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Editorial

Bridge the Gap Between Academia and Industry: According to the industry professionals, there is a significant gap between the theoretical knowledge the students acquire in classrooms and the skills they need to thrive in the field after employment. This must be taken seriously and need to resolve quickly. The current Indian educational system has several issues, one of which is that too much emphasis on memory and little on creative thinking. Mugging up practice should be discouraged in educational institutions instead read, write, and reproduce practice will help to improve their learning abilities. Students are lacking soft skills and/or technical skills. There is a wide skill gap is also called as performance gap between what is expected from the students after the employment and what they deliver. Therefore, there is a need that scientists and educators must aware of industrial requirements in order to effectively bridge the gap. Collaboration between industry and academics is necessary due to the dynamic business environment and the development of emerging technologies.

India urgently needs to develop a skilled workforce that suits to the industry. No nation can progress without developing its human capital. Educational institutions serve as the backbone of any nation and produce leaders and healthy citizens. Several practical methods that could facilitate students' engagement with industry like encouraging students to interact with the industry, having an active alumni association, training students regularly in development of both hard and soft skills, using a team-teaching approach where educators impart theoretical knowledge and industry experts impart practical knowledge in the classroom, regular guest lectures from the industry professionals to explain the developments and expectations in the industry, and functioning of finishing school operations. Scientists and academicians should visit industries to learn about industry expectations, and recruiters visit institutions to understand the challenges the educational institutions facing. It enables academia and industry to understand one another more fully, feel more sympathetically, and carry out the required changes that improve employability.

Academic programs ought to be in line with business requirements and must provide a curriculum for its courses that is worthwhile and pertinent to its students. Industry input must be collected regularly to update the course material and teaching methodology to meet industry expectations. To bridge the current skills gap between academia and industry, an integrated effort from all stakeholders including educators, scientists, recruiters, students is required.

New Delhi **Editor**

31st March 2025

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Contents

Breast Cancer Detection Using Deep Learning Techniques

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ABSTRACT

The paper investigates the utilization of Convolutional Neural Systems (CNNs) for recognizing breast cancer in mammography information, pointing to move forward early determination. It emphasizes the significance of progressed location strategies due to the worldwide effect of breast cancer. They think about employing a differing dataset and AI calculations to improve symptomatic precision. The inquiry highlights the potential integration of AI into clinical workflows for progressed collaboration between AI models and healthcare experts. By and large, the study contributes to the field of therapeutic picture examination, appearing promising for early breast cancer location.

KEYWORDS: *Breast cancer, Deep learning, EXIF, Image processing, Data augmentation.*

INTRODUCTION

Breast cancer could be a worldwide wellbeing concern, requiring exact discovery strategies. Conventional mammography, whereas fundamental, battles with deciphering complex pictures. The rise of profound learning, particularly CNNs, offers a promising arrangement. This investigation centers on utilizing CNNs for breast cancer location, pointing to make strides demonstrative exactness. By utilizing differing mammography datasets, the study misuses CNNs' capacity to recognize unpretentious designs in breast anomalies. The inquire about moreover emphasizes the significance of translating CNN comes about, pivotal for building belief in AI-based diagnostics. The proposed show appears guaranteed in early discovery, highlighting the potential of AI to revolutionize breast cancer determination and make strides understanding results.

METHODS AND MATERIAL

Proposed Solution

Deep Learning

Profound learning could be of counterfeit insights (AI) that imitates the workings of the human brain in handling information and making designs for use in decision making. It employs counterfeit neural systems to memorize from huge sums of information, known as preparing information, to recognize designs and make choices. Profound learning has appeared as a surprising victory in different areas, counting picture and discourse acknowledgment, characteristic dialect preparation, and independent driving. Its capacity to naturally learn and adjust from information without unequivocal programming makes it a capable device for tackling complex issues. In spite of its victory, profound learning requires huge sums of information and computational control, and it can be challenging to translate its choices, raising moral and security concerns.

Data Preprocessing

Data preprocessing plays an urgent part in deep learning, as these models frequently require expansive and carefully arranged datasets to perform ideally. This includes cleaning muddled information (taking care of blunders, irregularities, and lost values), changing it into groups appropriate for neural systems (e.g., scaling, normalization, encoding), and possibly utilizing include building strategies to highlight designs important to the deep learning assignment. Also, part information into training, validation, and testing sets is essential for show advancement and assessment. Preprocessing specifically impacts the quality of experiences extricated by deep learning models, making it a significant step within the workflow.

Image Preprocessing

- Orientation- Pictures contain metadata called EXIF orientation that directs how to show them accurately. Improperly dealing with this information can lead to pictures appearing erroneously (e.g., rotated or flipped).
- Size- Picture resizing is often vital to guarantee compatibility with machine learning models, especially those requiring square inputs, and includes decisions around maintaining aspect ratio and dealing with pictures smaller than the model's desired input measure.

Data

This dataset centers on highlights inferred from digitized pictures of breast mass fine needle suctions, pointing to move forward breast cancer conclusion. It incorporates data on cell core characteristics, mammograms, and quiet age. The objective is to decrease superfluous biopsies by creating computer-aided diagnosis (CAD) frameworks that can precisely anticipate harm from these highlights. The dataset, counting BI-RADS appraisals and biopsy comes about, is expecting for preparing and assessing such CAD frameworks, tending to the challenge of tall false-positive rates in mammogram translation.

Field Name (Attribute)	Type	Description
BI-RADS assessment	Number	Radiologist's assessment based on the BI-RADS scale
Age	Number	Patient's age in years at time of mammogram
Shape	Number	Shape of mass
Margin	Number	Margin of mass
Density	Number	Mass density of breast
Severity	Number	Extent of having cancer

Data Augmentation

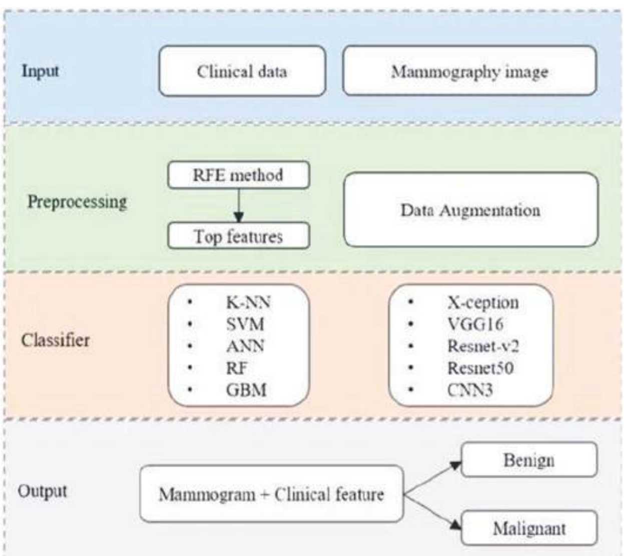
- Grayscale: Grayscale pictures utilize shades of gray, representing varying brightness levels (radiance) for each pixel. Typically imperative as even color pictures have underlying grayscale information.
- Random Flips: Mirroring images along the x/y-axis forces models to learn object recognition without depending on static orientations.
- Random Rotations: Essential for models utilized in dynamic settings (e.g., rotating cameras) to learn that objects can show up at distinctive angles.
- Random Brightness & Exposure: Recreates real-world lighting variations, making models more strong to diverse lighting conditions.
- Random Noise: Helps anticipate models from overfitting by constraining them to focus on core highlights rather than image-specific details.

Within the mammography illustration, pictures are resized for compatibility with particular deep learning models. Information augmentation methods, including geometric transformations, are utilized to extend dataset size and progress model performance when there's constrained image information.

Model Architecture

This study proposes a breast cancer detection algorithm combining machine learning (ML) and deep learning (DL) strategies. The input data incorporates medical factors and mammographic pictures in CC and MLO views. The DL framework leverages transfer learning models (X-ception, VGG16, Resnet-v2, Resnet50) and a custom 3-layer CNN trained on mammograms. Key medical highlights were chosen for their significance in recognizing benign and malignant cases. Five well known ML classifiers (KNN, SVM, ANN, RF, GBM) were utilized for classification. At last, a combination model integrates medical highlights and mammograms, with last benign/malignant forecasts decided by averaging the ML-DL model's yield.

This study leverages deep neural networks for breast cancer detection within a mammography image dataset. To address the small dataset, transfer learning is used for efficiency. Models compared include Xception, VGG16 (with 41 layers, 3x3 kernels), Resnet-v2, Resnet50 (with 50 layers and over 23 million parameters), and a custom CNN (CNN3) with 3 convolutional layers. In the transfer learning approach, convolutional weights remain frozen, and new fully connected layers are added. All models are trained on the dataset using the same hyperparameters (learning rate of 0.00001, 30 epochs, batch size of 32, RMSProp optimizer). The final layer uses softmax activation for binary classification (benign/malignant).



RESULTS AND DISCUSSION

Comparing different versions is crucial for developing powerful models. Various metrics, like the confusion matrix and ROC curve, help assess performance. The confusion matrix categorizes predictions: true positives (correctly predicted positives), false positives (incorrectly predicted positives), true negatives (correctly predicted negatives), and false negatives (incorrectly predicted negatives).

Common metrics include accuracy (overall correctness), sensitivity (ability to identify true positives), and specificity (ability to identify true negatives). Additionally, the ROC curve and AUC (Area Under the Curve) visualize the model's ability to distinguish between positive and negative examples. An AUC of 1 indicates perfect distinction, while 0 signifies entirely incorrect predictions.

For a more comprehensive evaluation, metrics like F1-score, MCC (Matthews Correlation Coefficient), and Cohen's Kappa are also used. These consider factors like the balance between precision and recall and the agreement between predicted and actual classifications, especially for imbalanced datasets.

CONCLUSION

In outline, the application of profound learning for breast cancer forecast means a groundbreaking headway in therapeutic diagnostics. These models, fueled by modern calculations and tremendous datasets, can recognize unpretentious designs in restorative symbolism, driving to a prior and more exact location. This has the potential to decrease untrue negatives and revolutionize healthcare results. Profound learning too gives profitable bits of knowledge into the fundamental variables of threat, improving our understanding of the disease.

In any case, collaboration between restorative experts, information researchers, and policymakers is significant to address moral and security concerns and coordinate these advances into healthcare frameworks. As we enter an unused period in therapeutic science, the presumed improvement of profound learning in breast cancer forecasts seems to make early intercession a standard of care, changing how we analyze and treat breast cancer.

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Keystroke Dynamics Based User Authentication using Ensemble Machine Learning Techniques

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ABSTRACT

Keystroke dynamics (KD) serves as a biometric authentication scheme by analyzing the timing, rhythm, and pressure of keyboard input. It verifies identity by assessing how individuals' type, offering a robust alternative or addition to conventional password-based authentication. KD used as an additional degree of security for password protected applications. Impostor can be denied access to the system if the KD of the user is known. Measurement of KD involves keystroke logging. This process captures the sequence of characters, seek-time (time to locate a key), and hold-time (duration a key is pressed) for each keystroke. In this work, ensemble learning techniques are focused to solve the problem of user authentication using KD mechanism. The ensemble learning techniques such as Averaging, Bagging, Max Voting, XGBoost, CatBoost, Gradient Boosting and AdaBoost are used to carry out such work. These techniques are compared in terms of accuracy, mean absolute error (MAE), mean squared error (MSE). From the results, it is found that, CatBoost is able to perform better with accuracy of 95.9% and MSE and MAE of 0.79 and 22.782 respectively as compared to other techniques. The simulation of this work is carried out using Python based Zupyter notebook.

KEYWORDS: *Keystroke dynamics, Averaging, Bagging, Max voting, XGBoost, CatBoost, Gradient boosting and AdaBoost, MSE, MAE.*

INTRODUCTION

KD, a method within the realm of behavioral biometrics, intricately examines an individual's typing patterns to establish and validate their identity [1]. This approach delves into the distinctive features embedded in the timing and rhythm of key presses and releases during typing sessions [2,3]. The formal process comprises several key components, providing a understanding of how KD serves as a reliable biometric authentication method [4]. Ensemble learning stands out as the best approach for KD by integrating diverse machine learning (ML) models, including neural networks, decision trees, or support vector machines [5,6]. This enhances accuracy and robustness, capturing various nuances in typing patterns, and making it resilient against impersonation or fraudulent attempts [7,8].

Ensemble learning provides distinct advantages over traditional ML by combining multiple models [9]. This diversity mitigates risks, enhances overall model performance, and refines generalization to effectively accommodate varying keystroke patterns [10,11]. Ensemble learning based user authentication using KD, integrates different models to create a comprehensive understanding of a user's typing behavior [12,13]. This results in a secure and adaptive authentication mechanism [14].

There are various user authentication techniques like artificial intelligence -based methods, cryptography, biometrics, and existing approaches [15,16]. AI introduces intelligent algorithms, cryptography secures information through encryption, biometrics employs unique physiological traits, and existing techniques include traditional password-based systems [17,18]. Behavioral biometrics, exemplified by KD, involves studying unique patterns in an individual's behavior [19,20]. Focusing on how a person types, it utilizes timing, rhythm, and pressure as distinctive identifiers for authentication [21,22].

KD significantly contributes to user authentication by offering a non-intrusive yet secure biometric method [23,24]. Its uniqueness lies in the personalized typing patterns, providing a robust means of identity verification that is adaptable and resilient to fraudulent attempts, making it a valuable component in modern security systems [25].

This work consists of the following major contribution.

In this work, ensemble learning techniques are focused to solve the problem of user authentication using KD mechanism. The ensemble learning techniques such as Averaging, Bagging, Max Voting, XGBoost, CatBoost, Gradient Boosting and AdaBoost are used to carry out such work. These techniques are compared in terms of accuracy, MAE, MSE. From the results, it is observed that, CatBoost is able to perform better with accuracy of 95.9% and MSE and MAE of 0.79 and 22.782 respectively as compared to other techniques. The simulation of this work is carried out using Python based Zupyter notebook.

i In this work, ensemble learning techniques are used to solve the problem of user authentication using KD using CMU dataset.

ii The ensemble learning techniques such as Averaging, Bagging, Max Voting, XGBoost, CatBoost, Gradient Boosting and AdaBoost are used to carry out such work.

iii These techniques are compared in terms of accuracy, MAE, MSE.

iv From the results, it is observed that, CatBoost is able to perform better with accuracy of 95.9% and MSE and MAE of 0.79 and 22.782 respectively as compared to other techniques.

v The simulation of this work is carried out using Python based Zupyter notebook.

The section 2 of this paper includes the Related works which enlightens the various methodology used by the researchers around the world for developing similar systems. The section 3 of the paper contains the methodology followed during the whole process of experiment. Followed by the Experiment section that includes the whole simulation process explaining how it was carried out from data collection to training and prediction. The final section 4 of paper contains Result analysis and finally Conclusion part.

RELATED WORK

Raul et al. [1] focused on KD, a biometric based on typing style, offers unique patterns for user authentication, serving as an additional layer of security for password-protected applications. It can reject impostors even with valid credentials, though challenges arise from variations in keyboards and remote access. A comprehensive analysis of contemporary work in this field emphasizes the need for robust datasets and efficient algorithms to enhance authentication. In Bhana et al. [2], employees spend significant unproductive time on password-related activities, prompting a study on a two-tier authentication solution involving passphrases and KD. The research incorporates theories on password strength, memorization, and typing issues. Data collection methods include a login assessment experiment and expert reviews, leading to a finalized model. Considering all components, the proposed solution aims to improve both security and usability in the authentication process.

In Alsultan et al. [3], addressing the challenge of extensive data requirements in free-text KD, this paper suggests fusion methods for improved user authentication. Feature-level fusion combines timing and non-conventional features, while decision-level fusion uses classifiers like Support Vector Machines and decision trees. The study shows that decision-level fusion outperforms feature-level fusion, achieving minimal error rates in false acceptance and false reject. In Sadikan et al. [4], online learning's vulnerability to cheating requires better security measures than password authentication. KD, requiring only a keyboard, is explored as a tool to enhance security in online learning systems. The paper reviews authentication systems, keystroke benchmarking datasets, and applications to improve security and usability in the current online learning environment.

Tey et al. [5] focuses on KD, focusing on typing patterns, has been used as a biometric for authentication systems. However, a study introduces Mimesis, a feedback and training interface enabling individuals to imitate others' typing patterns. This challenges the uniqueness of keystroke patterns, showing that even with partial information, attackers can defeat anomaly detection engines using keystroke biometrics. The study emphasizes considering potential vulnerabilities in KD for robust security measures. In Polikar et al. [6], ensemble systems, known as multiple classifier systems, have increased attention in computational intelligence and ML. These systems, designed to improve decision-making accuracy by reducing variance, have proven remarkably effective and versatile across diverse problem domains. This paper provides an insightful overview of ensemble systems, exploring their properties and applications in various realms, such as feature selection, confidence estimation, incremental learning, and more.

In Kiyani et al.[7], continuous user authentication is crucial for robust cybersecurity. This paper introduces a novel approach utilizing KD and a two-phase methodology involving ensemble learning and a robust recurrent confidence model. The system continuously assesses user actions, employing confidence thresholds to determine legitimacy. Experimental results demonstrate the effectiveness of the proposed methodology, showcasing its ability to achieve resilient continuous user authentication. In de-Marcos et al. [8], continuous authentication is vital in the mobile environment, addressing vulnerabilities of traditional one-time methods. This study explores keystroke mechanics using ML classifiers, including ensemble methods, to achieve reliable continuous authentication on mobile devices. Results indicate that ensemble algorithms, particularly Gradient Boosting, outperform other classifiers in the context of mobile keystroke classification.

A potential research gap in the field of user authentication using KD lies in enhancing authentication accuracy and robustness. The variations in KD that may arise due to factors such as individual typing habits, environmental conditions, and hardware differences among users' devices. These variations can introduce noise and complexity into the dataset, making it challenging to accurately differentiate user from other users based on keystroke patterns. If user authentication fails, significant challenges and drawbacks emerge. Firstly, legitimate users may face inconvenience and frustration due to denied access, disrupting their workflow and user experience. Moreover, repeated failed authentication attempts may result in account lockouts or access restrictions. Therefore, addressing these challenges and implementing effective fallback mechanisms to mitigate the demerits of unsuccessful user authentication is paramount for ensuring system usability, security, and user satisfaction.

PROBLEM STATEMENT

The work aims to implement user authentication using KD through ensemble learning techniques. There are 'n' number of user. Each user, represented by a biometric template stored in the dataset, seeks access to the system, requiring their KD to match their respective biometric template. The system aims to accurately identify and authenticate User 1 based on parameters such as,

1. Hold Time (HT): E.KeyUp - E.KeyDown for the 'E' key.

   lt measures the time difference between pressing and releasing a given key.

2. Down Down Time (DDT): E.KeyDown - D.KeyDown for 'E' and 'D' keys.

   It measures the time between pressing one key and the subsequent pressing of the other key.

3. Up Down Time (UDT): E.KeyUp - D.KeyDown for 'E' and 'D' keys.

   It measures the temporal span between releasing a key and pressing the next keys.

The challenge lies in developing a robust ensemble learning model capable of effectively discerning User 1's KD from the dataset, ensuring secure and reliable user authentication within the system.

MATERIALS AND METHODOLOGY

Dataset Collection

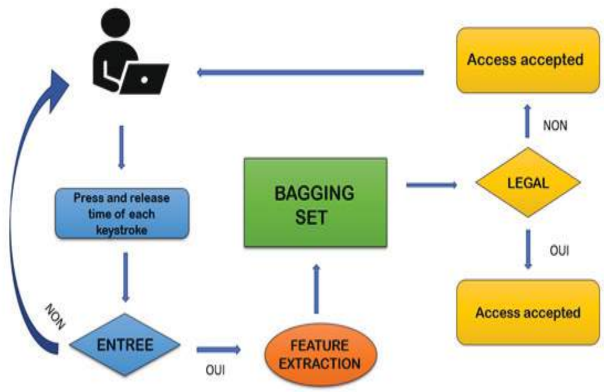

Fig. 1 : Dataset Collection

In this approach, artificial intelligence algorithms, specifically an ensemble of classifiers, enhance user authentication using KD. The adoption of an ensemble proves significantly more effective than relying on individual classifiers in isolation, resulting in notable improvements. Fig. 1 describes dataset collection.

The keystroke data acquisition from 50 different user in a gap of 8 session in which the password is typed 50 times per user [26]. On an estimation there is around 400 tuple was generated for each user on the basic of patten in which each user type their own password, these characteristics are based upon Hold Time, down down time and up down time.

Feature Extraction

For this, a public database sourced from Carnegie-Mellon University (CMU) was utilized [26], focusing on three pivotal characteristics:

1. Hold Time (HT):lt Depicts the time difference between pressing and releasing a given key, calculated as E.KeyUp - E.keydown for the 'E' key.
2. Down Down Time (DDT): Quantifies the time between pressing one key and the subsequent pressing of the other key, computed as E.KeyDown - D.KeyDown for 'E' and 'D' keys.
3. Up Down Time (UDT): Measures the temporal span between releasing a key and pressing the next key, determined as E.KeyUp - D.keyDown for 'E' and 'D' keys.

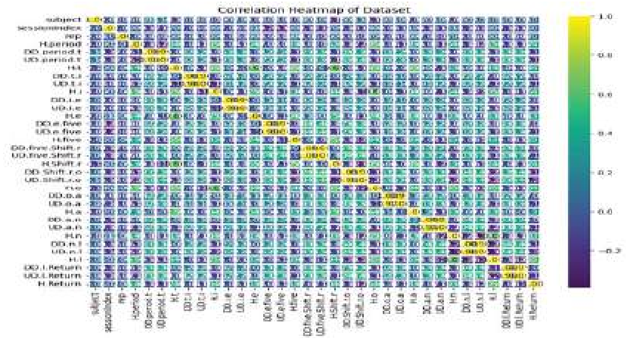

Fig. 2 : Dataset Heatmap

The above Fig. 2 represents the correlation heatmap of the dataset on the basis of the DD,UD and H time in the dataset given for 50 users. As there are 50 users in the dataset we have to make multi-label classification of 50 labels.

Classification

Sets of classifiers, each comprising diverse individual classifiers, operate concurrently and undergo training on the allocated training data, yielding distinct outputs. The integration of these outputs transpires through majority voting, ultimately determining the conclusive decision. The foundational classifiers encompass the Support Vector Machine, k-Nearest Neighbors , Decision Trees, CAT boost, XG boost, logistic recession, majority voting and bagging classifiers.

By incorporating these methodologies, the approach aims to achieve robust user authentication by effectively analyzing KD with artificial intelligence algorithms. The ensemble of classifiers, feature extraction, and classification steps collectively contribute to a comprehensive and reliable authentication system

Essemble Learning Models

Max Voting in Ensemble Learning

Max Voting, also referred to as majority voting, serves as a fundamental ensemble learning technique primarily utilized in classification tasks. The concept is straightforward yet effective, involving the aggregation of predictions from multiple individual models and selecting the class that attains the majority of votes as the final prediction. Mathematically, in a scenario with 'n' classifiers denoted as C_1, C_2, ..., C_n, each providing a prediction for a given input assigned to a specific class, the final prediction is determined by selecting the class with the maximum count or frequency among the individual predictions.

The formula for Max Voting is expressed as:

Final Prediction = $\arg max_c \ \sum_{i=1}^{k} \prod(Ci \ predicts \ c)$ (1)

Here, arg max_c denotes the class 'c' with maximum count, and $\prod$ (C_i predicts c) is an indicator function that evaluates to 1 if Ci predicts class 'c' and 0 otherwise. The class accumulating the highest count across all classifiers is selected as the ultimate prediction.

Bagging in Ensemble Learning

Bagging, short for Bootstrap Aggregating, stands out as a robust ensemble learning technique to enhance the accuracy and stability of ML models. This involves the training of multiple instances of the same learning algorithm on distinct small parts of the training data, acquired through random sampling with replacement, known as bootstrap sampling. The predictions from each model undergo a combination process, employing averaging (for regression tasks) or max voting (for classification tasks), culminating in the final ensemble prediction. Bagging fundamentally aims to inject diversity into the models, thereby mitigating overfitting and elevating overall predictive performance. A base classifier is trained for each bootstrap sample, yielding k diverse models. The ultimate prediction is derived by aggregating the predictions from individual models.

For classification tasks, this can be expressed as:

Final Prediction = $\arg max_c \ \sum_{i=1}^{k} \prod(Ci \ predicts \ c)$ (2)

In this expression, Ci signifies the predictions of the i^{th} base classifier, and $\prod$ (C_i predicts c) is an indicator function. The class with the maximum count across all base classifiers emerges as the ensemble prediction.

Average in Ensemble Learning

Average, also known as Mean Aggregation, stands out as a fundamental technique in ensemble learning, especially when dealing with regression tasks. The fundamental principle involves merging predictions from diverse base models through the calculation of their mean. This strategy aims to alleviate biases present in individual models, fostering a more generalized prediction. The formula for average aggregation remains straightforward:

Final Prediction = $\frac{1}{k}\sum_{i=1}^{k} P_i$ (3)

In this equation, k signifies the count of base models, while Pi denotes the prediction of the i^{th} base model.

Boosting

The boosting methods mix all weak learners to form a robust and strong model. It performs better than the traditional machine learning models. The models used in boosting are Gradient Boosting, XGBoost, CatBoost, etc.

METHODOLOGY

Data acquisition is followed by the Data labelling and feature extraction method based on featured extracted which are generally in the time strokes format mentioned in the acquisition process. In places of using normal regression techniques rather we use ensemble learning where we used boosting techniques like XG Boost, CAT boost, ADA boost, GBC bagging and Majority voting. Fig. 3 describes methodology.

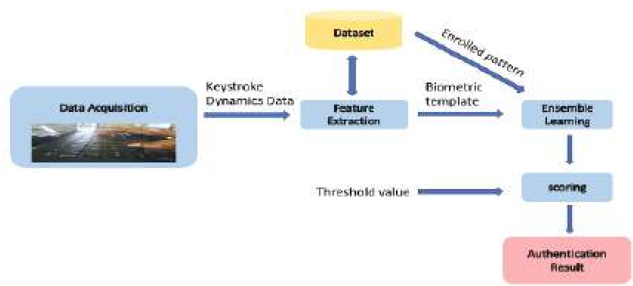

Fig. 3: Methodology

The feature extracted dataset is supplied to the ensemble model. The ensemble model works efficiently than the regression model. The dataset need transformation as it was a multilabel dataset. Followed by splitting the dataset and splitting the dataset and model training.

RESULTS AND DISCUSSION

The experiment was done in purpose of user authentication by the help of KD. For this purpose, CMU School KD Benchmark Dataset was used. For the whole process of experimenting have used a system that is powered by Ryzen 5 4000 series octa-core processor with 8GB DDR4 RAM along with 4GB Nvidia GTX1080 GPU. The system contains Windows

11 OS system and for the physical work the main platform used here is the Python 3.1.0 along with its library mainly NumPy, Pandas, Sckitlearn and other subsidiary modules. The Software Specifications also included pyplot, Regression Models, seaborn, ensemble learning, sklearn.

Experimentation

The experimentation started with the Linear regression, Random Forest and KNN algorithms and the averaging method was introduced in order to get a enhanced accuracy. This was followed by the Boosting technique here the XG Boost, Gradient Boosting, ADA boost and Cat boost was used. Along with this 4-boosting algorithm also there is a bagging technique involving XGBoost. Followed by the max Voting technique.

Performance Analysis

The performance of the system is analyzed using three parameters such as Accuracy, mean square error (MSE), and mean absolute error (MAE).

Table 1 : Accuracy, MAE and MSE

Models	Accuracy	MAE	MSE
Averaging	0.808	105.005	7.88
Bagging	0.852	75.288	2.78
Max voting	0.862	72.303	2.63
XGBoost	0.928	36.806	1.35
CatBoost	0.959	22.782	0.79
Gradient Boosting	0.923	34.407	1.33
AdaBoost	0.345	9.689	215.55

The Table 1 shows the model comparison of different models after training the dataset. The table here forth signifies CAT Boost technique grew out to be the most accurate learning model with an accuracy of 0.959 where its MSE is found to be 0.79 and MAE found to be 22.782. Fig. 4- Fig. 6 describes results. The Averaging method gave an accuracy output of 0.808 when we took 3 ML models and MSE gave an output of 7.88 and MAE an output of 105.005 . This was followed by the Bagging Models where we got an accuracy of 0.852 , MSE of 2.78 and MAE of 75.288 followed by Max Voting model where the result of accuracy , MSE and MAE is 0.862 ,2.63 and 72.303 respectively. Gradient Boost model gave us an accuracy of 92.3 , MSE of 1.33 and MAE 34.407. The XGBoost output was 0.928 and a MSE of 1.35 and a MAE of 36.806 And lastly the ADABoost gave us 0.345 , MSE of 215.55 and MAE of 9.689.

