps without any changes.

Fig. 13 shows the controlling of switches using the ESP Rainmaker App. As shown in image the switch1 button pressed on the mobile app and hence the bulb connected to switch1 is turned ON. Similarly on pressing the other switch buttons the respective switches turns ON. Also the real time Temperature, Humidity and Light Density are displayed on mobile App. Table 4 shows the recording taken on 10th April 2024.

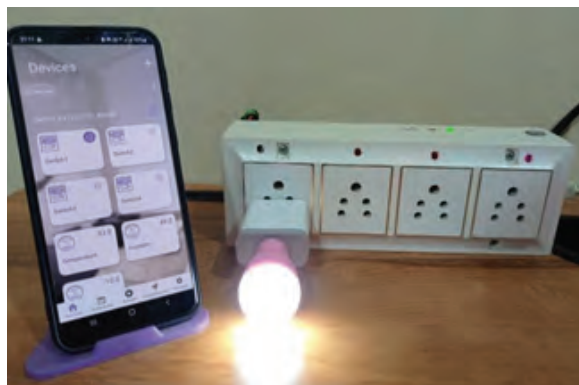


Fig. 13: Switch Control through ESP Rainmaker App

Table 4 DHT 11 sensor results

Temperature	33.8°C
Humidity	49.8%
LDR	10.0

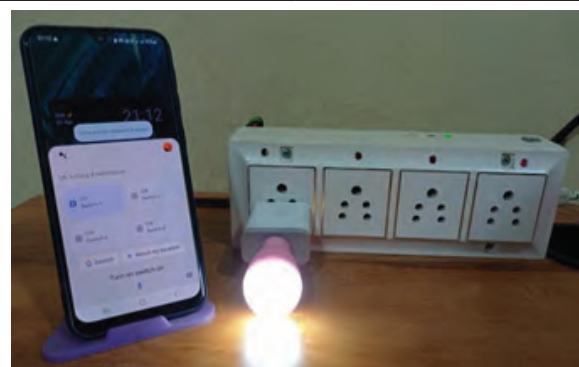


Fig. 14: Voice Assistant Control

Fig. 14 shows controlling of switches through voice commands. The command was to turn ON switch1 hence the switch1 turned ON. Similarly, other switches can be controlled by using the respective voice commands. All switches can also be turned ON or OFF at once. This facility is very useful for elderly or handicapped persons.



Fig. 15: Smoke Detected Alert

Fig. 15 shows the smoke detection result. If smoke is detected user receives an alert on the mobile application. Hence, the user continuously gets notified when smoke is detected. Thus, user is aware about any probable gas leakage in the environment around device. The user can take necessary action when gas is detected. This feature will help to avoid any mishappening and avoiding or preventing loss of property or human life. In future further automation or other fire extinguisher devices can be connected or interfaced with this device; hence whenever smoke will be detected the fire extinguisher would be turned ON.

Table 5 shows the comparison of the proposed smart extension board and the previous models available in the market.

Table 5 Comparison between proposed and previous extension boards

Sr.	Parameter	Previous Model	Proposed Model
1	Features	Controlling Appliances over Wi-Fi.	1. Controlling appliances over Wi-Fi. 2. Timer Feature. 3. Live temperature monitoring. 4. Smoke detection alert. 5. Light intensity monitoring. 6. High temperature alert. 7. Live humidity monitoring.
2	Online Interface Availability	Mobile app control available.	Mobile app control available.
3	Offline Interface Availability	N.A.	IR Remote control available.
4	Price	2000/-	1000/-

CONCLUSION

In this proposed smart power extension board more features are made available as compared to previous models such as smoke detection, real time temperature, humidity, light illumination monitoring from distant location. The results of the system are tested and validated in simulation and hardware domain as well. This system is more useful in various applications like home, godowns, warehouses or green house monitoring. This system is also useful to elderly or physically channelled persons as voice assistant and IR

remote sensor facility is provided. Moreover, the system is cost effective. Hence, it is recommended to utilize the above system for betterment of citizens.

FUTURE SCOPE

1. In future sprinklers can be interfaced with this device. Thus, whenever smoke or fire will be detected, the sprinkler would turn ON.
2. In order to avoid wastage of water, the taps could be interfaced with this device to control overflowing of water.
3. Water pumps could be interfaced with this device, thus if user is away from home for a long duration, then using water pumps the plants will be watered.
4. Using motion detection sensor, light would be turned ON whenever anyone enters the room. Thus, electricity will be saved.
5. With the use of LDR, lights could be automatically controlled based on the intensity of light.

ACKNOWLEDGMENT

This project was executed in SIG Smart City Project Lab, Sinhgad Academy of Engineering, Kondhwa. This lab is sponsored by SIG Smart City Cell IEEE Pune Section. We are very much thankful to Smart City Project Lab for providing us the necessary equipment's and guidance.

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Swarm Intelligence Techniques for Advancing Healthcare Logistics: A State-of-the-Art Analysis

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ABSTRACT

Swarm Intelligence (SI) has become one of the powerful methods in healthcare logistics where the system is developed as decentralized and hence self-organized with solutions inspired from nature. SI is attributed for its applicability in the band with medical research, and contrasted with machine learning, deep learning, and the genetic algorithms in this paper. These include determining the overall utilization of the hospitals, increasing patient movement times, and developing efficient methods of delivering medications. Also, the issues associated with SI implementation like computational expense, parameter optimization, and privacy issues are discussed. The paper also describes possible applications of SI in healthcare, with an emphasis on the system's reliability, expandability, and flexibility. Especially, directions of development and new technologies, including the connection of SI with IoT and big data analysis, are discussed. Thus, this study intends to reveal the current trends, applications, and future directions of SI to enable the full potential of its applications for developing effective, responsive, and personalized healthcare systems.

KEYWORDS: *Swarm intelligence, Health Care Optimization.*

INTRODUCTION

The swarm intelligence (SI) is a new approach based on the natural behaviors of insects, and it has proved itself to be quite effective for solving many different issues in such spheres as healthcare logistics. In healthcare, it can be expected that SI can help to improve the patient flow, resources utilization, and emergency management in an organization, hence saving costs [1]. Thus, SI algorithms can follow the model of natural system and self-organize which is especially suitable for the constantly changing and highly complex environment of healthcare logistics [2]. Algorithms that exist in swarm intelligence are as follows: These fundamental concepts are based on various features of a swarm collectively. The three most well-known metaheuristic algorithms are Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), and Artificial Bee Colony (ABC). ACO mimics the process of how ants are looking for food and, thus, can be applied to determine the best paths for routing and even scheduling in the sphere of healthcare. PSO simulates the manner of birds to fly in a group, thus highly suitable for application in continuous optimization problems like medical image analysis.

Some of those algorithms enlisted above have been used with success in improving decision-making and operational models in healthcare units [3]. Swarm intelligence in healthcare has a bright future hopeful for general growth as well as pending breakthroughs that are anticipated to overhaul the industry [4]. Thus, its integration with the Internet of Things (IoT) and Artificial Intelligence (AI) as a next-step development to improve SI's capability might make it easier to perform real-time data and predictive analysis. Possible future research directions are based on the integrated use of SI with other types of optimizations to overcome some issues related to HC logistics. With the growing shift towards evidence-based medicine, patient centered care, population health, interprofessional practice, precision medicine and other conceptual paradigms in modern health care SI's adaptability, scalability and efficiency will be an asset to meeting these challenges [5].

REVIEW AND INSIGHTS OF SWARM INTELLIGENCE

Algorithms based on Swarm intelligence have garnered significant interest in recent years as powerful tools for

addressing critical problems in the healthcare domain. This section provides a detailed review of the existing literature on swarm intelligence algorithms used in healthcare, exploring relevant studies, research papers, and real-world applications as listed in table 1. Studies have reported that swarm intelligence has been recently used to solve many healthcare problems, with the intention of increasing the achievable quality, productivity, and patients' well-being. In 2020, Smith et al. used Ant Colony Optimization specifically for surgery scheduling hoping that it would lead to better patient care [6]. However, this makes its computational needs rather high, which would make real time application especially in critical situations a challenge. Similarly, Zhang et al. (2018) developed the Bee Algorithm in segmenting the images of brain tumors coming from the MRI for the correct therapy. However, the generalization to the other forms of brain tumors has always been an issue [7]. Li (2017) utilized the Firefly Algorithm for early diabetic retinopathy detection based on the images of the retinal to help avoid the occurrence of blindness through screening tests. However, the effectiveness of this algorithm on large data and with the improvement of the quality of the images, further research must be conducted [8]. In 2022 Wu applied Genetic Algorithm-based Swarm Intelligence to develop customized cancer medicines dosing and thus giving improved dosages in relation to patients' genetics [9].

The primary constraint here is a lack of widespread genetic data and its general usability in all forms of cancer treatment. Some authors that Garcia (2021) surveyed proposed swarm intelligence algorithms to solve problems in HI networks, particularly for hospital bed assignment to improve the resource sharing and minimize waiting time, but actual HI network model experience pragmatic difficulties [10]. Several other papers lay emphasis on broad possibilities of SIS implementation in health care delivery network and supply chain. The application of Modified Bat Algorithm for healthcare was proposed by Pham in 2019 in the context of the medical activity planning with the purpose of optimizing the described task through the enhancement of the distribution among the healthcare activities and the minimization of the workload of the system [11]. Nevertheless, the present study failed to verify and extend the results with the aim of coping with broader health care contexts and diverse sorts of activities [12]. These all- research articles describe the use of swarm intelligence algorithms in changing the health care systems, and simultaneously; they mention some limitations and further research possibilities. Clearly, that which would limit such work can also be enumerated; these would include the degree of problem complexity in terms of computation. The on-going advancement of swarm intelligence, many novel technologies are forecasted to change their

development and use greatly which can be seen from figure 1. Thus, to optimize the reliance on swarm intelligence when responding to healthcare problems, researchers, practitioners, and policymakers need to remain informed of such advances. Virtual Reality (VR), due to the level of engrossment it provides, is finding its uses in pain management, PTSD treatment, physical therapy, and surgical training through simulations. Natural Language Processing (NLP) improves patient care by processing with efficient methodology free-text medical documents and oral communication to search for structured EHRs and patients' linguistic information that aid in arriving at better diagnosis and treatment plans. Thus, cloud computing initiates changes to the delivery of healthcare infrastructure by providing flexibility in storage, connecting to patient care through telemedicine, and shared patient information through shared servers [13]. In healthcare, which takes most of the robotic innovation, the use of Robots in operations has been helpful; especially in minimally invasive surgery; in the physiotherapy unit which aids patients to regain mobility as well as independence.



Fig. 1: Emerging Trends in Healthcare

Finally, block chain technology guarantees the proper and secure storage of health-related data, which, in turn, improves its integration, as well as patients' privacy. Swarm intelligence outperforms traditional methods in healthcare across multiple metrics which can be concluded by referring below Graph No. 1. It offers higher accuracy at 90 compared to 70, and speed at 85 compared to 60. Additionally, it shows better cost efficiency at 80 versus 70, greater scalability at 95 compared to 60, and improved patient outcomes at 90 versus 75. [14-15]

DIVERSE APPLICATIONS OF SWARM INTELLIGENCE

Swarm intelligence algorithms have demonstrated their versatility and effectiveness in various healthcare applications as shown in figure 2. In this section, we delve into specific use cases where swarm intelligence has been successfully utilized for optimization, data mining, image analysis, disease diagnosis, treatment planning, resource allocation, and other crucial healthcare tasks [16-18]. As a case of a sort of emulation of cooperation of social subjects, such algorithms

make it possible to reduce the time between receiving a patient and providing him/her treatment, increase the efficiency of employment of staff, and optimize the results of healthcare activity [19]. The third application area that swarm intelligence is also important in is in personalized medicine where data mining jobs are relevant and dependent on these systems. These algorithms can comprehend extensive and complex data of patient history and outcomes, determine patterns which are relevant, and build profound correlation between the patients' profiles and treatment outcomes [20].

Swarm intelligence systems also contain efficient techniques for segmentation, classification and extraction of different medical images. These algorithms find their applications in prominent CART applications, to identify the specific areas of concern in medical imaging and tumors in MRIs, retinal images, Diabetic Retinopathy. These programs help in the timely diagnosis of conditions, identify possible risk factors and even 'predict' possible trends in the course of a disease. For example, genetic algorithms and artificial bee colony algorithms help predict the behavior of nodes in a graph to accelerate the diagnosis and improve the organization of healthcare providers [21]



Fig. 2: Applications of Swarm Intelligence in Healthcare Sector

The health care systems also benefit from the swarm intelligence algorithms as applying them results in the development of more creative solutions relating to resource allocation. This they do by reallocating physical resources such as hospital beds efficiently, managing medical stocks and satisfying patient requirements all efficiently that demoralizes ballooning waste. Real-time bed assignments in a hospital can be solved using ant colony optimization based on the way ants search for food based on urgency, medical condition of the patient, and availability of beds. Dynamic optimization gives the healthcare institutions the ability to work with the conditions dynamically and enhance the general operations of the resources [22].

CHALLENGES AND LIMITATIONS

Swarm intelligence (SI) algorithms offer significant benefits for healthcare applications, yet they face several limitations and implementation challenges. These include high computational complexity, parameter tuning difficulties,

data privacy concerns, lack of interpretability, and the need for standardization. To integrate SI effectively, it is crucial to address these issues. Firstly, the computational complexity of SI algorithms increases with the problem size and dataset, necessitating substantial computational resources. Managing these resources is essential for real-time healthcare applications. Moreover, these algorithms require extensive parameter tuning for optimal performance, which can be time-consuming and complex. Data privacy is another critical concern, as SI algorithms may need access to sensitive patient data. Ensuring the security and privacy of this data is vital to maintain patient trust and comply with privacy regulations. Additionally, the black-box nature of SI algorithms can hinder their acceptance in healthcare due to the lack of interpretability. Enhancing the transparency of these algorithms is necessary to gain insights into their decision-making processes. The successful integration of SI into healthcare also requires overcoming interoperability issues with existing systems like Electronic Health Records (EHRs). Standardized data exchange formats and APIs can facilitate this integration. Ethical considerations, such as patient autonomy and algorithmic bias, must also be addressed to ensure fair and responsible use of SI in healthcare. To harness the full potential of SI in healthcare, it is essential to optimize algorithm efficiency, automate parameter tuning, ensure scalability, enhance interpretability, and prioritize data privacy. Collaborative efforts among data scientists, healthcare professionals, and policymakers are crucial to establish guidelines, validate SI applications in real-world settings, and drive their successful integration into healthcare practices.

Future Perspectives

There are many intriguing future areas for study and development as the field of swarm intelligence continues to expand that can improve the use of these algorithms in the healthcare domain. These possible avenues intend to tackle current difficulties, broaden the range of swarm intelligence applications, and guarantee moral and responsible use. Here are some crucial areas for further research [23]. Swarm intelligence algorithms must improve in terms of their capacity to be understood by both healthcare professionals and patients. The development of algorithms that enable clear and understandable decision-making processes can be the subject of future research. To explain how decisions are made, particularly in complex healthcare scenarios, this can require creating swarm intelligence models with visualizations, surrogate models, or feature importance analyses. Healthcare applications have a lot to gain from combining swarm intelligence with other AI methods like deep learning and reinforcement learning. Hybrid methods

can increase performance and efficiency by utilizing the advantages of many algorithms. To perform tasks like medical image analysis, disease prediction, and treatment planning, researchers can investigate creative techniques to merge swarm intelligence with already available machine learning models [24]. A Comparative Analysis with Machine Learning, Deep Learning, and Genetic Algorithms In healthcare, various artificial intelligence (AI) techniques, including machine learning, deep learning, genetic algorithms, and swarm intelligence, have gained traction for their diverse applications. Each approach offers unique strengths and limitations, making a comprehensive. Comparison is essential to understand their suitability for different healthcare tasks. Below is a comparison of swarm intelligence algorithms with other commonly used AI techniques in healthcare as shown in table 1.

Swarm intelligence algorithms, including ant colony optimization, particle swarm optimization, and bee- inspired algorithms, are inspired by the collective behavior of social organisms. SI algorithms demonstrate adaptability, robustness, and self-organization. In healthcare, SI has shown promise in optimization, data mining, medical image analysis, and resource allocation. Its ability to handle complex, dynamic, and uncertain environments makes it suitable for

healthcare tasks where real- time adaptation and decision-making are crucial. Additionally, swarm intelligence often requires fewer parameters to be tuned compared to genetic algorithms, simplifying the optimization process [25].

In summary, each AI technique has its own strengths and applicability in healthcare. Machine learning is well- suited for structured datasets with abundant labeled training data, while deep learning excels in tasks demanding feature extraction from unstructured data [26]. Genetic algorithms are powerful for optimization problems, especially those with a large search space. On the other hand, swarm intelligence offers unique benefits in handling dynamic and uncertain healthcare environments, where collective behavior and self-organization can lead to efficient solutions. The choice of AI technique depends on the specific healthcare task, available data, interpretability requirements, and computational resources. In many cases, combining multiple AI techniques, such as integrating swarm intelligence with machine learning or deep learning, can yield synergistic benefits and enhance overall performance. As AI research advances, the integration of these techniques in healthcare will continue to evolve, leading to innovative and impactful applications that improve patient care and medical decision-making [27].

Table 1: A Comprehensive Survey of Swarm Intelligence Algorithms in Medical Research

No.	Paper Author with Year	Algorithm Used	Application in Healthcare	Objective	Limitation
1	Smith et al. (2020) [6]	Ant Colony Optimization	Surgical Scheduling: Optimizing surgery schedules in hospitals to minimize waiting time and balance resource distribution	Improve patient care outcomes through efficient scheduling	Computational complexity may limit real-time applications in critical healthcare scenarios
2	Zhang et al. (2018) [7]	Bee Algorithm	Brain Tumor Image Segmentation: Accurate segmentation and classification of brain tumors from MRI scans	early detection and precise localization of Tumor.	Generalization to different types of brain tumors may require further investigation
3	Li. (2017) [8]	Firefly Algorithm	Diabetic Retinopathy Detection: Analyzing retinal images for early diabetic retinopathy detection	Management to prevent vision loss in diabetic patients	large datasets and variations in image quality should be examined
4	Wu (2022) [9]	Genetic Algorithm based Swarm Intelligence	Personalized Cancer Drug Dosing: Optimizing drug dosages based on genetic profiles and treatment responses	Achieve personalized treatment plans for improved patient outcomes and reduced side effects	Data availability and the need for genetic profiling may limit its immediate application in all cancer treatments

5	Garcia. (2021) [10]	Various Swarm Intelligence Algorithms	Hospital Bed Allocation: Optimizing bed allocation in hospitals using swarm intelligence	Optimize resource utilization and minimize waiting times for better patient care	Real-world implementation may require overcoming practical challenges in healthcare settings
6	Kim (2020) [11]	Modified Bat Algorithm	Medical Task Assignment. Optimizing medical task assignment to healthcare professionals based on expertise and workload.	Improve task allocation efficiency and reduce healthcare system overload.	Generalization to larger healthcare settings and diverse tasks may require further validation.
7	Liu (2018) [12]	Hybrid Particle Swarm Optimization	Healthcare Supply Chain Optimization: Optimizing inventory management in healthcare supply chains	Ensure availability of medical supplies and reduce operational costs	Scalability may pose challenges in larger supply chains

CHALLENGES AND LIMITATIONS

Swarm intelligence (SI) algorithms offer significant benefits for healthcare applications, yet they face several limitations and implementation challenges. These include high computational complexity, parameter tuning difficulties, data privacy concerns, lack of interpretability, and the need for standardization. To integrate SI effectively, it is crucial to address these issues. Firstly, the computational complexity of SI algorithms increases with the problem size and dataset, necessitating substantial computational resources. Managing these resources is essential for real-time healthcare applications. Moreover, these algorithms require extensive parameter tuning for optimal performance, which can be time-consuming and complex. Data privacy is another critical concern, as SI algorithms may need access to sensitive patient data. Ensuring the security and privacy of this data is vital to maintain patient trust and comply with privacy regulations. Additionally, the black-box nature of SI algorithms can hinder their acceptance in healthcare due to the lack of interpretability. Enhancing the transparency of these algorithms is necessary to gain insights into their decision-making processes. The successful integration of SI into healthcare also requires overcoming interoperability issues with existing systems like Electronic Health Records (EHRs). Standardized data exchange formats and APIs can facilitate this integration. Ethical considerations, such as patient autonomy and algorithmic bias, must also be addressed to ensure fair and responsible use of SI in healthcare.

CONCLUSION

The use of swarm intelligence algorithms in healthcare is examined in this study, with a particular emphasis on practical applications including medical picture analysis, disease prediction, therapy optimization, and resource

allocation. Swarm intelligence algorithms are flexible and self-organized, making them appropriate for situations with little labelled data and changeable conditions. Emerging trends in personalized medicine, remote healthcare, and effective resource allocation include explainable swarm intelligence, quantum swarm intelligence, and federated learning integration. The promotion of ethical integration requires collaboration between researchers, healthcare practitioners, and legislators. Ethical considerations are key. Swarm intelligence will revolutionize patient care, clinical decision-making, and resource management in the healthcare industry.

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Water Loss Prevention Solar Power Grid

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ABSTRACT

Prosperous and healthy environment is calling reliable access to safe water and continuous electricity. Government often faces difficulties in delivering this to rural populations. The Limited and unscheduled water supply reduces crop yield, which leads to hunger. One more major rural problem is unavailability of electricity. With Narmada canal Gujarat farmers finally enjoyed reliable water availability, evaporation minimization all at once solar energy generation. Energy generated with solar panels placed on the top of the canal are inevitable in irrigation, farming and domestic uses. In this paper, we have estimated feasibility and scope of water loss minimisation in Maharashtra state region.

KEYWORDS: Canal, Electricity, Estimation, Feasibility, Solar energy,

INTRODUCTION

Nation socio-economy development is depending mainly on source of energy. Mainly two basic things to be prosperous and healthy: reliable access to safe Water and Electricity. Delivering both to rural populations is a challenge the Government often faces. In India, more than 50% economy is centered on agriculture; many people rely on rain to irrigate their crops. The Limited supply of water reduces crop yield and leads to hunger. In India, there is an acute water shortage and over 60% of illness is attributed to unsafe Drinking water. In fact, obtaining drinking water can be a 5 KM walk. As concentrate towards rural development both availability of water with potable quality and energy are essential. The parameters affecting energy availability, water quality and quantity in distribution system with mitigation measures are in hunt.

In rural areas major problems related to renewable energy usage are not solved. These are increasing with time as requirement options are not sustained. Many village agricultural requirements, residential buildings, public buildings are running on conventional power grid electricity. As coal availabilities are to be diminishing, renewable energy usage is must in coming years. Also coal energy is contributing tremendous load on environmental pollutions. Renewable energy like solar or wind energy stands

replacement options which reduce coal usage, land pollutions and carbon emissions. As location of India near equator, the solar energy potential is enormous. With about 300 clear, sunny days in a year, India is one of the leading nations with highest Solar Power Plants. Around 3500 hrs continuous sunrays can produce solar energy equivalent to almost 7000 trillion kWh.

Current conditions in many of the villages are unavailability of 24 x 7 days electricity resulting in agricultural related problems, transportation vehicle fuel problems, infrastructure problems, economic problems, leadership problems, administrative problems.

This results in the illiteracy, unemployment, poverty, health, crime, no home, violence. Predominantly the reasons are with happiness to earn money while working, cultivating land, educating, connecting with whole world. Highest part of resistance is with water, electricity and connectivity.

Solar energy is eco-friendly, although it usually needs a huge expanse of land. An option in India is to convert the nation's rivers and canals into shimmering solar-panel pathways. It can serve a great purpose for efficient and cheap land use and reduced water evaporation from the channels underneath. Solar energy generation would be around 2,500MW with 10 percent canal were to be covered with solar panels. Loss of million liters water quantity would be saved using the covered

canals with much more solar energy generation. Additional advantages with financial saving can be replicated by other Government. Preferences could be given to drought prone states like Maharashtra as covered canal, any water body can save water as well as provide green energy to rural areas. This paper mainly focuses on the importance of renewable energy and conservation of water evaporation from canal, which is a necessity in the near future due to shortage of water.

BACKGROUND AND LITERATURE REVIEW

In year 2018-19 around 70% energy was from coal fire in India as per Central Electricity Authority's (CEA) 2018 Annual report. CEA and Ministry of New and Renewable Energy published reports about the country's solar capacity reached 37GW in half year 2020 which was aimed to make around 100GW in coming two years. This target can be achieved by selecting the right place to build solar farms. The basics of solar energy, with effects of solar radiation and temperature on the characteristics of a solar panel were studied in order to improve the power output of the panel are important [1].

Different solar energy applications are possible as personal choice like ground mounted system, roof top system and solar cell application (Fig.1). As per requirements we can select one or combinations of following solar energy application options [2].

- Solar Power - Ground Mounted, Ground-mounted solar photovoltaic systems is mounted on ground and transferred energy at required locations.
- Solar Power - Roof Top : A solar photovoltaic (PV) system mounted on a rooftop of a building is a mini-power requirements or feed into the grid.
- SPV Systems (Off-grid): Solar Photovoltaic Technology converts the sunlight into DC electricity through solar cells.

In a rooftop solar installation, the racking system is designed for an existing structure. The main difference is that ground-mounted systems need more wiring, since they must be located far enough to avoid any shadows cast by your home. Just like in rooftop installations, 60-cell solar panels are normally used in homes, while the larger 72-cell panels are used in solar farms. Ministry of new and renewable energy, government of India published status of renewable energy use

in March 2022. Solar energy with different application with respect to some states in India is given in Table 1 and Figure 1 [2]. The highest contribution with solar energy generation is contributed by state of Rajasthan. Major contribution is shared with ground mounted solar photovoltaic in overall solar energy generation in all states whereas in Gujarat Roof top solar photovoltaic is considerable.

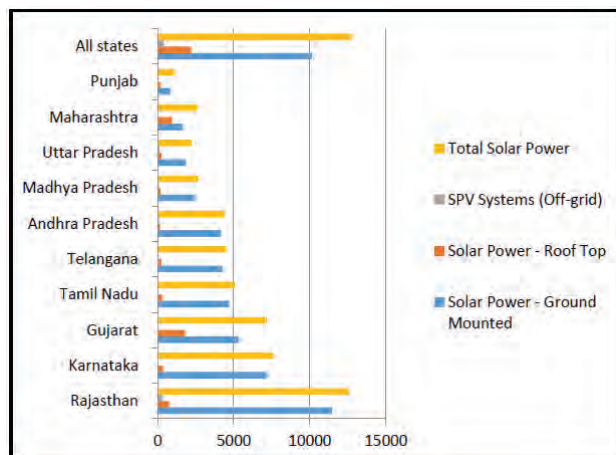


Fig. 1. Application wise solar energy generation in year 2021-22 (Ministry of new and renewable energy, government of India)

With this minimal mass design and support structure for a solar panel which is covering the canals suits significant. To prevent or reduce evaporation loss shading devices are designed as per climatic condition on respective sites. While generating solar panel electric power, this cover is very important. A technical as well as economical consideration in design results in feasible design also depends on location of respective sites. Solar panel covering canals analyzed with respect to effect of evaporation, water quality-quantity variables on power production with the mathematical model. es Optimizing technique applied on this model and found the optimum conditions with the same [4]. Dissolved oxygen concentration, algae, nutrients, and pH of the water were investigated under water quality variables. Result from this model provides the most favorable covering percentage of the canal's area that would lead to minimum evaporation volumes, maximum power, and yet preserving and meeting the standards of the water quality variables of the covered waterway [4].

Table 1. Application wise Solar energy generation in year 2021-22 (Ministry of new and renewable energy, government of India)

State	Solar Power - Ground Mounted (MW)	Solar Power - Roof Top (MW)	SPV Systems (Off-grid) (MW)	Total Solar Power (MW)
Rajasthan	11493.75	748.44	322.68	12564.87

Karnataka	7213.26	347.24	30.31	7590.81
Gujarat	5333.67	1805.33	41.03	7180.03
Tamil Nadu	4679.53	333.61	54.04	5067.18
Telangana	4277.97	233.80	8.71	4520.48
Andhra Pradesh	4149.29	149.13	88.34	4386.76
Madhya Pradesh	2459.02	177.29	81.64	2717.95
Uttar Pradesh	1851.50	258.78	134.15	2244.43
Maharashtra	1646.24	942.05	42.73	2631.02
Punjab	828.58	222.51	48.98	1100.07
All states	10147.57	2205.96	406.98	12760.51

Solar panel covering canal provides two applications renewable energy generations and saving water loss through evaporation from canal [5-6]. Evaporation is a complex process and plays a critical role in water resources management. The reservoir “Nath Sagar” is located in Marathwada Region of Maharashtra state of India. The evaporation from this reservoir studied with four evaporation models [6]. These four evaporation models are Penman, Priestly-Taylor, De Bruin, and Harbeck. They evaluated these four models to predict the evaporation, metrological data were the inputs to the model. To evaluate the accuracy of the proposed models they used Root Mean Square Error (RMSE), Mean Bias Error (MBE) and coefficient of determination (R²). With evaluation they published that the De Bruins model to be the best model for evaporation prediction with a coefficient of determination (R²) of 0.92 and the root mean square value (RMSE) of 0.865 and the mean bias error (MBE) of -0.35 for this Nath Sagar Reservoir of Maharashtra.

From published reports it is found that, ten-megawatt plant has preserved 16 hectares of land and might prevent 90 million liters of water from evaporating every year. In addition, the lower temperatures cause by the water bodies below the canal-top plants boosting panel efficiency by around 2.5 – 5%. However, there are certain disadvantages. The expense of constructing canal-top solar plants is greater than that of traditional solar plants. Since the water below raises the threat of corrosion, the supports must be galvanized with a defensive zinc layer.

To reduce their dependence on the monsoons, India’s farmers have taken 12 million electricity connections and 9 million diesel pump sets with which they pump up groundwater for irrigation. Although agriculture’s share of India’s economy is declining—it contributes to less than 15% of India’s GDP—it still employs 50% of the country’s workforce. Not surprisingly, perhaps, up to 20% of all the electricity used in India is for agriculture, mostly for irrigation. In some states, this can account for as much as 30-50% of all the electricity used in the state.

CANAL WATER PRESERVATION WITH SOLAR ENERGY

Canal water preservation with solar energy is an innovative approach adopted by India to provide a renewable energy source for farming activities without consuming agricultural land. As India’s large canal systems have mini hydel plants on the canal with grid access in place easy solar panel grid possibilities are possible. The potential from canal-top solar plants is significant at a minimum of 10 GW solar power generation, considering installation atop major canal systems in India [2]. Ten major canal systems in India covering a length of about 10,097 km are possible for canal-top solar installation. With a potential 10 GW of canal-top solar panels around 40000 acres of land can be saved as same area is used for both applications [2]. More or less 2-3 MW power generation for every km of the canal, assuming 15-20metre canal width, even if 50% of this canal length (about 5000 km) is usable. That gives us solar power systems that can be installed saving more than 40,000 acres of land [2]. Apart from this, covering the canal with PV panels also leads to canal water savings as shading provides a cooling effect and reduces the water loss due to evaporation [1-3].

Gujarat Project work of Solar panels on Narmada River

When the man-made Narmada Canal was developed, the people of Gujarat finally had reliable access to water. Sustainable reliable power to the rural areas while conserving water by preventing evaporation around in 2010 was tried in Gujarat. One example of renewable electricity at the same time water preservation was developed with Narmada canal and in working condition. Narmada Canal with solar panel covering gave advantages like renewable energy availability with conserving water loss on same land area, nil carbon emission and several rural developments. Narmada Canal covered with solar panels.

Sun Edison’s leadership developed this solution, solar panel covered canal that would deliver renewable electricity and

water. This design proved to be unique by Sun Edison team. Their first thought was to model the project after an existing floating solar farm in California's Napa Valley (US) where moored panels float on pontoons. But as vital as water is to the people who live and farm along the canal and its 19,000 km of branches, the authorities did not want to risk the panels disrupting water flow and rejected that idea. They need a power plant that spanned the canal but did not touch the water. Site selection was a critical aspect. The main canal is too wide to build a spanning plant, so the engineering team looked at the narrower branches of the canal for possibilities. They also wanted a location near a city with reliable roads, access to a grid (to evacuate the power) and a north-to-south orientation (to ensure the best sunlight exposure). After presenting three options to the Minister, the current site near Sanad was selected. What was originally a 250 kW pilot project became a 1MW project with confidence in the lifelong benefits it would deliver. Unlike ground-mounted systems where there is one support in place every three meters, the 16-meter spans of the Narmada Solar Energy.

Plants have one center support and connect to the canal banks. The spans are built in sections referred to as blocks. There are eight blocks in total and 226 MEMC 280 W Silvantis™ Solar Modules covering nearly 1 KM of canal. In the center of the span there is an opening to allow maintenance access to the canal. The blocks are designed with walkway and 15 meters of separation to allow workers access to clean the panels. The construction of the plant involved the efforts of civil engineers to design the support system, electrical engineers to design the power plant, a manufacturing firm to build the supports and a construction firm to build the structure.

Capacity installed: The idea of canal-top solar in Gujarat was started at Chandrasan village, about 45 km from Ahmedabad. This was stated with the 1 MW PV plant on a 750 m stretch of Sanand branch canal. This was developed by Gujarat State Electricity Corporation Limited with support from the Sardar Sarovar Narmada Nigam Limited. Encouraged by the project's success, Ministry of New and Renewable Energy (MNRE) launched a pilot-cum-demonstration project scheme to develop an aggregate 100 MW of grid-connected solar PV power plants on canal banks and canal tops through state-run agencies [2].

Installation: Canal-top projects cost more than normal ground-mount and floating solar PV plants as these require a significant structure to span the canal to support the panels. While land-based installations cost around INR 3 crore / MW, the cost for canal-top installation could be INR 4.5-6 crore/MW depending upon canal width [2].

The main component that makes the difference is the support

structure. The structures could be installed end-to-end or without touching on the ends of the canals. In the latter approach, piers are installed within the canals and panels mounted such that these don't touch the end of the canals so that the canal ends are not disturbed. For wider canals, such as those in Punjab, it's important to install piers within the canals. Till date, this is the widest canal-top installation in India with a width of 35 metres and no piling done inside the canal. Another approach is to use suspension with high tensile steel to mount the modules in Uttarakhand.

The other designs can be putting support during the construction phase of the canal itself. If the canal-top is planned at the time of construction of canals, it can help reduce in capital cost and solve both the purpose of generation of electricity and saving water [2].

Canal-top installations in India use polysilicon module technology due to its better cost economics. The cost of structures for canal top in itself is high, so using a commercially viable technology makes better sense. The overall structure's weight reduction result in higher cost due to light weight materials cost.

Challenges: Everywhere not same width canals are possible. Depending on water demands and land availabilities designs are different. Therefore too wide or too narrow canals pose a challenge to designing an efficient and cost-effective system. The support structure goes up by quite high as the span of the canal increases. In case of ground based solar panel project three to four meter span between columns installation. In case of canal- roof solar panels project quiet high range of span to deal with as more than 15 meter canal widths. Not only canal widths but running water also pretence challenges. Installation of solar PV panels and system with running water in the canal poses higher safety issues than ground-mount or floating solar power plants. Further, the support structure must allow access to the canal and not impact the canal and canal lining. Module cleaning and operation and maintenance could also be a challenge considering access to panels.

ESTIMATION OF FEASIBILITY FOR NASHIK LEFT BANK CANAL IN MAHARASHTRA

For cost comparison study we considered various Indian as well as international brands. We considered solar canals over Nashik left bank canal in Maharashtra for cost comparison. A Trapezoidal Unlined Canal section was considered for average meteorological values during the span of 7 Days the flow of water is assumed to be flowing at equal discharge and equal height. Canal dimension considered is 4.2m top width; 3m base width; 3.6m canal water surface width; 3m

height of canal; 1.5m height of water level; 1000m length of canal. Canal water surface area is 0.36 Hectare and Canal top Area is 4200m². Total canal volume of flowing water is 4.95 ML. Solar panel covering Nashik left bank canal is shown in Figure 2.

Evaporation with 30°C water temperature, 50% relative humidity and 12 km/hr wind velocity at 1m above ground was evaluated with Meyer's Formula [6-7]. The mean barometric reading assumed to be 750 mm of Hg. Thus total evaporation volume found 0.2 ML/week in 7 days from 0.36 Hectares of surface area with open canal. If we cover canals with solar panel the evaporation volume will be around 0.08 ML/week. This is around 40% of the uncovered canal [8-9]. With solar panel covered canal results achieved are ,

- Saved Water of about = 1,17,000 L / week
- Total Green Energy generated = 350 Kw / day
- Saved Land = 1.03 Acres.

Table 2. Solar panel cost comparisons

Pointers	Vikram Solar	Luxra	Canadian	Jinko	Trina
Cost	20/wp	20/wp poly mono-22/wp	23.50/wp	24-25/wp	24-25/wp
Capacity and Energy Generation	300wp to 350wp or Energy gen:3.5kwp	325wp in poly, mono-335-370wp	360-400wp	360-400wp	350-400wp
Durability	25	20years	25	25	25
Size and Dimension	1960*990*35	1975*990*35	1960*990*35	1960*990*35	1975*990*35
Country of origin	India	Germany	Canada	Japan	China

CONCLUSION

The generation of renewable energy with solar panels covering man-made irrigation canals is the highly efficient effort in India started in the state of Gujarat. Not to neglect that these bodies of water are man-made at the same time the innovated part do not host or disturb wildlife. With solar panel covering the manmade canal is reducing water evaporation from canal and not harming natural habitats, ecosystems as well as natural rivers. At the same time the canal running water further serves to cool the solar panels, preventing overheating and lending an average efficiency increase of 2-5% power generation. The main innovation was towards reduction in evaporation loss by providing shade from the sun's heat. The over-canal solar panels benefits show the reduced evaporation and the inherent energy generation. With feasibility we conclude that,

- We can save water from evaporation as well as save land, carbon emission and many other benefits.

- Carbon Emission Reduction= 1050 kg / day
- Carbon Credits Generated = 32.67 Equivalent



Fig. 2. Solar panel covered canals images

With respect to capacity to generate electricity, dimensions of parts, area of solar panel cost comparisons is done and presented in table 2. Also few parameters are considered like, durability, technology, amount of water restricted from getting evaporated, amount of costly land saved for solar application , best and most efficient solar panels available in the market for this project.

- We can generate maximum amount clean renewable energy and we should reap maximum benefits from these sources.
- The canal top solar power plant is an innovative idea that efficiently utilizes land and conserves water.
- It provides a better administrative model for smart village, smart city, and irrigation projects. Further, it can be developed under the public private partnership (PPP) mode. With declining cost trends, canal top projects are expected to acquire a larger share of national solar targets.
- Large capacity canal top solar parks may offer faster and more economical deployment of solar power projects in India.

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Experimental Investigation of Mechanical Properties of Polypropylene on adding Additive

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ABSTRACT

This paper outlines a proposed investigation into the effects of incorporating Bio degradable additive, containing bio-based additives, on the mechanical properties of polypropylene (PP). The study aims to provide valuable insights into potential enhancements and modifications of polypropylene's mechanical characteristics through the integration of Poly-Bio master-batches. This study will contribute to the development of sustainable alternatives with enhanced mechanical performance, providing a foundation for future research and industrial applications.

KEYWORDS: Bio degradable additive, Mechanical properties, Testing methodologies, Optimal concentration, Bio-degradable plastics.

INTRODUCTION

Plastics, synthetic or semi-synthetic materials, are essential in modern life due to their versatility and numerous beneficial properties such as being lightweight, strong, flexible, and cost-effective to produce. Historically made from fossil fuels, newer plastics are increasingly derived from renewable resources. From 1950 to 2017, approximately 9.2 billion tonnes of plastic were produced, with over half since 2004. In 2020, global plastic production reached 400 million metric tonnes, and projections suggest it could exceed 1,100 million tonnes annually by 2050 if current trends continue. [1]

Primary applications Packaging: Dominates plastic use in both industrialized (33%) and developing (42%) countries.

Construction: Includes items like piping and vinyl siding.

Automobiles: Up to 20% plastic, including dashboards and bumpers.

Medical: Equipment and implants. [2]

Decomposition and Pollution: Plastics degrade primarily through photo-oxidation, with varying rates depending

on their chemical composition. Marine environments see slower breakdown due to conditions like salinity and water temperature. Micro-plastics are a significant concern, affecting both marine and terrestrial ecosystems. Harmful effects of Poly-Propylene are Non Bio-degradability, Wild life hazards, Pollution. Polypropylene is a crucial component in the automotive industry, particularly for battery casings. The global market for polypropylene battery casings is expected to grow significantly, driven by the rise of electric vehicles and renewable energy storage systems.