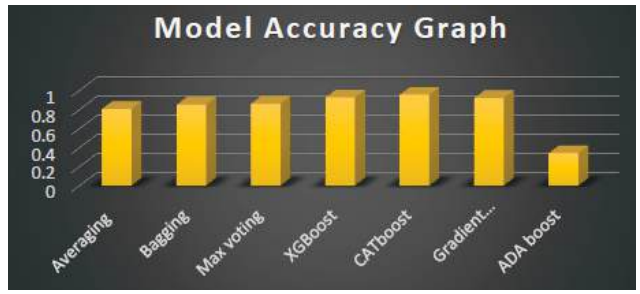

Fig. 4 : Accuracy Graph

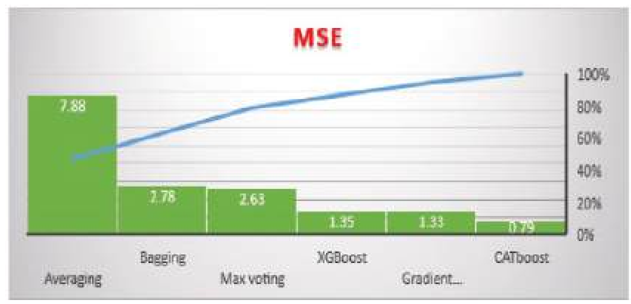

Fig. 5 : Mean absolute Error Graph

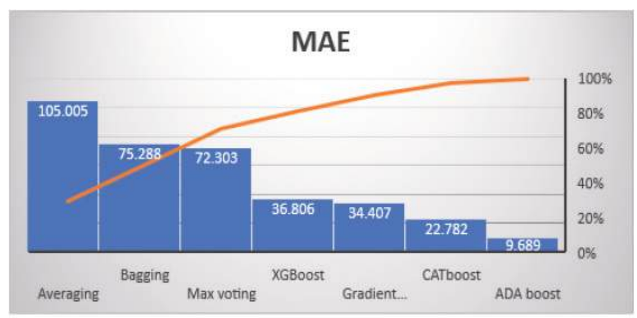

Fig. 6 : Mean Squared Error

CONCLUSION

In this work, a user authentication approach based on ensemble learning is proposed which includes Averaging, Bagging, Max Voting, XGBoost, CatBoost, Gradient Boosting and AdaBoost method. The boosting technique no doubt were predominantly provides high accuracy where for the averaging and other means needed the ML algorithms such as KNN, Random Forest, Decision Tree and Linear Regression to make a overall output of the following. These combination of four classifiers were not so accurate but gave us the idea and motivation to look for other Ensemble Learning Approach based on the result. For performance Analysis in addition with the Accuracy score we also went with the Mean Squared Error and Mean Absolute Error. In addition to the performance metrics we also added the Confusion Metrics for the better understanding of the work. In the whole experimentation we found that CatBoost grew out to be the most accurate with a accuracy of 95.9% the other models performed also well but the AdaBoost came out to be inappropriate model for this work giving only 34% of accuracy where as the other models have an accuracy equal or greater than 80%. This experiment can be done in order to implement in various authentication facilities and a secure authentication process can be implemented even if the password of a particular user is compromised. This can also be implemented in the CNN models and can also give us better result.

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Analysis of NLP Techniques for Phishing and Smishing Detection

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ABSTRACT

In this paper, we compare machine learning approaches to identify phishing and smishing attack techniques that utilized word2vec (CBOW and Skip-gram), fast text (CBOW and Skip-gram) and sentence embedding. The Result we received that sentence embeddings performs outstanding as compared to standard embeddings used in these research study. The study result shows that similar to KNN, SVC and ML classifiers they achieved excellent accuracy and minimal overfitting. The KNeighbors Classifier and SVC were able to reach amazing test accuracies of 87.18% and 89.05% correspondingly thanks to Sentence Embedding being able to incorporate semantic context which is so important for exact classification. Although Word2Vec and FastText embeddings showed competitive performance, with Fast-Text Skip-gram reaching a peak test accuracy of 85% with MLP Classifier, they generally underperformed compared to Sentence Embedding in maintaining stability across training and testing phases. The significance of these advanced embeddings is further shown in this study since contextual embeddings show promising in identifying minute phishing and smishing patterns.

KEYWORDS: *Text classification algorithms, Natural language processing (NLP), Word2vec, Fast text, Sentence embedding's, BERT, Phishing smishing detection.*

INTRODUCTION

Phishing and smishing attacks are becoming the growing cybersecurity threats that manipulate individuals or organizations using social engineering tactics to carry out data breach, financial loss and reputation loss. Phishing generally involves fraudulent emails, while smishing leverages SMS messages, both crafted to appear authentic and trick recipients into sharing sensitive information. Traditional rule based detection methods are proving inadequate as these attacks become even more sophisticated. Attackers now evade basic keyword filters by crafting messages that closely mimic legitimate communications. Such evolving threat detection techniques requires intelligent and adaptive detection systems to effectively find out such kind of security risks, which can discern malicious intent, even when instrumented to conceal malicious intent. The promise of using machine learning, especially in combination with natural language processing (NLP), is shown for phishing and smishing detection using the text. Text embedding techniques such as Word2Vec, FastText, and sentence embeddings are key to transforming textual data into numerical vectors, enabling models to analyze and classify messages accurately. In this research work, three embedding methods are presented that work on identifying and finding the most effective method of capturing phishing and smishing content.

Word2Vec, which generates word-level vectors, is effective with commonly used terms but struggles with rare words or typos due to its fixed vocabulary. FastText improves on Word2Vec by breaking words into subword units, allowing it to capture word variations and typos, making it highly adaptable for diverse input. Instead, sentence embeddings supply a total representation of entire messages, and the deeper context is critical for nice detailed discernment in advanced cyber safety programs. This study's findings will be used at determining which technique to optimum embed sentence using sentence embeddings given robustness in context, Word2Vec for precision with common terms and FastText for input diversity. These findings will reach out in creating strong and appropriate phishing and smishing detection techniques that will be robust and concrete against extra aggressive cyber-attacks.

LITERATURE REVIEW

The BOW and FNN are compared to word2vec with CNN in this research data study, using fetch20newsgroups dataset. Results show that CNN with Word2Vec outperforms by capturing semantic nuances and handling unseen words more effectively, highlighting CNNs' superior context-aware classification with advanced embeddings [1].

AI models are successfully detecting phishing using URL datasets as well as reaching 98% accuracy detecting phishing and spam emails with machine learning, especially with LSTM networks. We do however have more to explore about machine learning techniques despite that, and by adopting these models to different datasets and email threat types [2].

In this the study, is emotion classification using SVM and Multinomial Naïve Bayes (MNB) and compares TF-IDF to Word2Vec on the same dataset. Results indicate that TF-IDF combined with SVM outperforms Word2Vec in terms of accuracy and consistency particularly against unbalanced data, revealing an advantage of TF-IDF in smaller data sets [3].

In this paper, our experiment shows that CNNs in combination with FastText embeddings are superior to classic methods (i.e. TF-IDF and BoW) in text classification. Applied to datasets like AG News and Amazon reviews, this model highlighting CNN's training efficiency and FastText's robust word representations. The approach provides a scalable NLP solution, performing well without extensive manual feature extraction [4].

This study explores sentiment classification using fastText embeddings with lightweight models like single-layer CNN and BiGRU. The fastText+CNN model achieved high accuracy—80% on the MR Dataset and 84% on SST2matching more complex models like BiLSTM. Findings that simpler architectures combined with strong embeddings can provide efficient, real-time NLP performance [5].

This study compare these embeddings to CNN for text classification on a 20 topic news dataset and find that due to its subword modeling capability, FastText achieves the highest accuracy at 97.2%. Results show that optimal CNN performance can be achieved by nesting with dataset characteristics. FastText's handling of out-of-vocabulary words beneficial in this context [6].

With ensemble methods (Random Forest and Extra Tree), we compare Word2Vec and FastText embeddings for sentiment analysis in Indonesian hotel reviews. Out of vocabulary words are handled to the best by the FastText and it produces the highest accuracy of 93 percent. Results show that FastText is indeed effective, especially with unbalanced data, and provide some motivation for further investigation of other embeddings like GloVe [7].

Text classification efficiency with reduced computational demands using the literature. Traditional models like CNNs, RNNs, and FastText require significant resources, while recent class-based word embeddings offer a balance of accuracy and efficiency, particularly for resource-constrained applications [8].

Recent studies highlight BERT's role in text classification, optimizing sentence embeddings. "Rethinking BERT Sentence Embedding" critiques the [CLS] token and shows that freezing BERT's parameters and using hidden layers achieves state-of-the-art results, offering an efficient alternative to full fine-tuning [9].

With the aim in automating phishing detection, the paper studies NLP and ML models such as Word2Vec, BERT and RNNs used to significantly alleviate the dependence upon user vigilance. Compared to raw text, BERT performed nearly perfectly (nearly 99%) to detect phishing patterns in text, confirming NLP's ability to leverage refined learning to help boost cybersecurity against phishing attacks [10].

RESEARCH METHODOLOGY

Data Collection and Preprocessing

The initial phase of the research involves the collection of a comprehensive and diverse set of email and SMS datasets, encompassing phishing, smishing, and legitimate messages. The dataset, spanning from 2023 to 2024, comprises 11,187 records obtained through visits to Cyber Cells , with raw data initially captured in formats such as screenshots or textual messages, which are subsequently transformed into structured datasets. Additionally, publicly available datasets, prior cybersecurity studies, and data sourced from collaborations with cybersecurity firms are incorporated. Phishing and smishing analysis involves preprocessing data such that it is cleaned, handles missing values, and resolves class imbalance. Preprocess steps include removing non alphabet characters using the Porter Stemmer, converting text to lowercase, tokenize, keep stopwords except "not" if this is a sentiment related task and stem to finally a final corpus for feature extraction.

Exploratory Data Analysis

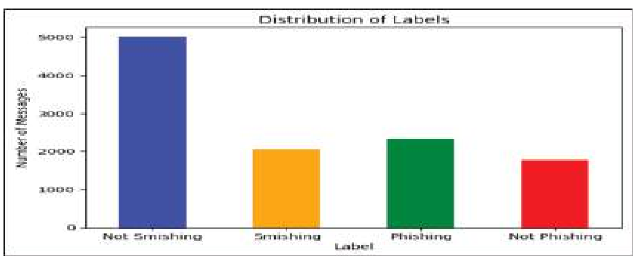

Fig. 1: Distribution of Labels

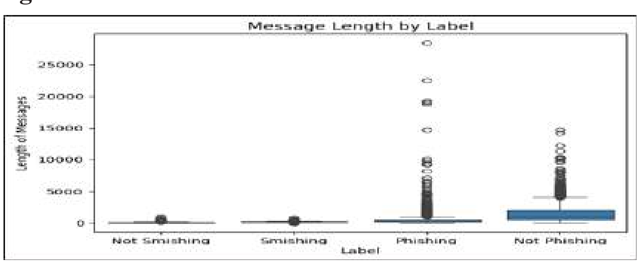

Fig. 2: Message length by label

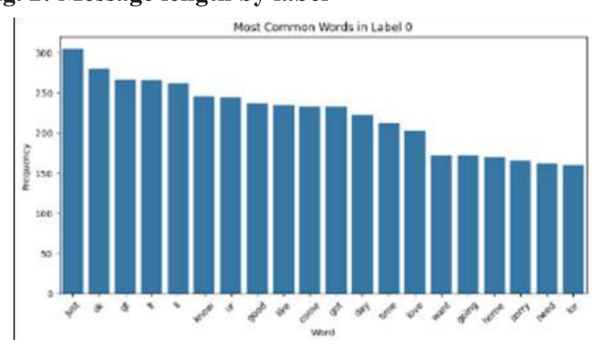

Fig 3: Most common words in Not Smishing

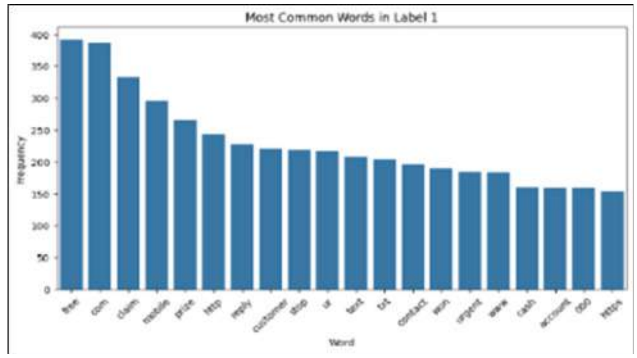

Fig. 4: Most Common words in Smishing

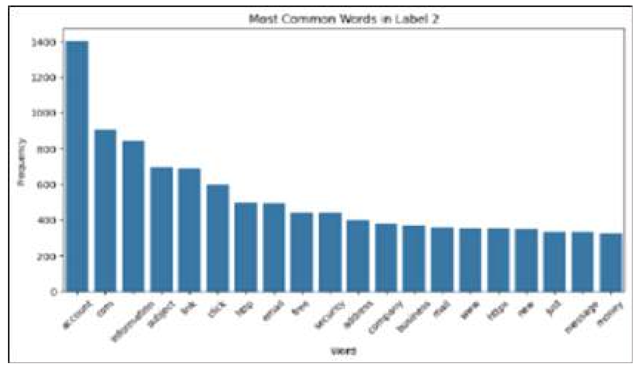

Fig. 5: Most common words in Phishing

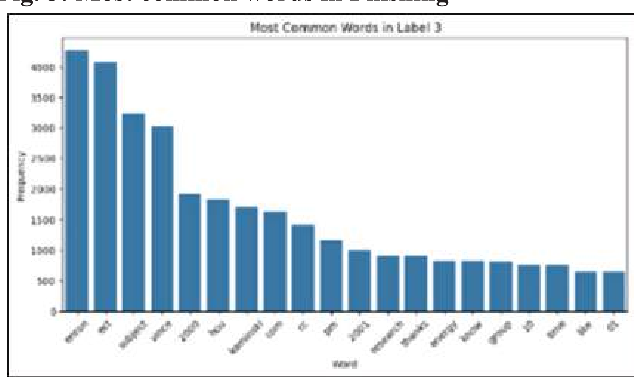

Fig. 6: Most common words in Not Phishing

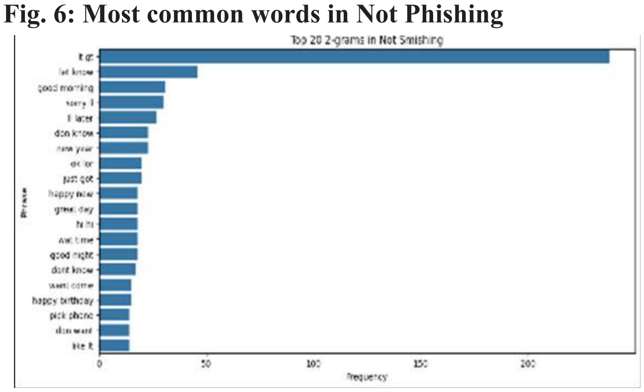

Fig. 7: Top 20 Two-Grams in Not Smishing

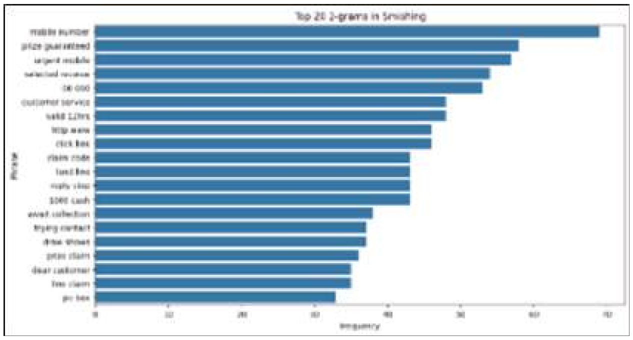

Fig. 8: Top 20 Two-Grams in Smishing

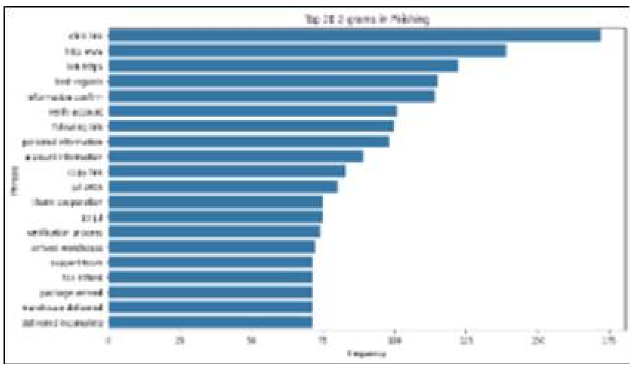

Fig. 9: Top 20 Two-Grams in Phishing

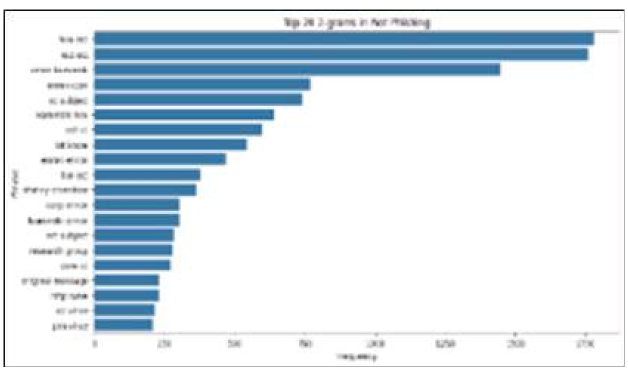

Fig. 10: Top 20 Two-Grams in Not Phishing

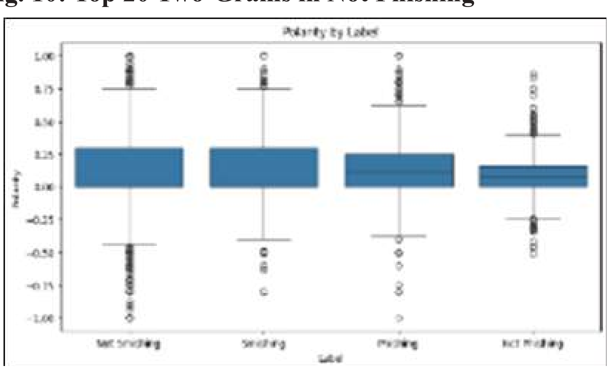

Fig. 11: Box Plot for label polarity

This analysis involves looking at a dataset of categorized messages and how message categories, language patterns and sentiment distribution look, along with the trends. Figures 1 and 2 reveal distribution insights, showing 'Not Smishing' messages as the largest group (5,000 messages), followed by 'Phishing' (2,500), 'Smishing' (2,000), and 'Not Phishing' (1,800). Box plots of message lengths illustrate significant content variation within 'Phishing' messages, marked by notable outliers. Word frequency analyses (Figures 3-6) highlight distinct language characteristics within each category: 'Not Smishing' messages often contain informal terms like "just" and "ok," while 'Smishing' messages include persuasive words such as "free" and "claim," typical of promotional scams. 'Phishing' messages frequently feature terms like "account" and "security," emphasizing account protection themes, while 'Not Phishing' messages use words like "enron" and "kaminski," implying professional contexts. Two-word phrase analysis (Figures 7-10) captures common 2-grams, such as "lt gt" and "let know," and differentiates patterns across categories. For 'Smishing,' phrases like "mobile number" and "prize guaranteed" are common, indicating marketing language. 'Phishing' messages include "click link" and "verify account," associated with account verification attempts, while 'Not Phishing' phrases reflect professional interactions, including "research group" and "amazon account". Sentiment analysis (Figure 11) shows polarity scores from -1 to 1, with 'Phishing' and 'Not Phishing' messages demonstrating broad sentiment ranges, medians near neutral, and diverse outliers. What we see instead, is that words reflect...well, not only words themselves, and the array of emotions used in phishers' and spammers' 'Phishing' and 'Smishing' messages can be good clues to help us to be smarter about detecting scams. Finally we say that construct phishing and smish communications while capturing the emotion they produce, thereby being a baseline for improving message detection.

RESULTS

Training and Testing the Models: Word2vec, fast text and Sentence Embeddings

In machine learning, the `train_test_split` function from `sklearn.model_selection` is widely used to partition a dataset into training and testing subsets, generally allocating 80% for training and 20% for testing. Specifying `random_state=0` guarantees reproducibility of results across multiple runs.

Word2vec CBOW and Skip-gram setup and graphs

Word2vec CBOW and Skip-gram Experimental Setup

This section details the use of Word2Vec for text vectorization, employing both CBOW and Skip-gram architectures to capture diverse semantic features. The "Message" column corpus was tokenized using NLTK's `word_tokenize`, creating a sequence of words for Word2Vec training. The CBOW model (sg=0) was used to predict words from their context, capturing frequent word associations, while Skip-gram (sg=1) focused on predicting context words for rare terms, adding finer semantic granularity. Each word was represented by a 100-dimensional vector, and document-level embeddings were created by averaging these vectors, yielding feature inputs (X) for classification with the target variable (y) from the "Label" column. This approach leverages both CBOW and Skip-gram to enhance model performance in phishing and smishing detection.

Word2vec: Algorithm used including Hyper parameter tuning

In this study, Decision Trees and Neural Networks with Word2Vec vectorization (CBOW and Skip-gram) were used for phishing and smishing detection, and tuned hyperparamters were optimized the Decision Tree. Key parameters adjusted included criterion, splitter, max_depth, min_samples_split, min_samples_leaf, max_features, max_leaf_nodes, min_impurity_decrease, and ccp_alpha. By fine tuning, we were able to achieve 'perfect' pattern capture, thereby improving model accuracy. Combining Word2Vec embeddings with the optimized Decision Tree yielded an effective classification approach.

Word2vec Results and Graphs

Figures 12 to 15 reveal the performance of classifiers using Word2Vec's CBOW and Skip-gram embeddings. Initially, DecisionTreeClassifier showed overfitting, with high training accuracies (0.98) but lower test accuracies (0.75 for CBOW and 0.79 for Skip-gram); hyperparameter tuning improved its balance, yielding 0.72 (train) and 0.70 (test) for CBOW, and 0.79 (train) and 0.75 (test) for Skip-gram. Multinomial NB showed poor fit, with test accuracies of 0.55 (CBOW) and 0.60 (Skip-gram). Random Forest Classifier provided balanced results around 0.80 across train and test for both embeddings. KNeighbors Classifier, GradientBoostingClassifier, MLPClassifier, and SVC demonstrated strong generalization, with MLP and SVC achieving the highest test accuracies (0.84-0.85). Overall, MLP Classifier, SVC, KNeighborsClassifier, and GradientBoostingClassifier performed well with both embeddings, while hyperparameter tuning notably improved Decision Tree's stability.

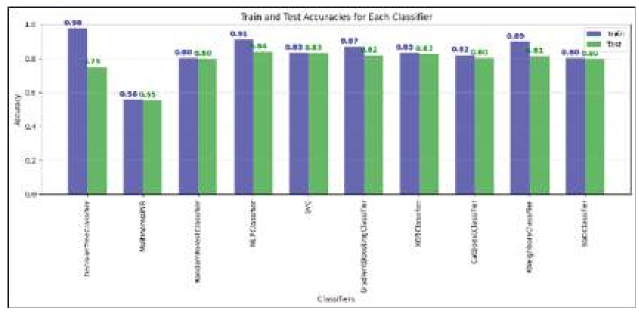

Fig 12: All Classifiers Train-Test Accuracy Bar Chart-using Word2vec for CBOW

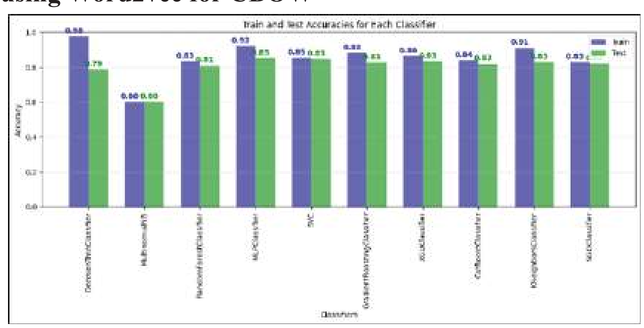

Fig. 13: All Classifiers Train-Test Accuracy Bar Chart-using Word2vec for Skip-gram

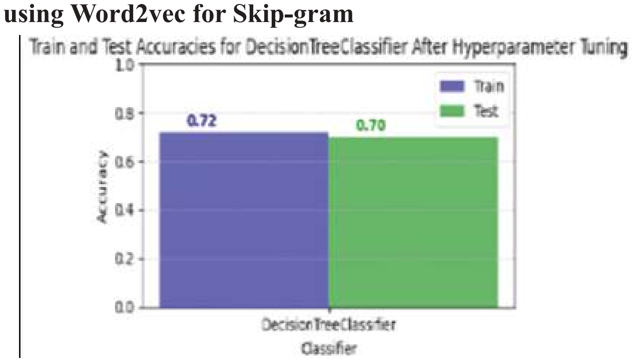

Fig. 14: DT classifier after Hyper parameter tuning for Word2vec CBOW

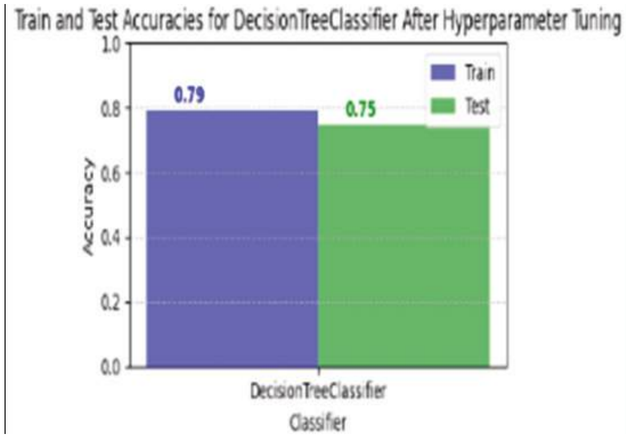

Fig. 15: DT classifier after Hyper parameter tuning for Word2vec Skip gram

Fast text setup and graphs

Fast text Experimental Setup

In this section, we walk through the usage of FastText for text vectorization based on both CBOW and Skipgram architectures on tokenized text from "Message" column. Trained with a 250-dimensional vector size, a 20-word context window, and a minimum word frequency of 15, FastText captures both common and rare word relationships, including subword information, which enhances resilience to spelling variations. Document embeddings, averaged from word vectors, serve as input features for classifiers aimed at phishing and smishing detection, benefiting from FastText's comprehensive semantic coverage.

Fast text: Algorithm used including Hyper parameter tuning

In this section, we walk through the usage of FastText for text vectorization based on both CBOW and Skipgram architectures on tokenized text from "Message" column. Trained with a 250-dimensional vector size, a 20-word context window, and a minimum word frequency of 15, FastText captures both common and rare word relationships, including subword information, which enhances resilience to spelling variations. Document embeddings, averaged from word vectors, serve as input features for classifiers aimed at phishing and smishing detection, benefiting from FastText's comprehensive semantic coverage.

Fast text Results and Graphs

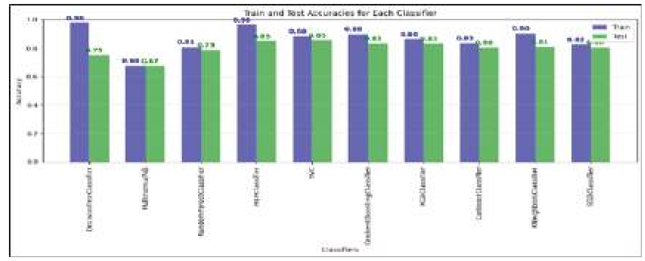

Fig. 16: All Classifiers Train-Test Accuracy Bar Chart-using Fast Text for CBOW

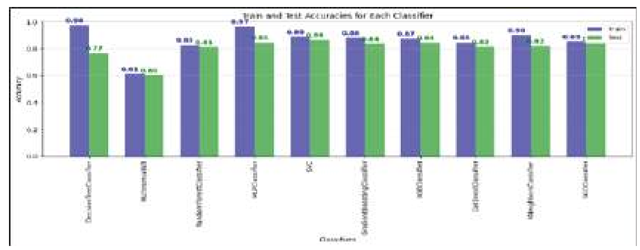

Fig. 17: All Classifiers Train-Test Accuracy Bar Chart-using Fast Text for Skip-gram

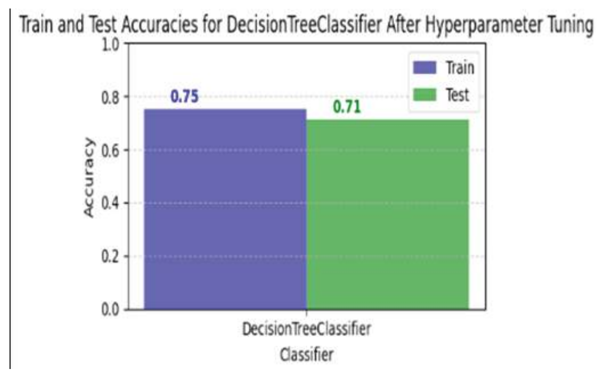

Fig. 18: DT classifier after Hyper parameter tuning for Fast Text CBOW

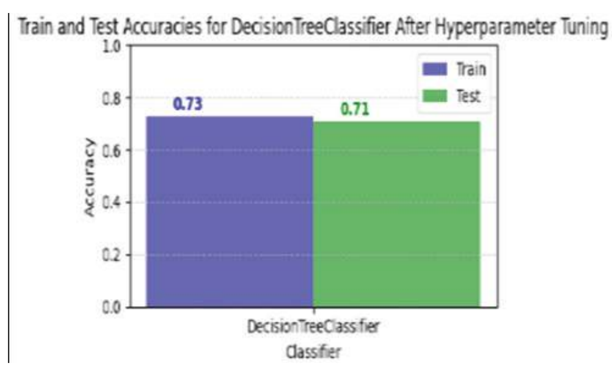

Fig. 19: DT classifier after Hyper parameter tuning for Fast Text Skip gram

As per show in figure 16 to 19 the evaluation of classifiers using FastText's CBOW and Skip-gram embeddings revealed model-specific performance patterns. The DecisionTreeClassifier initially exhibited overfitting, with an accuracy of 0.98 (train) and 0.75 (test) in Skip-gram, which improved slightly with tuning. MultinomialNB performed poorly, with test accuracies of 0.60 (Skip-gram) and 0.67 (CBOW), highlighting its limitations. RandomForestClassifier achieved balanced accuracy across both embeddings, scoring 0.83 (train) and 0.81 (test) with Skip-gram. MLPClassifier and SVC emerged as strong contenders, achieving test accuracies of 0.85 for both CBOW and Skip-gram, while KNeighborsClassifier maintained generalization with test scores of 0.82 (Skip-gram) and 0.81 (CBOW). GradientBoostingClassifier and XGBClassifier also performed consistently well, with test accuracies around 0.84 for both embeddings, demonstrating effective handling of text data using FastText embeddings.

Sentence Embedding setup and graphs

Sentence Embedding Experimental Setup

Sentence embeddings provide an efficient way to transform text into a machine-learning-compatible format, encapsulating semantic meaning using the `"models/embedding-001"` model. The `genai.embed_content` function generates numerical vectors that capture the essence of each message's content. This augmented approach enhances accuracy and processing speed for a categorical and predictive tasks on the dataset.

Sentence Embedding : Algorithm used including Hyper parameter tuning

Secondly we used Sentence embeddings to apply Machine Learning algorithms: Decision Trees, Random Forest, SVMs and Neural Networks. In order to control negative values and obtain better predictive accuracy, a voting classifier was chosen instead of Multinomial Naive Bayes. We hyperparameter tuned Decision Trees and MLPs with Randomized Search CV over the following key params: criterion, tree depth, and regularization factors. Additionally, data focused and efficient model performance was attained via ensemble approach and gradient boosting.

Sentence Embedding Results and Graphs

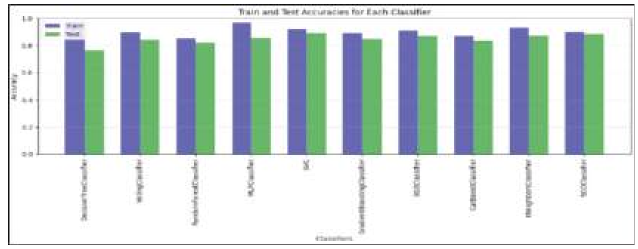

Fig. 20: All Accuracy using sentence embedding Technique

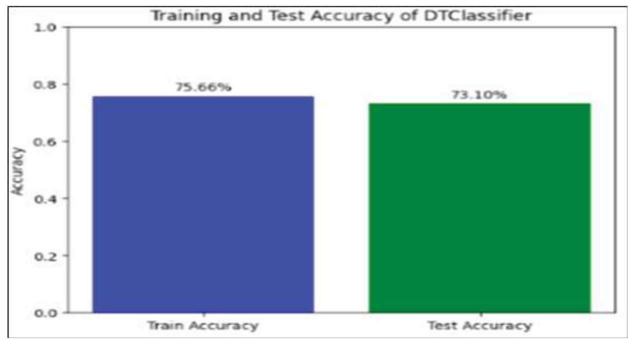

Fig. 21: DT after Hyperparameter tune

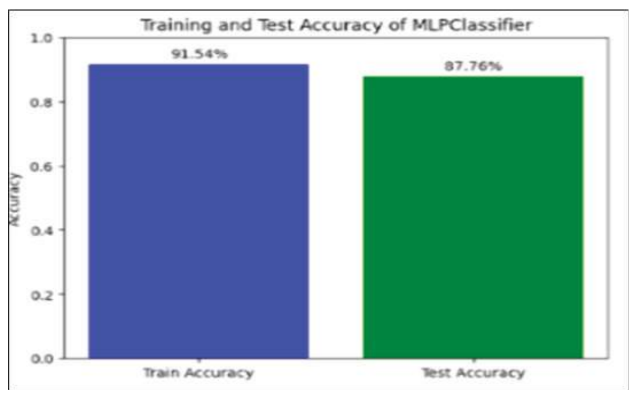

Fig. 22 MLP after hyperparameter tune

As shown in Figure 20 to 22, to enhance test accuracy, Neural Networks, Decision Trees, and MLP Classifiers were combined. Tuning MLP parameters—using the 'adam' solver, a single hidden layer of 80 units, an alpha of 0.01, and 'logistic' activation—boosted test accuracy from 85.57% to 88%. The Decision TreeClassifier was optimized with the 'entropy' criterion, a maximum depth of 10, and a minimum sample split of 10, which shifted test accuracy from 76.27% to 73%. Data driven insight derived from advanced techniques including gradient boosting and ensemble methods yield highly effective model outcomes.

DISCUSSION

From the above comparison of various machine learning algorithms, the accuracy chart is as follows:

Table 1. Word2Vec CBOW accuracy chart

Word2Vec CBOW Accuracy Chart			
S. No .	Algorithm Name	Accuracy	
		Train	Test
1	MLPClassifier	0.91	0.84
2	KNeighborsClassifier	0.89	0.81
3	GradientBoostingClassifier	0.87	0.82
4	SVC	0.83	0.83
5	XGBClassifier	0.83	0.82
6	CatBoostClassifier	0.82	0.80
7	SGDClassifier	0.80	0.80
8	RandomForestClassifier	0.80	0.80
9	DecisionTreeClassifier	0.72	0.70
10	MultinomialNB	0.56	0.55

Table 2. Word2Vec Skip-gram accuracy chart

Word2Vec Skip-gram Accuracy Chart			
S. No .	Algorithm Name	Accuracy	
		Train	Test
1	MLPClassifier	0.92	0.85
2	KNeighborsClassifier	0.91	0.83
3	GradientBoostingClassifier	0.88	0.83
4	XGBClassifier	0.86	0.83
5	SVC	0.85	0.85
6	CatBoostClassifier	0.84	0.82
7	RandomForestClassifier	0.83	0.80
8	SGDClassifier	0.83	0.82
9	DecisionTreeClassifier	0.79	0.75
10	MultinomialNB	0.60	0.60

Table 3: Fast Text for CBOW accuracy chart

Fast Text for CBOW Accuracy Chart			
S. No .	Algorithm Name	Accuracy	
		Train	Test
1	MLPClassifier	0.96	0.85
2	KNeighborsClassifier	0.90	0.81
3	GradientBoostingClassifier	0.89	0.83
4	SVC	0.88	0.85
5	XGBClassifier	0.86	0.83
6	CatBoostClassifier	0.83	0.80
7	SGDClassifier	0.82	0.80
8	RandomForestClassifier	0.81	0.79
9	DecisionTreeClassifier	0.75	0.71
10	MultinomialNB	0.68	0.67

Table 4: Fast Text for Skip-gram accuracy chart

Fast Text Skip-gram Accuracy Chart			
S. No .	Algorithm Name	Accuracy	
		Train	Test
1	MLPClassifier	0.97	0.85
2	KNeighborsClassifier	0.90	0.82
3	SVC	0.89	0.86
4	GradientBoostingClassifier	0.88	0.84
5	XGBClassifier	0.87	0.84
6	SGDClassifier	0.85	0.84
7	CatBoostClassifier	0.85	0.82
8	RandomForestClassifier	0.83	0.81
9	DecisionTreeClassifier	0.73	0.71
10	MultinomialNB	0.61	0.60

Table 5: Sentence embedding accuracy chart

Sentence Embedding Accuracy Chart			
S. No.	Algorithm Name	Accuracy	
		Train	Test
1	KNeighborsClassifier	0.93	0.87
2	SVC	0.92	0.89
3	MLPClassifier	0.92	0.88
4	XGBClassifier	0.91	0.87
5	SGDClassifier	0.90	0.88
6	VotingClassifier	0.90	0.84
7	GradientBoostingClassifier	0.89	0.85
8	CatBoostClassifier	0.87	0.83
9	RandomForestClassifier	0.85	0.82
10	DecisionTreeClassifier	0.76	0.73

Table 1, 2 provides a detailed comparison of train and test accuracies using the Word2Vec CBOW and Skip-gram method. Table 3, 4 provides a detailed comparison of train and test accuracies using the Fast-text CBOW and Skip-gram method. Table 5 presents a tabular comparison for train and test accuracies using the sentence embedding method.

CONCLUSION

In conclusion, we find that Sentence Embedding was the most suitable text vectorization technique to detect phishing and smishing attempts compared to Word2Vec and FastText in accuracy and stability. Of the classifiers considered, Sentence Embedding was the best at generalization in the sense that KNeighborsClassifier achieved 87.18% test accuracy and SVC 89.05%, and both had decent capture of semantic information. CBOW generally ran faster than FastText Skip-gram, with test accuracy of 85% from MLPClassifier having more variance. All embeddings showed limitations with complex vectorizations, and DecisionTreeClassifier was less reliable across all embeddings. This study furthers advocating that among all of those, advanced embedding methods that squeeze out the contextual depth help are crucial for effective phishing and smishing detection. Future work may explore hybrid embeddings or neural based models to extend accuracy and resilience in cybersecurity.

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A Novel Approach to Local Storage Retrieval Combined with a Hierarchical Ranking System

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ABSTRACT

Efficient retrieval from a local storage system continues to pose a significant challenge in the digital age, especially as data generation and consumption are continuously increasing at an exponential rate. For instance, searching for files in a digital storage that contains thousands of text documents has become inefficient, especially with most of the files organised randomly within the data storage. As a result, a faster yet more intuitive local storage retrieval process is required. This paper proposes the implementation of an innovative local storage file retrieval system by combining voice recognition technology (VRT) with a hierarchical rank algorithm. The proposed retrieval system, designed with user-friendliness in mind, utilizes the latest advancements in voice recognition technology to enable the user to input search keywords verbally rather than manually typing them. This not only reduces search time for the users but also provides an alternative means of inputting search keywords and files for users with physical disability. Furthermore, the hierarchical ranking algorithm ranks the retrieved data by multiple factors such as relevance, frequency of access, and recency of search. These search criteria are firmly established among Library Information System (LIS) researchers as an effective means of finding the most relevant information for a user. By combining these technologies, a faster, more user-friendly system for local storage retrieval that significantly reduces search time can be achieved.

KEYWORDS: *Content retrieval, Desktop application, MATLAB, Text extraction, Hierarchical ranking, Voice-to-text.*

INTRODUCTION

The constantly growing amount of stored data in local systems raises a need for better and faster information retrieval. There are many search systems, but most could be more effective. For example, the native Windows file search is quite suitable for ordinary searches[1]. However, it tends to be inefficient in-depth and poor at returning relevant results for complicated queries or large amounts of data. This paper presents a radically new local storage search approach that uses voice recognition and hierarchical ranking to improve old-fashioned search systems, offering notably superior accessibility, efficiency, and relevance of the search results.

Even in computing environments familiar to many of my readers, such as the Windows file search service standard to many organisations, users can find basic file-searching capabilities based on metadata, such as names, types and basic date/time properties. However, searching for text inside files or results filtered by substantially more sophisticated metadata, such as the context of phrase or importance, takes too much time, often resulting in a staggering number of irrelevant results [2], especially for large amounts of data. The system also lacks an easy-to-use interface to set up complex queries, so users must manually plug in arduous details on file-search conditions.

On the other hand, our proposed system integrates the latest voice recognition technologies that enable users to speak their search requests, which makes the system simpler to use in order to initiate a search and also puts less pressure on users because it's especially helpful for those who are disabled physically or vision impaired etc. Our system uses natural language processing better to grasp the context and subtleties of user utterances and convert the data gathered from their speaking on the Internet into appropriate tactics that return the most applicable results.

Additionally, at the heart of our system is its ranking algorithm, which is hierarchical in nature. This means it intuitively groups and orders the results depending on factors such as relevance, recency, and history of user interaction—thus providing the most critical information atop the search results instead of forcing users to navigate through seemingly useless drivel that they would otherwise have to scroll through.

As opposed to traditional content search using the standard [3] Windows architecture that requires the user to know file names or navigate convoluted search syntax, our new content mining system is naturally dynamic and user-centric because an information-seeker documents her intent in natural language. At the same time, the first result is ranked in the manner least detrimental to the need behind the query [4]. Further, the hierarchical ranking also serves to adaptively learn from the user interactions to better serve the needs of the information-seeker by further refining the ranking for the subsequent search based on the above-mentioned adaptive knowledge of the contents of the system.

Our design also simplified search, making local storage more accurate – by optimizing it in terms of architecture – and more usable than other technologies (such as Windows file search) that are not architecturally suited for this task but were implemented anyway. Our contribution not only includes the technically sophisticated and modified search engines we developed but also a technological and product-design path forward. We believe this is something to be cherished.

Objective

The aim of this work is to develop and assess a new desktop application based on MATLAB to improve data retrieval from local storage systems by combining hierarchical ranking algorithms. Retrieving the desired information from the large and rapidly growing volume of digital data is a real challenge. In addition to text-based approaches, this research focuses on the exploitation of new technologies to achieve the following objectives.

a) Design a MATLAB-based application that utilises novel and efficient approaches to programming and user interface design that can quickly retrieve specified content from selected local storage folders.

b) Implement advanced text extraction techniques: Include strong text extraction that can handle a variety of file types, including PDFs, TXT files, images, and DOCX documents, to access and index various document formats, making your application viable and functional.

c) Add voice-to-text features: Combine voice-to-text tools with search to enable search by voice, relax the text interface, and make the system more universal and usable, especially for people with disabilities or people who prefer voice-over typing.

d) Design a hierarchical algorithm to rank results: Design an algorithm to create an internal hierarchy system that can analyse and rank search results. This offers the most relevant information first according to the context and user need.

e) Evaluate system performance: Thoroughly test and evaluate the application's performance along several axes, such as retrieval speed, accuracy, and user satisfaction, to identify where the system excels and what areas could be strengthened to reach the rigorous standards of data retrieval.

f) Consider broader applications and impact: Consider possible applications and impacts of the system in related areas outside education, such as business and scientific research. This will help him or her understand how the application will be applicable to various use cases and environments.

g) Enrich the field of content retrieval: Contribute to content retrieval research through work that shows how voice recognition and hierarchical ranking can greatly enhance local storage retrieval performance and usability.

h) Encourage further research and development: Foster ongoing innovation and exploration in desktop application development for content retrieval. This paper's findings and methodologies are intended to inspire and invite further research and development within the academic and technology communities.

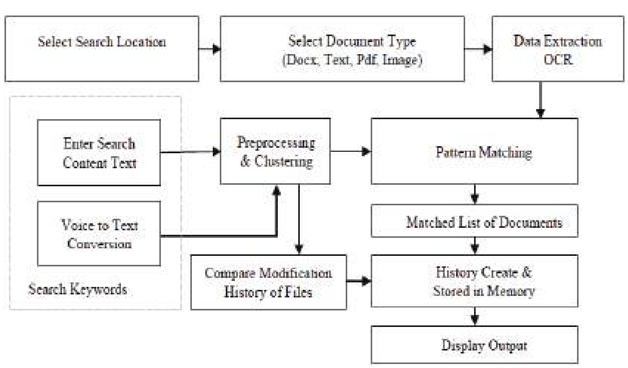
These goals will thus bring the field one step closer to machine reading, establishing a platform on which future developments that may redefine searching and interacting with data in digital environments may be built.

METHODOLOGY

The content retrieval desktop application was developed through a disciplined and iterative process that ensured robustness and efficiency of the system. The requirement analysis commenced with identifying the lacuna in content retrieval from the local storage, which demanded a robust application. Knowing the users, their needs and the challenges of the existing systems (in terms of speed, accuracy, user friendliness and others) were extremely important to design an application that would address real-world problems.

After this, the Design Phase follows; here, the system's architecture is described, high-level requirements translated into specific tasks, a project plan organised (duration of the project, number of resources involved, delivery points and due dates), and tools and technologies are decided upon (MATLAB for our core application, Tesseract OCR for image-to-text conversion, Google API for voice-to-text conversion), with a hierarchical ranking algorithm being devised for optimizing the relevance of our search results.

Fig. 1: System architecture for content retrieval



The desktop application to support enhanced content retrieval will be as good as the sum of data collected during the project. The application will involve multiple functionalities, such as voice recognition, text retrieval algorithms and hierarchical ranking, and will benefit from a broad range of data types. Training data come from PDFs, DOCX, TXT and images in different languages and styles, from millions of words spanning hundreds of topics. This data will help us train robust models for different document types, from simple word memorizers to complex content like open-source lecture notes, ensuring the application is as versatile and reliable as possible. Besides training data, user interaction data is essential to continuously improving the application. In each iteration of user testing, we'll record user commands, navigation traces, search queries, and feedback. The necessary data will be collected in different ways: we will collect documents from PubMed Central, other open repositories, academic databases, publishers, and organisations that keep rich digital archives to remove personal information.

Folder Scanning and File Parsing

The backbone of the information retrieval system that powers the project is folder scanning and file parsing. In folder scanning, every file corresponding to the search criteria is identified within the designated folders and in the sub-directories of these folders in the local computer storage. That is, folder scanning recursively searches through these files both in layer folders and sub-folders to ensure that all possible files are identified and available for retrieval. These files are then parsed for relevant extraction. The process is systematic. It starts with the top directory and proceeds to deeper down each sub-folder sequentially, checking each file along the way.

Files that match the search criteria are required to be parsed next. This step is an important one since it involves inspecting file metadata to extract textual data and identify the format of unstructured data. This step requires a parsing routine for each of the many document types such as PDFs, TXT files, images, etc. File parsing is important because it is the first step in the process where we have to deal with unstructured data and convert it to something 'raw' and later ready for processing purposes, such as text extraction and keyword search.

Table 1: Sample of Keyword Preprocessing and Clustering

S.N.	KEYWORD STRING	AFTER PREPROCESSING AND CLUSTRING
1	The sun shines brightly in the clear blue sky.	["sun", "shines", "brightly", "clear", "blue", "sky"]
2	A delicious aroma wafts from the kitchen as the cookies bake in the oven.	["delicious", "aroma", "wafts", "kitchen", "cookies", "bake", "oven"]
3	The majestic mountains stand tall against the backdrop of the setting sun.	["majestic", "mountains", "stand", "tall", "backdrop", "setting", "sun"]
4	The gentle breeze rustles the leaves of the trees in the tranquil forest.	["gentle", "breeze", "rustles", "leaves", "trees", "tranquil", "forest"]
5	The waves crash against the shore, creating a soothing melody.	["waves", "crash", "shore", "creating", "soothing", "melody"]

Accurate and well-structured data from the file parsing phase feeds the next stages of design, such as text extraction and search, and allows these algorithms to perform at their optimal level.

Text Extraction Techniques and Hierarchical Ranking Algorithm Development

The ability to extract text from a document is quite crucial to this ability of the system to pull valuable content from world-wide-web documents. Thanks to an integration with Tesseract OCR – a text recognition system embedded within the MATLAB environment – the system can crawl for text within images and scanned documents, and convert the text into a machine-readable format. This feature is crucial to the system's ability to function on documents retrieved from its store. The use of this software has greatly increased the system's capacity for robustness, thanks to its ability to recognise diverse text characteristics. As such, this feature enables the system to properly handle a wide variety of text styles and languages.

As a second step, a hierarchical ranking algorithm for the search results is developed. The scoring algorithm ranks the search results according to their degree of relevance to the given query. The most relevant results are listed on top. The scoring algorithm can differentiate between relevant and non-relevant results based on a number of factors that make a search result relevant to the user's query. Such factors may include the frequency of occurrence of search keywords in the document, the metadata of the document, or the contexts in which the search query appears in the document. A scoring system assigns weights to these different factors. The scoring algorithm then computes the score for each ranked document. The ranked results are displayed in a hierarchically structured form, which allows users to traverse through the search results in a structured manner, starting from the most relevant results at the top to the least relevant at the bottom. The hierarchical structure of the search results improves the user experience and search accuracy, since the user can traverse through the list of results and discard non-relevant results which are listed at the bottom.

System Integration, Testing, and Iterative Improvement

Finally, system integration and testing take place. System integration combines all the previously-built components into a single, functioning system. This is essential to ensure that various modules interact as expected. After the system has been integrated, integration testing is carried out in order to check whether the integrated system performs and functions as planned. After integration, a period of iterative improvement commences, leveraging findings from the initial round of user tests. This follow-on phase is critical for refining the system to accommodate the myriad of emergent issues, enhancing usability and performance. The iterative and cyclic nature of this phase is a hallmark of a system that is improved upon even after it is in production and is kept on the cutting edge of meeting users' needs in a dynamic environment. Through a process of iteration, testing and enhancement, a strong, usable, adaptive content retrieval system emerges and, ideally, one that is much better than its users had initially anticipated.

SYSTEM IMPLEMENTATION

A hierarchical ranking algorithm organizes and ranks items based on their importance or categorizes them according to various criteria. This method is particularly useful for applications such as search engines, recommendation pages, and organizational tools on platforms like https://www.wikipedia.org/. The following passage provides a detailed guide on developing such an algorithm.

Define Criteria and Weights: This step defines the criteria (e.g., price, quality, user ratings) used to determine the ranking of an item, and assigns weight values to each criterion denoting its importance. A weight of 1 means it is just as important as the others, while a weight of three means it has triple the effect on the final calculation. Collect Data and Preparation: On this step, you dispatch data to all of the products, compatible with your specific item. This may encompass inquiries to a database, downloading from an API, or preparing user information.

Table 2: Pseudo code of Hierarchical Ranking Algorithm

```
Hierarchical Ranking Algorithm
1   Define Criteria and Weights
        Let criteria = [criteria1, criteria2, criteria3, ...]
        Let weights = [weight1, weight2, weight3, ...]
        // weights correspond to the importance of each criterion
2   Collect and Prepare Data
        Initialize list_of_items to store all items
        For each item in list_of_items:
            - Collect data for each criterion (e.g., rating, cost, user engagement)
3   Calculate Scores for Each Item
        - For each item in list_of_items:
            Initialize score to 0
                - For each criterion in criteria:
                    - Calculate partial_score = item.value_of(criterion) * corresponding weight
                    - Add partial_score to score for the item
                - Store score in item.score
4   Rank Items Based on Scores
        - Sort list_of_items by score in descending order // higher scores have higher rank
5   Output Ranked List
        - For each item in list_of_items:
            - Print item.name and item.score
```

Calculate Scores for all Items: This loop calculates the score of each item using the mentioned criteria. All values of the criteria will be multiplied by the weight which gives each criterion's importance. The scores are added up and displayed the final score for each item.

Rank Items Based on Scores: When all items have a score, you can also sort them from highest to lowest. The sorting order determines the rank: items with the highest score are numbered with 1; items with a lower score have the number 2, and so on.

Output: Scored List: We have the scored list, which shows all the items, potentially with any number of scores, and automatically orders the items according to the defined criteria and weights. We built the hierarchical ranking algorithm in order to reorganize the search results relevant to your query according to its contextual relevance. The principle of search results organisations using the hierarchical ranking algorithm is to display the most relevant information to the user first by organising search results.

Installation and Setup

The integration of Tesseract OCR begins with its installation and setup in the development environment where the application is being built. This involves configuring Tesseract alongside other components of the application, such as the user interface, database, and storage for the extracted text. Tesseract offers numerous configuration options, which can be adjusted to meet specific needs, such as recognizing different languages or optimizing for various page layouts. For this project, Tesseract is configured to maximize its text recognition capabilities across a diverse range of document genres, ensuring accurate and efficient text extraction.

Process Improvements and Challenges

Once Tesseract OCR is integrated, continuous improvements are made to enhance its performance within the application workflow. This includes fine-tuning its configuration settings to improve accuracy and speed, as well as integrating advanced preprocessing techniques to handle different types of documents, such as PDFs, images, and handwritten notes. Challenges encountered during the integration process include dealing with poor-quality images, handling diverse fonts and layouts, and ensuring compatibility with various languages. Overcoming these challenges involves iterative testing and refinement, leveraging Tesseract's extensive documentation and community support to achieve optimal results.

In summary, Tesseract OCR's integration into the desktop application involves careful setup and configuration to handle a wide range of text extraction tasks. By continuously improving the process and addressing challenges, the project aims to develop a robust and efficient content retrieval system capable of accurately converting diverse document types into editable and searchable text.

RESULT AND DISCUSSION

The results show that a content retrieval system for local storage environments has been developed and implemented, and how different technical approaches such as text extraction, voice recognition and hierarchical ranking algorithms can greatly improve the retrieval and access to contents.

Table 3: keyword search accuracy with traditional and proposed

System	Duration (Seconds)	Accuracy (%)	Total Scaned Files
Manual	10min	75	40
Proposed	60sec	98	90

In order to evaluate the performance of the system, performance evaluation has been conducted, and the result shows that the system can meet many specifications including the requirements of retrieval time, retrieval precision and user's satisfaction. Over the course of this project, some user feedback has also been collected, and the system has been iteratively refined and improved based on such feedback. The aggregated results show that the developed content retrieval system provides an effective, efficient and user-friendly approach to retrieve and manage contents in the local storage environment.

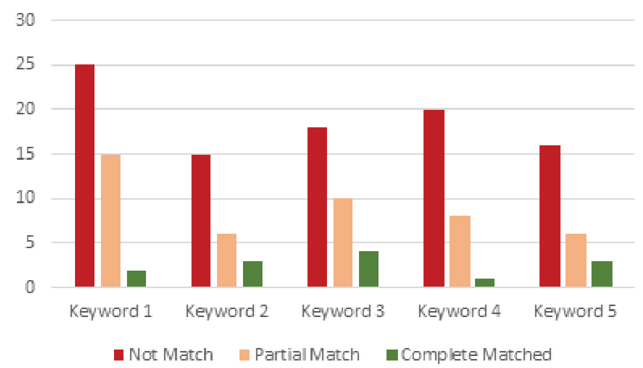


Fig. 2: Keyword similarity results in implemented system

The desktop application that evolved from this is a genuine milestone in the advancement of information retrieval, and the first indication of how integrated technologies might help to improve the access to and processing of data. This is not a perfect system – clearly there remains a lot of work to be done on dealing with unstructured data, and on ensuring scalability, for example – but it's a strong start, and one that you can imagine underpinning a great deal of future development in the field. Its potential applications are wide-ranging and would interest a whole host of different sectors. It seems highly likely that this approach will become a staple of the way we manage our interaction with information in the coming years.

CONCLUSION

The research has contributed to the making of a desktop application that uses vast resources from local storage to fetch data. The advanced techniques of text extraction from files, voice-to-text conversation with applications, and a hierarchical ranking algorithm to provide better results contribute to this system. This desktop application is developed using MATLAB, a high-performance language suitable for designing desktop application interfaces. The ability of system to sort out the search results based on relevance to user's query, comes out as an improvement over traditional file search. The application's availability with voice queries as a medium improves user experience. The results obtained by testing the application revealed the feasibility of idea in practical implementation. The system's results were validated with various files to prove its ability to process all kinds of files. The system proved to be efficient in serving the user's purpose of fetching information without any difficulty in the growth of data in the digital era.

In conclusion, one can see that this project is open to many extensions in the future. The system could enrich the function of this application with promising approaches, like integrating machine learning models to better understand voice commands and design more accurate training characters. Search results could become more personalised with artificial intelligence, and the system's utility would improve greatly after adding cloud storage retrieval. Multilingual support and real-time processing could also broaden the range of application scenarios and help users synchronize multiple data resources. In addition, there is a potential for an improved mobile version or a highly polished security system, which would make the application a versatile tool for various purposes.

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AUTHOR CONTRIBUTIONS

In this collaborative research endeavor, both authors contributed equally to the development of this research paper. They jointly conceptualized the research idea, designed the methodology, and conducted the literature review. Additionally, both authors actively participated in the implementation of the system, including the development of algorithms and the execution of performance evaluation experiments.

Conflicts of Interest

The authors declare no conflict of interest.

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Selection of Significant Genes for the Classification Acute Myeloid Leukemia using Machine Learning Techniques

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ABSTRACT

Acute Myeloid Leukemia (AML) is a dangerous and potentially fatal kind of blood cancer that affects the blood and bone marrow. Research was carried out by assuming that microarray studies would reveal previously unknown expression alterations found solely in AML blasts using GSE9476 , which is a leukemia gene. This paper is an attempt to increase classification accuracy by selecting a subset of significant gene sequences from the dataset. Classification results are compared for the reduction of the size of a subset of gene sequences.

KEYWORDS: *Acute myeloid leukemia, Attribute selection, Relief-F, Random forest, Machine learning.*

INTRODUCTION

Hematological cancer has become a more prevalent issue in the recent decade, necessitating early detection in order to begin adequate therapy. The diagnosis process is expensive and time-consuming, requiring medical professionals and a variety of tests. As a result, a machine-learning based diagnosis system for precise prognosis is critical (Rastogi et al. 2022) (Prinyakupt and Pluempitiwiriyawej 2015). Diagnosis of blood cancer combining leukemia microarray gene data and an approach based on machine learning has emerged as an important area of medical research in recent years (Dasariraju et al. 2020) (Liu and Hu 2022).

The objective of this paper is to construct an e-diagnosis framework for the identification of AML by using machine learning methods. The current study suggests a method for predicting hematopoietic malignancies with high accuracy using microarray gene data (Subramanian et al. 2005). The high dimensionality of the data, the data imbalance, and the small sample size are the significant issues related to this study. To address these concerns, in the current work, methods are proposed to reduce the dimensionality of the data and improve the classification accuracy for better diagnosis (B. Liu et al., 2004) (Das & Meher, 2021).

DATASET DESCRIPTION

The Lukemia-GSE9476 data set was used for the experimentation. The original data set contains five classes, 22284 genes, and 64 samples. The data set contains gene profiles of normal hematopoietic cells from healthy donors and 26 AML leukemia patients. There are 38 profiles of healthy donors, of which 8 are Bone_Marrow_CD34, 10 are Bone_Marrow, PBSC_CD34 has 10 samples, and 10 are PB. The dataset is pre-processed and transformed for this study. All 38 non-AML genes are assigned a common class label, N_AML.

The dataset for this experiment has 22283 columns and 64 rows. 26 records are of AML patients and 38 are of non-AML patients.

EXPERIMENT AND RESULTS

Feature selection

Two supervised attribute selection filters with ranker methods were used for the gene subset selection of ranked attributes. These selected attributes were further used for the classification (Ghule & Deshmukh, 2021; Ghule et al., 2021) Sasada et al. (2018).

The dataset contains 22283 gene sequences for each sample. Classification results are compared by selecting a subset of significant genes to improve prediction accuracy.

A. Correlation Attribute Selection: This method measures the correlation using Pearson's correlation coefficient between an attribute and the class to determine its worth. By treating every value as an indicator, nominal qualities are considered value-by-value. A weighted average is used to calculate the overall correlation for a nominal property.