Plastics, especially polypropylene, are indispensable in various industries but pose significant environmental challenges. Efforts to mitigate plastic pollution include developing bioplastics and enhancing public awareness. Polypropylene's role in manufacturing, especially in the automotive sector, highlights the need for sustainable practices and innovative solutions. This comprehensive overview provides a detailed understanding of the production, applications, types, and environmental impact of plastics, with a focus on polypropylene, setting the stage for further research and potential solutions to the challenges posed by plastic pollution.[3]

LITERATURE REVIEW

The literature review is acknowledged in the following areas: new developments in biodegradable plastics, biodegradable plastic applications, different substitutions for traditional plastics, and the production of plastic from organic waste. Effect on mechanical properties of polypropylene. The area of study for converting current non-biodegradable polymers to biodegradable plastics is further studies for their changed mechanical properties. According to Gan et al The negative environmental impacts of traditional, non-biodegradable plastics and the advantages of biodegradable polymers in terms of their strength and adaptability were discussed.[4] According to Amzan et al PP, which makes up 16% of the global plastics industry, is a material that is frequently used to create finished goods for consumers, including plastic packaging. Since just 1% of plastic bottles are recycled once they are purchased, a significant amount of plastic ends up in landfills. Major cause of pollution so can be Bio-degradable solution should be proposed to reduce harmful effects of landfilling of Polypropylene.[5] According to Jessica et al evaluation of degradation of Polypropylene with commercial additives are studied.[6] According to Abdel et al In this research paper, biodegradable polymers, treatment, composites, blending and modeling are studied. Environmental fate and assessment of biodegradable polymers are discussed in detail.[7] According to Aya et al biodegradable polymers, treatment, composites, blending and modeling are studied. Environmental fate and assessment of biodegradable polymers are discussed in detail.[8] There is a scarcity of literature on the mechanical properties of polypropylene blended with biodegrading additives. This research aims to prepare biodegradable blends with 2.5% and 7.5% additives by weight in polypropylene and investigate their mechanical properties compared to existing polypropylene.

Biodegradable Plastic for Battery Case Material: A notable gap exists in the research on using biodegradable plastic as a battery case material. The addition of additives to existing thermoplastic polymers to create biodegradable battery cases presents a significant opportunity.

Mechanical Characteristics of Polypropylene Blends: Limited research has been conducted on the mechanical characteristics of polypropylene blended with additives. Most research focuses on biodegradable polymers from plant and animal-based products, which are challenging to manufacture and implement.

Blending Existing Non-Biodegradable Polymers: Few researchers have investigated blending existing non-biodegradable polymers with additives to make them biodegradable. The major research objective in this field is

to develop or enhance biodegradable polymers to improve properties like mechanical strength and flexibility. This research aims to address these gaps by producing and testing blends of polypropylene with biodegrading additives to assess and compare their mechanical properties.

METHODOLOGY

Manufacturing of Polypropylene and Biodegradable Additives Blend Specimens is as follows.

Raw Material Preparation

Polypropylene (PP): Obtain high-quality PP granules.

Biodegradable Additives: Procure the specific amount required for the blend.

Blending

Weighing: Accurately weigh the PP and biodegradable additives according to the desired blend ratio.

Mixing: Use a high-speed mixer or a tumbler mixer to ensure uniform distribution of the biodegradable additives in the PP granules.

Drying

Pre-Drying: Pre-dry the blend to remove any moisture using a dehumidifying dryer at around 80-90°C for 2-4 hours, depending on the manufacturer's recommendations.

Injection Molding Machine Setup

Machine: Use a horizontal injection molding machine.

Mold: Install the appropriate mold for producing standard specimens (e.g., ASTM D638 Type I for tensile testing).

Process Parameters

Temperature Settings: Feed Zone: 180-200°C Compression Zone: 190-210°C, Metering Zone: 200-

220°C, Nozzle: 210-230°C, Mold Temperature: Set between 30-60°C, based on specific material requirements.

Injection Molding Process

Injection Pressure: Adjust the injection pressure (typically 60-100 MPa) to ensure proper filling of the mold.

Injection Speed: Set the injection speed to balance between minimizing shear stress and ensuring complete mold filling.

Holding Pressure: Apply holding pressure (typically 50-80% of injection pressure) to compensate for shrinkage.

Cooling Time: Set an appropriate cooling time to solidify the part without warping (typically 20-60 seconds, depending on the part thickness).

Specimen Ejection and Handling

Ejection: Carefully eject the specimens to avoid damage.

Post-Processing: Inspect the specimens for any defects such as flash, sink marks, or warpage.

Testing and Quality Control

ASTM Standard Compliance: Ensure specimens conform to relevant ASTM standards (e.g., ASTM D638 for tensile properties, ASTM D790 for flexural properties).

Conditioning: Condition the specimens as required by the specific ASTM standard (e.g., 23°C and 50% relative humidity for 48 hours).

Documentation and Record-Keeping

Batch Records: Maintain detailed records of the material batches, blending ratios, process parameters, and any deviations.

Test Reports: Document the test results and ensure they meet the required specifications.

Key ASTM Standards for Reference

ASTM D638: Standard Test Method for Tensile Properties of Plastics.

ASTM D790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

ASTM D1238: Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.

This detailed guide outlines the steps involved in manufacturing polypropylene and biodegradable additive blend specimens according to ASTM standards using a horizontal molding machine.

EXPERIMENTAL WORK

This Paper presents the experimental procedures and results of a paper aimed at enhancing the biodegradability of polypropylene by adding various concentrations of biodegradable additives. The paper involved conducting a series of tests, including Tensile Strength, Izod Impact, and Flexural Test, according to ASTM standards. The data collected from these tests will help determine the optimal percentage of additives for improving the biodegradability of polypropylene without compromising its mechanical strength. Tensile test Report on Bio composite Plastics (ASTM D790)

Introduction: The purpose of this report is to present the results of the tensile tests conducted on bio composites in

accordance with ASTM D638 Type IV standard. The tests were performed using a Universal Testing Machine with a crosshead speed of 50mm/min. The specimens used in the tests were dumbbell-shaped, with overall dimensions of 165 mm × 19 mm × 3 mm.



Fig. 1: Tensile Specimen ASTM D638

- Test Procedure UTS (ultimate tensile strength) :

Polypropylene samples were meticulously molded using an injection molding machine

This process adhered strictly to ASTM standards, ensuring consistency and precision in sample preparation for subsequent mechanical property testing.

The ensuing variables were assessed and examined:

UTS (ultimate tensile strength): The highest stress a material can bear before failing is represented by its ultimate tensile strength. It is a vital factor in determining how strong a material is.

Yield Strength: The tension at which a material starts to bend plastically is known as the yield strength. It denotes the material's resistance to long-term deformation.

Elongation at Break: The material's ductility and capacity for deformation before to failure are shown by the elongation at break.

In conclusion, the tensile tests conducted on the bio composites in accordance with ASTM D638 Type IV standard were very helpful in revealing the mechanical characteristics of the substance. The findings showed that the composite materials have a high ultimate tensile strength of 20.53 MPa for 7.5% additives and 21.84 MPa for 2.5% additives. The material also demonstrated good ductility, as shown by its 141% for 7.5% additives and 119% for 2.5% additives elongation at break. These results suggest that the bio composites are appropriate for uses that call for both strength and flexibility.

- Flexural Test Report on Bio-composite Plastics (ASTM D790)

Introduction: This report's objective is to describe the results of a flexural test on bio-composite plastics that was carried out in accordance with ASTM D790's recommended test procedure. The test was designed to evaluate the bio-composite material's flexural characteristics, such as flexural strength and flexural modulus. Experimental Details:

Material: The bio-composite substances used in this test were polypropylene with 2.5% and 7.5% additives. These combinations were chosen for their potential to enhance the biodegradability of the polypropylene while maintaining its mechanical strength.

Preparation of Specimens: The bio-composite materials were created into standardized test specimens in accordance with ASTM D790's guidelines. The specimens were of a size 127mm × 12.7mm × 3mm. The total number of specimens prepared for testing was 10, 5 for each additive concentration.

Depending on the properties of the material, a three-point bending arrangement was employed for the loading configuration. The load was applied by the test device at a predetermined pace, and the resulting deflection was measured.

Observations and Discussion Curves for Load-Deflection: Data on load and deflection were gathered for each specimen during the flexural test. The relationship between applied load and deflection for the bio-composite materials was depicted by the load-deflection curves.

Flexural Strength: The maximum stress a material can sustain before breaking is represented by flexural strength, commonly referred to as rupture modulus. It is computed by dividing the greatest load observed during the test by the specimen's cross-sectional area. The materials' average flexural strengths were determined as 28.76 MPa for the 2.5% additive and 25.88 MPa for the 7.5% additives.

- Izod Impact test on Bio composite Plastics (ASTM D256)

This study intends to explain the Izod test that will be carried out in compliance with ASTM D256 standard. The impact resistance or toughness of a material, particularly plastics, is assessed using the Izod test. The rules and requirements for carrying out the Izod test are provided by ASTM D256.

Test Method

Resources: The substance on which the Izod test will be performed must be mentioned in the test plan. It is significant to remember that a variety of materials, including thermoplastics and thermosetting materials, can be tested using the Izod method.

Test Requirements: The Izod test shall be carried out in accordance with ASTM D256 requirements. This standard describes how to use a pendulum-style impact machine to test the impact resistance of plastics. It details the measurements of the specimen, the test parameters, and the computation techniques.

Testing Instruments: An Izod impact tester, also known as a pendulum-type impact machine, is necessary for the Izod test. This device has a striker that strikes the test specimen and a pendulum arm. To provide precise and trustworthy findings, the machine needs to be calibrated before the test.

Test Specimen: The ASTM D256 specifications shall be followed by the test specimen used in the Izod test. The specimen is often a rectangular sample with a notch that is designed to induce Test Procedure:

The Izod test follows the following general procedure:

Specimen Preparation: Prepare the test specimens according to the dimensions specified in ASTM D256. Ensure that the specimens are free from any defects or imperfections that could affect the test results.

Conditioning: Condition the specimens in the specified environmental conditions, such as temperature and humidity, as per the material requirements or any specific test conditions mentioned in the test plan.

Test Setup: Set up the Izod impact tester by ensuring the machine is properly calibrated and the striker and pendulum arm are in the correct position. Follow the manufacturer's instructions for operating the machine.

Test Execution: Place the test specimen securely in the fixture of the impact tester. Release the pendulum arm, allowing it to swing and strike the specimen at the notch. The impact will cause the specimen to fracture or break.

Recording Data: Measure and record the energy absorbed by the specimen during the impact. This can be obtained from the deflection of the pendulum arm or by using appropriate measurement devices provided by the impact tester. In conclusion, the Izod Impact tests conducted on the bio composites in accordance with ASTM D256 standard were very helpful in revealing the mechanical characteristics of the substance. The findings showed that the composite materials have energy lost per unit cross-sectional area at the notch of 26.98KJ/m² for 7.5% additives and 23.09KJ/m² for 2.5% additives.

RESULT

Tensile test Report on Bio-composite Plastics (ASTM D638)

This report's goal is to describe the findings from tensile testing on bio composites that were performed in compliance with ASTM D638 Type IV standard. A universal testing machine with a 5 mm/min crosshead speed was used

for the tests. Dumbbell-shaped test subjects with overall measurements of 165mmx19mmx3mm were used. Depicts following results.

Table 1. Tensile Test Result table

Material	Tensile Strength(MPa)	% Deviation from PP
Polypropylene	23	NA
PP with 2.5% additive	21.84	-5
PP with 7.5% additive	20.53	-10.74

Table 2. Elongation Result table

Material	% Elongation
Polypropylene	106
PP with 2.5% additive	119
PP with 7.5% additive	141

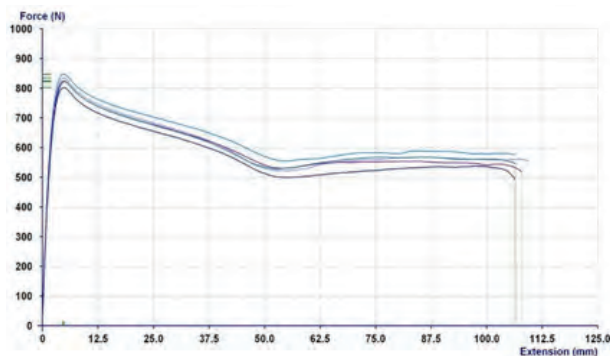


Fig 2 Graph from lab report for 2.5% additive

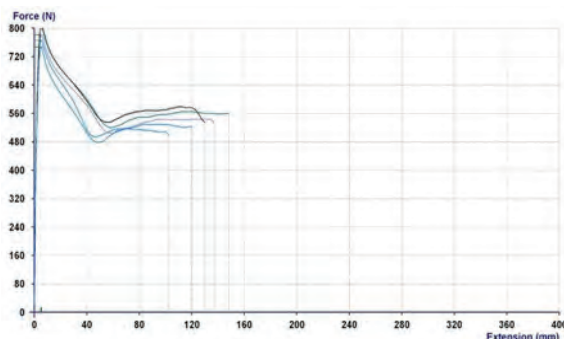


Fig 3 Graph from lab report for 7.5% additive

Following are the graphs of flexural test. The flexural test graph represents the relationship between the applied load and the corresponding deflection of the specimen. It illustrates how a material responds to bending forces and demonstrates its ability to withstand such loads before failure occurs.

Flexural testing

Flexural tests conducted conferring to standard ASTM D790, using a Universal Testing Machine. The support span of 48 mm and a crosshead speed of 2 mm/min were used while performing the test.

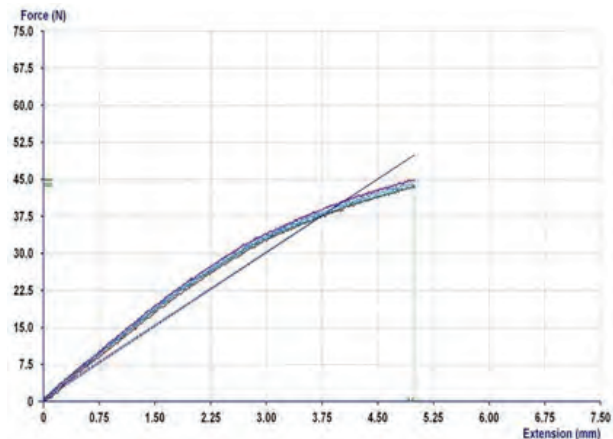


Fig. 4: Graph from lab report for 2.5% additive

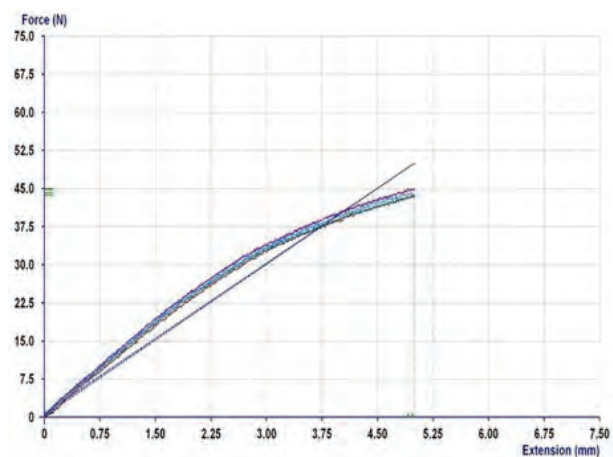


Fig. 5: Graph from lab report for 7.5% additive

- Izod test will be conducted conferring to ASTM D256 to find the impact properties of the specimens. The test will be performed on the Izod impact testing machine. The specimens of dimensions 64 mm×12.7 mm×3 mm will be tested.

Table 4 shows Impact Properties below:

Table 4 Impact Energy table

Material	Energy/ Thickness(J/m)	% Deviation from PP
Polypropylene	100	NA

PP with 2.5%		
additive	130.5	30.5
PP with 7.5%		
additive	139.9	39.9

Following is the comparisons of different mechanical properties of four blends.

Table 4: Impact Energy table

Test	PP	PP with 2.5% Additives	PP with 7.5% Additives
Tensile Strength(MPa)	23	21.84	20.53
Elongation(%)	106	119	141
Flexural Modulus(MPa)	1200	1048.4	957
Izod Impact	100	130.5	139.9

CONCLUSIONS

From the investigation of mechanical properties, it is found that:

- Tensile strength decreases by 5% for 2.5%additive and 10.74% for 7.5%additive.
- Flexural modulus decreases by 12.6% for 2.5% additive and 20.25% for 7.5%additive respectively.
- Impact strength of the blend material increases by 30.5% for 2.5% additive and 39.9% for 7.5% additive respectively.

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Experimental Investigation of Flexural Properties of Glass Fiber Material With Vacuum & Filament Winding Process

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ABSTRACT

Glass fiber reinforced composite materials are extensively used in HV & MV switchgear applications. Typically, these are used for the purpose of operating rods and for static insulation. Sometimes, these are also used for housing resistor blocks. These materials are subjected to considerable mechanical, thermal & electrical stresses. Their long-time behavior will directly impact the performance of switchgear in which they are used.

In this paper, experimental investigation of flexural properties of different kind of circular tubes made of glass fiber with vacuum process and filament winding process are discussed. Glass fibers are the most common of all reinforcing fibers for polymeric matrix composites (PMC). In the glass fiber, the polymeric resin act as matrix and glass fibers as the reinforcement medium. The principal advantages of glass fibers are low cost, high tensile strength, and excellent insulating properties.

Filament winding & vacuum method is a mostly used manufacturing technique for producing fiber-reinforced composite components used in the HV & MV applications. For the study purpose, the component developed & tested from both processes. The test samples were subjected to 3-point bending and tensile test to calculate the modulus of elasticity produced from both processes.

KEYWORDS: *Glass fiber, Flexural strength, Three point bending test, Electrical substation equipment, Filament winding, Vacuum process, Modulus of elasticity.*

INTRODUCTION

Composite materials are materials that mix two or more distinct components to get properties that aren't achievable with the matrix or fiber alone. Depending on the requirements of the application, each component has distinct selection criteria. The maximum working temperature of the composite is established by the matrix material, which also bonds the fibers and distributes loads and stresses among them. You will succeed if you follow these guidelines.

The classification of matrix materials into thermoplastics and thermosets is based on the necessary glass transition temperature. Applications for glass reinforced polymers (GFRP) are numerous in engineering. These composites' mechanical performance attributes include matrix stability

and strength, as well as fiber strength and Young's modulus. By choosing the right glass fiber compositions and orientations, GFRP composites with the required qualities and functional traits may be produced. These composites have steel-like qualities; they are somewhat less dense than steel but stiffer than aluminum [1, 3].

Composite materials are used in a wide range of industrial applications and have several unique features. Many different types of blades make up a sizable component of these materials. The primary prerequisites are attributes and usage circumstances. With the rapid expansion of the electrical sector, these kinds of materials appear to be used in an increasing number of electrical applications.

In the high voltage equipment's, the most common used composites are glass fiber and Aramid fiber for electrical

insulation purpose. The some of the examples of composite application in electrical industries are shown in Fig-1.



Fig. 1: Application of composite in electrical industry

For electrical industry application the modulus of elasticity (Flexural modulus) & short time dielectric strength is more important for the functional or application purpose. Flexural modulus is usually measured using volume extraction method, three point bending test & tensile testing method. In this paper the potential of glass fiber material with filament winding and vacuum impregnation method will be illustrated in the terms of mechanical properties. The information presented will give a comparison of both the process.

MATERIAL & MANUFACTURING METHODS

The Material selected for the presented study is Insulating tube which is used in electrical industry & is produced by different process and with glass fiber material. The Insulating tube is generally produced by vacuum impregnation & Filament winding methods. The choice of a composite material depends principally on the reinforcement type and fibers used. Orthotropic composite materials have mechanical properties that vary according to the direction.

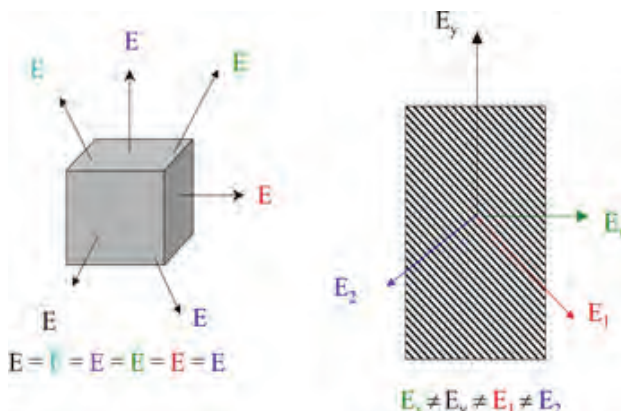


Fig 2: Isotropic Vs Orthotropic material

Glass Fiber-reinforced polymer composites

This matrix composite is composed of a polymer resin matrix and a glass fiber reinforcing medium. Due to their unique properties, these materials may be used in a wide range of applications. The typical range of fiber sizes is 3 to 20 microns. Because it can be readily pulled into high-strength fiber, glass is a commonly used fiber material. Of all the synthetic fibers, glass fibers are the most commonly employed because of their exceptional strength, durability, thermal stability, impact resistance, chemical resistance, friction resistance, and wear resistance. However, while operating on traditional machining methods, the machining of glass fibers is difficult, sluggish, and exhibits a shorter tool life [2,3].

Vacuum Impregnation Process

To remove trapped air, gasses, and excessive resin, a vacuum is drawn during the vacuum bag molding process. Nylon or polyvinyl alcohol (PVA) is evenly applied to the wet lay-up to form a non-adhering layer and vacuum sealed after the development of reinforcement and resin. A vacuum is created inside the mold as a result of the film being stretched firmly. After that, the composite is either cured or consolidated at room temperature or at a higher temperature. The composite layers underneath the underlay are compressed by atmosphere pressure, giving the laminate tubes a better level of look and quality [3].

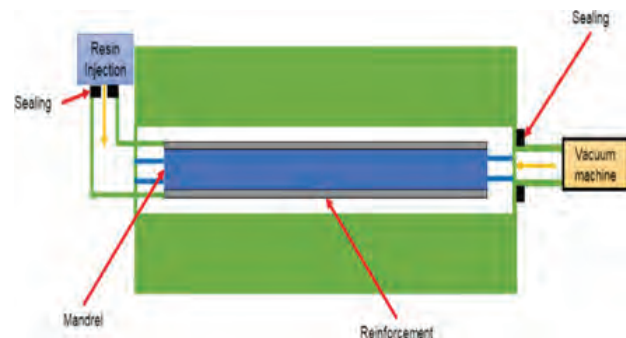


Fig. 3: Vacuum Molding process Advantages

1. Any fiber & matrix combination is possible
2. The surface finish of the product is with better quality
3. The simple design of the mold is required to produce the component

Disadvantages

1. The speed of the manufacturing is very low
2. The low pressure is required for vacuum creation

Filament Winding Process

The filament winding process is used primarily in the manufacture of pressure vessels or tanks, cylindrical parts

with open or closed ends. It involves winding filaments, under tension, around a rotating mandrel. The mandrel rotates about its axis while a carriage moves horizontally back and forth along this axis. Glass and carbon fibers are common examples of filaments. These fibers are first impregnated in a resin bath and then wound on the mandrel surface. After reaching the required thickness, the resin is cured (with the help of an oven or heating elements) while the mandrel is still in place. After curing, the mandrel is removed to obtain the hollow product. The process results in high-strength components since fiber loading is maximized and control over uniformity and fiber orientation is excellent [3].

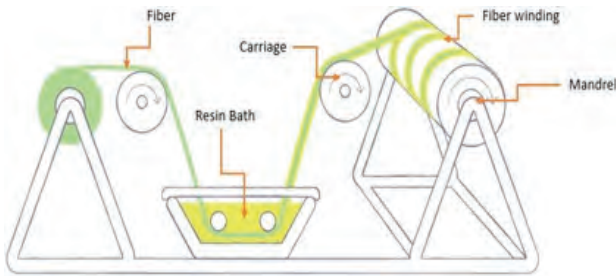


Fig. 4: Schematic Filament winding process

Advantages

1. The process is very fast and economical. Resin content can be controlled very precisely by metering.
2. Fiber cost is minimized since there is no need for a secondary process of converting the fiber to fabric before use.
3. Structural properties of the laminates are, however, excellent.

Disadvantages

1. The procedure is restricted to convex forms that may be joined to create components. It is not possible to lay fibers longitudinally.
2. High mandrel cost at first investment.
3. Unpleasant external surface results from component outside surface not being molded.
4. For the resins to penetrate, the spinning speed must be restricted.

METHODS FOR FLEXURAL MODULUS EVALUATION

The elastic modulus or modulus of elasticity of composite material which is being used in electrical equipment manufacturing industries can be calculated by the three different methods.

Volume Extraction method

The elastic behavior of a continuous and oriented fiber composite loaded in the longitudinal direction of the fiber. In this case, it is assumed that 1. the fiber–matrix interface bond is very good, so that the deformation of matrix and fibers is equal. The modulus of elasticity can be derived from the following formula,

$$E_{cl} = E_m V_m + E_f V_f \quad (1)$$

Where, E_{cl} = Modulus elasticity of Composite E_m = Matrix modulus. Elasticity

V_m = Volume of matrix

E_f = Fiber modulus of elasticity V_f = Volume of fiber

Table 1: Properties of fiber & resin [2]

	Young Modulus E , (GPa)	Tensile strength, σ_{TS} , (MPa)	Density ρ , (gm/cm ³)	Tensile strain, ϵ_t (%)
Fiber: E-class	73	2300-2500	2.6	1.5-2
Matrix : Epoxy resin	3.4	50-60	1.2	4-5

Tensile test

The material sample that is subjected to the tensile test with the UTM machine. The test specimen is made from the actual drive tube.

The known purpose of the tensile test is to measure the tensile strength and modulus of the composite material. However, with additional instruments, the axial Poisson ratio can also be measured. The standard specimen for tensile testing of continuous fiber composites is a flat, straight, hollow tube or cylindrical rod.

The sample is taken from a hollow tube with both ends connected with metal ends. The UTM is connected to both metal ends and is recommended for clamping the sample. It protects the sample from the load acting directly on the sample and damaging it. The load is therefore transferred to the specimen through the clamps. It also protects the outer fibers of the material. The metal ends can be made from a variety of materials, including steel, copper and aluminum. Details of the specimens and the tensile tests with the UTM can be found in Figures 5 and 6 [4,5].

Three point bending test

The beam is a tube sample and is simply supported near its ends. In three-point bending, the beam is loaded in the middle. Since there are three important points (two end supports and a

central load point) along the span of the beam, this method is called a three-point bending test.

In this test, a specimen with a tubular cross- section is placed on two parallel support pins. The load force is applied in the middle with the help of load jaws. The support pin and the loading jaws are mounted so that they can rotate freely around an axis that is parallel to the pin axis and the specimen axis [6].

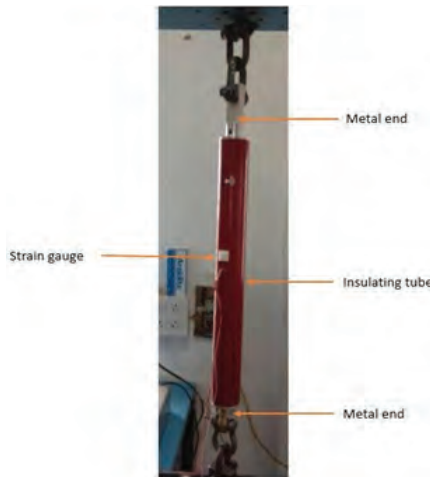


Fig. 5: Tensile testing of sample -on UTM

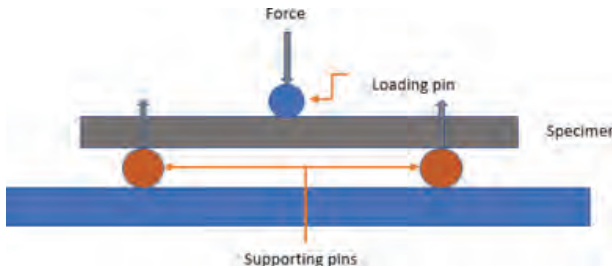


Fig. 6: Schematic of the Three-point bending test

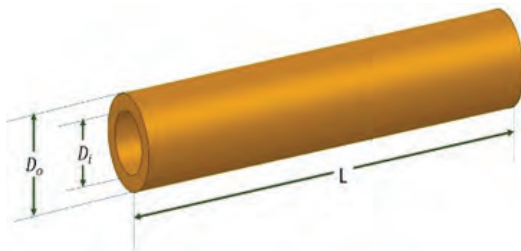


Fig. 7: Test specimen for 3-point bending

The three-point bending test generates a tensile stress in the outer fiber of the specimen and a compressive stress in the inner fiber of the specimen. This creates an area of shear stress along the centerline. The following figure shows the bending moment in relation to the different types of load.

$$\delta = \frac{Fl^3}{48EI} \quad (2)$$

$$\sigma_b = \frac{M}{Z} \quad (3)$$

Where,

F= Load applied on the center of beam

L= Span of the beam

E= Modulus of Elasticity

I= Moment of inertia

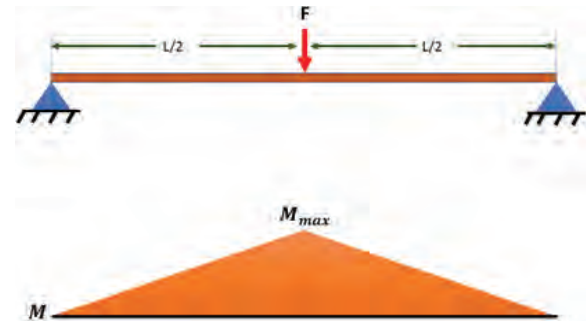


Fig. 8: Simply supported analogy for 3-point bending

RESULTS & DISCUSSIONS

The 3-point bending test were performed on the glass fiber samples made with vacuum & filament winding process. The test was done acc.to procedure defined in section 3.3. In the Fig. 10 actual setup picture is shown.



Fig. 9: Three point bending test on sample

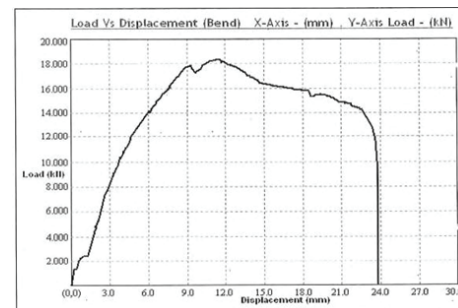


Fig. 10: Load Vs Displacement for sample 1 – GF with vacuum process

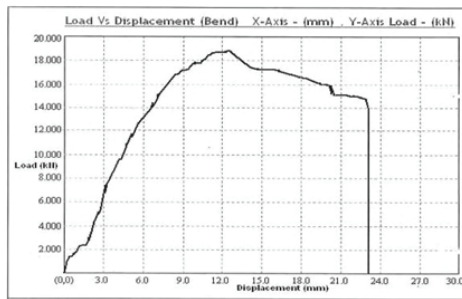


Fig. 11: Load Vs Displacement for sample 2 – GF with vacuum process

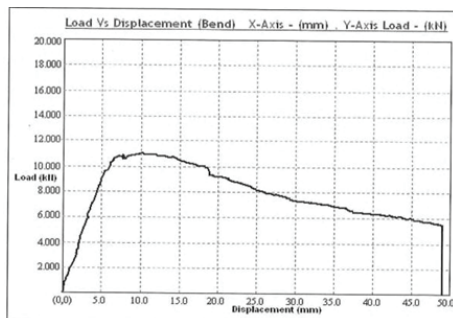


Fig. 12: Load Vs Displacement for sample 1 – GF with Filament winding process

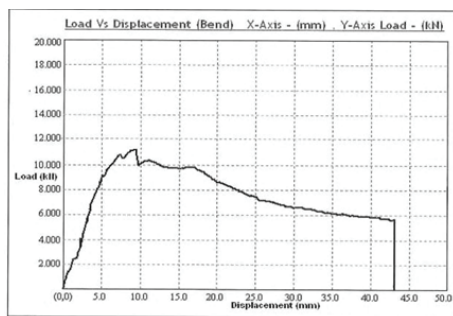


Fig. 13: Load Vs Displacement for sample 2 – GF with Filament winding process

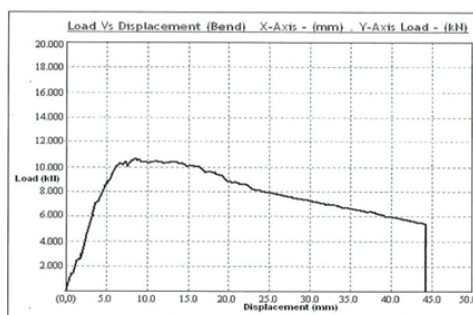


Fig. 14: Load Vs Displacement for sample 3 – GF with Filament winding process

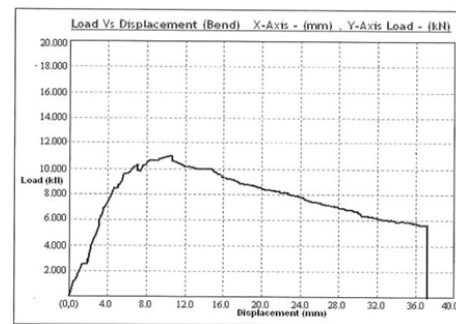


Fig. 15: Load Vs Displacement for sample 4 – GF with Filament winding process

From the 3-point bending test, we got the values of max. load and displacement at max. load. From that we have evaluated the Flexural modulus & values are plotted in the Fig.17.

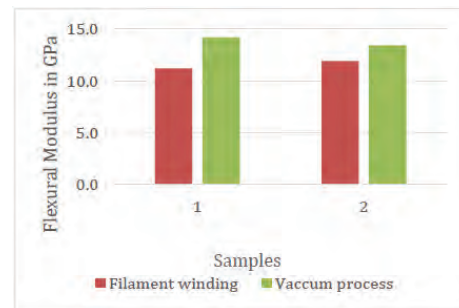


Fig. 16: Flexural modulus value for different samples with 3-point bending method

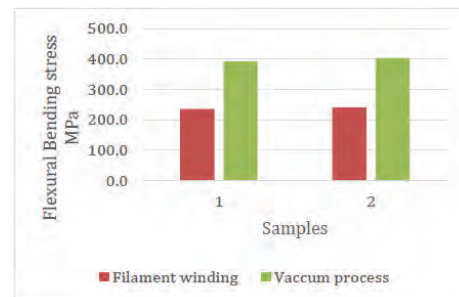


Fig. 17: Flexural Bending stress value for different samples with 3-point bending method

Filament winding process flexural modulus and stress is less comparing to the vacuum molding process. The reason for the less flexural modulus and stress is the filament winding process is not controlled and operation performed in ambient temperature.

The tensile testing was performed acc. to section 3.2 & data gathered regarding the load & strain values. From that modulus of elasticity were calculated & its value observed

was 24 GPa. The flexural modulus along the fiber direction and transverse direction varies due to the degree of anisotropy of continuous & oriented fiber composites.

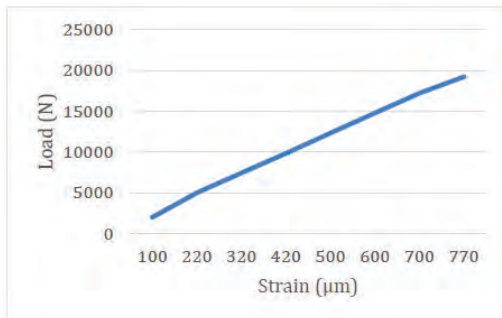


Fig. 18: Tensile testing on GF with vacuum process

CONCLUSIONS

In this paper mechanical properties such as Flexural bending strength & Flexural modulus of the glass fiber tube made with the vacuum resin transfer molding and filament winding process were compared. Various aspects of the glass fiber manufacturing with vacuum & filament windings process are also covered. It is possible to manufacture the composite material required for electrical industry with vacuum & filament winding process. With the proper care in the design and manufacturing, required performance parameters like short time dielectric strength, modulus of elasticity & tensile strength etc. can be achieved with vacuum & filament winding process with the same quality and reliability.

- Vacuum molding process results in higher and consistent Flexural modulus and Flexural bending stress values.

- Vacuum molding process consumes more time compare to the filament winding process consequently more expensive process.
- Filament winding process flexural modulus and stress is less comparing to the vacuum molding process
- The users should choose the process depending on the serviced technical requirements of the component under manufacture.

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Experimental Study on Mechanical Properties of Glass and Jute Reinforced Composites

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ABSTRACT

Composite materials are increasingly favored over conventional materials due to their enhanced mechanical properties and lightweight characteristics. Within composite materials, both the matrix and the reinforcement play pivotal roles: the matrix bears the load and transfers it to the reinforcement. Reinforcements may be synthetic or the natural fibers. Concerns over the environmental impact of synthetic fiber production have spurred recent research into natural fibers as reinforcements. This study investigates the incorporation of jute natural fibers alongside synthetic glass fibers for reinforcement. Epoxy resin is utilized to fabricate three types of composites: A111, B222, and C333. A111 consists entirely of glass reinforcement, comprising 68% with 12 layers of glass. In contrast, B222 features 43% glass reinforcement and 7% jute reinforcement, arranged in layers of G/G/J/G/G (one layer of jute, two layers of glass, and then two more layers of glass). C333 includes 31% glass reinforcement and 14% jute reinforcement, arranged in layers of G/J/G/J/G. Mechanical property testing according to ASTM standards demonstrates that as Mechanical properties likewise deteriorate as total reinforcement increases. When it comes to short beam shear strengths, B222 and C333 are comparable to A111 in terms of compressive strength.

KEYWORDS: *Natural fiber Composite, Elastic properties, ASTM testing, Jute.*

INTRODUCTION

Composite materials have become increasingly popular across a range of industries because of their superior mechanical qualities and lightweight nature compared to traditional materials. With a matrix designed to effectively distribute loads to the reinforcement, these materials are engineered to increase overall strength and durability. Both synthetic and natural fibers, such as carbon or glass, can be utilized as reinforcements in composite materials. Natural fibers come from renewable sources like plants and animals. Natural fibre-reinforced composites offer notable environmental advantages over their synthetic equivalents. To begin with, the production of natural fibers requires fewer chemicals and waste products than the production of synthetic fibers, which typically require petrochemicals. This reduction in the use of chemicals and waste production allows for lower environmental impact to be achieved throughout the material's lifecycle. Moreover, natural fiber

composites can achieve comparable performance to synthetic fiber composites with higher fiber content. By using a greater proportion of fibers, these composites reduce the amount of polymer matrix needed, which not only lowers material costs but also reduces the environmental footprint associated with polymer production. The lightweight nature of natural fiber composites is particularly advantageous in industries like automotive and aerospace, where reducing weight translates directly to improved fuel efficiency and reduced emissions. This aspect contributes significantly to environmental sustainability by lowering carbon emissions and promoting energy efficiency. Another environmental benefit of natural fibers is their potential for energy recovery through incineration at the end of their useful life. Unlike synthetic fibers, which can release harmful toxins when burned, natural fibers burn more cleanly and can even contribute to energy generation through controlled combustion. A vast variety of plant and animal fibers, such as wool and silk, as well as plant fibers like jute, sisal, flax, and banana fibers, are utilized

as natural fibers in composites. These fibers are selected according to their unique qualities; jute, for instance, is prized for its robustness, affordability, and biodegradability, which make it ideal for a range of structural uses. The integration of natural fibers into composite materials represents a significant step forward in sustainable engineering practices. Industries can improve the performance of their products and promote environmental stewardship by decreasing their dependency on synthetic materials and utilizing the advantages of natural fibers. As research continues to innovate in this field, the potential for natural fiber composites to replace traditional materials in a wide array of applications grows, promising a more sustainable future for industries and the planet alike.

LITERATURE REVIEW

Because of their advantageous mechanical qualities and environmentally beneficial traits, natural fibers have attracted interest in the field of soil reinforcement. Bordoloi et al. discussed the infiltration characteristics of natural fiber-reinforced soil, highlighting their potential in geotechnical applications [1]. Alkbir et al. conducted a comprehensive review on crashworthiness parameters and fiber properties of natural fiber-reinforced composite structures, underscoring their role in enhancing structural integrity [2]. Suresha et al. studied the impact of TiO₂ filler loading on the physical mechanical properties abrasion resistance of (jute fabric) reinforced epoxy composites, offering insights into material enhancement strategies [3]. Razera and Frollini explored composites based on jute fibers and phenolic matrices, focusing on their properties and application potential [4]. Amirabadi-Zadeh et al. developed silica-decorated graphene oxide nanohybrids as reinforcements for woven jute fabric-reinforced epoxy composites, achieving significant improvements in mechanical performance [5]. In their investigation of the high Cycle fatigue life of hybrid composites reinforced with jute fiber for axial flow fan blades, Chinta et al. demonstrated the robustness and appropriateness of these materials for demanding applications[6]. Wang et al. characterized KH-560-modified jute fabric/epoxy laminated composites, evaluating their surface structure, thermal behavior, and mechanical properties [7]. Thang and Huyen examined eco-friendly polymer composites using water hyacinth fibers, emphasizing sustainable alternatives and their application potentials [8]. Sultana et al. optimized the properties of jute fiber-reinforced concrete using response surface methodology coupled with the crow search algorithm, demonstrating effective modeling approaches for enhanced material performance [9]. Ighalo et al. reviewed recent advances in the treatment of natural fibers for reinforced plastic composites, providing a comprehensive overview of treatment methods and their impact on composite

properties [10]. Kandemir et al. explored natural fibers in aligned discontinuous polymer composites produced via the HiPerDiF method, highlighting their structural benefits and processing considerations [11]. Jiang et al. investigated the hydrolytic degradation behavior of poly(lactic acid) reinforced with short jute fibers, offering insights into the environmental durability of bio-based composites [12]. Phani Prasanthi et al. conducted an experimental and simulation study characterizing the mechanical properties of green natural reinforced composites, demonstrating their suitability for various engineering applications [13]. da Luz et al. provided an overview of graphene-incorporated natural fiber polymer composites, discussing their enhanced mechanical and functional properties [14]. In their review of the mechanical characteristics, processing variables, and trends of PLA composites reinforced with flax and jute fibers, Sanivada et al. highlighted developments in sustainable material solutions[15]. In the realm of construction materials, Zakaria et al. explored the potential of jute fiber reinforcement in concrete, emphasizing its benefits in enhancing structural durability and sustainability [16]. Liu et al. investigated enzymatic hydrophobic modification of jute fibers for composite reinforcement, presenting novel approaches to improving fiber-matrix interactions and composite performance [17].