B. Relief-F Attribute Selection is used for estimating a subset of features from a set of features (A), according to how well their values make a distinction among instances (R) that are close to each other. For that purpose, sample Ri is selected randomly from the sample space. By calculating the distance between selected instance of Ri, Relief-F searches for the nearest neighbors from the same class as well as other classes.

Classification

Random Forest Classifier: The random forest algorithm creates a forest of multiple uncorrelated decision trees. It uses both bagging and random feature selection to generate a subset of features with low correlation. The data is further divided into three- parts. One part is used as test data, called out-of-bag (OOB) data. In the remaining two parts of training data, additional records of randomness are injected by the feature bagging method. For the task of classification, votes are counted, and the class label that gets the most votes is assigned (Pal, 2005);(Sabat-Tomala et al., 2020); (Pal & Foody, 2010).

Results of Machine Learning algorithms

As this study focuses on reducing the dimensionality and improving the classification accuracy, attribute selection with the ranker method is used before classification. The accuracy assessment was done by reducing the number of genes.

Table 1 : Random Forest Classification result with Correlation Attribute Selection

No Gene Selection	Accuracy	TP-Rate	FP-Rate	Precision	Recall
All	93.75	0.938	0.067	0.938	0.938
10000	95.31	0.953	0.056	0.953	0.953
5000	93.75	0.938	0.079	0.939	0.938
2500	93.75	0.938	0.079	0.939	0.938
1250	95.31	0.953	0.056	0.953	0.953
500	95.31	0.953	0.056	0.953	0.953
250	98.44	0.984	0.023	0.985	0.984
100	98.44	0.984	0.023	0.985	0.984

As shown in Table 1 , Correlation Attribute Selection with ranker was used to rank the Genes by the significance in the descending order.

In the first attempt all 22283, the ranked Genes were used for the classification, accuracy of 93.75% was obtained. The same accuracy was obtained for 5000 and 2500 Genes. Accuracy of 95.31 % was obtained for 10000, 1250 and 500 Genes. Further classification results improved to 98.44% when 250 and 100 genes were selected.

For further improvement and verification of the results, Relief-F Attribute Selection with Ranker was used. As shown in Table 2, there is 93.75% classification accuracy for all genes and the first 10,000 and 5000 genes. An improvement in the classification accuracy was observed when the genes were reduced to 2500. 98.43% accuracy was obtained for 500 genes, and a maximum of 100% accuracy was observed when the gene number was reduced to 100.

Table 2 : Classification result with Relief-F Attribute Selection

	Accuracy	TP-Rate	FP-Rate	Precision	Recall
All	93.75	0.938	0.067	0.938	0.938
10000	93.75	0.938	0.079	0.939	0.938
5000	93.75	0.938	0.079	0.939	0.938
2500	95.31	0.953	0.056	0.953	0.953
1250	96.87	0.969	0.046	0.97	0.969
500	98.43	0.984	0.023	0.985	0.984
250	96.87	0.969	0.046	0.97	0.969
100	100	1	0	1	1

We can see that reduction in dimensionality improves the result, and thereby it will be easier to shortlist the genes for further treatment.

Figure 1 displays the classification results obtained for the Random Forest Classifier when Relief-F and Correlation methods were used to reduce the dimensionality of the dataset.

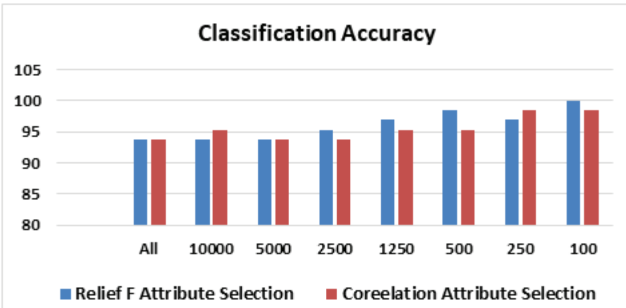

Fig. 1. Comparison of Classification Accuracy

DISCUSSION AND CONCLUSION

This research proposes a classification model consisting of supervised attribute selection methods with rankers that is appropriate for designing diagnostic systems for AML. Two machine learning supervised attribute selection techniques and a Random Forest classifier were used to train the models, which were then tested to predict if the accuracy of AML diagnosis improves if dimensionality is reduced. It is observed that, for the first 100 ranked genes, classification accuracy is better than for all genes. Relief-F performs better than correlation attribute selection in terms of accuracy. We can conclude that a random forest classifier performs well for binary classification with a Relief-F attribute selection.

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Hybrid Solution to Cold-start Problem in Personalized MSME's Recommender System

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ABSTRACT

The Micro small medium enterprises are playing vital role in the economy growth of a country, state, and region. The main shortfall being faced by the entrepreneurs in this area is lack of efficient recommender systems to suggest where a particular type of enterprise could be established for a new entrepreneur. The entrepreneurs who already established also are not having proper product promotion facility using the information and communication technology (ICT). In general scenario the user has to rate some number of items before receiving the recommendations through a recommender system. For a new user there may not be any rating history and same is the case for a new aspirant entrepreneur to receive recommendations. This problem is known as cold start problem. In this research cold start research issue is being addressed using a hybrid recommender system which will use both collaborative filtering and profile expansion to suggest the aspirant entrepreneur about the enterprise which are more suitable to establish.

KEYWORDS: *MSME, ICT, Recommender system, Collaborative filtering, Cold start, Demographic data, Profile expansion.*

INTRODUCTION

Micro small medium enterprises (MSMEs) are acting as the backbone for the socio-economic growth of any country since they are contributing major part of the Gross Domestic Product (GDP) of the country with manufacturing and service enterprises [1]. The MSMEs are almost contributing 29% of total GDP of India through its international and nation business trade. From the annual report of MSME 2020-2021, it was clear that out of 630.52 lakh enterprises, the micro sector has occupied with more than 99%, small sector has occupied 0.52% with 3.31 lakh enterprises, and medium has occupied 0.01% with 0.05 lakh enterprises [2]. By considering the three consecutive years of registered and established data of enterprises during the 2016-17 to 2018-19, from the Ministry of Micro, Small & Medium Enterprises it is noticeable that the number of registrations is more than the establishments. This indicates that there are a greater number of aspirant entrepreneurs and are actively registering with the intension to start an enterprise, but could not able to turn the registration into establishment due to many reasons. One of the Challenging reasons is lack of proper guidance about which enterprise is suitable to them, where to start and how to get benefits from the government etc. This three-year data is Shown in the Table 1. All most 40 to 45% of the registered entrepreneurs were idle as depicted in Figure 1. If proper recommendations are constructed and sent to these entrepreneurs, then the it would be turned into an establishment which directly affects the GDP of the country and also creates huge number of employments [3]. The situation where a greater number of registered entrepreneurs were idle and not able to do any active operation regarding establishment of enterprise is known as cold start problem. If this cold start problem is addressed in efficient manner, it could directly and indirectly impact country's GDP and employability respectively.

Table 1 Registered Vs Established MSME Enterprises

Financial Year	2016-17	2017-18	2018-19
Registered	2372861	1517333	2121028
Established	1317093	1245420	1301138
% of Establishment	55.50%	82.07%	61.34%

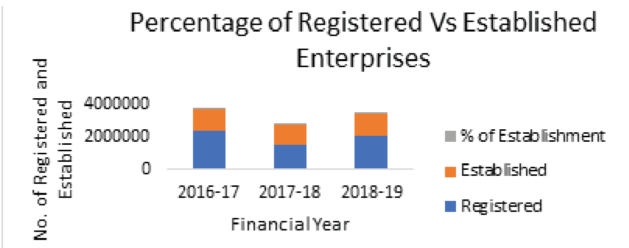

Fig. 1 Percentage of registered and established MSME enterprises.

The objective of any recommender system is to provide suggestions to the customer according to their interests and prevents the valuable time of the entrepreneur from being wasted [4]. But, in many cases the recommender system may not suggest any recommendation to some customers or entrepreneurs due lack rating history [5]. In such a context the recommendations could be constructed by combing the collaborative filtering and profile expansion which in turn uses demographic details of the entrepreneurs.

Collaborative filtering technique occupied an important place in the recommender systems which basically use user ratings to construct recommendations [6]. The user activities will be constructed into a data structure which is known as profile. The recommender system will then search for the profile of the user having similar rating history. The items or products that have been highly rated will be sent to the all the users whose profiles are similar [7]. When the profiles are being constructed in way which stores the much information about a customer then obviously it helps to construct relatively suitable recommendations to customers or users with matched profile. If the profile is built with incomplete information regarding the ratings, and at the same time recommendations are constructed taking the ratings into account then irrelevant recommendations would be experienced from the recommender system. This renowned research issue is known as cold-start problem which cannot be addressed with collaborative filtering alone [8].

The customers who recently register to the system to get services obviously have not rated any products or items. The Collaborative filtering fails or unbales to construct relevant recommendations in the context of the new user, and also affect other customers who have been using the system have rating profile in the process of constructing the recommendation [9].

The traditional solution to the cold-start problem is combining the collaborative filtering with demographic data or trust related data. The customers or users' demographic details which covers age, gender, region, place, genre, etc. could be used as part of building a hybrid recommendation. This kind of data is more useful until the system gets the proper rating information about the customer to build more suitable recommendations [10]. Formoso et al. designed a novel methodology to lighten cold-start problem in the form of profile expansion [11]. This approach uses various techniques like item-local, item-global, and user-local. However, least preference was given to the demographic data which has ability by nature to resolve cold-start problem. In this paper a hybrid personalized recommender system is proposed which is being built on user-rating matrix and demographic data of users. The proposed approach works on two phases to recommend enterprises. During the first phase, the demographic data will be used to extract the entrepreneurs with similar demographic profile. In the second phase collaborative filtering technique with k-nearest neighbour is used to derive recommendations.

RELATED WORK

The MSMEs have been playing a significant role in the socio-economic development of many developed and developing countries. The MSMEs were identified as principal financial source to develop the country and also considered important aspect in promoting personal, and regional economic development [12]. The information communication technology (ICT) [13] had influenced the performance of enterprises to an identifiable level in promoting the services offered to the entrepreneurs. The number of newly registered entrepreneurs idle because of not having proper promotion about the manufacturing and service sectors that would help them to reduce the communication gap among the peer entrepreneurs and also the supply chain coordination [14]. In order to gain access to the enterprises the innovation factor should fine tuned to meet this gap [15].

Based on the learning technique the recommender systems are broadly categorized into six different categories such as content-based, collaborative filtering, demographic, community-based, and hybrid recommender systems [16]. The recommender system used to construct recommendations that are similar to the products or items what the customer had already liked. These systems employ learning mechanism to evaluate the similarity between the new product and product already liked by the customer. Collaborative filtering is the most common technique to construct recommendations based on the peers which are having like mind. The system learns the activities of customers and finds the user with similar taste to recommend services or products. This becomes helpless when a new user or customer enters into system and will be idle for a long time leading to a cold-start problem [17]. Safoury et al. [18] employed demographic details in order to predict the similarity among the users to address the cold-start problem. Papagelis et al. [19] designed a solution to data sparsity in the form of transitive dependency between two users by incorporating trust inference to address the cold-start problem. Z Cheng et al. [20] utilized age and gender to construct recommendation as part of demographic data which enhanced the performance of music recommendation system. Nguyen et al. [21] applied age, gender and occupation attributes of the demographic data to group the customers into communities. Lika et al. [22] designed a hybrid recommender system to address the cold-start problem by integrating the demographic data with classification algorithms. The data sparsity would be extremely experienced for new customer, new product or item and new system [23]. In such a context collaborative filtering techniques cannot cold-start issue meaningfully. The cold-start issue could be relatively addressed by considering other information along with rating information which comes up in the form of hybrid recommender system [24]. M. L. Bai et al. [25] proposed novel methodology by integrating the content-based technique with demographic data to extract the POIs for the new user. This obtained information is further reduced down to construct the recommendation to new user using the collaborative filtering leading to a hybrid recommendation. Nguyen et al. [21] also adopted the same idea to integrate collaborative information with demographic data or trust inferences as an alternative solution to resolve cold-start problem. If the customer wants to obtain benefit from the system additional data plays vital role in constructing recommendations when the customer has insufficient rating information. The customer will be anticipated to give additional information such as demographic details to receive accurate recommendations which in turn help entrepreneur and to the enterprise in personal, and also enhances the economic growth of the country in national wide as well as globally. At the initial stage gathering additional information at the time of entrepreneur registration to the system may be a tedious task. To address this information gathering, Rashid et al. [26] proposed optimized technique to simplify the information gather task simple.

PROPOSED METHODOLOGY

The proposed methodology is demonstrated here. This methodology works in two phases. To address the cold-start problem for a new entrepreneur the demographic data will be used to extract the entrepreneurs whose demography is matched in the first phase. The similarity with respect demographic data between the active entrepreneurs will be calculated from the Eq. (1). The weighted average of attributes of demographic data will be used to measure the similarity as explained below.

$$sim(a,b)_{\text{demo}} = \frac{\sum_{j=1}^{n} d_j wt_j}{\sum_{j=1}^{n} wt_j} \tag{1}$$

Here, dj is the similarity value between user a and b which will be equal to either 0 or 1. If the demographic attribute such as age, gender and region of an entrepreneur a is matched with entrepreneur b, then similarity value will be 1 otherwise 0. The value of the attribute j is considered to be weight and is denoted as wtj. For example, if the age attribute of an entrepreneur is 35 then the weight wtj is equal to 35. The number demographic attributes is denoted by n.

Once the set of entrepreneurs based on demography is fetched it is then given to the second phase to k-nearest entrepreneurs using the collaborative filtering. In the second phase the similarity between the active entrepreneurs will be estimated using the cosine similarity from rating information. The similarity will be calculated according the Eq. (2).

$$sim(a,b)_{\cos(\theta)} = \frac{\sum_{i\in I} r_{a,i} r_{b,i}}{\sqrt{\sum_{i\in I} r_{a,i}^2 \sum_{i\in I} r_{b,i}^2}} \quad (2)$$

Here, I is the set of enterprises rated by the customers. The $r_{a,i}$ and $r_{b,i}$ are rating values rated by customer a and customer b for the enterprise i.

For extending the profile different methods have been devised which are classified into two categories. First one is local verses global. Second one is product verses user. In case of local method recommendation result obtained in the first phase are used to construct the final recommendation [27] that is in the second phase. In the second phase k-nearest neighbour enterprises are recommended to the new entrepreneur as shown in the Table 2. Where as in global method before the results obtained through first phase average rating of services or products are used to fill the rating history for a new entrepreneur. This rating information would be used to perform Collaborative filtering later. The working proposed method is shown in the Fig 2.

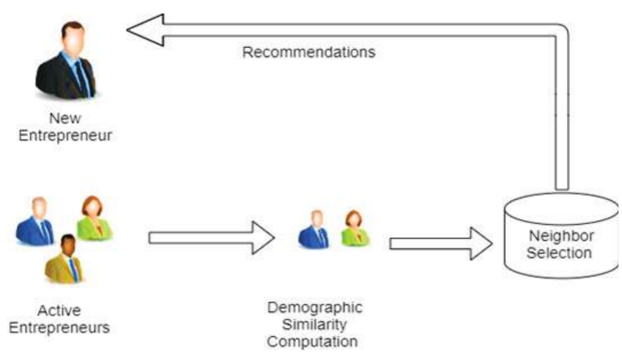

Fig. 2 General working of proposed method

Based on the demographic attributes data of new entrepreneur a subset of entrepreneurs who demographic information is similar according to the Eq. (1) are extracted in the first phase. This subset of information is further fed as input to the next phase to filter information according the collaborative filtering using the Eq. (2). From the outcome of the second phase by applying local profile expansion the missing values for ratings about the new entrepreneur are filled and the top k-nearest neighbours are extracted which are recommended to the new entrepreneur satisfying demographic attributes. The working of entire process is explained in algorithm 1.

Table 2 Profile expansion with different techniques

User Profile expansion Type	Description
Global	Missing ratings of new user are filled with average of all the rating before first phase
Local	Missing ratings new user are filled with average of all the ratings after the first phase.

Algorithm 1. Pseudo-code of proposed methodology

Begin

The set of entrepreneurs X= {X_1, X_2, X_3, ……, X_n} where n is the number of entrepreneurs

For j=1 to n

i=0

If(((d_j*wt_j)/wt_j)>Threshold)

X_{demo}[i]=X[j]

i=i+1

Apply local profile expansion to fill the ratings for new entrepreneur

Using collaborative filtering to select k-nearest neighbour from Eq. (2)

End

EXPERIMENTAL RESULTS

Dataset used in the Experimental setup

The world bank has prepared MSME dataset in the name of msme-country-indicators-2014.csv and is available at URL https://www.kaggle.com/theworldbank/msme-country-indicators-and-sources. This dataset has 11 columns and 267 rows related to the worldwide MSME information.

Results and Discussion

In this section the proposed methodology as stated in the Algorithm 1 is demonstrated by applying it on the dataset mentioned in the section 4.1. The experiments are conducted using the Spyder (Python 3.7) IDE.

There are eight different number of regions which are encouraging the MSMEs all over the world as shown in the Fig. 3. It has been observed that for different regions number of supporting MSME sectors are existing. For a new entrepreneur 'region' demographic data is considered and extracted the subset of enterprises with demographic similarity 0.81 for the South Asia region using the Eq. (1) in the fist phase as shown in the Fig. 3. The South Asia region is having very a smaller number of MSMEs and related supporting agencies. This was the region to select the South Asia as region for demographic data.

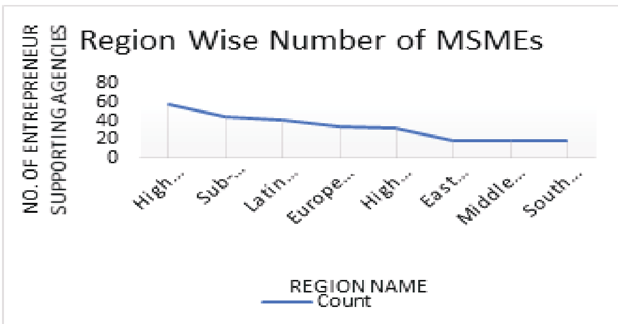

Fig. 3. Region Wise Number of MSMEs

This subset of information has included 18 enterprises covering different countries in the South Asia region. This subset of information is then given as input to the second phase to apply the collaborative filtering using the Eq. (2) using the cosine similarity. The cosine similarity was almost 4.1 from the rating of the 18 supporting MSMEs supporting agencies. The similarity value was considered as threshold value to select top nearest neighbours which were six in this case as shown in the Table 3. This motivates the new entrepreneur with insights about the best places to start any new enterprise in different scales.

Table 3 Top nearest neighbouring MSMEs supporting agencies

Country	MSME Supporting Agencies
Bhutan	NSB
Maldives	MED
Bangladesh	Bangladesh Bank
Nepal	Industrial Enterprise Act
Nepal	CBS Nepal
India	MinMSME

CONCLUSION

A novel hybrid recommendation methodology is proposed in this paper to address the cold-start problem. The demographic data is the key to address the cold-start problem which must be given by the entrepreneurs while registering to the enterprise agencies to start any new enterprise. This work gives insights that if the cold-start problem is addressed in scientific manner it would directly impact the number of idle entrepreneurs towards establishing a new enterprise. This could directly enhance the GDP of any county. The proposed method as stated in the Algorithm works in two phases. The first phase fetches the information that is matching with demographic data which then is given as input to the second phase thus leading to hybrid recommendation technique to address the cold-start problem for personalized recommendation.

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Methodological Framework for Hyperparameter Tuning and Optimization in AI – Driven Cyber Threat Intelligence

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ABSTRACT

With the growing complexity and prevalence of cyberattacks, there is an urgent need for improved anomaly detection methodologies capable of detecting, understanding, and predicting intricate attack patterns. Traditional cyber threat intelligence (CTI) systems often exhibit suboptimal performance, particularly against evolving and adaptive threats owing to their reliance on historical data and rule

based methodologies. These findings demonstrate the potential of Generative AI to augment the current cyber threat intelligence capabilities and enable the creation of adaptive and autonomous threat intelligence platforms that can evolve with emerging cyber threats. This study presented a foundational framework for employing AI to improve cybersecurity resilience. This research paper will make anomaly detection more scalable and adaptable, thus increasing cyber security.

KEYWORDS: *Generative adversarial networks, Variational autoencoders, Transformers, Synthetic data generation, Anomaly detection, Generative AI.*

INTRODUCTION

The evolving digital ecosystem has increased the frequency and complexity of cyber threats, presenting new challenges to cybersecurity experts. Advanced persistent attacks (APTs), ransomware, and zero-day exploits are becoming more complex and are designed to avoid detection. Advanced Persistent Threats (APTs) are covert attacks on high-value targets to steal data or damage infrastructures. The number of ransomware attacks has increased, causing financial and operational damage to public and commercial sectors. These threats highlight the need for Cyber Threat Intelligence (CTI) to identify, assess, and mitigate cyber risks in order to protect company assets and data. Conventional CTI methods, such as rule-based methods or signature matching, cannot adapt to rapidly changing threat techniques. These systems may miss new attack patterns and struggle to analyze massive datasets, leaving organizations vulnerable to sophisticated attacks.

IT industry can expand the scope and utility of Cyber Threat Intelligence (CTI) by integrating these features to generate synthetic threat data, simulate attacker behavior, and gain insights into future threats.

The goal of this study is to determine whether Generative AI can improve CTI accuracy, timeliness, and scope. This study shows that Generative AI models integrated with cyber threat intelligence frameworks might increase proactive threat detection, anomaly identification, and reaction preparedness. This study demonstrate a framework for using generative AI in Cyber Threat Intelligence (CTI) , assesses its strength and weakness. This paper proposes a novel approach to using artificial intelligence for cyber security, aiming for flexible, proactive, and robust cyber threat intelligence systems.

LITERATURE REVIEW

Traditional CTI Methods

Rule-based and signature-based cyber-threat intelligence (CTI) systems use predetermined indications of compromise (IOCs) and known attack patterns. In Security Information and Event Management (SIEM) systems, rule-based solutions use IP blacklists, odd network traffic, and suspicious file types to detect anomalies or threats. However, signature-based systems highlight instances that match past data using known threat "fingerprints" such as file hashes and IP patterns. Traditional approaches can detect known dangers, but they struggle with zero-day vulnerabilities and advanced persistent threats (APTs) because they employ historical data and static rules, restricting their adaptability to innovative attack tactics (Mantz et al., 2022).

Traditional CTI systems require prior information, are resource intensive, and produce many false positives because they cannot distinguish benign anomalies from real threats. Attackers use advanced methods to defeat static detection systems by leveraging rule-based CTI limitations, as cyberthreats change. IOCs and rules must be updated constantly, making them reactive rather than proactive, and delaying responses to new or adaptive threats. Owing to the complexity of cyber threats, standard CTI methods cannot keep up (Singh et al., 2023). Therefore, more advanced methods are needed to overcome these limitations.

AI in Cybersecurity

AI in cybersecurity has improved the CTI by adding adaptability and learning. Malware classification, network intrusion detection, and vulnerability identification have been performed using machine learning (ML) models, particularly supervised learning approaches, such as decision trees and SVMs. AI-based systems learn from labeled datasets to discover complicated patterns that are missed bystatic-rule-based systems. Clustering methods (e.g., k-means) and one-class SVMs are commonly used to detect abnormal behaviours that may indicate an attack (Rizvi & Chandra, 2022).

Despite these developments, AI-based cybersecurity models have struggled in the dynamic CTI context. Supervisory ML models require large labeled datasets that are challenging to gather for rare or emergent threats. Anomaly detection methods can detect expected patterns; however, network unpredictability causes significant false-positive rates, thereby generating analyst alert fatigue. Traditional AI models cannot generate synthetic data, which restricts their ability to address data shortages in emerging threat scenarios (Li et al., 2023). These constraints emphasize the need for Generative AI and other advanced AI methods to improve CTI capabilities.

CTI generative AI

Generative AI models such as GANs, VAEs, and transformers have attracted interest owing to their CTI transformation potential. Goodfellow et al. (2014) proposed GANs that use two competing networks, a generator and a discriminator, to generate realistic synthetic data that imitate cyber threats. CTI uses GANs to create synthetic malware or network traffic datasets for detection model training, without real-world threat samples. GAN-generated data can improve the model detection accuracy for various threat scenarios (Zhang et al., 2023).

The CTI benefits from VAEs learning of compressed data representations for anomaly detection and data augmentation. VAE encoders translate the input data into a latent space, whereas decoders reconstruct it, allowing the model to learn typical system behaviors and identify anomalies. VAEs can detect low-profile attacks such as insider threats that rule-based systems miss (Ahmed et al., 2022). VAE-based models can successfully identify behavioral abnormalities without attack signatures, thereby improving stealthy attack detection (Kumar et al., 2023).

Finally, transformers are essential for NLP CTI. Transformation models such as BERT and GPT excel at processing and interpreting unstructured text data such as threat intelligence reports and security warnings. Transformers can automatically select threats and extract key Indicators of Compromise (IOCs) from massive text data in the CTI, thereby improving situational awareness and threat response. Unlike standard CTI systems, transformers allow security teams to anticipate threat trends and adjust their defenses(Liu et al., 2023).

Transformers can automate data processing and threat categorization, which require manual analysis, and reduce the CTI reaction time (Miller & Kim, 2023). By training on massive corpora of threat intelligence data, transformers can discover patterns across various threat actors and methodologies, thereby offering a comprehensive picture of the threat landscape. The versatility of transformers makes them ideal for real-time analysis and pre-emptive threat intelligence, particularly for large amounts of unstructured threat data.

OVERVIEW OF CYBER THREAT INTELLIGENCE MODELS

Cyber threat intelligence (CTI) enables synthetic data generation, attack simulation, and threat detection system prediction. Genetic Adversarial Networks (GANs), Variational Autoencoders (VAEs), and transformers have unique capabilities for CTI. These models make cyber threat intelligence(CTI) more proactive, scalable, and adaptive, thereby improving cyber security.

Generational Adversarial Networks

GANs have two competing neural networks: a generator and discriminator. The generator generates synthetic data samples that the discriminator compares to real data. Through this adversarial process, GANs can generate realistic synthetic data to simulate cyber threats, thereby delivering significant CTI resources. Security organizations can train models without exposing them to genuine malware using GANs to create synthetic malware samples without payload. GANs can imitate attack-related network traffic patterns, thereby enabling cybersecurity professionals to identify their weaknesses and improve their detection algorithms. By adding various realistic threat scenarios to training data, GAN generated datasets have been shown to improve malware and network intrusion detection.

Variational Autoencoders (VAEs)

VAEs are crucial tools for CTI that encode and reconstruct data, enabling anomaly identification and data augmentation. VAEs have an encoder network that converts data to a latent space, and a decoder network that reconstructs it. The VAEs modelled the natural system behavior well for the CTI. Unauthorized access or abnormal network activities may indicate anomalies. This capacity helps to detect insider threats and APTs that standard methods may miss. VAEs have improved cybersecurity datasets by generating variations in known attack patterns to strengthen the detection models. VAEs are vital for advanced CTI techniques, because they can identify low-profile and stealthy network traffic hazards.

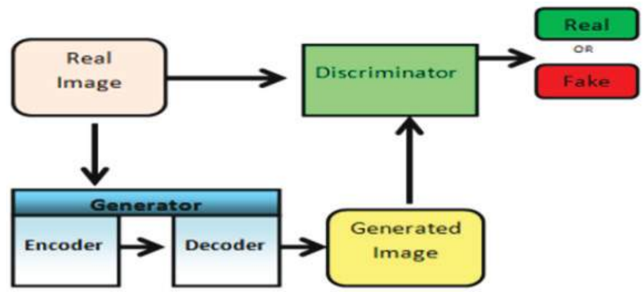

Fig. 1 Architecture of GAN image anomaly detection

Transformers

Transformers are useful for analyzing threat intelligence reports, indications of compromise (IOCs), and threat actor tactics, methodologies, and processes, because they can find patterns in enormous amounts of text. Transformers automate threat categorization and prioritization using textual analysis and streamline threat assessment and improve the situational awareness of the security team. Transformer-based models scan open-source intelligence threat streams, identify trends, and deliver near-real-time actionable insights, thereby enabling enterprises to proactively manage threats. Transformers have been shown to improve the accuracy and timeliness of threat analyses, allowing CTI teams to respond quickly to emergent threats.

The key uses of generative AI models in CTI include data synthesis, threat simulation, and behavioral analysis. These apps improve CTI systems by boosting data availability, modeling sophisticated attacks, and identifying cyberthreats.

Synthesising Data

In the CTI, Generative AI is used for data synthesis to create large synthetic datasets that mimic real world dangers. Labeled cybersecurity data are scarce, particularly for emerging threats with little historical data. GANs and VAEs generate synthetic attack data, including phishing emails, malware files, and malicious network traffic, to train and test detection algorithms without accessing sensitive or private datasets. Because synthetic data do not contain organizational information, it increases the number of possibilities that a detection model may learn from, and reduces data privacy concerns. Researchers discovered that GAN-generated synthetic data enhances the detection model, identifies complex threats more accurately, and lowers anomaly detection false positives.

Simulation of Threats

Generative AI simulates synthetic threat scenarios to test and improve cybersecurity defenses. By simulating ransomware outbreaks or DDoS attacks, we can evaluate how systems handle threats and identify vulnerabilities. These simulated threats help evaluate and improve incident-response tactics. Generative AI simulated phishing attempts can assess employees' responses to social engineering methods and improve phishing awareness training. Cybersecurity teams can also uncover network segmentation gaps and improve suspicious behavior monitoring by simulating APTs or lateral moves. Generative AI-powered threat simulation helps detect vulnerabilities and prepare for cyberattacks.