METHODS

Composite Material Preparation

Choosing between Synthetic and Natural Fiber

Due to its availability and the variety of plants and animals in our surroundings, jute natural fiber was chosen for this study. Two canvas sheets were used for the study: one made of jute fiber and weighed 240 GSM (grams per square meter), while the other was made of glass synthetic fiber and weighed 360 GSM.

Chemical Treatment of the Natural Fibers

Researchers are looking into a number of treatments to improve the surface properties of natural fibers in order to enhance adhesion and compatibility with hydrophobic matrix materials and mitigate potential compromises in the mechanical properties of natural fiber-reinforced composites. Chemical bonds, molecular attractive forces, and mechanical interlocking are some of the factors that affect the bond between the fibers and matrix materials. Strong adhesion would ideally be facilitated by hydrogen bonds between the hydroxyl groups in the resin and the hydroxyl groups found in natural fibers. However, as water molecules occupy available hydroxyl groups on the fiber surface during curing, moisture can weaken this bond. This can leave voids in the

cured composite after the water evaporates. By removing bonding sites, proper drying of fibers prior to use helps preserve strong bonds and lowers subsequent moisture absorption. Alkalization, which involves treating natural fibers with KOH or NaOH, is a popular technique to reduce the amount of moisture that they absorb. Through the removal of exposed hydroxyl groups that have a tendency to form bonds with water molecules, this treatment lowers the fiber's capacity for hydrogen bonds. Additionally, it dissolves hemicellulose, which is the most hydrophilic part of natural fibers and reduces their capacity to absorb moisture. Studies reveal that when jute fibers are treated with 5% NaOH instead of 10% NaOH, the mechanical properties of the fibers in composites are better. To prevent ongoing reactions that may degrade fibers over time, thorough washing is essential after alkalization treatment. In this study, jute fiber canvas sheets were immersed in a 5% NaOH solution for 24 hours, followed by meticulous washing and drying in sunlight

Specimen Preparation plan

A111, B222, and C333 composites were the three varieties that were made. With the use of twelve layers of glass fiber sheets, A111 is made entirely of glass reinforcement. Glass and jute reinforcements are used in B222; they are layered in a G/G/J/G/G pattern, with two layers of glass fiber sheets coming first, then one layer of jute fiber sheets, and finally two more layers of glass fiber sheets. Glass and jute reinforcements are also included in C333, but they are arranged in a G/J/G/J/G layer configuration, with glass and jute layers switching places.

Composite Manufacturing

Hand layup was used to create the three types of laminated composites, A111, B222, and C333. Glass synthetic fiber sheets weighing 360 GSM and jute fiber canvas sheets treated with 5% NaOH were used as reinforcement. In a weight ratio of 100:90:2, epoxy resin (MY 740), hardener (HY-918), and accelerator (DY 062) were mixed together. The glass reinforcement sheets and jute reinforcement sheets were hand laid up, with epoxy resin placed in between each layer, in the desired order. The produced composites were then allowed to cure for a day at room temperature before being compressed for two hours at 120 degrees Celsius using a press machine. The composites were then pressed for a further two hours and allowed to cool naturally to room temperature.

Percent Reinforcement of fibers

The prepared composite A111 has dimensions of (420 x 430 x 3.2) mm and a mass of 1.14 kg. Twelve layers of glass fiber sheets, each weighing 360 GSM, make up this composite. One layer of glass fiber sheet has an area of (420 x 430) mm², or 0.1806 m². One glass fiber sheet's mass can be computed using the formula below:

The mass of one glass fiber sheet is equal to $\text{Area} \times \text{GSM} = 0.1806 \text{ m}^2 \times 360 \text{ GSM} = 65.01 \text{ g}$.

$\text{Area} \times \text{GSM} = 0.1806 \text{ m}^2 \times 360 \text{ GSM} = 65.016 \text{ g}$ is the mass of one glass fiber sheet.

With 12 layers in A111, the total mass of the glass fiber sheet reinforcement is as follows: The total mass of the reinforced glass fiber sheet is $12 \times 65.016 = 780.92 \text{ g}$.

A111's glass reinforcement percentage is computed as follows:

A111's Glass Reinforcement Ratio = $780.92/1140 = 68\%$

In a similar manner, the percentage of glass and jute reinforcement for B222 and C333 was determined. Table 1 displays the percentage reinforcement for each composite.

Table 1 Specimen Preparation

Composite Material	A111	B222	C333
Size of Sheet (mm)	420 x 430 x 3.2	330 x 370 x 2.7	350 x 390 x 2.76
Mass of Sheet (kg)	1.14	0.41	0.47
GSM of Glass sheet	360	360	360
GSM of Jute sheet	-	240	240
Percentage (%) Glass reinforcement	68	43	31
Percentage (%) Jute reinforcement	-	7	14
Total percentage (%) reinforcement	68	50	45

Testing of the Composites

The prepared composites A111, B222, and C333 were subjected to various tests following ASTM standards to evaluate their mechanical properties. Each test was conducted to assess specific characteristics of the composites, ensuring a comprehensive analysis of their performance.

Tensile Test

The ASTM D-3039 standard was followed when conducting the tensile test. The results of this test indicate the composite materials' tensile strength and tensile modulus. After specimens from the composite sheets were cut, they were put under a uniaxial tensile load until they failed. The material's stress-strain response, which sheds light on the material's resistance to tensile forces, was recorded in order to determine the tensile properties. Fig. 01 shows the Tensile Test Specimen after Test.

Compression Test

The ASTM D-3410 standard was adhered to when performing

the compression test. The composites' modulus and compressive strength are determined by this test. A universal testing machine was utilized to prepare the specimens and apply a compressive load to them. The way the composites behaved under compressive loads demonstrated their ability to withstand deformation and failure under compression. Figure 02: Compression Test Specimen following Test.



Fig. 1: Tensile Test Specimen after Test

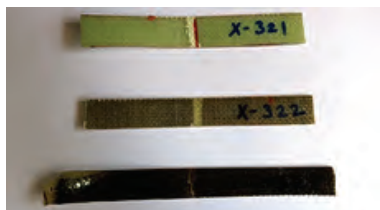


Fig. 2: Compression Test Specimen after Test

Flexural Strength Test

Using the ASTM D-790 standard, the flexural strength of the composites was ascertained. In this test, a supported beam specimen is loaded at its midpoint and kept there until it fails. The load-displacement data was used to calculate the flexural strength and modulus. The results of this test reveal the composites' stiffness and bending strength. Fig. 03 shows the Flexural Test Specimen after Test.

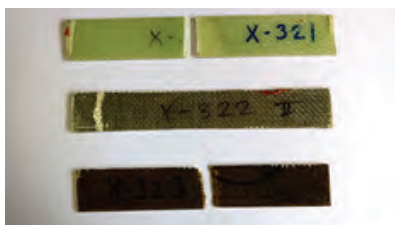


Fig. 3: Flexural Test Specimen after Test

Short Beam- Shear Strength Test

Using the ASTM D-2344 standard, the short beam shear strength was evaluated. A three-point bending load was applied to the specimens, and the maximum load at failure was noted. The inter-laminar shear strength of the composites is assessed in this test, which is essential for comprehending the quality of bonding between the reinforcement layers and the matrix. Fig. 04 shows the Short beam Test Specimen after Test.



Fig. 4: Short beam Test Specimen after Test

Density Calculation and Determination

The density of the composites was determined using the ASTM D-792 standard. This standard specifies the method for measuring the density of plastics by displacement. Specimens were weighed in air and then in a liquid of known density. The density was calculated using the difference in weights and the known density of the liquid. This test provides insights into the material's overall composition and uniformity. Table 2 shows the ASTM Standards for Tests.

Table 2 ASTM Standards for Tests

Test	ASTM Standard	Description
Tensile Test	ASTM D-3039	Measures tensile strength and modulus by subjecting specimens to a uniaxial tensile load until failure.
Compression Test	ASTM D-3410	Assesses compressive strength and modulus using a compressive load.
Flexural Strength Test	ASTM D-790	Determines flexural strength and modulus by applying a load at the midpoint of a supported beam.
Short Beam Shear Test	ASTM D-2344	Evaluates interlaminar shear strength using a three-point bending load.
Density Determination	ASTM D-792	Measures density by displacement, comparing weights of specimens in air and a known liquid.

RESULTS AND DISCUSSION

The mechanical properties of composite materials are crucially evaluated through ASTM standards such as D-3039 for tensile strength, D-3410 for compressive strength, D-790 for flexural strength, D-2344 for shear strength, and D-792 for density determination. These tests provide essential insights into how composites perform under various loading conditions, from tension and compression to bending and shear. Additionally, ASTM D-5630 assesses filler or ash content, crucial for understanding material composition. Together, these standards ensure reliable characterization of composite materials, guiding their application in diverse industries by ensuring performance consistency and durability. Fig 05 to 16 shows the load vs displacement plots of each test and each specimen.

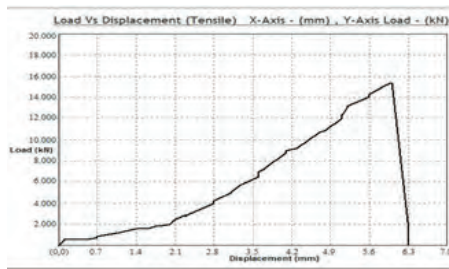


Fig. 5: A111 Tensile test

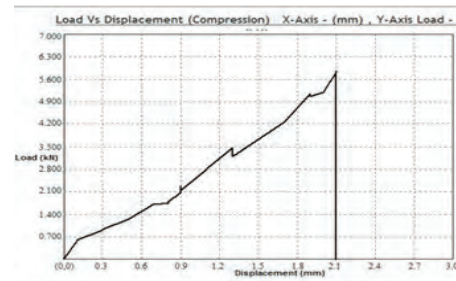


Fig. 10: B222 Compression test

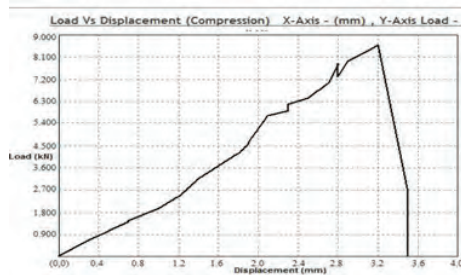


Fig. 6: A111 Compression test

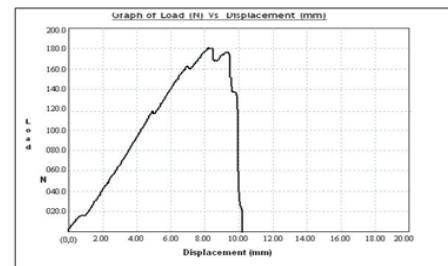


Fig. 11: B222 Flexural test

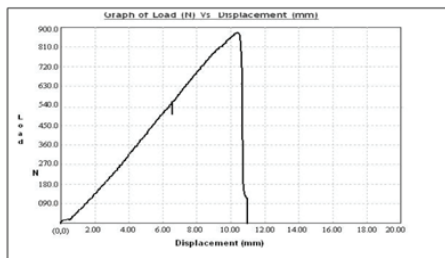


Fig. 7: A111 Flextural test

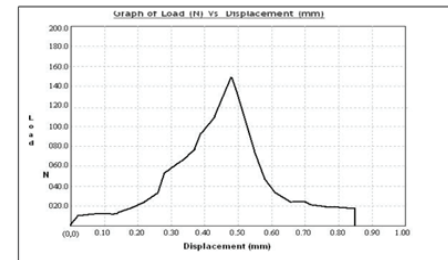


Fig. 12: C333 Short beam test

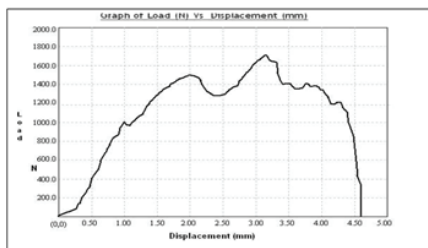


Fig. 8: B222 Short beam test

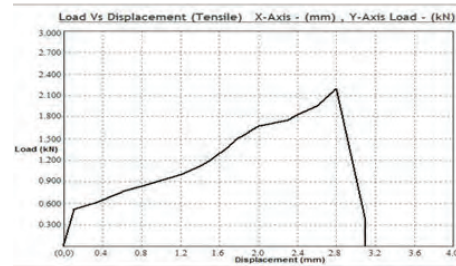


Fig. 13: C333 Tensile test

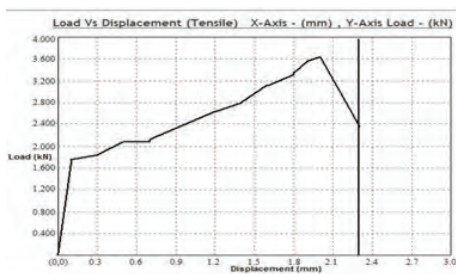


Fig. 9: B222 Tensile test

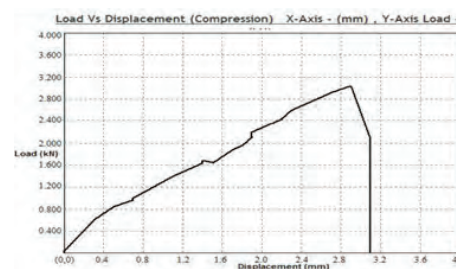


Fig. 14: C333 Compression test

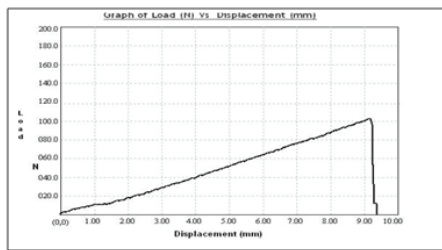


Fig. 15 C333 Flexural test

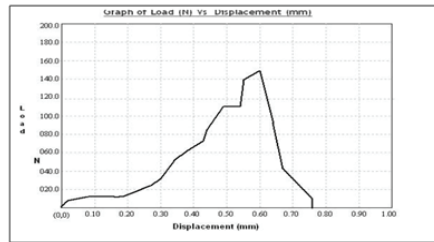


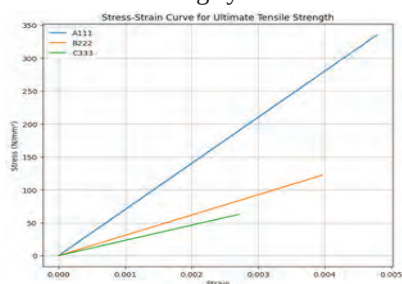
Fig. 16: C333 Short beam test

The filler or ash content of a material, as determined by the ASTM D5630 standard test method, is reported as 1.19%. This method is commonly used to quantify the amount of filler or inorganic residue present in plastics. The measured content of 1.19% indicates the proportion of non-combustible components, such as minerals or additives, within the material. ASTM D5630 is essential for assessing the composition and purity of materials, providing valuable insights into their chemical makeup and suitability for various applications.

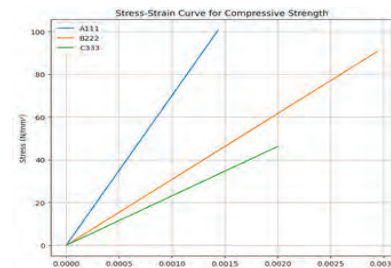
Table 3 Result Table

Composite Material	Nature of Composite (Arrangement of layers)	Percentage Glass reinforcement	Percentage Jute reinforcement	Percentage Total reinforcement	Ultimate Tensile Strength (N/mm ²)	Compressive Strength (N/mm ²)	Flexural Strength (N/mm ²)	Short Beam Shear Strength (N/mm ²)	Density (g/cm ³)	Short Beam Strength (N/mm ²)
A111	All Glass layers (12 number of Glass layers)	68	-	68	335.091	100.59	545.456	61.882	1.915	61.88
R222	G/G/J/G	43	7	50	122.074	90.691	197.378	8.077	1.345	8.07
C333	G/J/G/J/G	31	14	45	62.763	46.283	109.234	8.078	1.347	8.07

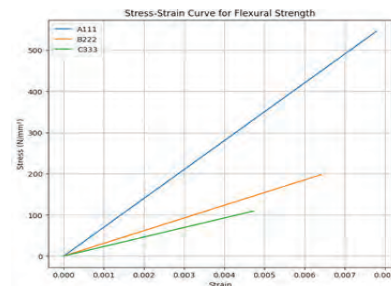
Stress strain curves for various tests are plotted based on readings obtained from testing system.



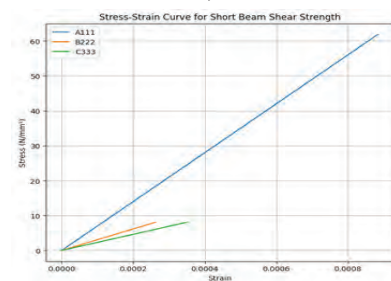
a)



b)



c)

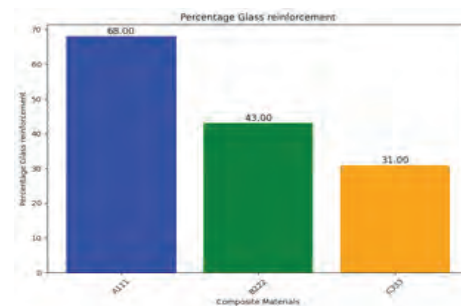


d)

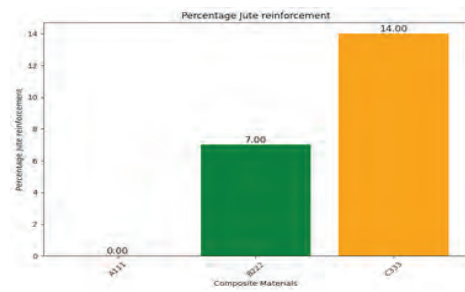
Fig. 17 Stress Strain Curves for a) Tensile Test b) Compression Test c) Flexural Test d) Short Beam Test

Figure 17 shows the Stress Strain Curves for a) Tensile Test b) Compression Test c) Flexural Test d) Short Beam Test

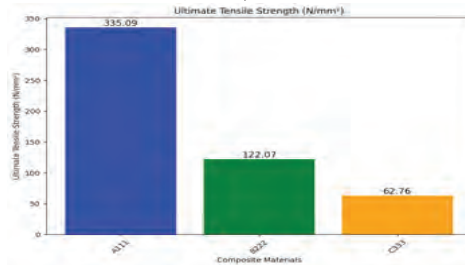
Fig 18 shows the Comparison plot of a) % glass reinforcement b) % jute reinforcement c) Ultimate tensile strength d) Compressive Strength e) Flexural strength f) Short beam test, g) Density



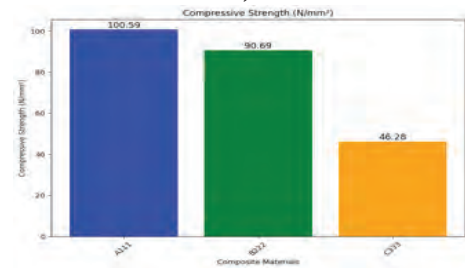
a)



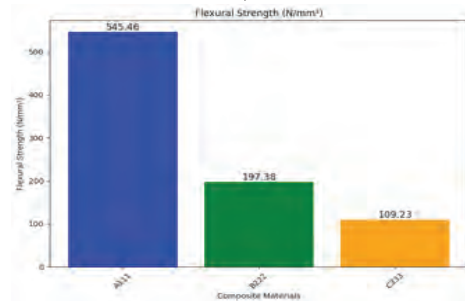
b)



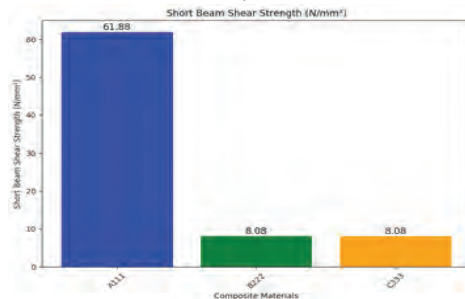
c)



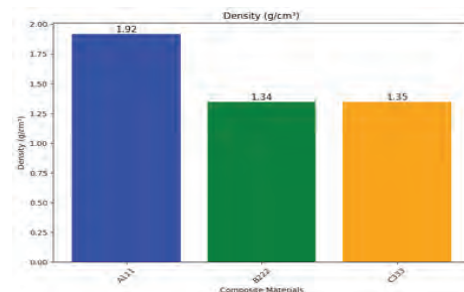
d)



e)



f)



g)

Fig 18 Comparison plot of a) % glass reinforcement b) % jute reinforcement c) Ultimate tensile strength d) Compressive Strength e) Flexural strength f) Short beam test, g) Density

The results from testing composites A111, B222, and C333 reveal distinct performance characteristics influenced by their reinforcement compositions and layer arrangements. A111, comprising solely glass layers in its structure, demonstrates the highest ultimate tensile strength at 335.09 N/mm², indicating robust performance under tensile loading. Its high percentage (68%) of glass reinforcement contributes to substantial mechanical strength across various tests, including compressive strength (100.59 N/mm²), flexural strength (545.4 N/mm²), and short beam shear strength (61.88 N/mm²). In contrast, B222 and C333, which incorporate both glass and jute reinforcements in different layer sequences, exhibit lower mechanical properties overall. B222, with a 43% glass and 7% jute reinforcement composition, shows intermediate results across tests, reflecting a balance between the strength contributions of glass and the added properties of jute. C333, with the lowest glass reinforcement percentage (31%) and highest jute reinforcement (14%), demonstrates reduced mechanical strength across all tests compared to A111 and B222, highlighting the trade-off between lightweight properties from natural fibers and the structural integrity provided by glass. These findings underscore the importance of composite design and reinforcement selection in optimizing material performance for specific engineering applications, balancing strength requirements with considerations for weight, sustainability, and material cost.

CONCLUSIONS

Three types of composites, A111, B222, and C333, were prepared with varying compositions of glass and jute reinforcements. A111, comprising 68% glass reinforcement across 12 layers, exhibited superior mechanical properties in terms of ultimate tensile strength, compressive strength, flexural strength, and short beam shear strength. As the percentage of glass reinforcement decreased in B222 and C333, mechanical strengths also decreased, highlighting

the impact of reinforcement composition on material performance. Specifically, B222, with 43% glass and 7% jute reinforcement, showed comparable compressive strength to A111 but with a lower density and environmental footprint due to its reduced use of glass layers and incorporation of jute. This suggests potential advantages for applications prioritizing both strength and sustainability.

In future applications, B222 could be considered for scenarios where its equivalent compressive strength to A111, coupled with its lower density and environmental benefits, make it a favorable choice. The study underscores the feasibility of using locally available natural fibers like jute as viable alternatives for reinforcement in composite materials, aligning with sustainable practices and potentially offering diverse engineering solutions.

ACKNOWLEDGMENTS

Thanks to Mr. Parijat Bhave of FAN Services Laboratory in Nashik and Mr. Pradeep Pingale of Om Industries in Nashik for testing the prepared composite in accordance with ASTM standards, the authors would like to express their gratitude.

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School Database Management System using MySQL

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ABSTRACT

The School Database Management System (SDMS) is a comprehensive webbased application designed to stream line the administrative processes of educational institutions. This system leverages the power of Java and MySQL to provide an efficient and user-friendly interface form an aging various aspects of a school's operations. This system incorporates a secure login system to authenticate users (e.g. administrators, teachers, students, parents) and grant access based on pre defined roles and permissions. The system allows for the creation, modification, and retrieval of student profiles, including personal details, contact information, enrollment status, and academic records. SDMS allows for the recording and monitoring of student attendance, providing reports and notifications for absenteeism or irregularities. The system supports the computation grades', assessments, and the generation of academic transcripts for individual students. Administrators and teachers can create, manage, and grade assignments and exams, while students can access their assessments and results. SDMS facilitates communication between parents and teachers through features like messaging, notifications, and progress reports. The system includes functionalities for tracking fee payments, generating invoices, and providing financial statement stop rents and administrators. SDMS offers various reporting capabilities, including student performance reports, attendance summaries, and financial statements, enabling data-driven decision-making. The application implements robust security measures to safeguard sensitive information and provides mechanisms for regular data backups. The use interface side signed with a clean and intuitive layout, ensuring ease of navigation for all stakeholders, including administrators, teachers, students, and parents.

KEYWORDS: Database design, MySQL, JAVA swing, automation, Transparency, Centralized data.

INTRODUCTION

A School Database Management System is an environment that manages all the data of the students who are studying in an educational institution. These students' data is computerized through an automated system.

The implementation of a School Database Management System has completely transformed educational institutions by simplifying administrative tasks, increasing the precision of data, and enhancing overall efficiency. This advanced solution provides a wide range of features that cater to the diverse needs of educational institutions. From student enrollment and attendance tracking to grade management and report generation, the system offers comprehensive capabilities that streamline essential processes. Its seamless integration and user-friendly interface empower educators to dedicate their time and energy to promoting student success and achieving academic excellence. By automating various processes and centralizing information, this system revolutionizes the way

educational institutions operate, creating a more streamlined and productive environment for both students and staff. With its robust functionality and innovative approach, the School Database Management System sets a new standard for educational administration and contributes to the continuous improvement of the learning experience.

In terms of efficiency, the School Database Management System offers a wide range of features that cater to the specific needs of educational institutions. For instance, the system allows for easy generation of reports. The automated School Database Management Systems are designed to efficiently manage and store crucial information utilized by various institutions, such as schools and colleges. The project, titled "School Database Management System," aims to assist schools and institutes in managing various student-related details. This system will aid the accounts department in maintaining fee-related information and basic details like security deposits and transportation fees. Additionally, it will

support the administration department in managing students' basic information and monitoring fee details. Primarily developed for school/institute authorities, this package streamlines tasks such as maintaining student personal details, academic details, daily attendance records, recording cash transactions, and printing receipts. By automating these processes, the package facilitates the administrative and accounts departments in managing students' personal and fee-related Information efficiently

LITERATURE REVIEW

The literature review encompassed a comprehensive examination of various sources, including research papers, publications, books, existing bibliographic information, and recommendations from the project panel. These research papers supplied ample data for the survey. Automation is the process of minimizing manual labor with the aid of computers, computer-operated software, and devices. Certain tasks beyond human capacities can be accomplished through automation techniques. An early example is the Library Automation System at the University of Toronto from 1963-1972 [1], a pioneering achievement managing data with an automated system. The primary objective of implementing automation is to enhance efficiency, reduce delays, increase production flexibility, lower prices, eliminate human errors, and address labor shortages with a high degree of accuracy[2]. The introduction of Automation in Educational Assessment in Nigeria[3] demonstrates how an online automation system can eliminate human errors and ensure fairness during exams. The challenges faced in transitioning from a paper-based system to an online automated system, as discussed in "Defining the Paperless Workplace with the Paper Metaphor" [4], highlight the struggle organizations face in bridging the gap between conventional and online systems. However, the "Automated Project Grading & Instant Feedback System" [5] provides an example of an automated system that enhances the efficiency of manual project grading with easily managed feedback. In institutional organizations, a hierarchical approach is followed, with teachers, staff, and students having different privileges. To manage this, we implemented an access control method based on roles to match the ranking within the organization. Given the large number of users in an academic institution, it is crucial to grant specific privileges according to their positions, ensuring the system's security. The role-based access control method streamlines user differentiation, making the system faster and more efficient. Activities are restricted to specific users to prevent code of conduct violations, maintaining fairness in the system. Hence, the new system is named the "School Management System."

The prevailing offline paper-based system has numerous disadvantages, including excessive time spent on manual record-keeping, resource wastage, and inefficiencies in data logging leading to inconsistent records. Many academic institutions still use this traditional method for student management. Information is not globally accessible, requiring physical meetings for data exchange. To address these limitations, we propose a web-based school management system, an online automated approach for everyday record-keeping in academic organizations. This system simplifies access to student information in a specific class, facilitating comprehensive evaluation of student development. The web application provides easy access to attendance reports, defaulter lists, fee details, admission status, etc., reducing the need for manual work prone to human errors and time consumption. The proposed system for student management processes documents and records in institutional organizations through automatic computer techniques, replacing traditional ledger and manual documentation methods. It streamlines procedures like registering student details, assigning departments based on chosen courses, and maintaining records, reducing costs and personnel requirements. Since the system is online, data is accessible to everyone, making it efficient for simultaneous data access from anywhere at any time. "An Integrated Automated Paperless Academic Module" [6] emphasizes that online systems should follow the hierarchical management approach of offline paper-based systems. The creation of a user hierarchy, dependent on employee rankings, ensures efficient resource acquisition. This hierarchy includes various roles linked together, creating a contrast between institutional and task roles.

BACKGROUND

The School Database Management System project was devised to aid the institution in maintaining student details efficiently. Previously, records were managed manually; however, the implementation of this system enables the concerned sectors to enhance productivity, reduce time, and minimize associated costs. Automating the system facilitates proper record maintenance, decreases manpower, reduces costs, and ensures accurate functioning. The primary objective of this package was to automate the entire student detail maintenance process, thereby alleviating the burden on the department responsible for managing student records. This resulted in improved efficiency, reduced costs, and eliminated the need for manual work. Additionally, the system allows for easy access to past student details and enables the generation of reports. In summary, the system was developed to automate the processing of student details, which previously relied on manual methods. Earlier, student information was preserved manually or on paper, posing

challenges for proper management. With the implementation of this system, the school can maintain data accurately and precisely. The system's automation facilitates proper record maintenance, reducing manpower, man-days, and associated expenses while ensuring accurate functioning. The primary goal of the system was to automate the student detail maintenance process, alleviating the burden on the department responsible for managing student records. This automation resulted in improved efficiency, cost reduction, and time savings previously required for manual work. Furthermore, the system enables access to past student details and facilitates report generation. In summary, the system was necessary to automate student detail processing, previously managed manually.

The main aim of the proposed system is to build such a system that can improve conveniences. This system can overcome all the limitations present in the existing system. The school database management system provides efficiency, data security and helps to decrease the manual work by providing many facilities. They are as follows:

- Data security of the institution.
- Accuracy of the data stored.
- Proper management of the staff members and students.
- Minimize manual paper work such as data entry.
- Minimize time needed for the detail maintenance process.
- High efficiency and cost reduction.
- Better service provided than the previous existing system.
- User friendly interface with interactive features.

Data Flow Diagram of School Database Management System

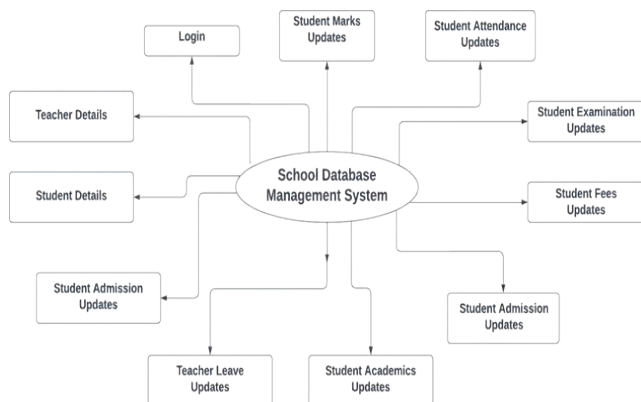


Fig. 1. School Database Management System

PROPOSED METHODOLOGY

Creating a School Database Management System (SDMS) using Java Swing for the user interface and MySQL for the database involves specific steps tailored to student and staff related functionalities. Below is a proposed methodology for developing a SDMS:

- **Create the database schema:** Identify the functionalities related to student management, such as student registration, personal information, attendance tracking, exam results, and reporting. Identify the functionalities related to the teacher/staff members such as personal information, leave application, etc. Create a normalized database schema with tables for students, teachers, courses, attendance, and grades. Establish relationships between tables using primary keys and foreign keys.
- **Connect the MySQL database with the Java Application:** Install and configure MySQL server on your machine or a dedicated server. Create the necessary database and tables based on your design. Use JDBC to establish a connection between your Java application and the MySQL database. Implement methods for connecting, querying, and handling database operations. Design the user interface using Java Swing components to include forms for student registration, personal details, attendance tracking, and grade recording. Implement methods to Create, Read, Update, and Delete operations for student information, attendance, and grades. Connect these operations to buttons or actions in your Java Swing GUI.
- Create the login system for multiple users and the administrator: Implement a login system for administrators, teachers, and possibly students. Use secure practices for storing and handling user passwords. Create functionality to record and track student attendance. Include features like marking absent/ present, generating attendance reports, and setting thresholds for attendance warnings. Also create features for entering and managing student grades for different courses. Include grade calculation, grade scale configuration, and the ability to generate grade reports.
- Add the functionalities in order to customize the data: Implement some of the essential features to generate various reports, such as student information, attendance reports, and grade reports. Allow filtering and customization of reports. Implement error handling and validation to ensure data integrity and prevent the input of invalid data. Provide meaningful error messages to users.

- **Perform all the functionalities in the application:** Conduct thorough testing of your application to identify and fix any bugs or issues. Test different scenarios, such as student registration, attendance tracking, and grade recording. Document your code, explaining the purpose of each class, method, and variable. Create user manuals or documentation for end-users and administrators.
- **Test the configured system:** Package your Java application and distribute it with instructions for installation. Ensure that the MySQL database is setup and configured on the target system. Monitor the system for any issues or bugs after deployment. Provide updates and maintenance as needed, addressing any user feedback, or changing requirements.

Use Case Diagram for School Database Management System

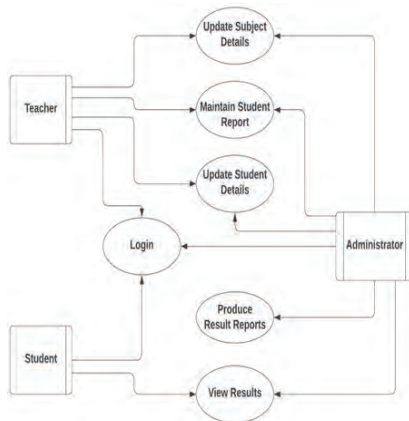


Fig. 2: Use Case Diagram for SDMS

Software Testing of the School Database Management System

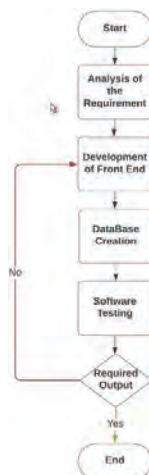


Fig. 3: Data Flow Diagram of testing SDMS

EXPERIMENT

The system adopts a hybrid development approach, combining two distinct development environments. One of these environments is Java, while the other is a web-based platform. The Java platform serves as the transactional program, enabling users to conduct real-time school-based transactions such as Subject control, Enrollment, Assessment, and report printing. On the other hand, the Web-Based System facilitates interaction with the system through various user roles, allowing functions such as admission, Student Information management, and the generation of collective reports such as class lists, student grades, grade evaluations, and faculty grade input. It is possible to create a database by inserting a list of names, roll no. personal details, etc. for various types of data in a database or other research endeavor. It gives direction on the interpretation of the data and representation of data items in the context of a project.

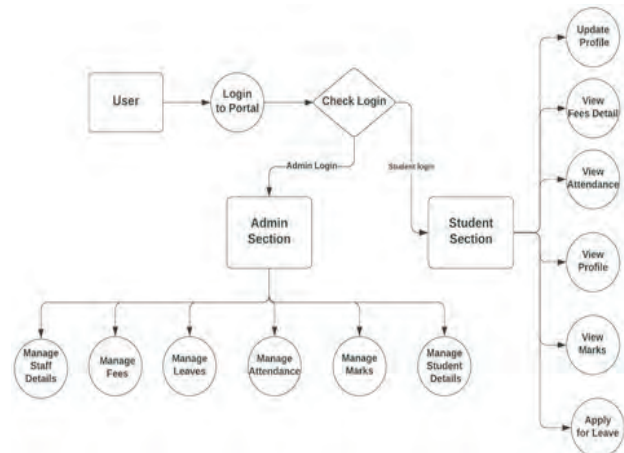


Fig. 4: E-R Diagram for SDMS

Sample Records

Students Records in the School Database Management System

name	fname	rollno	dob	address	phone	email	aadhar
Ashish Singh	Udaya Singh	08403	25-Mar-2002	Son Numbda	7738322545	ashish@gmail.com	7228427895
Aparna Singh	Ash Singh	02564	19-Apr-2002	Pharagpur	7680420002	aparna@gmail.com	6276325464
Anamika	Aparna	07700	21-Nov-2002	Ghose Gupat	6478512456	anamika@gmail.com	54640310463
Ashish Singh	Raj Singh	07502	20-Jan-2002	Indore MP	6576030210	ashish@gmail.com	54632789578
Sushant Singh	Trishu J	05107	19-May-2002	Banars UP	760403841	sushant@gmail.com	56394592637
Prashant Singh	Singh J	07190	20-Jan-2002	Jaipur	6276402201	prashant@gmail.com	12456789012
Anamika	John J	04800	26-Sep-2002	Ghose Gupat	676039463	anamika@gmail.com	76054632034
Murali Chandra	Chandra J	06128	26-Jan-2002	Nash, Maharashtra	453272857	murali@gmail.com	22467891028
Prashant Chandra	Chandra J	02208	19-Feb-2002	Indore MP	4574030201	prashant@gmail.com	46574561224
Anamika	Anamika	13100	19-May-2002	Pune Maharashtra	345274807	anamika@gmail.com	12465789010

Table1: Students Database Record

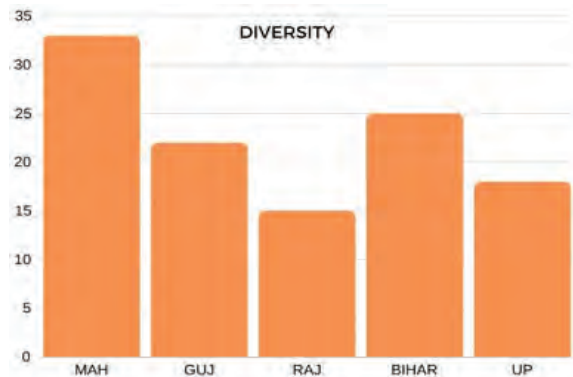
Teachers Records in the School Database Management System

name	empId	dob	address	phone	email	class	class_id	salary	education	department
Sufya Kadam	101803	14-Feb-2024	Pune	9843820212	sufya@gmail.com	89	78	54478204237	B.Tech	Computer Science
Pooja Dedmal	101804	14-Feb-2024	Lavale	8074630210	pooja@gmail.com	90	78	1244678612	B.Tech	Computer Science
Prasad Kadam	101805	04-Feb-2024	Kohrud	9876543211	prasad@gmail.com	17	89	6442329636	B.Tech	IT
A.P.Padmalak	101806	24-Apr-2024	Katol	8076543211	ap@gmail.com	90	90	4567894321	B.Tech	Computer Science
Shubh Das	101228	21-Feb-2024	Mumbai	742387894	shubh@gmail.com	89	99	78906745342	B.Tech	Computer Science
Pooja Pandey	101207	21-May-2024	87888543287	9876543290	pandey@gmail.com	87	90	78904532189	B.Tech	Computer Science

Table 2: Teachers Database Record

Graphical Representations

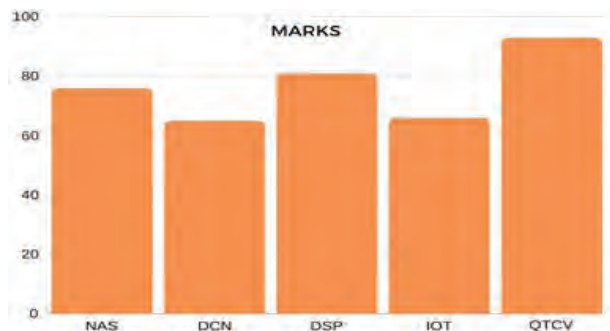
Graph 1: The graph represents the number of students and the different states from which they belong.



Graph 1: State Vs No. of students Graph

No of Students	State
Maharashtra	32.5
Gujarat	22.5
Rajasthan	15
Bihar	25
Uttar Pradesh	17.5

Graph 2 The graph represents the average marks that the students have obtained in various subjects



Graph 2: Different subjects Vs Marks obtained Graph

Subjects	Marks
NAS	78
DCN	65
DSP	82
IOT	68
QTCV	90

Graph 3: The graph represents the amount of the fees to be paid by the students studying in different sections and classes.



Graph 3: Classes Vs Amount of fees Graph

Class	Amount of Fees
1-5	48000
6-10	40000
11-12(CS)	35000
11-12(COM)	65000
11-12(BIO)	46000

Comparative Analysis

Ref no.	Description	Advantages	Limitations
[1]	Automation In University	Streamlines administrative tasks, enables quick retrieval of information for decision-making.	Dependence on technology, potential security and privacy concerns, initial implementation, and training
[2]	Automated attendance System	Reduces manual errors and provides real-time tracking of student attendance.	May face resistance or technical issues and raises privacy concerns if not implemented and managed properly.
[3]	The Automation of Educational Assessment	Scalability, and objectivity in evaluating student performance.	Risks of over reliance on technology, potential bias, and challenges in assessing certain qualitative aspects of learning.

[4]	The Paperless Workplace	Reduced environmental impact and streamlined document management.	Challenges in initial implementation, potential resistance to change, and concerns about digital literacy and data security.
[5]	Automated system for web-based computing such as the Project Grading and Instant Feedback System	Promoting timely learning improvement in web-based computing education.	Potentially overlooking qualitative aspects of student work, and limiting the depth of feedback
[6]	Integrated Automated Paperless Academic Module	Streamlines administrative tasks, enhances data accuracy.	Dependence on technology may lead to disruptions, potential security concerns, and initial implementation costs.

RESULTS

Login Page: This is the page which is displayed as soon as the user opens the application. It allows the user to login to the web application by entering the valid credentials.