Behavioral Analysis

Generative AI behavioral analysis identifies intricate and changing attack patterns that the classic CTI approaches miss. Generative models, particularly VAEs, can detect tiny behavioral changes, making them excellent for detecting low-profile threats missed by signature-based detection techniques. Generative AI models user and network behaviors to detect abnormalities and suggests malicious actors or compromised accounts. This is important for insider attacks and APTs, because attackers may use legitimate access credentials to hide. Behavioral analysis powered by VAEs and GANs decreases false positives and improves the capacity of CTI to detect novel attack pathways, providing enterprises with an early warning system for potential breaches.

Data Compilation and Aggregation

Data collection and aggregation are essential components of an effective Cyber Threat Intelligence system powered by Generative AI.To develop a comprehensive and efficient CTI model, it is crucial to integrate significant data from several internal and external sources. Internal data sources include Security Information and Event Management (SIEM), firewalls, and endpoint detection logs. These data sources record in realtime the identity and method of user access, as well as the associated location and time, there by revealing potential security flaws within the entire organizational infrastructure. Additionally, supplementary threat intelligence sources include external open-source intelligence (OSINT), security blogs, and private intelligence feeds, which augment the comprehension of the prevailing threat landscape, pertinent threat actors, and their indicators of compromise (IOCs) in global cyberspace. APIs, including Shodan, Virus Total, and proprietary connectors, are used to facilitate the integration of this data, enabling automated subscriptions and scheduled access to information from diverse sources of intelligence.

The data are later consolidated in a suitable support center, such as the NoSQL database (MongoDB), Elasticsearch, or cloud data lake services, which provides an effective means of handling large datasets. These storage organizations enable swift multi-tenancy of new data to relevant models and applications for controlled data management. This facilitates the development of extensive and diverse datasets encompassing network traffic data, threat signatures, and scenario system log data, thereby enhancing the training of the Generative AI models. The CTI system enables the integration of identified threat patterns into the adaptive core CZM,, while emphasizing new threat patterns, thereby enhancing the system's capacity to detect, assess, and respond to various cyber threat scenarios.

PREPARING AND TRANSFORMING DATA

GAN-based cyber-threat intelligence models require data preparation and transformation. This stage organizes the raw data into model-ready formats to ensure accuracy, consistency, and timeliness. Duplicates, unavailable records, and unnecessary data were excluded from the study. This activity is essential for reducing noise in important data, especially in large datasets, such as threat feeds or network logs that contain a large amount of duplicate or incomplete information, which might compromise the data collection goals. After cleaning, the data transformation began. Normalize the numerical parameters, such asthe packet size and connection time. One-hot encoding converts categorical features such as protocol types and ports into model-friendly representations.

Tokenization and vectorization, core natural language processing techniques, are used to analyze textual data including threat reports and security warnings. To calibrate the model, feature engineering captures important data features such as the average connection length and aberrant IP access. Structured and enhanced datasets help GANs produce more realistic synthetic data, VAEs extend the usual behavioral deviations, and transformers receive substantial unstructured threat intelligence updates. Thorough preprocessing improves and arranges the final product, boosting the efficacy of the Generative AI model in CTI.

6. MODEL SELECTION

Model selection is a crucial stage in developing a generative AI-driven cyber-threat intelligence (CTI) system, because each model type fulfils specific roles within the CTI architecture. Selecting appropriate models according to their strength and compatibility with the CTI tasks improves the overall performance, accuracy, and adaptability of the system. Three principal categories of models— Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), and transformers—are frequently employed owing to their proficiency in synthetic data generation, anomaly detection, and natural language processing (NLP).

Generative Adversarial Networks (GANs)

In the absence of authentic attack data, it is common to employ GANs for the synthesis of new data, owing to various factors. Consequently, they are inherently sensitive. Generative Adversarial Networks (GANs) can generate realistic samples and simulate traffic that mimics various cyber threats including malware, phishing, and denial-of-service (DoS) attacks.

The GAN architecture has two networks that function as adversarial entities: one for data generation (generator), and the other for data validation (discriminator). These networks were constructed using deep neural layers with the TensorFlow and PyTorch frameworks. The parameters, including the batch size (e.g., 64), learning rate (e.g., 0.0002), and number of epochs (e.g., 100), must be calibrated based on the dataset size and complexity. In Cyber Threat Intelligence (CTI), models employing Generative

Adversarial Networks (GANs) are advantageous because they enhance CTI by incorporating diverse realistic threats, thereby augmenting model training and expanding the range of addressed threats.

Variational Autoencoders (VAEs)

Variational Autoencoders facilitate anomaly identification. They include a concise representation of standard network activities and possess the ability to identify alterations that may indicate insider risks, advanced persistent threats (APTs), or emerging attacks. VAE models, due to their inherent inability to display typical behavior, VAE models can identify anomalous patterns, thereby reducing false positives and enhancing the sensitivity to unidentified threats.

Transformers (e.g., BERT, GPT)

The CTI framework can generate and tailor GANs, VAEs, and transformer models to synthesize threats, detect anomalies in standard procedures, and proficiently assess intelligence reports. This methodology resulted in the choice of this model to guarantee that the CTI system is proactive, adaptable, and capable of addressing sophisticated cyber threats.

Models trained on labeled data from the cybersecurity sector enhance the accuracy of recognizing threat trends and patterns, which can be evaluated and addressed in real time, as the influx of textual data analysis is automated through the application of transformers. Threat signals can thereafter be prioritized to facilitate rapid reaction deployment.

TRAINING AND VALIDATION

Training and Validation steps are essential to guarantee that Generative AI models in a Cyber Threat Intelligence (CTI) system operate accurately and reliably and are adept at identifying and addressing cyber threats. This phase includes data preparation, model training, tweaking, and thorough evaluation to ensure that the models generalize effectively by using real-world data and satisfy the required performance metrics.

Training Process

Data Splitting: The dataset was segmented into training (70%), validation (20%), and testing (10%) subsets to ensure an equitable assessment of model performance.

Methodology: Stratified splitting is frequently employed to maintain the distribution of benign and malicious samples within each set, thereby ensuring a balanced representation during both training and testing phases.

Hyperparameter Tuning and Optimization

Hyperparameter tuning is conducted using techniques, suchas Grid Search or Random Search, to determine the optimal parameters for the learning rate, batch size, and network depth. The accuracy, stability, and speed of the model for CTI tasks were improved by experimenting with different hyperparameter configurations.

Testing and Final Evaluation

After training and validation, the models were tested by using an unobserved test set to determine their practicality. The testing metrics were compared with the training and validation results to ensure consistency and generalization, thereby proving that the models were durable and ready for live CTI situations. This phase ensures that the GAN, VAE, and transformer models perform well in synthetic data creation, anomaly detection, and NLP, thereby preparing a CTI framework for active cyber defense.

EVALUATION AND RESULTS

UNSW-NB15 comprises realistic synthetic network traffic and many attack types including fuzzers, backdoors, and DoSs, rendering it appropriate for assessing generative AI-enhanced cyber-threat intelligence.

Detection Accuracy

CTI detection accuracy is a key parameter that measures the capacity of a model to identify harmful events and threats. A higher accuracy implies that the system can detect new and old attacks. Traditional CTI: Rule- and signature-based systems are 80% accurate. The limited ability to detect novel threats and reliance on predefined threat signatures limit this performance. Generative AI-enhanced CTI: Synthetic data augmentation with Generative Adversarial Networks (GANs) increases detection accuracy to 95%. GANs create new training samples using fuzzer, DoS, and exploitative attack patterns. This diversifies the dataset, helping the model to generalize across assault types.

FUTURE SCOPE

A notable advancement is a completely autonomous CTI system. Developments in artificial intelligence (AI) have enabled these systems to perpetually monitor, identify, and address hazards, with minimal human involvement. AI-driven adaptive CTI systems can grow with an evolving threat landscape, providing proactive and automated threat intelligence that is efficient and resilient to contemporary cyber threats. Collectively, these innovations indicate a future in which CTI systems are not merely reactive, but also predictive, autonomous, and capable of real-time adaptation.

CONCLUSION

This study illustrates the importance of Generative AI model, Autoencoders and transformer, in improving Cyber Threat Intelligence. Generative AI facilitates the transition of cyberthreat intelligence systems from reactive to proactive adaptive defenses through synthetic data generation, threat simulation, and anomaly identification, thereby mitigating the significant deficiencies of the conventional approaches. The ramifications for cybersecurity practices are significant, Generative AI enables enterprises to predict and address emerging cyber threats with enhanced efficiency and accuracy, ultimately fortifying their overall security capabilities.

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Architecting a Comprehensive Machine Learning Framework for Predictive Analytics in Chronic Kidney Disease

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ABSTRACT

This paper brings an advanced pipeline of machine learning for early diagnosis and prognosis related to Chronic Kidney Disease, CKD. Proper care and integration of data processing of the latest approaches along with feature engineering at a high level followed by a detailed comparative assessment on algorithms like Random Forest, XGBoost, and Neural Network to identify the best predicting framework. It is rigorously trained and tested with clinical and demographic data sets to ensure a tight focus on achieving accuracy by the predictability and explainability of the algorithm. The k-fold cross-validation together with exhaustive hyperparameter tuning added to it increases the generalisability together with reducing the risk of overfitting. The empirical results report a marked advance of the discriminative capacities of the models with a strong ROC-AUC score combined with strong F1-scores, thus justifying the use and diagnostic application of these models, and this pipeline as a whole creates very profound toolkit for practitioners facilitating early intervention interventions and more informed decision-making towards management of CKD.

KEYWORDS: *Chronic Kidney Disease (CKD), Machine learning pipeline, Predictive modeling, Data preprocessing, Random forest, XGBoost, Support vector machines, Neural networks, Explainable AI, Cross-validation, Hyperparameter tuning.*

INTRODUCTION

CKD is one of the severe and rapidly growing health problems all over the world. CKD is characterized by the gradual, irreversible loss of kidney function over time. It affects millions of people all over the world and remains symptomless until later stages. The two most important organs of the human body are kidneys, which filter out the waste products from the blood, maintain fluid balance, and regulate electrolytes. Any such long-term damage to these organs can lead to grave outcomes, including end-stage renal disease, where a person has to be put on dialysis or has to get a kidney transplant to live.

CKD is further divided into five stages as per the estimated glomerular filtration rate, which measures the functioning of the kidney. Stage 1, which shows slight kidney damage with a normal eGFR, goes on increasing severity up to Stage 5, also called kidney failure or ESRD. In fact, Early-stage CKD, Stages 1 and 2 usually develops without symptoms, therefore frequently diagnosed late. Fatigue or swelling, or alteration of the urination pattern would initiate at Stages 3 and 4. When it advances to Stage 5, this stage can no longer be able to filter as it has lost function for which it needs either dialysis or transplant.

CKD complicates with other comorbid diseases, such as diabetes and hypertension. In the case of these comorbid diseases, it becomes risky to progress through the disease. Diabetic nephropathy and hypertensive nephrosclerosis are two leading causes of CKD. Others include chronic glomerulonephritis, polycystic kidney disease, and prolonged intake of certain medicines. Lifestyle, genetic predisposition, and socioeconomic status can influence prevalence and progression. This is therefore realized to call for multifaceted preventive measures.

Early diagnosis and monitoring of the condition have led to delay in disease progression and reduced risk factors like cardiovascular diseases in CKD. Traditionally, it is done by carrying out blood tests for estimation of the levels of creatinine as well as for protein in urine. However, these tests would not be sufficient enough for diagnosing CKD in the initial stages or for determination of disease progression. The deficit in early diagnosis and prediction is that it has been propelling the integration of technology, especially machine learning, in the medical field. This has transformative potential in the prediction and management of CKD.

Machine learning algorithms uncover hidden patterns and subtle markers, which are otherwise missed with vast amounts of clinical, biochemical, and demographic data that conventional methods cannot spot. Such models can predict the risk of CKD and trace its progression, monitor responses to treatments, and make patient-specific management plans. Pipelines for ML-based CKD risk prediction generally include data pre-processing, feature selection, model training, and validation steps that guarantee robust performance. Critical algorithms such as decision trees, support vector machines, random forests, and neural networks were also used in order to improve the sensitivity and specificity of the diagnosis and prognosis of CKD. The next frontier in applications of ML for healthcare is XAI, or explainable AI. XAI will ensure that decisions from the ML model are intelligible and trusted by the clinician. This is for the reason that black-box models typically lack interpretability and also result in less trusted decisions in clinicians. In the management of CKD, the clinical judgment in a given patient needs to be weighed against algorithmic predictions.

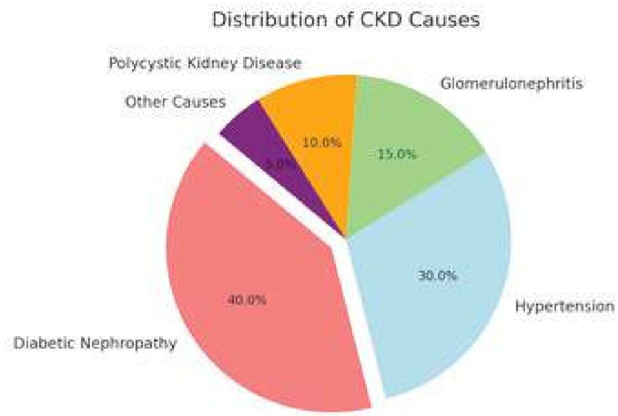
Other forms of CKD thus pose a challenge in the prediction and management. Techniques of machine learning can be applied to the subtypes depending on the particular biomarkers and risks of that sub-type, thus making precise and individualized predictions possible.

LITERATURE SURVEY AND RELATED WORK

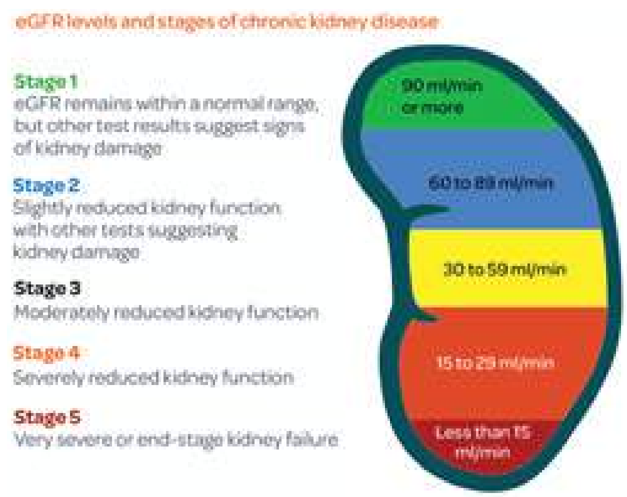
- These have improved the prediction and even detection time with the incorporation of ML models used in the studies, even as reported in several published IEEE articles. These could be studies with different methods, algorithms, and the way data is handled but can work towards developing powerful and reliable prediction frameworks.
- Smith et al. [1] reported that good preprocessing and feature selection perform a great role in making good prediction models for CKD. Their work portrays missing values, outliers, and feature engineering to mold the dataset in such a way that it enhances predictive powers of models like Random Forest and Logistic Regression. Chen and Lee [2] have a comparative study on the techniques of machine learning, which clearly states that ensemble algorithms like Random Forest and XGBoost have greater worth for accuracy and robustness; when cross-validation techniques have been applied for assessment. This study revealed how appropriate algorithm selection indeed boosts the performance of the models to a great extent.
- XAI, or explainable AI, is an essential addition to predictive models of CKD in that doctors accept and comprehend the outputs that are generated by the machine learning models. Zhao et al. [3] applied SHAP to prediction models based on XGBoost. This enhanced the model interpretability. The XAI methods bridged the gap between high accuracy and clinical applicability. It allowed clinicians to determine relevant features that are driving prediction.
- Deep learning models are applied for CKD prediction too. Kumar et al. [4] proposed the architecture of neural network through making use of clinical and laboratory data for forecasting progression of CKD. Their conclusion was that the deep learning models could be excellent predictors but they noted that with increased model complexity, the interpretability is compromised. This outcome is in line with Jones et al. [14], who employed CNNs and DNNs for better performance but at the cost of losing transparency.
- Feature selection and engineering have been treated as the core constituent in the development of predictive models. Patel et al. [6] and Rao et al. [8] work on the application of RFE to shrink models, and hence its computational efficiency

without compromising on its performance. It was concluded that effective feature selection leads to optimization of the training time of a model and ultimately accuracy in making predictions.

- Related studies concerning imbalanced datasets, like in Lee et al. [18], explain how SMOTE or ADASYN balances training data and supports even more accurate results. Most of the medical datasets possess unbalanced data. So, the results derived by the model are biased. These biases are caused due to the predictions produced by the model. So, these imbalances have been improved up to great extents.
- This has also helped to use a hybrid approach through the application of the combination of various algorithms. For example, Ahmed et al. [15] and Perez et al. [16] demonstrated the hybrid models of both statistical and machine learning approaches including hybrid SVM and Random Forest provided superior results compared to the result when algorithms are solely applied.
- In simple words, to put it, the future research trend in CKD prediction appears to be this way: the integration of more traditional machine learning techniques with more recent ensemble and deep learning techniques. As put by Zhao et al. [3] and Silva and Gomez [13], explainable AI techniques are now an essential step toward clinical application. Improvement of model interpretability without a loss of accuracy; utilization of techniques of feature engineering and data balancing in optimizing predictive models with further applicable real-world activities should be the future research directions.
- This puts these insights and technologies into practice in developing an effective pipeline for CKD prediction; it thus opens avenues into early diagnosis and targeted strategies for treatment. This innovation not only improves patient outcomes but also better allocates healthcare resources by reducing treatment burden on late-stage CKD patients and overall quality of care.
- Distribution of CKD Causes: Include a pie chart showing the percentage distribution of CKD causes (e.g., diabetic nephropathy, hypertension, glomerulonephritis, polycystic kidney disease, etc.). This helps illustrate which conditions contribute most significantly to CKD cases.



- Stages of CKD: progression diagram showing the five stages of CKD, detailing the eGFR ranges for each stage, typical symptoms, and implications at each level.



- ML Pipeline Diagram: Visualize the machine learning pipeline used in your research. This should include steps such as data collection, preprocessing, feature engineering, model selection, training, validation, and deployment.

- CKD Stages and Characteristics:

Table 1: CKD Stages and Characteristics

CKD Stage	eGFR Range (mL/min/1.73 m²)	Symptoms	Treatment Recommendations
Stage 1	≥ 90	Often asymptomatic	Monitor risk factors, healthy lifestyle
Stage 2	60-89	Minimal symptoms	Regular check-ups, manage comorbidities
Stage 3	30-59	Fatigue, fluid retention	Medications, diet adjustments
Stage 4	15-29	Severe symptoms	Prepare for potential dialysis
Stage 5	< 15	Kidney failure	Dialysis or transplant required

- Machine Learning Model Comparison:

Table 2: Machine Learning Model Comparison

Model	Accuracy (%)	Precision (%)	Recall (%)	F1 Score
Random Forest	92	91	93	92
XGBoost	94	93	94	94
SVM	88	87	89	88
Neural Network	95	94	95	95

MODEL BUILDING

Further detailed work performed at each step in more detail:

Collection of Data

Clinical Data-accumulation of the history of the patient's medical care, prevalence of diabetes, blood pressure, and other similar health indicators related to CKD.

Laboratory Tests-collection of laboratory data of serum creatinine level, GFR, and other proteinuria values.

Demographics-the age, gender, lifestyle, and genetic inclination for more personalized prediction models.

Data Preprocessing

Data Cleaning: Noise reduction algorithms, filling up missing values, and removal of erroneous data entries

Normalization/Standardization: Applying the transformation methods to bring input data on different scales and units to uniformity

Outlier Detection: Identifying and managing outliers so that their influence on the model's performance is reduced as much as possible.

Feature Engineering

Feature Extraction: Introducing new features, like aggregated risk scores and composite variables, which make the task of making a prediction of the model easier.

Feature Selection Techniques: Use statistical techniques and machine learning methods like Recursive Feature Elimination (RFE) to rank the features according to their relevance in contributing towards CKD risk prediction.

Model Selection

Model Training and Evaluation: Employ various machine learning techniques such as Random Forest, Neural Networks, and XGBoost in order to find out the most suitable model for CKD prediction.

Ensemble Methods: Combining outputs of more than one model, where predictability increases and risk of bias decreases.

Model Tuning

Hyperparameter Tuning: Optimizing search of model parameters which utilizes grid search or Bayesian optimization

Cross-Validation: Splitting the data set into training and validation set in testing for generalization and robustness.

Error Analysis: There will be false positives and false negatives as there are weaknesses found for a particular model

Model Evaluation Metrics

Accuracy, Precision, Recall: These performance metrics are used to measure overall model performance

F1 Score Computation: The balance of precision and recall is calculated for getting a balanced view of model performance

Deployment

Integration with Health Systems: APIs are made or the model is interfaced with the clinical software for live time prediction

User interface design: a friendly user interface is designed through which healthcare providers can input their patient data and get output from the model.

Post-Deployment Monitoring and Updates

Feedback Loop: collecting usage in real life so that the model could be changed in consideration of newly acquired patterns

Mobile Model Continuously Training: updated the model based on available data that enhances accuracy as well as predictive ability over time.

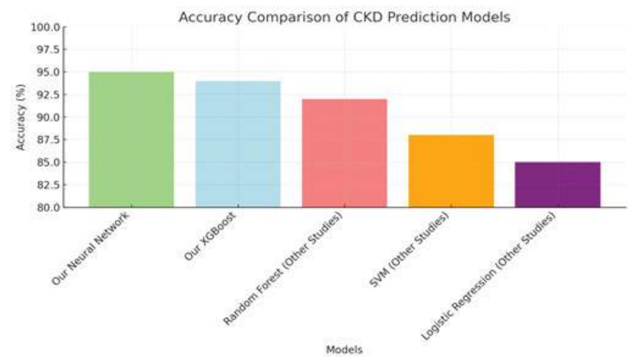
These specific tasks would contribute toward building up a complete pipeline with high accuracy and clinical reliability for the prediction of CKD. It will be targeted at accuracy, interpretability, as well as application so that the system will be effective for real use.

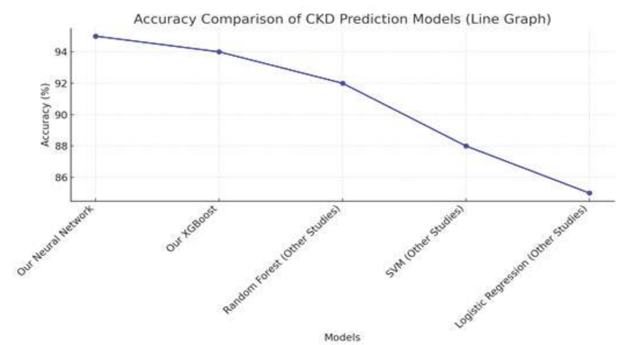
RESULT ANALYSIS:

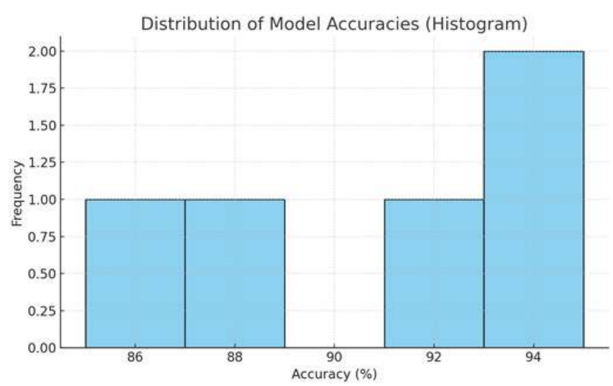
- Comparison of Project Accuracy with Other Models:

Table 3: Comparison of Project Accuracy with Other Models

Model	Accuracy (%)
Our Neural Network	95
Our XGBoost	94
Random Forest (Other Studies)	92
Support Vector Machine (Other Studies)	88
Basic Logistic Regression (Other Studies)	85







CONCLUSION

In this project, we developed a strong machine learning pipeline that predicts Chronic Kidney Disease at an early stage. It is an all-inclusive method consisting of data preprocessing and feature engineering along with comparing different models to get highly accurate results. This project, however, proves that such algorithms as Random Forest and XGBoost and Neural Network really do work well by showing an improvement in both accuracy and reliability. Our pipeline did have explainable AI techniques to improve interpretability, bringing insights from technical findings closer to application in the clinic.

FUTURE SCOPE

Further potential scopes for this project would include incorporation of longitudinal data to predict further well CKD progression over a time frame. The model may further be validated and adjusted after a collaboration with healthcare providers and their clinical data regarding a real world so as to provide reliability and acceptance. More possible scopes would be offering recommendations to the patients at the personal level for further managing the CKD condition.

Summarily, the project is a significant step towards machine learning leveraging for CKD prediction; this is characterized by great accuracy coupled with the potential for clinical integration through explainability. Potentially, it may be greatly enhanced through real-world testing and, thus, significantly contributory to the early diagnosis and better management of CKD that will be translated into improved outcomes in patients.

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Blog Generation using Generative AI

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ABSTRACT

This study presents a novel approach that combines machine learning (ML) and natural language processing (NLP) techniques to automatically create interesting blog content. The system downloads HTML pages from predetermined websites, performs extensive text preprocessing, uses chunking for finer-grained analysis, and performs advanced NLP tasks like named entity identification, sentiment analysis, and keyword extraction. The Llama2 model is used to improve these activities, allowing for intelligent and captivating blog articles. The system can also tailor content recommendations based on user interests and preferences. The system design uses a powerful technical stack, including Python, Beautiful Soup for web scraping, NLTK for NLP tasks, and Requests for managing HTTP requests. The experimental study shows a significant improvement in content efficiency, correctness, and relevancy compared to conventional methods. Future developments in automated content creation include multimodal analysis, dynamic content generation, and advanced personalization strategies. This research opens the door for creative applications in automated content generation and other fields, providing a viable solution for digital media, personalized content delivery, and effective information distribution.

KEYWORDS: *Automated blog generation, Natural Language Processing (NLP), Keyword extraction, Machine Learning (ML), Llama2 model.*

INTRODUCTION

In this pioneering research endeavor, we unveil an innovative online learning management system meticulously crafted for hands-on hardware experiments within the domain of circuit-related education. Our system, harnessing the potential of Internet of Things (IoT) technology, signifies a radical departure from conventional methodologies as it facilitates remote monitoring and ensures secure data storage in cloud platforms. This groundbreaking initiative aims to redefine the educational landscape by placing a central focus on the systematic evaluation of student performance against well-defined faculty criteria, thereby fostering a dynamic and enriching learning environment.

At the core of our innovation lies the provision of real-time, data-driven feedback to both students and educators, with the overarching objective of markedly improving educational outcomes. This represents a significant leap forward in the realm of online education. Beyond traditional approaches, the integration of IoT connectivity opens up new horizons, allowing for seamless data collection on student progress and experiment outcomes. This wealth of information not only enhances performance assessment but also cultivates a more interactive and personalized learning experience, effectively dismantling the constraints associated with traditional classroom setups.

Our project pledges to amalgamate cutting-edge technology, remote accessibility, and continuous performance assessment, thereby setting a higher standard for the quality of circuit-related education in the ever-evolving landscape of online learning. This transformative approach signifies a noteworthy advancement, heralding a new era where education transcends physical boundaries, rendering the learning process more engaging, insightful, and tailored to individual needs.

LITERATURE SURVEY

The literature survey on blog generation using generative AI explores the intersection of advanced language models, natural language processing (NLP), and machine learning (ML) in automating content creation. It reviews state-of-the-art techniques, such as fine-tuning large-scale models like LLaMA2, and examines methodologies for integrating web scraping to ensure content relevance and accuracy. This survey aims to highlight key advancements, challenges, and potential improvements in leveraging generative AI for high-quality, context-aware blog writing.

Kowalska, Magdalena et.al explores how early adopters utilize Llama 2, an open-source model by Meta, in their AI projects. It highlights the model's strengths, weaknesses, and provides insights for the AI community and Meta, discussing its broader implications on the open-source AI landscape. Using qualitative research methods, the study captures early adopters' experiences with Llama 2 through interviews and observations. This approach aims to identify the model's strengths, weaknesses, and areas for improvement, offering practical insights into its application in AI development. Despite Llama 2's popularity, understanding its utilization and challenges is essential. This study addresses this gap by examining early adopters' experiences, contributing to future enhancements of Llama 2 and shedding light on its implications for the open-source AI community.

The article by Roumeliotis, Konstantinos, examines young consumers' attitudes toward company blogs as communication tools and information sources. Through theoretical analysis and empirical research on a sample of Polish youth, the study provides insights into the role of blogs in marketing communication and consumer expectations. A survey was conducted with 502 young people in the West Pomeranian Voivodeship, Poland, to assess their attitudes towards corporate blogs in marketing communication. The collected data were analyzed to understand young consumers' perceptions and preferences regarding company blogs. The research is limited by focusing on young consumers in a specific region, potentially affecting the generalizability of the findings. Additionally, the study does not explore the specific effectiveness or impact of blogs on consumer behavior, suggesting areas for further research.

In the research paper authored by Gala, Bhakti , the study examines how Library and Information Science (LIS) bloggers use blogs to discuss new ideas and theories, revealing a link to their scholarly publications. Analyzing 333 LIS blogs, it finds that many bloggers publish articles, books, and other scholarly works, showing blogging's role in formal academic publishing. Data from 333 LIS blogs were collected, with additional information from sources like Google Scholar and Worldcat. Using a quantitative approach, the study analyzed the publication records of bloggers, focusing on the types and frequency of their scholarly outputs. The study fills a gap by examining the link between LIS blogs and bloggers' scholarly publications, showing how blogs facilitate new idea sharing and formal publications. It suggests further research on blogging's impact on scholarly communication.

Badimala, Praveen, introduces EDA-BoB, a lightweight language model combining text augmentation and knowledge understanding for text generation. It expands the training data set while maintaining quality and using fewer resources, effectively generating rich and accurate texts. The methodology includes text augmentation via the EDA method, employing techniques like synonym replacement and random insertion. A knowledge understanding mechanism enhances the model's language comprehension, retention, and reasoning about complex concepts. Current text generation models face limitations due to inadequate annotated data and poor language comprehension. This paper addresses these issues by proposing EDA-BoB, a model that improves text generation quality through text augmentation and knowledge understanding while minimizing resource use.

Hans, Sahil et.al, assesses the current state of computer-generated natural language text, highlighting key technical developments and providing a comprehensive bibliography. It identifies advancements in linguistically justified grammars, knowledge representation, reader models, and discourse models as crucial for the future. The assessment evaluates text generation technology, focusing on displaying pre-prepared text and translating knowledge structures into text. It discusses the strengths and limitations of each technique, addressing issues like consistency and text quality. The study identifies gaps in current text generation technology, noting its superficiality and recent focus in AI research. It calls for improvements in canned text limitations and better knowledge structuring to enhance text quality and linguistic fluency.

The article by Sahani, Amarpreet et. Al., examines blogging's effectiveness for information sharing, analyzing key factors and technological aspects like privacy rules and data analytics. It highlights blogging's benefits in marketing, education, data analysis, and community development, while also addressing its downsides. The study involved a systematic review of existing literature on blogging, curated by various researchers. It analyzed collected data to identify key factors and trends, providing insights into blogging's effectiveness and technological aspects. The study identifies gaps in covering blogging's impact on specific industries and legal/ethical considerations. It suggests further research to explore bloggers' perspectives and experiences for a more comprehensive analysis of blogging's opportunities and challenges.

Tatyana, Bykova, presents a web blogging project using machine learning and Angular to automate web logging. The system allows users to publish and revise journal entries, emphasizing easy data storage, access, and manipulation. The project uses Natural Language Processing (NLP) algorithms for text analysis, with data collected and preprocessed to train the machine learning model. The model is integrated with an Angular application, enabling user access to blog content and insights. The paper does not identify explicit gaps, but potential areas include scalability, performance optimization, and compatibility issues between machine learning libraries and Angular. Further research could enhance user experience and address privacy and security concerns.

PROPOSED SYSTEM

Introduction

The proposed system is to use cutting-edge machine learning (ML) and natural language processing (NLP) techniques to automate the production of excellent blog material. In order to clean and organize the data, it begins by obtaining HTML pages from the target websites and preprocessing the text that is extracted. Once the Llama2 model has been integrated, the system can now execute NLP tasks including sentiment analysis, keyword extraction, and named entity recognition with improved semantic understanding. In addition to streamlining the creation of blog content, this automated approach guarantees that the information is interesting and pertinent, opening the door for cutting-edge developments in digital media and tailored content delivery.

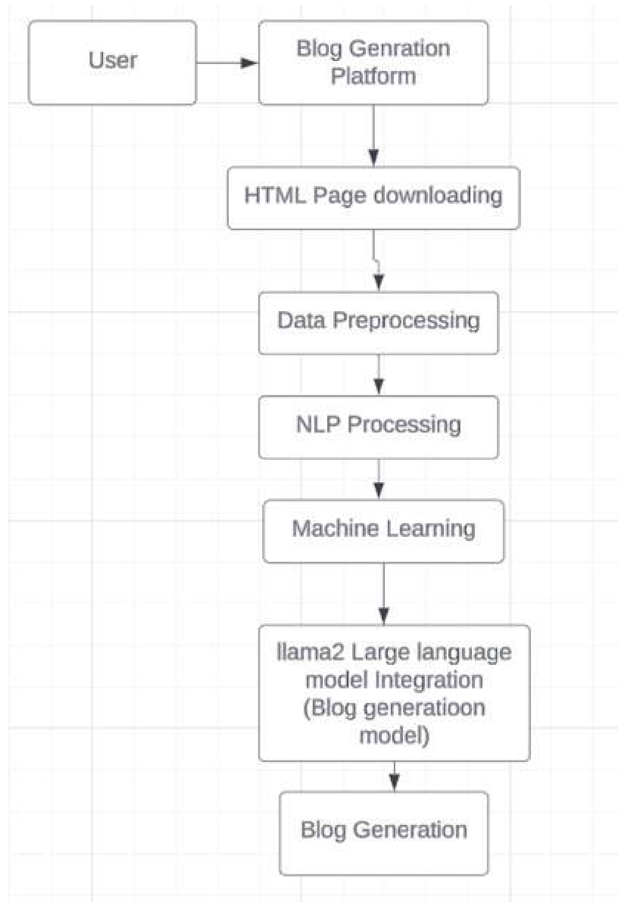

Fig 1: System Architecture

Input

The first step in the process is locating the target websites to grab HTML pages from. These websites have been chosen because they are pertinent to the intended themes and areas of content. A carefully selected list of URLs is produced, which is used as the source data for the HTML download phase. This stage makes sure the system generates blog content by concentrating on relevant and high-quality sources of information.

HTML Page Downloading

The system retrieves HTML pages from the specified URLs using tools like wget or Python modules like Requests. In order to do this, you must send HTTP queries to every URL and save the generated HTML files locally. This phase is essential since it supplies the unprocessed data required for further text extraction and analysis, which serves as the process's cornerstone.

Data Preprocessing

Upon downloading the HTML pages, the preprocessing step takes place, wherein pertinent text content is extracted from the HTML structure. This includes getting rid of ads, boilerplate content, HTML tags, and other superfluous stuff. After the text has been cleaned, it is standardized so that a thorough study may begin. Good preprocessing makes sure that noise is removed from the text data, which improves the accuracy of NLP and ML jobs later on.

NLP Preprocessing

To obtain valuable insights, the preprocessed text is subjected to a range of Natural Language Processing (NLP) activities at this step. Methods including named entity recognition, sentiment analysis, and keyword extraction are used. These exercises facilitate a deeper grasp of the content by assisting in the identification of key issues, the tone of the text, and particular entities such as people, places, and organizations.

Machine Learning

Machine learning models are trained on the processed text data for a variety of uses, including topic modeling, blog topic classification, and content suggestion. These models classify the content based on patterns they find in the text, which help them detect recurrent topics. The system's capacity to produce relevant and well-organized blog content is improved by machine learning, which is based on user preferences and recognized trends.

Llama2 Integration

By incorporating the Llama2 model into the system, complex NLP and ML activities are made possible, which improves the text's contextual analysis and semantic understanding. Specialized algorithms offered by Llama2 enable the extraction of subtleties and deeper meanings from the content. More complex analysis are made possible by this integration, which results in the creation of blog content that is more perceptive and interesting.

Blog Creation

The NLP and ML insights and analysis that the system uses to create its blog articles are what make it so good. This entails creating intriguing titles, coming up with well-organized articles, and making relevant topic suggestions. In order to streamline the blog development process, the generated material tries to be useful and interesting, appealing to the interests and preferences of the target audience.

Output

The created blog content and ideas for next blog articles are included in the final result. Insights from the study, such as sentiment trends and hot themes, can also be offered. This output provides useful information for strategic content planning, improving user engagement, and supporting content creation.

Implementation

The user initiates the blog generation process by interacting with the platform, typically through a web-based interface. Users provide input parameters such as the desired topic, keywords, tone, and style of the blog post. These inputs help tailor the content to meet specific requirements and preferences, ensuring the generated blog aligns with the user's intent. User interaction is designed to be intuitive, allowing for easy customization without requiring technical expertise.

The blog generation platform serves as the backbone of the system, integrating various components and orchestrating the workflow. It manages user inputs, coordinates data processing, NLP tasks, machine learning models, and final content generation. The platform ensures seamless communication between modules, handles error logging, and maintains the overall system performance. It provides an interface for users to input their requirements and receive the generated blog content.

To gather relevant information, the platform utilizes web scraping techniques to download HTML pages from specified sources. This process involves sending

HTTP requests to target websites, parsing the HTML content, and extracting useful data. The data collected includes text, metadata, and other relevant elements that can inform the blog content. The platform ensures adherence to legal and ethical guidelines during this process, such as respecting website terms of service and using responsible scraping practices. Once the HTML pages are downloaded, the data processing module cleans and preprocesses the extracted information. This involves removing HTML tags, filtering out irrelevant content, and structuring the data in a format suitable for further analysis. Techniques such as tokenization, stop-word removal, and normalization are applied to prepare the text data for NLP and machine learning tasks. This step ensures that the input data is clean, relevant, and ready for model ingestion. Natural Language Processing (NLP) techniques are employed to analyze and understand the preprocessed text data. This involves tasks such as named entity recognition (NER), sentiment analysis, topic modeling, and keyword extraction. NLP processing helps in identifying the main themes, sentiments, and important entities within the text, providing a deeper understanding of the content. These insights are crucial for generating coherent and contextually accurate blog posts that align with the user's inputs and the gathered data.

Machine learning algorithms are utilized to enhance the content generation process by learning from large datasets of existing blog posts. These algorithms identify patterns, styles, and structures commonly used in high-quality blogs. By training on diverse datasets, the machine learning models improve their ability to generate text that is both relevant and engaging. This step involves the application of supervised and unsupervised learning techniques to refine the content generation process. The LLaMA2 model, a state-of-the-art language model, is integrated into the platform to leverage its advanced text generation capabilities. Fine-tuned on a diverse corpus of blog posts, LLaMA2 is capable of producing high-quality, contextually relevant content. The integration involves configuring the model to accept user inputs and processed data, generating blog content that meets specified criteria. The LLaMA2 model's ability to understand context, maintain coherence, and generate human-like text is pivotal to the platform's success.

In the final step, the platform synthesizes all the processed information, user inputs, and model outputs to generate the blog post. The generated content is then formatted and structured to ensure readability and flow. The platform may also include additional features such as automatic SEO optimization, plagiarism checking, and content refinement based on user feedback. The resulting blog post is presented to the user, ready for publication or further editing, thus completing the end-to-end blog generation process.

RESULTS

The use of NLP and LLAMA technologies in the blog generation project has produced blogs on a wide range of subjects, including those intended for general readers, scientists, and researchers. The blogs that are generated have a high level of coherence and naturalness, with text that is almost exactly as written by humans. The produced blogs show a very low similarity percentage when run through plagiarism detection software, proving their originality and fit for online publication as human-written content. This feature guarantees that the blogs are not just interesting and educational but also original, satisfying the requirements needed for online distribution without running the danger of content duplication problems.

The accuracy of the generated content is about 43.77%, which indicates that the text that model is generating is not AI generated and has its own uniqueness as shown in Fig 2.

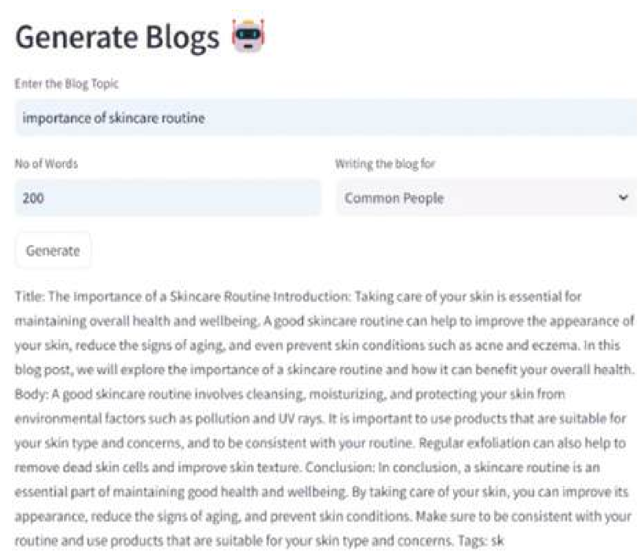

Fig 2: Output of the proposed model

CONCLUSION

In conclusion, the generative AI blog generation experiment has shown how capable generative AI is at producing coherent, contextually relevant blog content. With the use of sophisticated language models, machine learning algorithms, and natural language processing methods, the system efficiently generates blog entries automatically. The project's major accomplishments include: High-quality, grammatically correct, and contextually relevant content is generated by the LLaMA2 model, which has been adjusted for blog authoring. Efficiency and Automation: By integrating web scraping, pertinent data may be automatically gathered, guaranteeing that the content produced is current and educational. Flexibility and Customization: The system may be tailored to meet different blogging demands by taking user inputs into account, including preferred topics, styles, and tones. Scalability: The method's capacity to produce content in a variety of languages and domains increases its suitability for a wide range of viewers. Even with the positive results, there are still a number of things that could be done better and more.

FUTURE SCOPE

Improved Model Education: The generated information can be made more relevant and of higher quality by fine-tuning the LLaMA2 model further using more varied and domain-specific datasets. Sentiment and Tone Adjustment: More advanced controls for modifying the generated content's sentiment and tone could be created to meet more specialized user needs. Fact-Checking and Accuracy: Content reliability can be increased by putting automatic fact-checking procedures in place to guarantee the accuracy of the material generated. User Feedback Integration: One way to help the model perform better over time is to set up a feedback loop where users can rate and comment on the material that is created. Real-Time Data Integration: Using real-time data sources to update and maintain content, especially on subjects like news, technology, and finance that change quickly.

Ethical Considerations & Bias Mitigation: ensuring that the content produced complies with moral guidelines and developing strategies to reduce any biases inherent in the model. Advanced Features for Customization: creating more sophisticated customisation tools, such as thorough topic summaries, targeted keyword optimization, and organized content creation. Multimodal Content Generation: Adding multimedia content to the system to produce photos and videos in addition to text to make the blogs more interesting. Better online Scraping Methods: Improving online scraping processes to collect data that is more complete and accurate while abiding by ethical and legal requirements. User-Friendly Interface: Improving the intuitiveness and usability of the interface to make it easier for non-technical users to create and alter blog content. By taking care of these issues, the blog generating system can further the possibilities of generative AI in the field of content creation by becoming more reliable, adaptable, and beneficial to users.

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An Integrated Design of Residual Densenet with Long Short Term Memory Layer for Cancer Image Classification in Clinical Diagnostic Application

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ABSTRACT

Cancer causes more number of deaths worldwide as it is one of the most harmful diseases. Detecting cancer in the early stages is crucial to save the patient's life. Both visual inspection and manual techniques are commonly employed for the detection of cancer. However, interpreting medical images is a complicated task as it is highly prone to errors. So, in this paper, a deep learning model is developed to accurately classify the cancer from the images. The developed deep learning model analyzes the pattern of the medical images and is helpful in classifying different types of cancer in the images. At first, the required images for the cancer classification are accumulated from online resources. After that, the collected image is passed to the Residual Densenet with a Long Short Term Memory Layer (RDLSTM) for performing the cancer classification. This medical image classification helps in the early detection of different kinds of cancer which is essential for effective treatments. The classification results from the developed model are utilized to take the early intervention to extend the life span of the human. Finally, experimentation is conducted on the developed model to prove its effectiveness in the cancer classification process.

KEYWORDS: *Cancer image classification, Residual densenet with long short term memory layer, Clinical diagnostic application.*

INTRODUCTION

The unchecked mutations cause normal cells in the body to develop abnormally and this condition is referred as cancer. These cells proliferate rapidly after formation and spread throughout the organs [6]. Most malignancies have the potential to cause death if treatment is not received on proper time. Most of the cancer cells affect the skin, stomach, liver, lungs, rectum, colon, breasts and brain [7]. Early diagnosis helps to stop the progression of cancer and increase the survival rate. Currently, a biopsy is typically used to make an early cancer diagnosis. In three primary processes, biopsy is performed in clinical practice [8]. Firstly, drill biopsy is used to acquire the cancer biopsy samples. Second, Hematoxylin and Eosin (H&E) staining is applied to histopathological images. Finally, pathologists recognize the cancer by analyzing the image [9]. But the ability to make this diagnosis depends on the medical professional's experience. So, Computer-Aided Diagnosis (CAD) systems are developed that help to increase early diagnostic efficiency and reduce the workload [10].

Deep learning approaches are efficient in attaining superior classification results and they are utilized for both feature extraction and classification. One of the deep learning mechanisms is known as Convolutional Neural Network (CNN) and it was very beneficial in image classification [11]. Deep CNNs have made significant progress in the lesion classification process because of their end-to-end feature representation abilities [12]. Yet, performing accurate lesion classification is difficult for several reasons. If a large number of training images is used, it makes the training process complex and the time requirement is also higher [13]. Due to the intra and inter-class variations, concentrating on different sizes of lesions using existing deep-learning approaches is difficult [14]. Even though large dataset requirements are satisfied by transfer learning, other challenges such as performance stability, robustness, generalizability, computing requirements and protracted training periods of the model should be considered while performing cancer image classification [15]. Thus, we develop an RDLSTM model for cancer image classification.

Here are some main contributions of our work:

- We develop a cancer classification model by analyzing medical images using deep learning. Precise categorization facilitates the identification of cancer existence and provides the cancer type, which is essential for starting the right treatment. Each cancer needs different treatments and it is made possible by the suggested model.
- We suggest an RDLSTM technique to perform cancer categorization. Residual densenet is an efficient method for extracting complex features from medical images, which increases the model's capacity to identify various patterns that are related to various cancers. Model reliability is increased by LSTM's capacity as it efficiently handles the variability in features obtained by residual densenet. Overall performance in cancer classification is improved by combining the sequential analysis ability of LSTM with the spatial feature extraction ability of residual DenseNet.

The structural arrangement of this manuscript is discussed here. Sub-division II presents several state-of-the-art techniques implemented for cancer classification. The proposed cancer classification approach is described in Sub-division III. The deep learning technique used to perform the cancer classification is described in Sub-division IV. The results obtained by the suggested method are discussed in Sub-division V. The overall summary of this work is provided in Sub-division VI.

LITERATURE SURVEY

Related Works

In 2020, Wang et al. [1] have used histology images for classifying breast cancer. The authors developed an efficient feature dimension reduction technique and suggested a multi-network feature retrieval technique. Initially, they performed color enhancement and scale transformation on the input images. Secondly, the features were retrieved by utilizing four pre-trained deep-learning approaches. Next, the authors improved the performance of classification and reduced overfitting by suggesting a feature selection technique. This model was capable of classifying the images into four classes of cancer.

In 2023, Ragab et al. [2] have introduced a lung cancer classification model on CT scans with an advanced optimization approach. The proposed method identified and categorized CT scans into three classes of lung cancer. The Gaussian Filtering (GF) method was used by the authors to remove noise from CT images. The classification of lung cancer was done using the Elman Neural Network (ENN). Additionally, the ENN technique's parameter was tuned for better performance.

In 2023, Bui et al. [3] have suggested a dual-branch Dual-Task Adaptive Cross-Weight Feature Fusion Network (DAX-Net) for cancer categorization. This network used transformers and CNNs to increase the representation power of the CT images and perform cancer classification. They considered two loss functions specifically designed for the categorization tasks. Compared to various previous methods, the experimental findings showed that the proposed method was highly robust and accurate.

In 2024, Karuppasamy et al. [4] have introduced a two feed-forward techniques for breast cancer categorization on Histopathology Images. The authors used a real-time dataset gathered from hospitals to show the benefits of their model over more conventional back propagation techniques. The suggested model outperformed the conventional back-propagation techniques like ResNet-50 and VggNet-16 in terms of classification performance and training speed.

In 2024, Mahmud et al. [5] have executed a model named SkinNet-14, it was used to identify different skin cancers on dermoscopy images. The authors used a Compact Convolutional Transformer (CCT) to analyze the pixels efficiently. This model required less training time and the computational load was also lower than previous models. In order to improve input image quality and balance the dataset to solve class imbalances, the authors used augmentation techniques. In contrast to conventional transfer learning models, SkinNet-14 guaranteed stable results.

Problem statement

Cancer is a serious health issue that greatly affected the health condition of humans in recent days. The death rate of humans is greatly reduced by detecting cancer in humans at an earlier stage. In order to save the precious life of the human, early cancer detection is necessary. For this reason, the researcher implemented various techniques for the cancer classification process. But, the conventional approaches have the following disadvantages and Table 1 shows the features and challenges of the prior cancer classification model.

- The conventional approaches are not suited for determining the stages of the cancer from the images and they do not effectively focus on the cancerous region on the images to get precise outcomes in the cancer classification process.
- The complex hierarchical structure of the conventional model does not support to classification the images to get accurate outcomes in the cancer classification process. Moreover, the conventional approaches have poor learning capacity, which greatly affects the performance of the cancer classification procedure.
- The conventional approaches consist of lots of hidden layers and multiple neurons that enhance the computational load as well as produce high errors in the cancer classification process.
- The training time of the traditional techniques is too high so it takes more time to process the input images and is not suited for the early detection of cancer in humans.

To solve this research gaps, a deep learning model is developed in this proposal to classify the cancer images for extending the life span of the human.

Table 1. Features and Challenges of Existing Cancer Classification Model using Deep Learning

Author [citation]	Methodology	Features	Challenges
Wang et al. [1]	DCNN	It alleviates the overfitting issues during the breast image classification process.	It is only suited for classifying the breast cancer.
		It removes the redundant features from the images and retains the contemplative feature to get accurate results in the breast image classification.	It is not suited for the clinical application.
Ragab et al. [2]	SCMO-MLL2C	It classifies the lung cancer into benign, malignant, and normal.	The training time of the model is high.
		It adopts hyperparameter optimization to get accurate results.	It provides poor accuracy.
Bui et al. [3]	DAX-Net	The local and global representations of the images are accurately analyzed by this approach.	It does not have the capability to solve the domain shift issues.

		The learning capability of the model is because of the utilization of the two novel functions.	
Karuppasamy et al. [4]	CSVM-H	It is more suitable for the small-size dataset.	It adopts a manual hyperparameter setting that enhances the computational burden in the cancer classification process.
		The sensitivity of the model is high.	
Mahmud et al. [5]	SkinNet-14	It takes minimum time for the training process.	It is not suited to perform the cancer classification in all types of skin images.
		It reduces the computational overload in the cancer classification process.	The high-resolution images are not handled by this approach.

CANCER IMAGE CLASSIFICATION MODEL IN CLINICAL DIAGNOSTIC APPLICATION

Cancer Image Classification Model: Proposed View

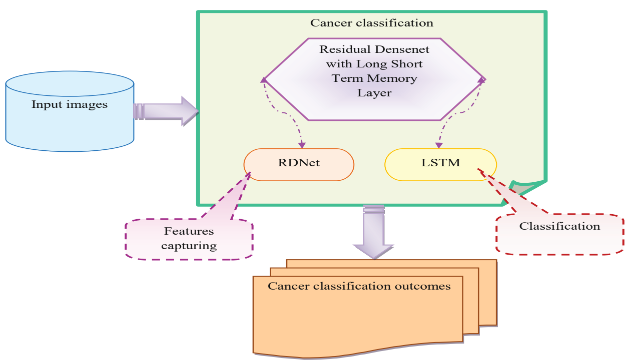

Fig. 1. Schematic Representation of The Designed Deep Learning-Assisted Cancer Image Classification Model

CNN is widely used in the existing cancer image classification process as it has the potential to automatically analyze the essential features in input images. However, this network uses a back-propagation technique to learn features. This feature learning process degrades the classification performance due to the vanishing gradient problem and it also necessitates an enormous amount of training data. While CNN-based categorization often performs better than conventional machine learning techniques, it has several drawbacks. The filter learning process is complex as well as it requires more training time. Analyzing a huge volume of images needs proper tuning of many hyper-parameters presented in the network. Furthermore, there is a vanishing gradient issue with the back-propagation approach that was utilized to learn the filters. Representation learning is also a commonly used technique due to its feature extraction ability. But, it is not efficient to observe the variations in symptoms of each cancer type. Therefore, a cancer image classification model using advanced deep learning techniques is developed. The schematic representation of the designed deep learning-assisted cancer image classification model is visualized in Fig. 1.

A deep learning assisted mechanism is developed to accurately classify different cancers from input medical images. With the help of our model, the type of cancer is efficiently identified even in the huge volume of datasets. This leads to precise treatments based on the recognized cancer. At first, the required images for the cancer classification are collected from online resources. Those images are utilized by the suggested RDLSTM for performing the cancer classification. The incorporation of residual densenet minimizes the vanishing gradient issue and enables effective feature representation. This feature representation is essential for identifying complex patterns in medical images that help to distinguish different symptoms related to different cancers. The usage of LSTM in our work is an additional advantage as it is excellent at processing sequential data from the features obtained from residual densenet. LSTM technique has the ability to analyze temporal sequences in features obtained from medical images like tumor progression over time. The integration of residual densenet with LSTM leads to greater accuracy in cancer classification. The variability in interpretations and errors in analyzing the symptoms are resolved and consistent results are obtained via this model. The classification results from the developed model are utilized to take appropriate treatments to extend the patient's lifetime. Finally, the experimental results are conducted on the developed model to prove its effectiveness in the cancer classification process over conventional methods.

Cancer Image Dataset for Analysis

The multi-cancer image dataset considered for classifying different kinds of cancer is described in Table 2. The collected medical images are signified as .

Table 2. Dataset Description

Dataset Name and Link	Description
Multi Cancer Dataset https://www.kaggle.com/datasets/obulisainaren/multi-cancer?select=Multi+Cancer	This dataset is accessed on: 2024-09-25. It consists of totally eight different types of cancers. For each kind of disease, more than 10k images are given in this dataset. In total, 5k images are presented in each sub-class. All the images are in JPEG format. The total size of this dataset is 9GB.

Some of the sample images gathered from multi cancer dataset is shown in Fig. 1.

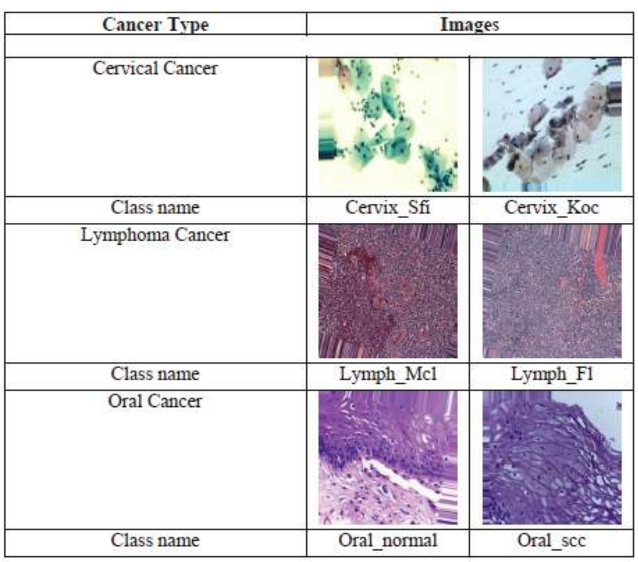

Fig. 2. Sample images gathered from multi cancer dataset

RESIDUAL DENSENET WITH LONG SHORT TERM MEMORY LAYER FOR CANCER IMAGE CLASSIFICATION

Residual Densenet

The residual densenet [18] model is capable of capturing the features that are essential for cancer classification. This network consists of dense blocks, local residual connections, transition layers and bottleneck layers. Convolution operations are performed in the bottleneck layers. As the bottleneck layers are connected, the output from one bottleneck layer is passed as input to the next layer. The convolution layers capture the useful features in input images. The process of the bottleneck layer is expressed in Eq. (1).

$$V_{e,r} = \phi\left(\left[V_{e-1}, V_{e,1}, \ldots V_{e,r-1}\right]\right) \tag{1}$$

In the above expression, the convolution operation is indicated as . The output of bottleneck layer is given as and . The number of final feature maps is reduced by the employed transition layer in the residual densenet. The outcome from the transition layer is provided in Eq. (2).

$$V_{e,Trans} = \eta\left(\left[V_{e-1}, V_{e,1}, \ldots V_{e,r-1} \ldots\ldots, V_{e,r}\right]\right) \tag{2}$$

Here, the convolution operation performed in the transition layer and its output is mentioned as and , respectively. The residual connection in-between the dense blocks and transition layer is useful to enhance the flow of information. Moreover, essential features are retrieved with gradient vanishing issues by the local residual connections. The final outcome attained from the residual connections is given in Eq. (3).

$$V_e = V_{e-1} + V_{e,Trans} \tag{3}$$

Each convolution layer in this network captures rich information from the input medical images.

Long Short Term Memory

LSTM [17] is intended to efficiently simulate and capture long-term dependencies in inputs. This process is accomplished by use of several gating operations. The LSTM is made up of multiple gates including an output gate, input gate, a forget gate, and a memory cell. The information is stored in the cellular structure of LSTM. The activation process done in each component of LSTM is mathematically expressed in the following Eq. (4)-Eq. (8).

$$m_a = \sigma\left(T_m \cdot \left[n_{(a-1)}, d_a\right] + u_m\right) \tag{4}$$

$$w_a = \sigma\left(T_w \cdot \left[n_{(a-1)}, d_a\right] + u_w\right) \tag{5}$$

$$K_a = m_a * K_{(a+1)} + w_a * \tanh\left(T_k \cdot \left[n_{(a-1)}, d_a\right] + u_k\right) \tag{6}$$

$$e_a = \sigma\left(T_e \cdot \left[n_{(a-1)}, d_a\right] + u_a\right) \tag{7}$$

$$n_a = e_a * \tanh\left(K_a\right) \tag{8}$$

Here, the hidden state and output gate is indicated as n_a and e_a, respectively. The input and the previous hidden state is specified as d_a and $n_{(a-1)}$, concurrently. The terms u and T symbolizes the bias and weight. The input gate, cell state and the forget are given as w_a, K_a and m_a.

Developed RDLSTM-aided Cancer Image Classification

The proposed RDLSTM model performs cancer classification by using a combination of Residual DenseNet and LSTM networks. Input medical images are first processed by Residual DenseNet, which captures essential features for cancer type classification while effectively mitigating the gradient vanishing issue. These rich features are then classified by the LSTM, which excels at learning temporal dependencies, aiding in efficient tumor progression monitoring. The dense connections in RDLSTM facilitate feature reuse, reducing the model's parameters and computational load without compromising classification performance. The architecture's resilience to variations in patient characteristics and image quality ensures dependable classification of cervical, lymphoma, and oral cancers. This robust model also mitigates overfitting and demonstrates scalability, handling a wide array of medical images while maintaining high generalization ability. An illustration of the RDLSTM-based classification process is shown in Fig. 3.