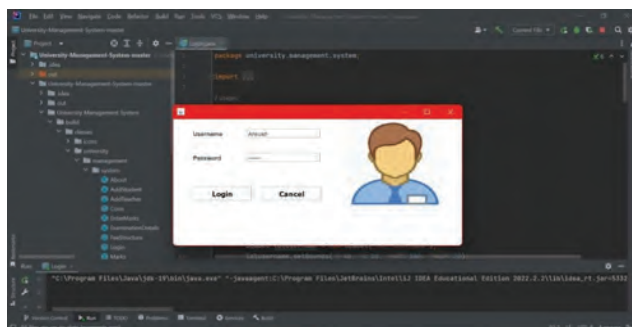
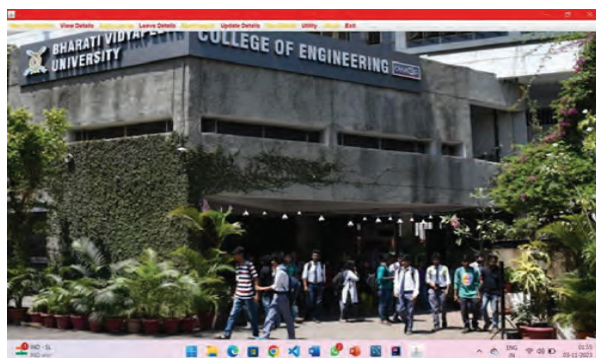


Fig. 5: Login Page1

Home page: The home page is the page that gets displayed to the system user when they login in to the web portal or the application.



Admin Module: This module comprises of the pages which are related to the inserting or updating the details of the students or the faculty members. These operations can only be made by the admin. The admin can insert new details of both, the students as well as the staff members and can perform the CRUD operations on them.

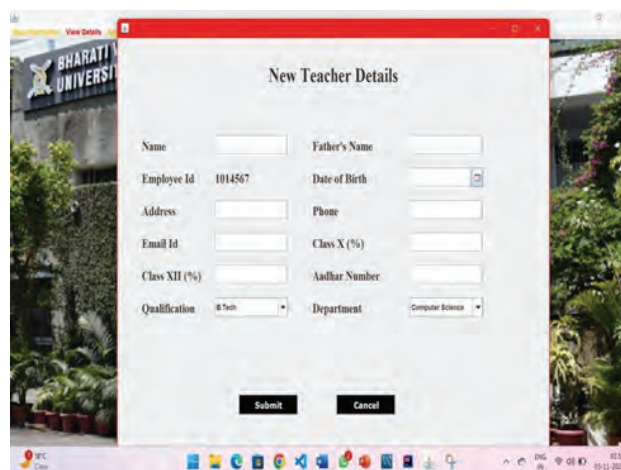


Fig.6: Insert new Details

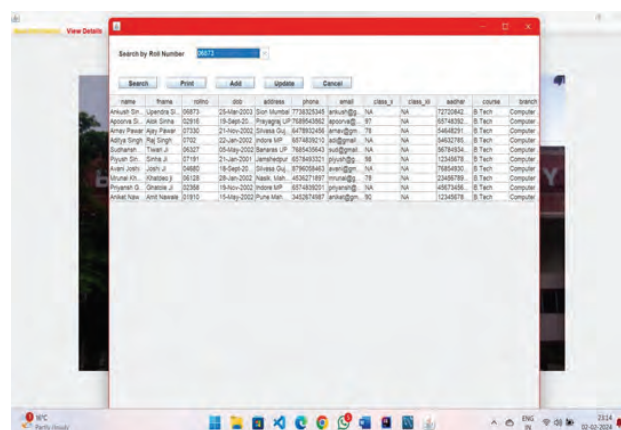


Fig. 7: View Information

CONCLUSION

School Database Management System can be used by the schools to maintain their student records and easily provides accurate information. All the collected information can be monitored and can be controlled remotely at any time. This system assists in automating the existing manual system. It reduces malpractice and enables paperless work. This application includes an admin login feature for updating student and faculty information as needed. This feature eliminates the need for paperwork, reducing the risk of data loss and redundancy. The system allows users to access, manage, and update their data effectively and efficiently. It

provides a centralized facility that can be easily modified and shared among multiple users. With a web-based front end, users do not need to directly interact with the database, enabling access from anywhere with an internet connection and a basic web browser. Additionally, it allows for querying to gather information for various surveys. Due to its ability to accommodate multiple users for reading and modifying student and teacher data, this system is ideal for educational institutions. All collected information is saved and accessible at any time. The user-friendly nature of this software makes it suitable for frequent use in all educational institutions. Our paper focuses on presenting information in an easily accessible manner, offering features like online registration and automating record generation processes within educational institutions. Our project enhances the upgradability of existing systems and simplifies record management for staff. Since this system can be used by many of the users in order to create, read and modify the student and teachers' data, it is ideal to use such systems.

FUTURE SCOPE

This project offers a user-friendly interface for managing student information. Each student will have a unique ID and password to access their personal data, including details such as personal information, marks, and attendance. This enhances transparency and reduces confusion, making it easier for students to access their information. In the future, students will also be able to upload and download class notes. Additionally, the entire project will be accessible as an Android app for added convenience. There are few examples of future opportunities that would surely help to sustain the web application for the school management systems: -

- The staff members can modify this application in order to store subject video lectures under the specific faculty names and also maintain the previous years' question papers in it.

- This system can also be used to take daily attendance and send SMS to the students and their parents automatically so that the parents have a regular record of their ward.
- This web application can also be deployed into mobile android application and that can be used in smaller devices such as mobiles, tablets, notepads, etc.
- The present school database management system can also be updated and modified in the future in order to maintain the activities in hostel such as the mess bill and attendance system even in hostels.

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Quantifying the Carbon Footprint of Real Estate and Infrastructural Development in India

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ABSTRACT

India's booming real estate and infrastructure sectors, while driving economic growth, raise significant climate concerns. India's rapid urbanization and development in infrastructure are crucial teamsters of economic growth, but raise significant concerns about their impact on climate change contributes significantly to the country's carbon footprint. Rapid urbanization and sprawling development lead to the "urban heat island effect," where cities become significantly heater than surrounding areas. Resulting this increases demand of energy for cooling, creating a vicious cycle. Linear infrastructure projects like roads and railways can fragment natural habitats, disrupting wildlife corridors and threatening biodiversity. Land acquisition for infrastructure projects often leads to deforestation and land degradation, impacting carbon sequestration capabilities and ecosystem services. More frequent and intense heatwaves, floods, and droughts can damage infrastructure and disrupt construction activities. Melting Ice and rising sea levels creep up coastal infrastructure and property. This paper investigates the carbon footprint of real estate and infrastructure development in India, employing a quantitative approach to assess their contribution to greenhouse gas emissions.

KEYWORDS: *Building energy consumption, Carbon footprint, Climate Change, Deforestation, Energy efficiency, Green building practices, Green House Gas (GHG) emissions, Infrastructure, Real Estate, Sustainable development*

INTRODUCTION

India's real estate and infrastructure development sectors are crucial drivers of economic growth, urbanization, and improved living standards. India's real estate and infrastructure sectors are experiencing unprecedented growth. India's real estate and infrastructure development presents a complex picture. While it fuels economic growth, it also poses significant sustainability challenges. This swift expansion also offerings significant challenges related to resource depletion, environmental pollution, and social inequities. While this development fuels economic progress, it intensifies concerns about the environmental impact, particularly greenhouse gas (GHG) emissions.

Lack of comprehensive data on embodied carbon in India's construction sector across different materials and life cycle

stages. Difficulty in accurately attributing deforestation solely to infrastructure projects, as other factors contribute to land-use change. At the outset, Real estate and infrastructure development in India likely contribute hundreds of millions of tonnes of CO₂ emissions annually (Labaran et. al. 2022, Andrew, 2018). While the exact figures require further research, the available data paints a concerning picture. Integrating life-cycle assessments, promoting data collection on embodied carbon, and adopting sustainable construction practices are crucial. By implementing effective mitigation strategies and prioritizing low-carbon development pathways, India can accomplish economic progress while ensuring a sustainable future.

Quantifying the carbon footprint of these sectors is essential for emerging effective mitigation policies and promoting

sustainable development practices. Addressing these critical issues requires a multifaceted approach, involving collaboration between the government, private sector, civil society, and the public. Quantifiable data and metrics can play a crucial role in monitoring progress, identifying areas for improvement, and ensuring that India's development is truly sustainable in the long run.

LITERATURE REVIEW

The real estate market in Indian is projected to reach \$1 trillion by 2030 (source: [IBEF:India Brand Equity Foundation]). India's urban population is projected to reach 600 million by 2030 (source: [United Nations]). This rapid urbanization demands for new housing, commercial spaces, and infrastructure [Reinhard Madlener and Yasin Sunak 2011 ; Subhes C. Bhattacharyya 2015 ; Franco, et.al. Rao, 2017; Chavan, et. Al. 2019; Gajender Kumar Sharma, Vidya V. Ghuge 2024]. The Indian real estate sector has attracted significant FDI, with a growing focus on sustainable development projects (Charles Rajesh Kumar. J & M. A. Majid 2020, Labaran et. al. 2022,).

The Indian government has dedicated significant resources to infrastructure development under initiatives like "Sagarmala" (port modernization) and "Bharatmala" (highway development). Estimates suggest India requires \$1.5 trillion annually to meet its infrastructure development goals (source: [World Bank]). Infrastructure projects aim to improve connectivity between cities, villages, and ports, facilitating trade and economic activity (Shubham Singh and Sendhilkumar Manoharan 2024).

Manufacturing of construction materials like steel as well as cement is energy-intensive (Morrow et. al. 2014 ; Andrew, 2018, Subash Dhar et. al.2020), leading to significant embodied carbon, the emissions associated with material production and transportation Supriya et al. 2023. National-level data on embodied carbon in India's construction sector is limited.

As per global greenhouse gas emissions 2016 studies the breakdown clearly shows that a range of sectors and processes contribute to global emissions (Fig. 1). Due to rising global cement demand, the cement industry is responsible for approx. 7% anthropogenic CO₂ emissions worldwide. Reducing CO₂ to the net zero level is the most important environmental objective to reduce the atmospheric concentration of greenhouse gases (Supriya et al. 2023.).

Over 7% of CO₂ emissions worldwide come from the cement sector ([IEA]). Building activities are responsible for 26% of worldwide energy-related emissions and 30% of global final energy consumption (with 8% coming from direct

emissions in buildings and 18% from indirect emissions from the generation of electricity and heat used in buildings). Even though severe temperatures in some areas increased emissions connected to heating, direct emissions from the buildings industry fell in 2022 compared to the previous year. Energy use in the buildings industry rose by over 1% in 2022. In 2022, buildings' direct CO₂ emissions dropped to 3 Gt, but their indirect CO₂ emissions rose to over 6.8 Gt (Fig 2). Compared to the 2015 trend, direct emissions from building operations decreased somewhat year over year in 2022.

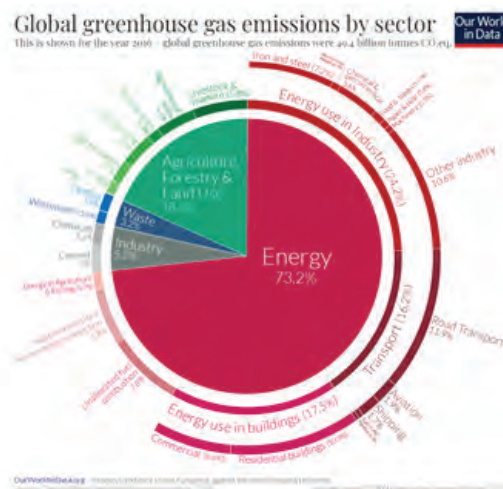


Fig. 1 : Global CO₂ contribution of Cement Industry

The usage of efficient and renewable building technology is growing, and minimum performance criteria and building energy codes are becoming more comprehensive and stricter across nations. However, in order to meet the Net Zero Emissions by 2050 (NZE) Scenario, the industry must undergo more rapid transformations. The implementation of the necessary measures to meet the 2030 targets of 20% of the current building stock and all new buildings being zero-carbon-ready2 must be completed within this decade.

Using a conservative estimate of 0.7 tonnes of CO₂ per tonne of cement ([US EIA]) and assuming that India produces about 300 million tonnes of cement annually ([India Brand Equity Foundation]), the embodied carbon starting cement production alone could be about 210 million tonnes of CO₂. In addition to evaluating the life-cycle impact of various material choices, more study is needed to measure the embodied carbon of typical construction materials like steel.

Civil engineering structures in India are notorious for energy inefficiency, relying heavily on the common fossil fuel for electricity (Santamouris and Vasilakopoulou 2021). The Indian Buildings Congress estimates that buildings consume nearly 40% of the country's total energy consumption.

Assuming India's total energy consumption is around 1800 Mtoe (Million Tonnes of Oil Equivalent) in 2023 ([BP Statistical Review]), buildings consume roughly 720 Mtoe. Considering an emission factor of 0.63 tonnes of CO₂ per Mtoe for coal ([US EIA]), this translates to approximately 454 million tonnes of CO₂ emissions annually from building energy use in India. Implementing stricter energy-efficiency codes and promoting green building practices can significantly decrease operational carbon emissions (Liu et.al. 2022, Silva et. al. 2024).

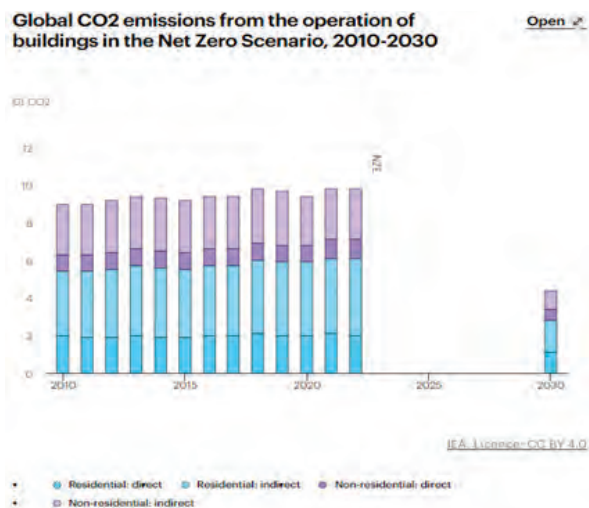


Fig. 2 : Global CO₂ emissions from the building operations

Land acquisition for infrastructure projects can lead to deforestation as well as land degradation, impacting carbon sequestration capabilities. A 2021 report by [Down to Earth] estimates India lost over 25 million hectares of forest cover between 1990 and 2019. Quantifying the exact carbon sequestration loss is complex, but it's a significant contributor. Integrating nature-based solutions like urban forestry and protecting existing forests can enhance carbon sequestration.

CARBON FOOTPRINT

India's Climate Commitments

The Government of India Climate Action Tracker (CAT) estimates that India's emissions will be around 4.0-4.3 GtCO₂e in 2030 under current policies. This estimate is slightly lower than to our last assessment (July 2023), largely due to a marginal decline in coal-fired power generation along with reduction in other energy-related CO₂ emissions from the industry and transport sector (CAT 2023).

Net Zero by 2070 Announced at 26th session of the Conference of the Parties (COP26), this ambitious target reflects India's commitment to tackling climate change. Panchamrit Commitments with five-point action plan

includes increasing renewable energy capacity, enhancing energy efficiency, focusing on sustainable lifestyles, and mobilizing climate finance. Renewable Energy Push where India aims to achieve 500 GW of installed renewable energy capacity by 2030, a significant increase from current levels. COP28 will inject fresh momentum into climate action, says PM Modi as summit begins. Prime Minister Narendra Modi, in an interview with a UAE news daily, showed optimism and said that the UAE-hosted COP28 will inject fresh momentum into effective climate action.

Some Challenges to Achieving Net Zero can be Energy Dependence on Coal as Coal remains a dominant energy source, necessitating a rapid transferal towards renewable energy sources. High-Energy Consumption with respect to India's growing population and industrial sector lead to a constantly increasing demand for energy. Infrastructure Gaps for developing a robust grid infrastructure to integrate renewable energy sources and manage peak demand remains a challenge. Above all, Financing the Transition where mobilizing the vast financial resources required for clean energy projects, grid modernization, and sustainable infrastructure development is crucial.

Effect of environment, climate and Carbon Footprint

India's real estate and infrastructure sectors are engines of economic growth with climate woes. Buildings in India are notorious for energy inefficiency. Older structures lack proper insulation and use outdated appliances, foremost to high electricity consumption and dependence on the common fossil fuel (Labaran et. al. 2022). According to the Indian Buildings Congress, buildings in India account for nearly 40% of the country's total energy consumption, a significant contributor to greenhouse gas emissions. The construction industry is a major consumer of resources like steel, cement, and concrete, all with significant embodied carbon – the large quantity emissions associated with their production as well as transportation (Andrew, 2018). A study by [IEA] (International Energy Agency) estimates that the global cement industry is responsible for 7% of global CO₂ emissions. Rapid urbanization and sprawling development lead to the "urban heat island effect," where cities become significantly warmer than surrounding areas. This phenomenon increases energy demand for cooling, creating a vicious cycle.

Building roads, railways, and other linear infrastructure often fragments habitats, disrupts wildlife corridors, and displaces biodiversity. Land acquisition for infrastructure projects often leads to deforestation and land degradation, impacting carbon sequestration and ecosystem services. A 2021 report by [Down to Earth] (Indian environmental magazine) found that between 1990 and 2019, India lost over 25 million hectares

of forest cover, partly due to infrastructure development (Jha 2023).

More frequent and intense heatwaves, floods, and droughts can damage infrastructure and disrupt construction activities. Rising sea levels threaten coastal infrastructure and property. The devastating floods in Kerala in 2018 caused billions of dollars in damage to infrastructure and property, highlighting the vulnerability of Indian cities to extreme weather events Mukherjee et. al. 2023.

The construction industry is a major consumer of resources like water, sand, and raw materials. Overexploitation can move towards shortages of resources and environmental degradation (Khatri-Jain 2023). A study by [CII] (Confederation of Indian Industry) estimates that construction consumes roughly 12% of India's total water resources. Construction activities generate air, water, and noise pollution, impacting public health and ecological balance. A 2021 report by [CSE] (Centre for Science and Environment) found that construction dust contributes to 20-30% of PM2.5 pollution in major Indian cities. Buildings in India often lack energy-efficient features, leading to high consumption in addition greenhouse gas emissions. The Indian Buildings Congress estimates that buildings in India account for nearly 40% of the country's total energy consumption. Construction and demolition activities generate massive amounts of waste, often ending up in landfills or dumped illegally, causing environmental and health problems. Referring to a ASSOCHAM report (Associated Chambers of Commerce and Industry of India), construction and demolition waste accounts for nearly 30% of solid waste generated in Indian cities. Infrastructure projects can lead to involuntary resettlement, impacting communities and livelihoods. Additionally, unequal access to basic infrastructure like sanitation and clean water disproportionately affects vulnerable populations.

Dust from construction sites, emissions from construction vehicles, and improper waste management contribute to environmental degradation. Buildings in India often lack energy-efficient features, leading to high energy consumption besides greenhouse gas emissions. Additionally, inadequate public transportation systems lead to enlarged reliance on private vehicles, further exacerbating emissions. Construction and demolition activities generate massive amounts of waste, often ending up in landfills or dumped illegally, causing environmental and health problems.

Displacement and livelihood loss in infrastructure projects can lead to involuntary resettlement, impacting communities and livelihoods. Unequal access to basic infrastructure like sanitation and clean water disproportionately affects vulnerable populations. Pollution from construction

and inadequate waste management pose health risks for communities residing near development projects.

Opportunities for a Sustainable Future

India boasts immense potential for wind, solar and biomass energy, offering clean and sustainable alternatives to the fossil fuel. Investing in and adopting advanced clean energy technologies can accelerate the transition towards net zero. The shift towards a green economy can create new jobs, boost energy security, and attract climate-conscious investments. Promoting sustainable agricultural performs can reduce emissions and enhance food security.

Adoption of green building technologies and utilizing prefabricated construction techniques, energy-efficient materials, and renewable energy sources can significantly reduce the environmental footprint of buildings. Waste management and recycling and Implementing innovative waste management systems and promoting the use of recycled materials in construction can minimize resource depletion and pollution. Smart infrastructure solutions by investing in smart grids and digital monitoring tools can optimize resource use and improve efficiency.

Energy-efficient design for optimizing building orientation, utilizing natural lighting and ventilation, and employing energy-efficient appliances can be the better option. Sustainable materials and using recycled or locally sourced materials minimizes environmental impact. Water conservation by implementing rainwater harvesting, low-flow fixtures, and water-efficient landscaping can minimize water use in buildings.

Strengthening environmental regulations and implementing stricter environmental impact assessments, enforcing pollution control measures, and promoting sustainable construction practices are crucial. Promoting green building codes, Policies incentivizing energy-efficient construction, use of recycled materials, and water conservation measures are essential. Urban planning for sustainability and developing compact, walkable cities with resourceful public transportation systems can significantly drop energy consumption and emissions.