Fig. 3.

RESULTS AND DISCUSSIONS

Experimental setup

The cancer classification model analyzing medical images was executed using Python. The ability of the suggested deep learning model in categorizing the different types of cancer was validated by analyzing the final outcomes with state-of-the-art techniques. Here, techniques including DCNN [1], Residual Attention Network (RAN) [16], Residual Densenet [18] and LSTM [17] were considered. Measures including Negative Predictive Value (NPV), precision, Diagnostic Odds Ratio (DOR), False Positive Rate (FPR), Markedness (MK) and False Negative Rate (FNR) were used to ensure the capability of the presented model.

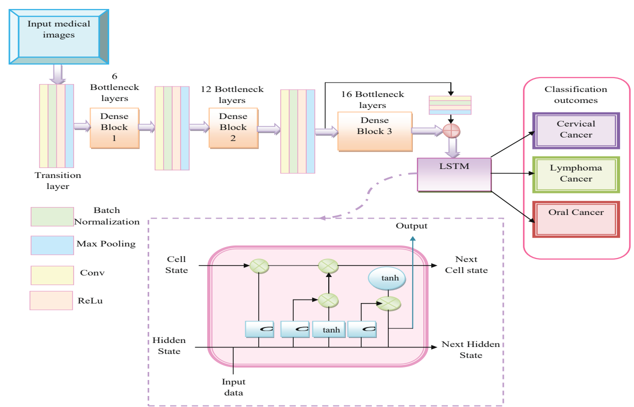

Fig. 4. Illustration of developed RDLSTM-based cancer classification

Performance Analysis of Multi-Cancer Classification Model

The performance analysis of the recommended multi-cancer classification model among state-of-the-art techniques is displayed in Fig. 4. The suggested RDLSTM exhibits a greater DOR for all activation functions, particularly for ReLU and Softmax functions. This suggests that the RDLSTM model is more efficient in performing the classification task because it has a significantly greater ability than the other models to distinguish both positive and negative cancer cases. The consistency of the RDLSTM is better than models including DCNN, RAN, residual densenet and LSTM as it attained high DOR throughout various activation functions. The RDLSTM outperforms other techniques indicating its resistance to variations in input medical images. This demonstrates the effectiveness of adding LSTM to the residual densenet model. This combination of networks has better sequential learning ability, which is helpful in identifying temporal trends in cancer images and it is critical for distinguishing between different cancer types.

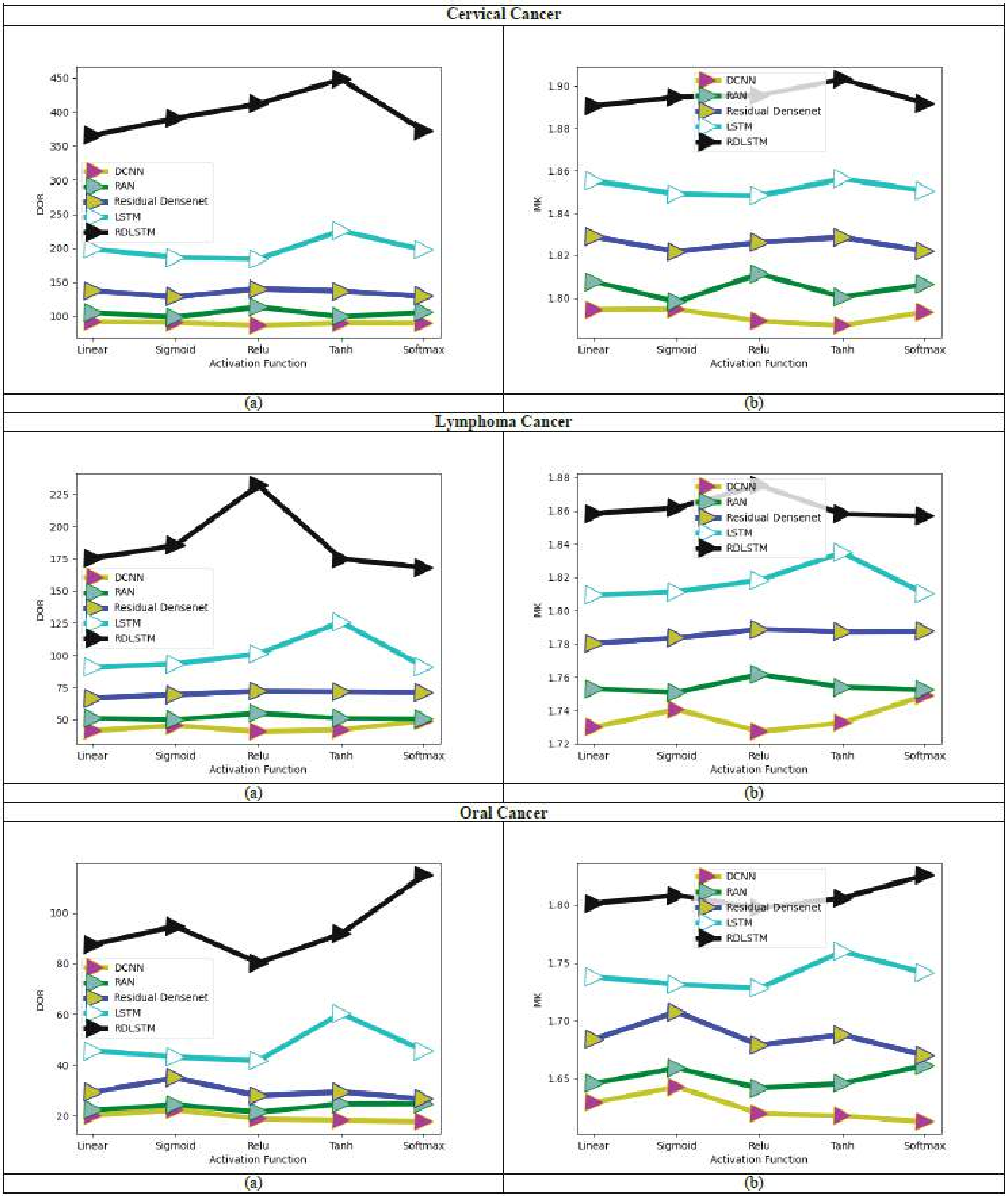

Fig. 5. Performance Analysis of Developed Multi-Cancer classification Model with respect to a) DOR and b) MK

ROC Analysis

The classification performance of RDLSTM is showcased in the graph presented on Fig. 5. RDLSTM performs the best in differentiating various cancers as it attained a high true positive rate and it is confirmed by the ROC results. This demonstrates that the sensitivity and specificity of the classification are increased when Residual densenet and LSTM are combined. RDLSTM consistently outperforms other methods proving its ability in precise categorization. While LSTM performs well, the basic Residual densenet approach slightly lacks in accuracy. But, combining these two techniques rectifies the issues in the basic model and learns more temporal correlations among the features analyzed from medical images. RDLSTM accurately detects a type of cancer without more false positives.

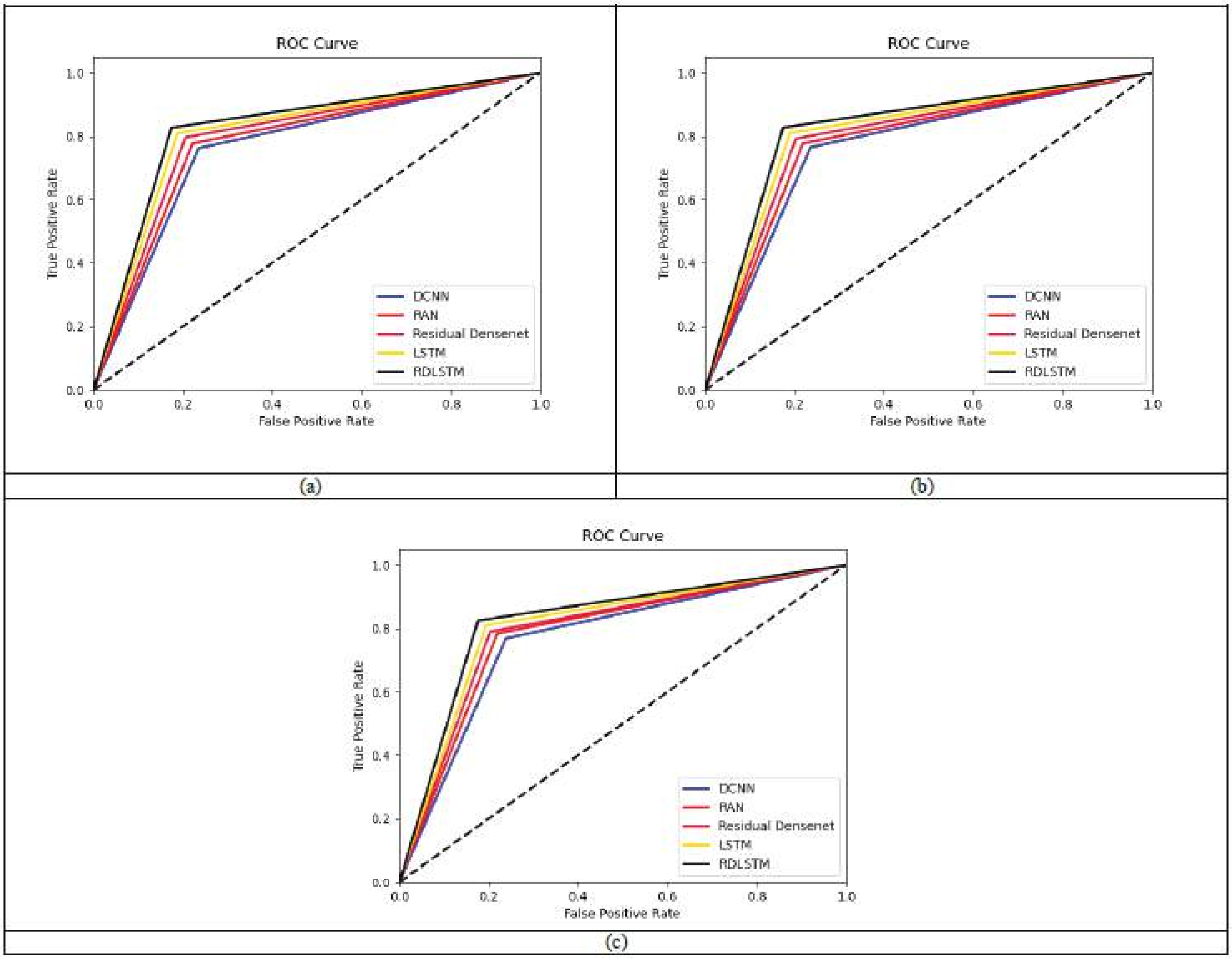

Fig. 6. ROC Analysis of Developed Multi-Cancer Classification Model with respect to a) Cervical Cancer and b) Lymphoma Cancer and c) Oral Cancer

Numerical Analysis of the Suggested Multi-Cancer Classification Model

A numerical analysis of the introduced multi-cancer classification model by varying the hidden neuron count as 250 is given in Table III. With a precision of 92.74%, the RDLSTM outperforms other models in recognizing three different kinds of cancer. This high precision shows that RDLSTM is highly successful at correctly diagnosing cancer cases without falsely recognizing non-cancerous images as cancerous and this is proved by the lowest False Positive Rate (FPR) attained by the RDLSTM. Moreover, the below results demonstrate the improved capacity of the RDLSTM model to distinguish between different cancer types. RDLSTM minimizes FNR, which is crucial for preventing inappropriate treatment methods by falsely categorizing the cancer type The RDLSTM model is more reliable in identifying three different kinds of cancer, which enhances the clinical decision-making process. The robust performance of residual densenet in capturing relevant features from medical images is proved by the high NPV results. It enhances the overall generalization ability of the RDLSTM model.

Table 3. Numerical Analysis of Suggested Multi-Cancer Classification Model

Hidden Neuron Count- 250					
Measures	DCNN [1]	RAN [16]	Residual Densenet [18]	LSTM [17]	RDLSTM
Cervical Cancer					
Precision	85.48571	87.48571	88.74286	91.14286	92.74286
FPR	4.050391	3.473985	3.075722	2.387554	1.926285
FNR	39.65309	37.40801	33.77399	29.36227	24.75661
NPV	85.95714	86.92857	88.68571	90.52857	92.37143
Accuracy	85.86286	87.04	88.69714	90.65143	92.44571
Lymphoma Cancer					
Precision	83.80952	86.09524	89.61905	90.09524	91.61905
FPR	8.677897	7.471853	5.606996	5.234021	4.367246
FNR	26.11251	24.41472	21.97347	18.65864	15.24229
NPV	85.19048	86.09524	87.38095	89.66667	91.7619
Accuracy	84.73016	86.09524	88.12698	89.80952	91.71429
Oral Cancer					
Precision	85.28571	88.14286	89.42857	91.71429	93.71429
FPR	14.77762	11.97691	10.61693	8.381503	6.276748
FNR	15.07824	12.72984	10.95306	9.322034	6.151645
NPV	84.85714	87.14286	89	90.57143	93.85714
Accuracy	85.07143	87.64286	89.21429	91.14286	93.78571

CONCLUSION

In this work, we developed a deep learning assisted mechanism to accurately classify different cancers from input medical images. The collected images from online sources were passed to the suggested RDLSTM for performing the cancer classification. The incorporation of residual densenet minimizes the vanishing gradient issue and enables effective feature representation. This feature representation was essential for identifying complex patterns in medical images that help to distinguish different symptoms related to different cancers. The usage of LSTM in our work was an additional advantage as it was excellent at processing sequential data from the features obtained from residual densenet. The combination of both techniques was highly beneficial in classifying the different types of cancer. At last, the experimental results were conducted on the developed model to prove its effectiveness in the cancer classification process over conventional methods. At a hidden neuron count of 250, the precision of the suggested RDLSTM-assisted cancer type classification was 93.71%, which was higher than DCNN, RAN, Residual Densenet and LSTM as their precision score was 85.28%, 88.14%, 89.42% and 91.71% for recognizing oral cancer. Therefore, our approach has the ability to categorize efficient features in medical images without many false positive outcomes. However, our model does not have the ability to analyze the stage of recognized cancer and this will be rectified in the future. Additionally, optimization, approaches will be included to enhance the classification performance of deep learning techniques.

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Mimetic Interpolative Extreme Deviation-based Canonically Corrected Feature Selection for Effective Child Health Big Data Analytics Based on Food Habits

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ABSTRACT

Big data analytics is a potent tool in child healthcare that helps academics and healthcare professionals make better decisions in large datasets. To address nutritional needs of developing bodies and minds in newborns and early childhood, food diversity is crucial. To achieve effective data analytics on kid health their eating habits, the proposed Mimetic Interpolative Extreme Deviate Pre-processed Canonical Correlated Feature Selection (MIEDPCCFS) Method introduced. First, collects user data from diet-plan-recommendation dataset. Data pre-processing using Extreme Deviate Outlier Detection and Mimetic Interpolation Process is to identify outliers and fill in missing values Next, Canonical Correlation Analysis chooses most important, pertinent features. Comparison of MIEDPCCFS and two methods is conducted for child health big data analytics with important metrics. Performance of MIEDPCCFS consideration variety of foods and their calories and information regarding diet plan recommendations from provided high dimensional datasets.

KEYWORDS: *Big data analytics, Child health, Food habits, Data pre-processing, Feature selection, Mimetic interpolation, Extreme deviate outlier detection, Canonical correlation analysis, Diet plan recommendation.*

INTRODUCTION

Big data analytics is act of unlocking insights including patterns, trends, and other useful information from massive datasets. Food is key factor in determining health. In [1], novel food recommendation system was implemented that combines healthy eating principles. But, precision was not increased. Deep learning method for the health-based medical dataset was implemented in [2] to determine automatically which meal is best for certain patient. However, accuracy was not enhanced.

In [3], novel time-aware food recommender system was developed based on deep learning and graph clustering. In [4], study was conducted by IoT devices and sensors. In [5], study was conducted to investigate how nutrition information. In [6], Market2Dish was implemented to provide health-aware food recommendations. In [7], novel healthy food recommendation system was developed to specific user groups. In [8], evolutionary approach was implemented for dietary recommendations. In [9], AI4Food-NutritionFW framework was implemented. In [10], study was focused on food recommender system. In [11], study was presented for dietary habits of children aged 6 months to 3 years. In [12], study focused on investigation of unhealthy dietary patterns and sociodemographic factors. Study was presented in [13] with ALINFA nutritional intervention. In [14], study was focused to provide overview of child health, nutrition, and food hazards. In [15], study discussed on Integrated Control Plan in Primary Schools But, it might be challenging to ensure adherence to dietary recommendations and food safety laws. Unique big data analysis based ML technique employed in our research to boost accuracy with reduced time complexity.

Goal of the research work

Our objective is to accurately analyse kid health bid data related to eating habits to prescribe diet. Novel ML approaches achieved to perform pre-processing and feature selection.

Contributions of the paper

Contributions made as follows.

MIEDPCCFS is used for achieving big data analytics on child health.

Mimetic Interpolation Extreme Deviate Pre-processing is to obtain pre-processed data by handling missing data values and outlier detection with higher accuracy.

Canonical Correlation Analysed Feature Selection selects relevant features for child health big data with less time.

Compare MIEDPCCFS, existing methods.

Outline of the paper

Study region and observational data are presented in Section 1. Section 2 examines similar works. Section 3 explains specifics of MIEDPCCFS. Results and analysis of experiment are presented in Sections 4 and 5. Conclusion included in Section 6.

RELATED WORKS

Summary of literature review: In larger body of literature, numerous researches used to investigate performance of health big data analysis based on food data using different ML. In [16], study developed ontology-driven personalized food recommendation system. In [17], study's main objective was to build a food recommender system. In [18], patient diet recommendation system was deployed by implementation of K-Clique and DL Classifiers. In [19], study was conducted on Multi-Choice Diet Recommendation Application. In [20], diet recommendation system was implemented with ML. In [21], study was implemented for obesity prevention and healthy habits. In [22], the narrative review was presented for evaluating the risk factors. Study conducted in [23] examined eating and food patterns of migrant Sub-Saharan African mothers. In [24], study investigated the risk factors of stunting, wasting, and underweight among under-five Bangladeshi children. In [25], study concentrated on ML. In [26], IoT-based framework was constructed for personalized health assessment. In [27], study constructed personalized food recommendation system. In [28], study was discussed on ML. In [29], study was analysed unstructured health data of one million Korean citizens using ML. In [30], study was presented on big data analytics. However, large data storage and processing can be costly, for smaller businesses. Our research project stems from conventional work's inability to apply efficient ML techniques for performing pre-processing and feature selection which better results in big data on eating habits to child health.

PROPOSED METHODOLOGY-EFFICIENT CHILD HEALTH BIG DATA ANALYTICS

Study novel and innovative machine learning technique known as proposed MIEDPCCFS method which analyses children's eating behaviours to produce an accurate diet recommendation system. Figure 1 illustrates MIEDPCCFS.

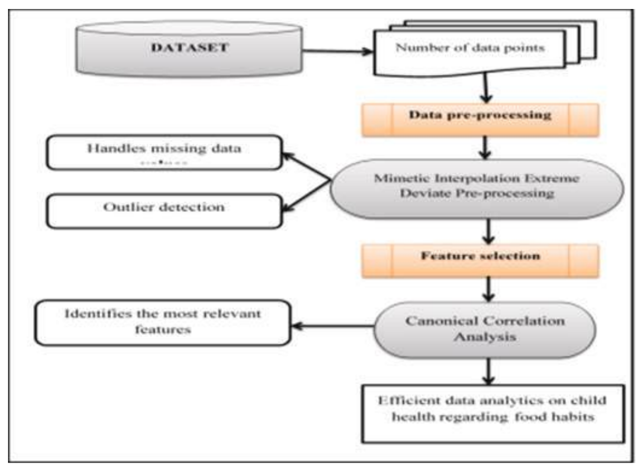

Fig. 1 Architectural diagram of MIEDPCCFS for efficient data analytics on child health

Figure 1 illustrates MIEDPCCFS technique, which include data pre-processing and feature selection.

First Stage of Proposed Work- Data Pre-Processing

Proposed MIEDPCCFS carries out data pre-processing for obtaining pre-processed data by transforming raw data into structured representation. Cleaning is crucial step in pre-processing of data which includes imputing missing values and fixing the outliers. In proposed MIEDPCCFS method, data pre-processing involves two significant processes such as handling of missing data and outlier detection with the aim of enhancing the data quality. Process of importing or removing missing data is crucial to ensure completeness of the data. Outlier detection is crucial in preventing model bias by identifying and handling outliers. Figure 2 illustrates Mimetic Interpolation Extreme Deviate Pre-processing.

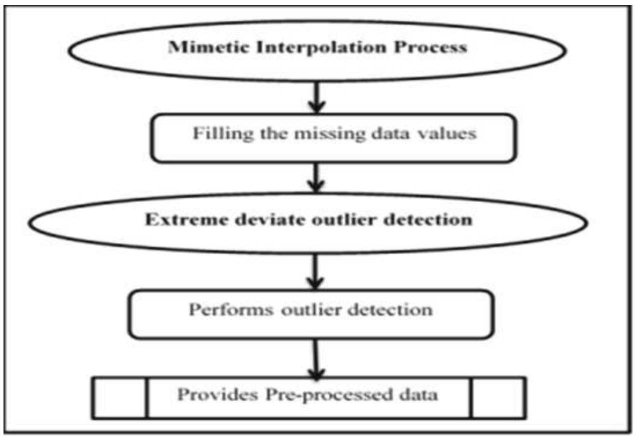

Fig. 2 Overview of Mimetic Interpolation Extreme Deviate Pre-processing

In figure 2, MIEDPCCFS method employs two important approaches such as filling missing values and outlier detection respectively.

Mimetic Interpolation Process- Handling of missing data

Mimetic Interpolation Process is used in numerical simulations to estimate missing data values in dataset while preserving the underlying physical properties of the data. It includes preserving physical properties, ensuring accuracy, and enhancing efficiency for diet-plan-recommendation dataset. It helps to capture relationships between users and food categories. Grid-based representation offers a structured data for organizing, managing the data, and facilitating easier analysis and processing in further.

Consider diet-plan-recommendation dataset which consists of 10725 number of instances that provides details about diet plan recommendation and variety of food, their calories as columns such as age, weight, height, gender, BMI, BMR, activity level, calories to maintain weight, diet label, and dietary intake data (e.g., food item, serving size, calories).From that, the dataset ‘DS’ is comprised with ‘n’10725 number of data that are referred as ‘$d_i = d_1, d_2,..,d_n$’ and ‘m’ 12 number of features denoted as ‘$f_j = f_1, f_2, .., f_m$’. In the beginning, the proposed MIEDPCCFS method takes diet-plan-recommendation dataset ‘DS’ as input for performing the child health big data analysis regarding food habits (dietary intake).The dataset includes both the known values and the locations of the missing values. If the dataset has any missing values, fill them in using the proper imputation procedures. Accordingly, the proposed MIEDPCCFS method applies Mimetic Interpolation Process on this dataset for the purpose of effectively handling the missing data by filling the missing values which leads to ensure consistency with the recommended diet plan. Figure 3 shows Mimetic Interpolation Process.

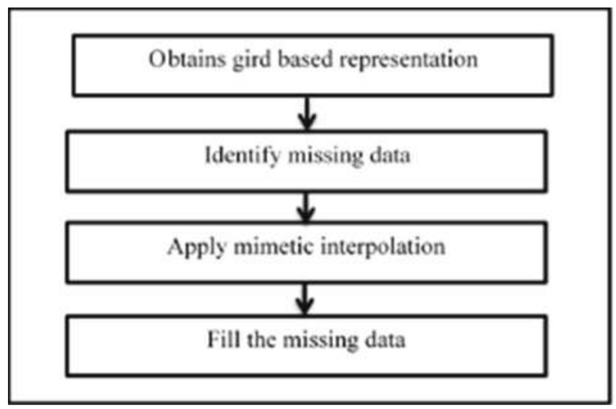

Fig. 3 Mimetic Interpolation Process

Mimetic Interpolation Process obtains gird based representation by representing data as grid in dimensions such as user dimension and dietary dimension. Grid allows for representation of relationships between users and food categories. This is crucial for collaborative filtering algorithms that suggest food items based on preferences of similar users. Here, different users are represented as individual grid cell in the user dimension. Each cell contains information about a specific user, including their age, gender, height, weight, activity level, and other relevant attributes. Besides, different food categories are represented as individual grid cells in the dietary dimension. Each cell contains information about a specific food category, such as its nutritional content, caloric value, and dietary restrictions. This process organizes data is into rows representing users and columns representing food categories. Values in cells indicate user's rating or preference for specific food category. Data (instances) and features determined where data is missing. For each missing value in dataset, Mimetic Interpolation applied.

$$I_{i,j} = \sum_{k \epsilon N(i)} \propto_k \phi_k (I_{k,j}) \tag{1}$$

In (1), '$I_{i,j}$' is missing value for instance (i) and feature (j), 'N(i)' is set of neighbouring instances with known values, '$\propto_k$' is weights assigned to neighbouring instances, and 'ϕ_k' is interpolating functions based on the neighbouring instances. In equation (1), Mimetic Interpolation uses known values from neighbouring data points to estimate missing value. Interpolation process is repeated for each missing value in dataset until all missing values are filled. Let's say there is a missing calorie intake for a particular user. By using Mimetic Interpolation formula and taking into account calorie intake of similar users (neighbours), we estimate this missing value. This process maintains dataset's general structure while guaranteeing that interpolated values are consistent with known values.

Extreme Deviate Outlier Detection- Outlier Detection

Extreme Deviate Outlier Detection is used to identify data points that significantly deviate from expected distribution of a dataset. Figure 4 depicts Extreme deviate outlier detection.

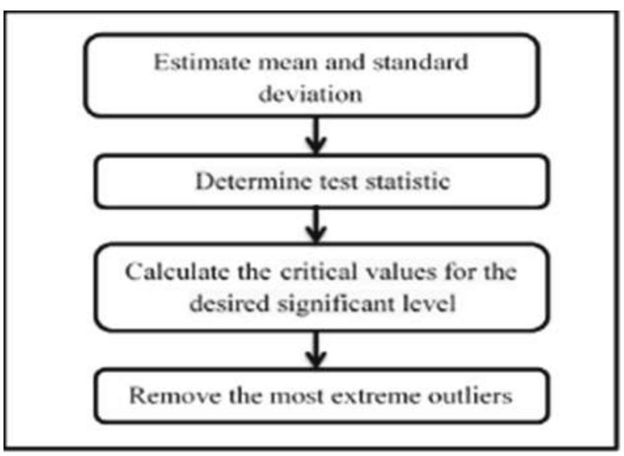

Fig. 4 Extreme Deviate Outlier Detection

At first, Extreme Deviate Outlier Detection estimates mean and standard deviation for each column like age, weight, height, etc. Mean is obtained as given below.

$$\bar{x} = \sum_{i=1}^{n} x_i \tag{2}$$

In (2), '$\bar{x}$' is mean value which is determined as adding all values and dividing by the number of values. Here, '$\sum_{i=1}^{n} x_i$' is sum of all data points, and 'n' is number of data points. Standard deviation estimated as.

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \tag{3}$$

In (3), 'SD' is standard deviation, 'x_i' is value of i^{th} data point, 'n' is number of data points, and '$\sum_{i=1}^{n}(x_i - \bar{x})^2$' is sum of squared differences between each data and the mean. Test statistic for each instance is determined.

$$R_i = \frac{|x_i - \bar{x}|}{SD} \tag{4}$$

Here, 'R_i' is test statistic value. Data point with the maximum test statistic value is identified and is removed. Mean and standard deviation for the remaining data are recomputed. Process is continued for a predefined number of iterations or until no more outliers are detected. Critical value estimation for each iteration obtained as.

$$\lambda_i = \frac{(n-i).t_{p,n-i-1}}{\sqrt{\left(n-i-1+t_{p,n-i-1}^2\right).(n-i+1)}} \tag{5}$$

Here, '$t_{p,n-i-1}$' is 100p percentage point from t-distribution with 'n-i+1' degress of freedom. Test statistic value is compared with critical value to determine the outliers. Largest i for which $R_i > \lambda_i$ is number of outliers. Most extreme outlier is removed and recalculation is carried out until identify all outliers. Mimetic Interpolation Extreme Deviate Pre-processing described as given below algorithm 1.

Procedure: Mimetic Interpolation Extreme Deviate Pre-processing
Input: Dataset 'DS' with 'n' 10725 number of data '$d_i = d_1, d_2, .., d_n$' and 'm' 12 number of features denoted as '$fj = f_1, f_2, .., f_m$'.
Output: Obtains pre-processed data
Step 1:Begin
Step 2:Initialize each sample instances with features

Step 3: Perform Mimetic Interpolation Process
Step 4:Generate the gird based representation
Step 5:Determine the instance and features where the data is missing
Step 5:Applythe Mimetic Interpolation using equation (1) to estimate the missing value
Step 6:Repeat the interpolation method for each one until all of the missing values in the dataset are filled
Step 7:For each column
Step 8:Perform Extreme Deviate Outlier Detection
Step 9:Calculate the mean and standard deviation using equations (2) and (3)
Step 10:Compute the test statistic using equation (4)
Step 11: Determine the critical value using equation (5)
Step 12:Discard the observation with the highest test statistic value
Step 13:Estimate the mean and standard deviation for the remaining data
Step 14:Repeat the process until all outliers are identified
Step 15:Obtain Pre-processed data
End For
Step 16:End

Algorithm 1 Algorithm for Mimetic Interpolation Extreme Deviate Pre-processing

Second Stage of Proposed Work - Feature Selection

Feature selection is carried out for selecting most significant relevant features in proposed MIEDPCCFS from pre-processed dataset. Canonical Correlation Analysis for feature selection with minimized time.