Further Research

- Conduct comprehensive life-cycle assessments of commonly used construction materials in India to quantify embodied carbon.
- Develop robust data collection mechanisms to accurately estimate the carbon footprint of real estate and infrastructure projects.
- Analyse the impact of different policy interventions,

such as green building codes and carbon pricing, on reducing the carbon footprint of these sectors.

CONCLUSION

Implementing sterner environmental regulations, carbon pricing mechanisms, and providing incentives intended for clean energy adoption are essential. Collaboration between the government, private sector, and research institutions can accelerate innovation and deployment of clean technologies. Investing in skill development for the green workforce and raising public responsiveness about climate change are crucial for long-term success. Collaboration with developed nations through technology transfer and financial support can significantly enhance India's climate action efforts. Strengthening environmental regulations, promoting green building codes, and encouraging compact, walkable cities through resourceful public transportation systems are crucial. Adopting green building technologies, implementing smart infrastructure solutions, and utilizing waste management and recycling practices can minimize environmental impact. Green bonds and other innovative financial instruments can incentivize investments in sustainable development projects. Raising public awareness about sustainability and promoting responsible consumer choices can drive demand for green buildings besides infrastructure. Nature-Based Solutions and Integrating green spaces obsessed by urban planning, restoring degraded land, and protecting natural ecosystems can help moderate the urban heat island effect and enhance resilience to climate change.

India's ambitious goal of achieving net zero by 2070 presents a substantial challenge but also offers immense opportunities for sustainable future. By addressing the challenges, harnessing existing and emerging technologies, and fostering international cooperation, India can chart a path towards a cleaner, greener future. The success of India's climate action will not only benefit its own citizens but correspondingly subsidize pointedly to global efforts in combating climate change.

This review focuses primarily on national-level initiatives. Including state and local government efforts can provide a more comprehensive picture of India's climate action strategy. The social impact of transitioning to a green economy needs careful consideration. Policies should ensure a just transition that protects vulnerable communities and promotes inclusive growth. Regularly monitoring progress towards the net zero target and adapting strategies based on data-driven insights is decisive for staying on track. By acknowledging the current challenges, taking on the opportunities, and implementing effective policies, India can transform its ambitious climate action goals into a sustainable reality.

Sustainability is no longer a choice but a necessity for India's real estate and infrastructure development by implementing stricter regulations, embracing innovative technologies, and adopting green building practices. A collaborative effort between government, developers, architects, and the public is essential to create a built environment that caters to the desires of the present generation without compromising the ability of future generations.

India's real estate and infrastructure development presents a complex picture. While it fuels economic growth, it also poses significant sustainability challenges. By adopting stricter regulations, embracing innovative technologies, and prioritizing social equity, India can navigate this complex landscape and build a sustainable tomorrow. Addressing these critical issues requires a multifaceted approach, involving collaboration between the government, private sector, civil society, and the public. Quantifiable data and metrics are better options in monitoring progress, improvement area identification, and ensuring that India's development is truly sustainable in long run.

ACKNOWLEDGEMENT

Authors acknowledge International Energy-Agency for making details available for different comparison and analysis.

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Conftable-Conference Paper Management System

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ABSTRACT

In the realm of academic and scientific research, conferences serve as crucial platforms for the exchange of knowledge, ideas, and innovations. However, organizing and managing conference papers can be a complex and time-consuming task. To address these challenges, this paper introduces Conftable, a revolutionary Conference Paper Management System (CPMS). Conftable streamlines the entire conference lifecycle, from paper submission to publication, offering solutions to intricacies in submission, peer review, and organizational coordination. This paper explores the development, features, and potential impact of Conftable, aiming to reshape the landscape of scholarly communication and knowledge dissemination.

KEYWORDS: *Conference paper management system, Conftable, Academic conferences, Paper submission, Peer review, Organizational coordination.*

INTRODUCTION

To designed software that makes it possible to hold a scientific conference of any size virtually or in hybrid mode. Conference management system from managing program committees to publishing proceedings, our system has got you covered.

In the ever-evolving landscape of academic and scientific research, conferences play a pivotal role in facilitating the exchange of knowledge, ideas, and innovations among scholars, researchers, and practitioners. These gatherings serve as a platform for presenting and discussing the latest findings, promoting collaborations, and fostering intellectual growth. However, the organization and management of conference papers can be a complex and time-consuming task for conference organizers.

To address this challenge, a Conference Paper Management System (CPMS) emerges as a sophisticated and indispensable tool designed to streamline and optimize the entire process of handling conference papers. The CPMS revolutionizes traditional paper submission, review, and publication procedures, enabling a seamless experience for authors, reviewers, and organizers alike.

In the following sections, we delve into the key features and applications of the CPMS, exploring how it transforms the conference paper management landscape. From online paper

submission and blind peer review to automated notifications, plagiarism detection, and collaborative editing, the CPMS is poised to be a game-changer in fostering a more transparent, accessible, and collaborative academic environment.

In the landscape of academic conferences, the traditional processes governing the submission, review, and publication of conference papers are often beset by challenges that impede the seamless exchange of knowledge. The escalating volume and diversity of research contributions demand a sophisticated solution. This paper introduces the development of a Conference Paper Management System (CPMS) designed to address these challenges comprehensively. The CPMS aims to streamline the entire conference lifecycle, offering solutions to intricacies in paper submission, peer review, and organizational coordination, with the overarching goal of enhancing the efficiency and impact of academic conferences. This introduction sets the stage for an exploration of the key issues and the transformative potential of the proposed CPMS.

In the realm of academia, conferences stand as crucibles of intellectual exchange, where researchers converge to share discoveries, insights, and innovations. However, the traditional mechanisms governing the submission, review, and publication of conference papers often struggle to keep pace with the evolving landscape of research. As the

scholarly community burgeons and diversifies, the need for a sophisticated Conference Paper Management System (CPMS) becomes increasingly apparent.

This paper introduces a groundbreaking initiative to develop a CPMS, an advanced platform meticulously designed to revolutionize the orchestration of academic conferences. The challenges inherent in the current paradigm, ranging from the complexities of paper submission to the intricacies of peer review and the demands of seamless organizational coordination, propel the necessity for an innovative solution. The CPMS proposed herein emerges as a holistic response to these challenges, promising not only to simplify administrative processes but to elevate the entire conference experience. Through a user-friendly submission interface, an optimized peer review process, and enhanced organizational efficiency, the CPMS aims to redefine the dynamics of academic conferences. This introduction lays the foundation for a detailed exploration of the envisioned CPMS, its features, and its potential to reshape the landscape of scholarly communication and knowledge dissemination in the academic community. The aim of this research work is to facilitate the entire process of organizing and managing conferences, particularly in relation to the submission, review, and correspondence of conference papers.

LITERATURE REVIEW

The efficient management of academic conferences plays a crucial role in fostering scholarly exchange and advancing knowledge within various fields. In recent years, there has been a growing emphasis on the development and utilization of web-based conference paper management systems to streamline the submission, review, and organization processes. This literature review aims to provide an overview of existing research in this domain, highlighting key contributions and insights offered by previous studies.

[1] presents a focused effort on the development of a web-based conference paper management system. Their work emphasizes the need to streamline the various stages of conference organization, from paper submission to review and eventual presentation. By leveraging web-based technologies, the authors aim to enhance accessibility and efficiency in managing conference proceedings. [2] offer a comprehensive survey of existing conference management systems, providing valuable insights into their features, functionalities, and overall effectiveness. Their research serves as a foundational resource for understanding the landscape of available solutions and identifying areas for improvement or innovation in conference management technology. [3] explore the application of machine learning techniques for predicting conference paper acceptance. By

leveraging advanced algorithms and data analysis, their research aims to improve the efficiency of the paper selection process, ultimately enhancing the quality and relevance of conference proceedings. [4] propose a structured framework for the design and implementation of conference management systems. Their work provides a systematic approach to addressing the diverse needs and requirements of conference organizers and participants, offering guidance on architecture, functionality, and scalability. [5] introduce “MyConfree,” a user-friendly web-based conference management system designed to streamline conference organization and paper management processes. Similarly, [6] present “Papyres,” a research paper management system aimed at facilitating efficient organization, retrieval, and collaboration on research papers within academic settings. These innovative solutions contribute to the ongoing evolution of conference management technology, offering novel approaches to addressing the needs of conference stakeholders. [6] proposes a requirement model for a mobile app tailored to conference paper management. Their research highlights the importance of adaptability and user-friendliness in meeting the needs of conference organizers and participants, particularly in an increasingly mobile-centric environment.

In summary, the literature reviewed underscores the significance of web-based technologies and innovative approaches in advancing the field of conference paper management.

By leveraging insights from existing research and technology, future efforts can continue to enhance the efficiency, accessibility, and effectiveness of conference organization and scholarly exchange.

METHODOLOGY

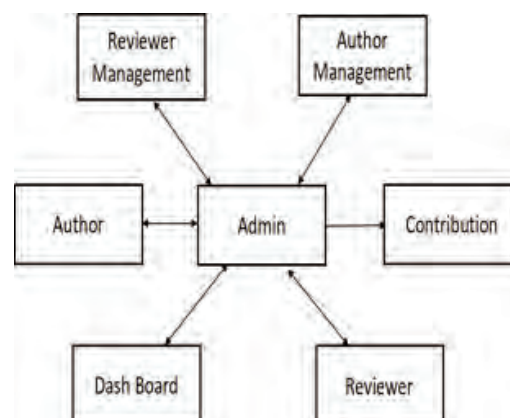


Fig. 1: Block Diagram

The Fig.1: Block Diagram illustrates the modular architecture of the Conference Paper Management System, showcasing

the seamless integration of key components such as paper submission, peer review, user management, and data analytics.

Brief description of the above block diagram

The block diagram depicts a Conference Paper Management System, with roles such as Admin, Reviewer Management, Author Management, Contribution, Reviewer, Dashboard, and Author. The Admin oversees the entire platform, managing user accounts and coordinating with reviewers and authors. Reviewer Management assigns qualified reviewers, monitors progress, and facilitates communication. Author Management oversees submission, review, and communication processes. Reviewers evaluate papers for quality and provide feedback. The system automates submission, review assignment, and decision-making, optimizing workflow. The Dashboard offers real-time insights into submission status and progress. Author descriptions capture relevant information for evaluation.

System Specification

Frontend (HTML, CSS, JavaScript):

- User Authentication: Implement login and registration pages.
- Dashboard: Role-based dashboards for authors, reviewers, and organizers.
- Paper Submission: Form for submitting papers with metadata and file uploads.
- Paper Review: Review forms for reviewers to assess quality, originality, etc.
- Conference Management: Creation of events, tracks, and deadlines.
- Notifications: System for alerting users about deadlines and assignments.
- Paper Publication: Searchable interface for accessing accepted papers.

Backend (Spring Boot)

- User Management: Registration, login, and role-based permissions.
- Database Management: Schema design for storing user profiles, papers, etc.
- Paper Submission and Review: APIs for submissions, storing files securely.
- Conference Management: APIs for creating conferences, managing deadlines.
- Notifications: System for sending emails or notifications.

- Data Analytics: APIs for generating statistics and reports.

Integration:

- Connect frontend and backend using JavaScript's fetch or AJAX techniques.

Deployment:

- Deploy Spring Boot app on a server like Tomcat.
- Host frontend on a web server or cloud storage service.

Algorithm

The algorithm outlines a process for user registration, authentication, and authorization, ensuring secure password storage and role-based access control. It details steps for conference creation, paper submission, review assignment, and the review process, including author revision and decision-making based on reviewer feedback. Error handling procedures are implemented, logging errors for debugging and providing user-friendly messages.

Data retention and archiving are addressed, with old conferences, papers, and reviews archived to separate storage while maintaining referential integrity. Overall, the algorithm provides a structured approach to managing user accounts, conference workflows, and data integrity within the system.

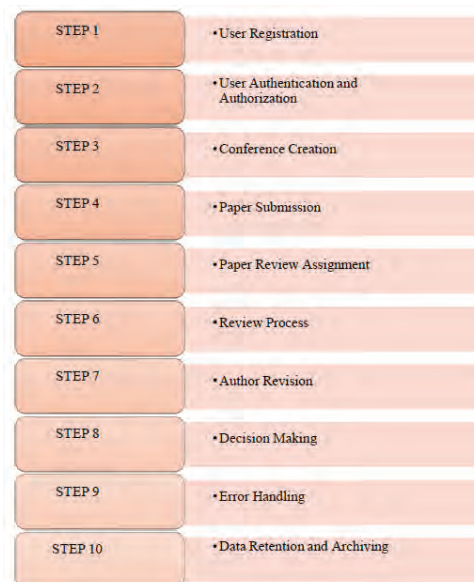


Fig. 2. Algorithm

RESULTS OF CONFTABLE

The Fig. 3 shows Result is the obtained screenshot, a graphical representation showcases the quantitative outcomes of the project, illustrating the significant impact of the implemented methodology on key performance metrics. The Fig. 3 shows

Result shows the overview of the dashboard for the project title CONFTABLE- Conference Paper Management System.

Fig. 4 demonstrates the user authentication process within the Conference Paper Management System (CPMS). The screenshot provides a clear visualization of the login interface, showcasing the steps users follow to authenticate and gain access to the system.

The screenshot captures the login page of the CPMS, highlighting fields for entering a username and password. The interface is designed to be user-friendly, with clear prompts and error messages to guide users through the authentication process. This section also illustrates the functionality for new users to register and create an account, as well as features for password recovery, ensuring accessibility and security for all users.

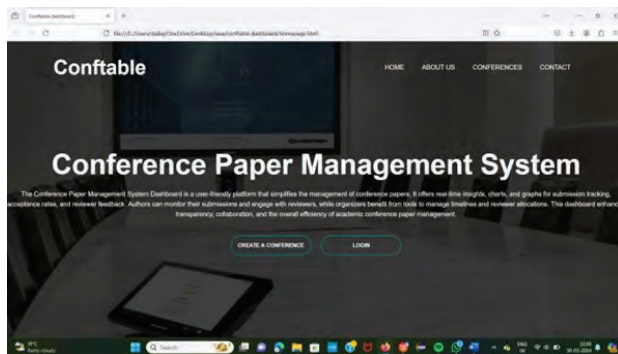


Fig. 3: Dashboard of the conference Management System

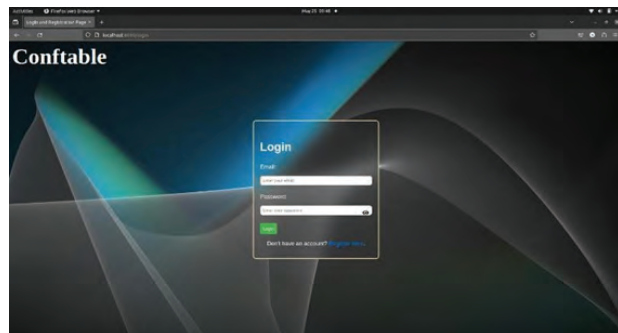


Fig. 4: User authentication process within the Conference Paper Management System (CPMS)

The create new conference form in the conference paper management system allows organizers to input essential conference details such as title, acronym, dates, venue, research area and contact phone number. It also includes sections for organizing committee information, submission guidelines, review process configuration, registration details, conference program, and additional logistical information. With intuitive design and validation checks, the form

streamlines the planning and execution of academic events within the system. The Fig. 5 shows Result is the obtained screenshot, The Fig. 5 shows Result shows the overview of the create new conference form for the project title CONFTABLE- Conference Paper Management System.

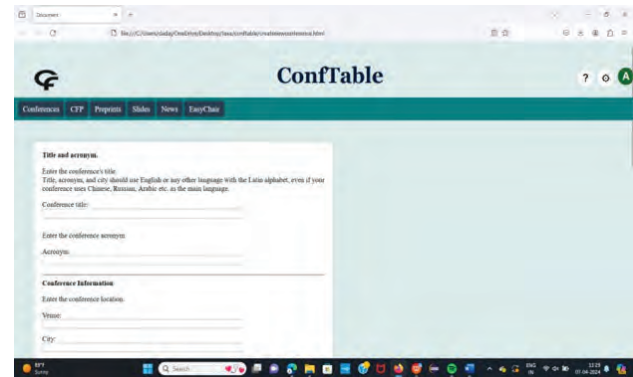


Fig. 5: Result shows the overview of the create new conference

Fig. 6 demonstrates the process of creating a new preprint within the Conference Paper Management System (CPMS). The screenshot provides a clear visualization of the interface used by authors to submit their preprints, showcasing the steps involved in uploading and managing their submissions. The screenshot captures the submission page for new preprints, highlighting fields for entering the paper title, abstract, keywords, and author details. It also shows the upload section for submitting the preprint file and any supplementary materials. The Fig. 6 shows Result is the obtained screenshot, The Fig. 6 shows Result shows the overview of the preprints form for the project title CONFTABLE- Conference Paper Management System.



Fig. 6. Preprints Form

Fig. 7 demonstrates the admin interface displaying the submitted papers within the Conference Paper Management System (CPMS). The screenshot provides a clear visualization of how admins can view and manage all submitted papers, showcasing the key details and functionalities available on this page.

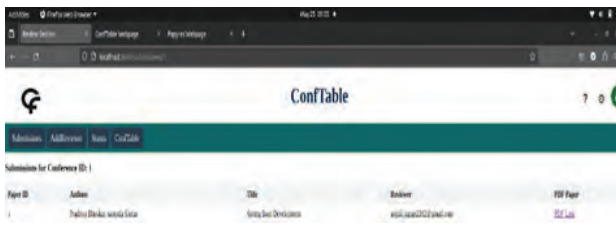


Fig. 7: Submitted Papers Page (Admin view)

Fig. 8 demonstrates the interface displaying submitted papers within the Conference Paper Management System (CPMS). The screenshot provides a clear visualization of how authors and organizers can view and manage submitted papers, showcasing the key details and functionalities available on this page.



Fig. 8: Submitted Papers Page (User view)

Fig. 9 illustrates the “Add Reviewer” page within the Conference Paper Management System (CPMS). This screenshot provides a detailed view of how administrators can add reviewers to the system, demonstrating the key fields and functionalities available on this page.



Fig. 9: Add reviewer page

CONCLUSION

In conclusion, the development of a conference paper management system represents a significant stride toward enhancing the efficiency and effectiveness of academic conference organization. This comprehensive solution aims

to streamline and facilitate every stage of the conference lifecycle, with a particular focus on simplifying the submission, review, and publication processes for conference papers.

The proposed system offers a range of benefits, including improved efficiency through automation, enhanced collaboration among stakeholders, centralized information management, and the flexibility to adapt to the unique needs of academic conferences. By incorporating user-friendly interfaces, robust security measures, and integration capabilities with existing tools, the system seeks to provide a seamless and positive experience for authors, reviewers, and organizers

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- Team Resonance Racing from AISSMS COE secured All India Rank 2 at Edgeline Championship 2025.
- 1st prize in the Robo-Race event by the College of Engineering secured at TECHNOMAN 2024.
- College of Engineering secured All India Rank 1 in BAJA SAE INDIA 2024.
- Team Quantum-GIS from the College of Engineering secured first place in the Smart India Hackathon 2022.
- College of Engineering secured the All India 5th Rank in E-BAJA All-Terrain Vehicle Competition 2023.
- College of Hotel Management and Catering Technology successfully created a world record by preparing 100 curries in 250 minutes with the help of 250 students & faculty members.
- Institute of Information Technology successfully implemented the HAM radio project, ensuring connectivity between remote villages.
- "Best practices in Education" awarded to the Institute of Information Technology by AICTE in 2018

- 2nd Place for Best Aerodynamic Analysis at the SAE ISS Drone Development, America (2022) secured by AISSMS COE.
- Champions of Prestigious Firodiya Karandak 2022 were awarded to the College of Engineering.
- College of Pharmacy has been the reigning champion in the National Pharmacy Week Competition at the undergraduate level, organized by the Indian Pharmaceutical Association, for the past five consecutive years.
- Institute of Management is ranked 10th among affiliated colleges in India by Outlook I-Care Magazine B-School Survey.
- Best college Award by Savitribai Phule Pune University received by the Institute of Management for the Year 2024-25
- Institute of Management re-accredited by NAAC with A+ Grade
- Institute of Information Technology has received the CII award for Industry-Academia 2024
- Best College Award (Professional courses urban category) by Savitribai Phule Pune University 2023-24
- Institute of Information Technology's ACM Student Chapter won ACM India's Outstanding Community Service Award 2023-24

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PUBLISHED BY
INDIAN SOCIETY FOR TECHNICAL EDUCATION
Near Katwaria Sarai, Shaheed Jeet Singh Marg,
New Delhi - 110 016

Printed at: Compuprint, Flat C, Aristo, 9, Second Street, Gopalapuram, Chennai 600 086.
Phone : +91 44 2811 6768 • www.compuprint.in