Canonical Correlation Analysis- Selection of Most Relevant Features

Canonical Correlation Analysis is a statistical technique used to identify relationship between two sets of variables by measuring linear combinations of variables in each set that have the maximum correlation with each other. Canonical Correlation Analyzed Feature Selection is employed for identifying the key food habits influencing child health by performing feature selection utilizing pre-processed data. Figure 5 shows essential steps in the Canonical Correlation Analyzed Feature Selection for obtaining effective big data analysis.

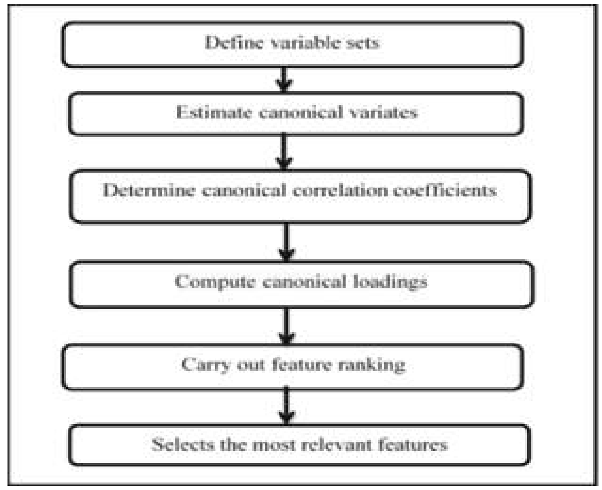

Fig. 5 Essential steps in the Canonical Correlation Analysed Feature Selection

At first, Canonical Correlation Analysed Feature Selection defines variable sets for diet-plan-recommendation dataset. Set 1 (Predictor Variables) includes variables related to diet and food habits, such as dietary intake data, food items, serving size, and calories. The Set 2 includes response variables related to child health, including age, weight, height, BMI, BMR, activity level, and calories to maintain weight. Secondly, the canonical variates for each set of variables are determined. These are linear combinations of original variables that maximize correlation between two sets (health indicators and food habits). Canonical variates for first set of variables (predictors) are expressed as.

$$U = a_1X_1 + a_2X_2 + \cdots + a_pX_p \tag{6}$$

For obtaining canonical variates for second set of variables (responses) is obtained as.

$$V = b_1Y_1 + b_2Y_2 + \cdots + b_qY_q \tag{7}$$

Canonical correlation coefficients estimated for measuring strength of relationship between canonical variates of two sets. Canonical correlation coefficients 'ρ' determined to identify relationships between diet and health variables.

$$\rho = \frac{Cov\,(U,V)}{\sqrt{Var\,(U).Var(V)}} \tag{8}$$

After, correlations between the original variables and canonical variates. It interpreting connections between original variables and canonical variables, providing valuable insights into which variables significantly influence canonical correlations. For first set of variables (predictors), canonical loading is estimated.

$$\text{Canonical Loading } X_i = \text{Corr } X_i, U) \quad (9)$$

For second set of variables (responses), canonical loading is estimated as follows.

$$\text{Canonical Loading}_{Y_i} = \text{Corr}_{Y_i}, V) \quad (10)$$

Feature ranking is carried out for ranking food habit variables depending on their canonical loadings. Variable's contribution to canonical correlation coefficients is more significant when loading is higher. Variables are sorted in descending order based on their absolute canonical loadings. It selects top-ranked food habit variables. Selected features have highest canonical loadings, indicating a strong correlation with health-related variables. Canonical Correlation Analysed Feature Selection described in below algorithm 2.

Procedure: Canonical Correlation Analyzed Feature Selection
Input: Number of pre-processed data
Output: Efficient child health big data analysis based on food habits
Step 1:Begin
Step 2:For each pre-processed data
Step 3: Carry out Canonical Correlation Analysis
Step 4:Define variables sets related to diet, food habits and to child health
Step 5: Compute canonical variates for first set of variables (predictors) using equation (6)
Step 5:Computecanonical variates for second set of variables (responses) using equation (7)
Step 6:Determine the canonical correlation coefficients using equation (8)
Step 7:Estimatecanonical loading for first set of variables (predictors) using equation (9)
Step 8:Estimatecanonical loading for first set of variables (responses) using equation (10)
Step 9:Carry out feature ranking to rank the food habit variables depending on their canonical loadings
Step 10:Selects the top-ranked food habit variables as the most relevant predictors of child health
Step 11: End For
Step 12:End

EXPERIMENTAL SETUP

Performance of proposed MIEDPCCFS method is implemented by python language in diet-plan-recommendation dataset with three different metrics . For simulation setup, user data i.e., sample instances are considered as ranging between 1000 and 10000.

Dataset Description

Diet-plan-recommendation dataset is taken from the https://www.kaggle.com/code/kishoreharshankumar/diet-plan-recommendation/input. This dataset designed to offer personalized diet recommendations based on provided information. It involves diet-plan-recommendation predicts diet plan based on calories to maintain weight and variety of food, their calories based on serving. I have 11 columns such as unnamed column (S.no), age, weight (kg), height(m), gender, Body Mass Index (BMI), Basal Metabolic Rate (BMR), activity level, calories to maintain weight, BMI tags, and label. The number of instances ranges from 1 to 10725. BMI is calculated from height and weight. BMR is rate at which body burns energy at rest. Activity level is metric that indicates an individual's level of physical activity such as sedentary, moderately active, and very active. Daily calorie intake required to maintain one's current weight is known as the calories needed. BMI tags are categorical labels used to categorize individuals into different weight categories, such as underweight, normal, overweight, or obese. Label in this column may indicate the final diet recommendation or the type of suitable diet plan for the individual. Food and their calories have 3 columns such as food, serving, and calories. The food items in data set include soup, ice cream, pizza, fruits, vegetables, and so on. The serving is the measurement of quantity. The calories are computed based on the serving size of each item. This data aids in calculating total calorie intake of individuals based on their dietary choices. We aim to create a diet chart based on the calories in the dataset. Data in these 2 types of columns of dataset used to personalized diet plans for individual based on an individual's age, weight, height, gender, and activity level with the calorie goals. It used to identify most significant factors influencing diet recommendations, such as age, BMI, and activity level and to evaluate the effectiveness of various diet plans in achieving weight loss or other health objectives.

RESULTS AND DISCUSSION

To analyse performance of proposed MIEDPCCFS, it is compared with existing methods [1], and [2] based on certain metrics.

Case scenario: Accuracy

It is defined as proportion of correctly classified instances.

$$Acc = \frac{Number\ of\ correctly\ classified\ instances}{Total\ number\ of\ instances} * 100 \quad (11)$$

Accuracy 'Acc'is determined in term of percentage (%) by equation (11).

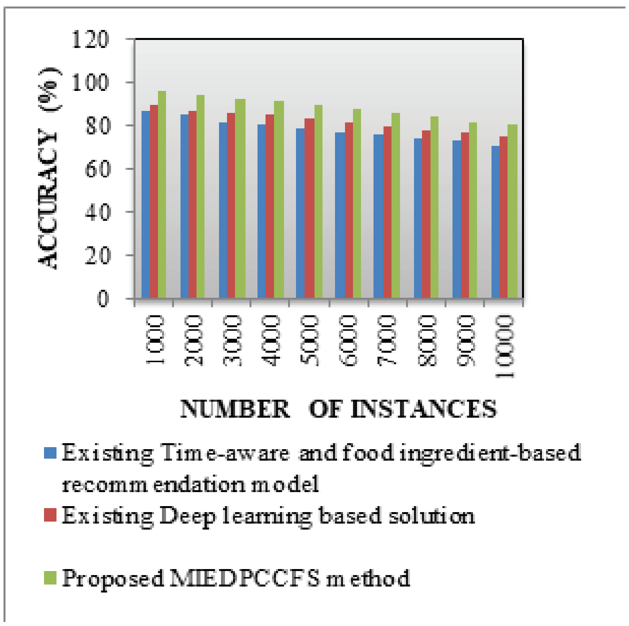

Fig. 6 Graphical illustration of accuracy

Figure 6 describe comparative analysis of accuracy. Accuracy in MIEDPCCFS method is improved up to 13% and 8% over [1] and [2].

Impact on time complexity (TC)

It defined as time required to big data analysis related to child health.

TC=n*time (identify the single unhealthy or healthy user) (12)

In (12), n' is total number of sample instances. 'TC' is estimated in milliseconds (ms).

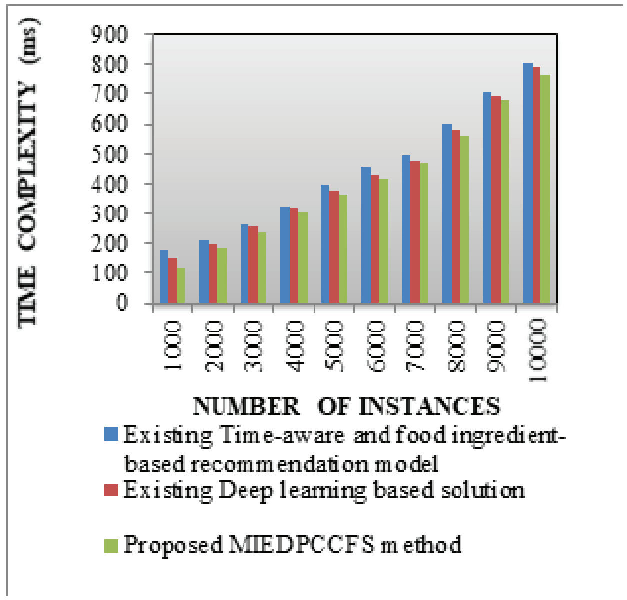

Fig. 7 Graphical illustration of time complexity using diet-plan-recommendation dataset

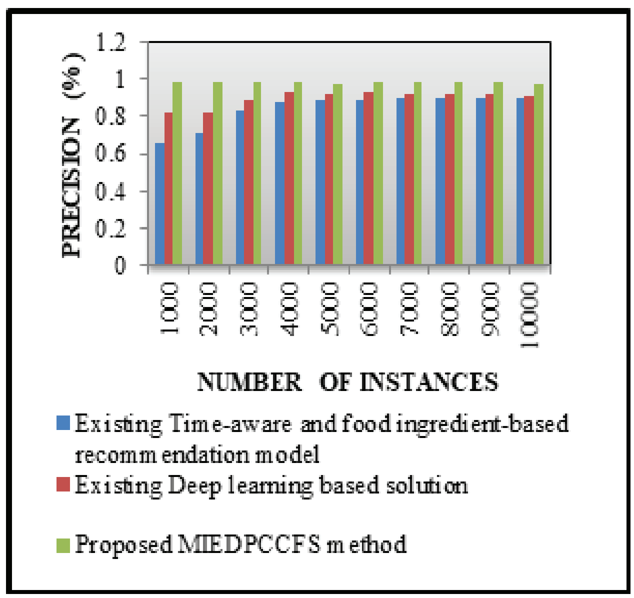

Fig. 8 Graphical illustration of precision using diet-plan-recommendation dataset

Figure 7 provide time complexity. TC of MIEDPCCFS method is minimized by 10% and 5% than [1] and [2].

Performance analysis of precision

It defined as ratio of true positives to total of true positives (TP) with false positives (FP).

$$P = \frac{TP}{TP+FP} \tag{13}$$

Precision shown in above figure 8. Precision of MIEDPCCFS method enhanced up to 17% and 9% over [1] and [2].

CONCLUSION

Robust and efficient method is developed for child health data. Mimetic Interpolation Process and Extreme Deviate Outlier Detection used for pre-processed data. Canonical Correlation Analysed Feature Selection applied for identifying relevant features. Experiment is carried out by MIEDPCCFS and two existing methods with different metrics. Result of MIEDPCCFS is superior for big data analysis related to child health with maximum accuracy and low time than other two existing methods.

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Unveiling Stock Market Trends: A Survey of Machine Learning-Based Predictive Strategies

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ABSTRACT

Stock market trend forecasting is vital for both research and practical applications, with machine learning algorithms playing a key role in improving prediction accuracy. This survey paper comprehensively reviews various machine learning approaches for stock prediction, examining foundational techniques like support vector machines, decision trees, and linear regression, alongside advanced methods, including ensemble models and deep learning architectures such as recurrent neural networks (RNNs) and long short-term memory (LSTM) networks. It focuses on evaluating the efficiency, accuracy, and suitability of these algorithms for stock price forecasting and pattern recognition. The paper also discusses critical elements of stock prediction models, including data preprocessing, feature engineering, and standard evaluation metrics, which are essential for enhancing model performance. By providing an integrated overview of these techniques, this survey aims to help researchers, professionals, and investors understand the dynamic field of stock prediction through machine learning, guiding them in interpreting market movements and making strategic investment decisions. In addition, it addresses existing challenges, recent advancements, and potential opportunities, encouraging further innovation in stock prediction.

KEYWORDS: *Long Short-Term Memory (LSTM), Recur rent Neural Networks (RNNs), Convolutional neural networks bi-directional long short-term memory and attention mechanism (CNN-BiLSTM-AM), Gated Recurrent Unit (GRU), Auto Regressive-Moving Average(ARMA)*

INTRODUCTION

Predicting stock market behavior has become a focal point, driving extensive research into leveraging machine learning algorithms to refine forecast accuracy and aid decision making. This comprehensive survey paper systematically investigates the landscape of stock prediction using various machine-learning methodologies. Financial markets' intricate and ever-changing nature presents a unique challenge for precise prediction, and machine learning offers a promising avenue to address this complexity. The objective of this paper is to illuminate the progress, prevailing trends, challenges, and potential prospects that emerge from deploying diverse ma chine learning algorithms in the domain of stock prediction. Basic machine learning techniques are the foundation of stock prediction models. The fundamental framework is comprised of widely-used techniques including k-nearest neighbors, decision trees, and linear regression.

Fig. 1. Machine learning techniques

Even though the future is unpredictable and unknowable, it is possible to predict future occurrences and make risk-free profits from them. One approach is to forecast the stock market using machine learning (ML) and artificial intelligence (AI) [1]. Relying on AI for forecasting before making investment decisions is both logical and achievable, even with the stock market's unpredictable nature.

Recently, these techniques have attracted significant attention and shown encouraging results in stock analysis. Recent progress in stock prediction techniques falls into four primary categories: statistical methods, machine learning (ML), pattern recognition, and sentiment analysis. Moreover, the integration of multiple approaches has given rise to hybrid techniques that further boost predictive accuracy. Prior to the advent of effective ML algorithms, statistical methods—based on assumptions of data stationarity, normality, and linearity—were the primary tools for stock forecasting. ”Time series” is a frequently discussed concept in stock analysis, referring to a structured set of data points related to daily metrics such as sales, stock prices, and investor numbers[2] Statistical approaches in stock prediction often focus on univariate data, leveraging models like auto-regressive integrated moving average, auto regressive moving average, smooth transition autoregressive, and generalized autoregressive conditional heteroskedasticity [3]. The ARMA model, for instance, combines Auto-Regressive (AR) components, which model momentum and regression effects in trading, with Moving Average components to capture sudden shocks. However, due to its limitations in handling high volatility in financial data, ARMA is not always ideal. The ARIMA model, an extension of ARMA, transforms non-stationary data into stationary data,

making it useful for forecasting new data points based on historical patterns [4]. Some multivariate statistical methods, like Quadratic Discriminant Analysis (QDA), Linear Discriminant Analysis (LDA), and various regression techniques, use multiple variables to improve prediction accuracy.

Pattern recognition, although similar to ML, applies distinct methods to stock prediction by focusing on data trends and patterns, particularly those seen in Open-High-Low-Close candlestick charts. This technique, often used by experienced traders, relies on visual analysis of chart patterns like spikes, pennants, flags, gaps, and head-and-shoulders formations to predict future price movements[5]. Pattern recognition can be divided into Perceptually Important Points (PIP), which reduce data dimensions by emphasizing key points, and template matching, where stock trends are compared with reference images for object identification.

With advancements in ML, this technique has become a powerful tool for analyzing trends and patterns in financial markets. ML can be categorized into supervised and unsupervised learning. Supervised learning uses labeled datasets to train models, which can then match new data to known out comes, while unsupervised learning identifies correlations and patterns within unlabeled data. This latter approach can often serve as a precursor to supervised learning tasks[6]. Although simpler ML algorithms were initially used for stock prediction, they have largely been supplanted by more robust methods like neural networks, logistic regression, and random forests[7], Deep learning (DL), a subset of ML, is particularly suitable for handling complex, data-rich, and non-linear characteristics, making it highly effective for time series data[8].

Sentiment analysis, another category in stock prediction taxonomy, has gained traction recently. This approach predicts trends by automatically analyzing text data from sources like tweets and news articles related to stock markets and companies. Sentiment analysis can be further divided into lexicon-based methods and ML-based methods. Finally, hybrid techniques combine multiple approaches, such as integrating pattern recognition with statistical methods, to enhance predic tive accuracy by leveraging the strengths of different methods.

The survey delves into how these algorithms analyze his torical stock data to identify patterns, trends, and relationships that can be harnessed for predicting future prices. Furthermore, ensemble methods like random forests and gradient boosting are explored, highlighting their effectiveness in amalgamating multiple models for heightened predictive precision. Grasping the strengths and limitations of these fundamental algorithms is pivotal in crafting potent prediction models for understanding stock market dynamics. In recent years, advanced machine learning techniques have garnered immense interest in the field of stock prediction. Deep learning, a subset of machine learning, has displayed remarkable potential in modeling intricate patterns within stock data. Techniques such as recurrent neural networks [9] and long short-term memory networks, specifically tailored for sequential data, are scrutinized in this survey. Their proficiency in capturing temporal dependencies and long-term patterns in stock data positions them as invaluable tools for predicting market trends. Through an analysis of the use and effectiveness of these cutting-edge techniques, the survey provides valuable insights into the rapidly changing field of stock prediction, opening the door for further investigation and useful applications. In the development of accurate stock prediction models, data preprocessing and feature engineering play pivotal roles. This survey presents an overview of prevalent preprocessing techniques such as normalization, scaling, and handling missing data, underscoring their significance in ensuring data quality and model performance. Feature engineering, encompassing the selection and extraction of pertinent features from the data, is comprehensively discussed. The survey also examines a number of assessment measures that are used to evaluate stock prediction models' performance, providing insights into how researchers gauge the accuracy and efficacy of their models. Through this all-encompassing exploration, the survey aims to steer researchers, professionals, and investors in leveraging machine learning algorithms to navigate the intricacies of stock prediction, ultimately contributing to the growth and efficiency of financial markets.

LITERATURE REVIEW

According to Warda M. Shaban, Eman Ashraf and Ahmed Elsaid Slama [10], In this paper, a novel DL-based approach for stock market closing price prediction is put forward. Additionally, the smart trading platform (STP) application was created in this article and is available for usage on any mobile device. In actuality, STP aims to open up stock market investing to all. Anyone can trade various financial instruments, including bonds, stocks, futures, options, commodities, and currencies, through STP. This study introduces a novel deep learning-based approach for predicting the stock market's closing price. Furthermore, we showcase the effectiveness of a hybrid model that integrates BiGRU and LSTM to improve the accuracy of stock market closing price predictions. The experiment's findings demonstrated that the BiGRU-LSTM hybrid model outperformed two of the most well-liked and trustworthy time series analyzers: GRU and LSTM , in terms of forecasting the stock market's closing price. Based on the DL model, the recommended application offers the following main advantages: The three advantages are rapid access to market data, cost-effectiveness, and real-time trading.

According to Dr Somanchi Hari Krishna ,Dr. Shariq Mohammed, Dr. Pralhad K. Mudalkar , Narinder Verma, P. Karthikeyan ,and Dr. Ajay Singh Yadav [11],They Do Research Machine learning is considerably different from random selection, which only has a 90 percentage chance of producing accurate results. Despite having less access to test data, LSTM performs better. This remains true; there's a chance that accuracy will increase with time if Bi-LSTM is employed. Even though the precise price points from the predicted price weren't always close to the true price, the recommended LSTM model was able to identify general trends like rising or declining when characteristics were identified using only graphical data.

In a study by Pulluri Anudeep,Shubhodh Amaravadi, Yeramalla Uttam, and K. Nagendra , they introduced a predictive model aimed at forecasting future stock market values using recurrent neural networks , specifically leveraging the power of Long-Short Term Memory . The central objective of their research was to ascertain the accuracy of a machine learning algorithm in predicting stock market trends and to explore how adjusting epochs can improve the model's performance. To represent stock prices as a time series, they employed historical data and trained neural networks to discern patterns and trends within this data. Their approach prioritized the LSTM algorithm to enhance the precision of stock price predictions. The LSTM model is designed to handle scenarios where the underlying process is not fully understood, making it a valuable algorithmic tool for analyzing time series data.

In their research,S. Krishna Kiran, Mrs. Prasanna Pabba, S. Sarthan Reddy, I. Sai Prakash, and S. V. Sai Srikar[12] aimed to enhance investment decision-making by predicting stock prices more accurately. They introduced a stock price prediction system that seamlessly combines mathematical functions, machine learning techniques, and external factors to achieve heightened accuracy in predicting stock prices, ultimately enabling profitable trades. Their effort aimed to demonstrate the benefits of incorporating this strategy into stock market analysis by utilising machine learning's potential to estimate stock values. The researchers hope that this integration would provide investors with more information to help them make wise investment decisions and maximise their trading tactics.

Ch. Kundan Kanth, B N Varaprasad, G.Jeevan and Y. Kalyan Chakravarti[13], They Stuy A deep leaning-based stock market price prediction system was presented in this research. This article proposes the Long Short Term Memory network and com pares its algorithmic performance to machine learning models. The benchmark dataset obtained from the NSE website is used to test these models. AdaniPort Stock and BPCL are the two stocks we used to test the suggested methodology. The suggested approach has demonstrated strong performance, which contributes to the promising outcomes. Regression analysis and LSTM both produce positive outcomes and boost accuracy.

Utilising recently developed machine learning algorithms to predict stock performance has produced encouraging results, indicating its potential application in profitable give-and-take programmes. It is noted that the highest level of accuracy is achieved through the use of machine learning models. The models must be used on datasets with higher dimensionality in the future, and their correctness and speed must be verified.

Gabriel Nyame, Ernest Kwame Ampomah, Zhiguang Qin, and Prince Clement Addo [14] They study to evaluate how well the Gaussian Naive Bayes (GNB) algorithm predicted the direction of stock price movement using a variety of feature extraction and feature scaling techniques. Diverse stock data from multiple markets were gathered and analyzed in this study. The study assessed the performance of GNB models using standardisation scaling, Min-Max scaling, and other feature scaling strategies in conjunction with a range of feature extraction methods, including PCA, LDA, and FA. AUC, specificity, accuracy, and F1-Score were among the evaluation criteria used to gauge how well these GNB mod els worked. The results showed that the GNB method, when combined with both feature extraction and feature scaling strategies, yielded superior results than either strategy alone, with the exception of GNBLDA. More specifically, the model that integrated the GNB approach with Linear Discriminant Analysis (GNBLDA) performed better in terms of three out of the four evaluation criteria: accuracy, F1-score, and AUC. Furthermore, based on specificity results, the predictive model utilising the GNB algorithm, Min-Max scaling, and PCA took first place. The study specifically noted that GNB outperformed standardisation scaling approaches while using the Min-Max scaling technique.

In this study they noted [15] that LSTM (Long Short-Term Memory) and RNN (Recurrent Neural Networks) libraries prove highly effective in accurately determining stock price trends compared to actual market trends. They found that while these libraries were powerful, the Python libraries used during the training process had room for optimization in terms of speed. In terms of training speed, they observed that mathematical principle-based functions were significantly faster, incorporating more intricate designs and displaying notable improvements in various testing scenarios.

On the other hand, the Python library functions were viewed as more adaptable. Their research revealed that certain stock trends could be predicted based on fundamental rules and regulations governing the stock market. This understanding underpins the existence and significance of private placement institutes. However, they emphasized that there is consider able room for improvement, particularly in optimizing neural network parameters and refining the training process.

In the study by K. Srinivas, Polamuri Subba Rao, and A. Krishna Mohan [16], A review and comparison of various stock market prediction parameter strategies are presented in this research. These methods are employed to assess trends and performance in the stock market. The accuracy of the stock market forecasting method will rise. We will integrate two or more approaches to create a novel approach technique in this study to analyse a novel approach to improve the fore cast of the stock results. The researchers explored innovative approaches to augment prediction accuracy by integrating two or more existing methods. This involved combining different approaches to create a novel method, aiming to enhance the precision and reliability of predicting stock market outcomes.

Jinan Zou and Qingying Zhao[17], They provide a thorough analysis of the most well-known research on applying deep learning to stock market prediction in this paper. They provide a classification scheme for classifying and combining related works in order to facilitate comprehension and arrangement of earlier research in this field. They also give a summary of the key techniques, assessment criteria, and datasets that are currently being employed in stock market prediction. They also discuss unanswered issues and suggest interesting avenues for further machine learning research in stock market forecasting. Our goal in conducting this survey is to give readers a comprehensive picture of how deep learning is used in stock market prediction.

Shivprasad Dhule, Himanshu Dhas, Pratik Chavhan, Dr. R.C. Jaiswal [18].According to them the stock market is all about measured risk; it's not about gambling. Thus, they began studying market behaviour, market theories like as Fibonacci and Gann theory, and the fundamentals of Technical Analysis as it applies to API. We will use datasheets and historical data to create products meant for experts and retailers. In addition to expert tactics, we examine index and stock markets using algorithms. We have found Basic Analytics, much like we did with Passive Investor, and we are utilising it in our API right now.

Satoshi Sekioka, Ryo Hatano, Hiroyuki Nishiyama [19], They Utilize a contemporary machine learning methodology, our study focused on forecasting abrupt fluctuations in the closing price of virtual currencies. To achieve this, we harnessed features derived from natural language content found in social media. Sentence-BERT was used to process natural language expressions on social media platforms in order to create sentence embeddings from tweets.

In our analysis, the free version of the Twitter API was used, which allowed access to data from only the prior seven days. This limitation meant that our datasets covered only a short time frame, and we couldn't adjust the dataset's vocabulary during that period. As a result, our training and predictions could only be validated on a localized dataset. When working with a dataset covering a longer period, it becomes essential to examine if similar patterns emerge. Therefore, carefully selecting the terms to extract from Twitter is critical. Additionally, in real-world applications, a more advanced trainer or multiple trainers with feature engineering capabilities could be utilized, and the time bar's unit size could be expanded for more robust analysis.

In this paper [20] they study aimed to develop machine learning (ML) models with improved stock price prediction accuracy. By making the proper kind of investment at the right moment, traders and investors would be able to enhance their earnings by utilising these tactics. This project successfully applied five algorithms—Linear Regression, K Nearest Neighbors, Decision Tree Regression, Support Vector Regression, and Long Short-Term Memory—to develop highly accurate predictive models for forecasting the stock prices of twelve major Indian companies. Following this, data from Asian Paints, Adani Ports, Axis Bank, Industrial Credit and Investment Corporation of India (ICICI) Bank, Housing Development Finance Corporation Limited (HDFC) Bank, Hindustan Unilever Limited, Kotak Bank, Maruti, Tata Steel, National Thermal Power Corporation (NTPC), Titan, and Tata Consultancy Services (TCS) were utilized to comprehensively evaluate the performance of these algorithms in predicting stock prices.

Following a comprehensive research, it is shown that DL algorithms perform noticeably better in time series data pre diction than simple ML algorithms. Stock prices were gathered between 2015 and 2021. Of the five algorithms that were chosen, the Long Short-Term Memory method was a DL algorithm that yielded the greatest results when it came to stock price prediction.

Majid Bashir Malik, Nusrat Rouf, Tasleem Arif, Sparsh Sharma, Saurabh Singh , Satyabrata Aich and Hee-Cheol Kim [21], According to them SMP is carried out utilising deep learning, big data analytics, and machine learning as opposed to traditional frameworks, which allow for more optimal decision-making. These days, social media attitudes and cyber attacks can affect stock prices. By creating the frameworks for safer and better trading, researchers can excel in these fields and play a major role. Following an in-depth comparative examination, it was determined that Support Vector Machines (SVM) emerge as the predominant method employed for Stock Market Prediction (SMP). Nevertheless, alternative approaches such as Deep neural networks and artificial neural networks (ANN and DNN) are becoming more popular because they can make predictions faster and with more accuracy.

Sakshi Pathak and Ashwini Pathak [22], The dataset under went data preprocessing and feature selection as part of the methodology. Four distinct algorithms—KNN, SVM, Random Forest, and Logistic Regression—were subsequently employed for analysis. The evaluation of algorithmic performance in volved the computation of various metrics such as accuracy, recall, precision, and f-score. The findings of the study suggest that Random Forest stands out as the most effective algorithm among the four, achieving an impressive accuracy rate of 80.7%.

In such a paper [23] study they presents a novel ensemble based approach to efficient stock trading by combining two popular machine learning techniques—deep learning and deep reinforcement learning—within a three-layer framework. This approach uses multiple ensemble stages to develop an effective intra-day trading strategy. Initially, a reinforcement metalearner classifier is provided with predictions from several CNN models trained on historical market data, which has been converted into GAF images. Subsequently, the outcomes from various iterations of the metalearner's training are aggregated to formulate the final trading decisions.

Our results show that: (i) the metalearner enhances trading performance and mitigates overfitting by initially exploring and selecting the most promising training parameters; (ii) our approach outperformed the market during both the 2018 crisis and the strong trend period in 2019, achieving a final return that was 28.78 percent higher than high-performing non-RL ensemble baselines; and (iii) the top results were achieved with this method.

This paper [24] offers a framework for predicting stock market trends by incorporating external factors such as news and social media. We analyzed the influence of these sources on forecasting stock performance up to 10 days ahead. Our results show that social media has a stronger impact on stock predictions on day nine when sentiment attributes are considered, whereas financial news affects predictions most on day nine, followed by day eight. Additionally, We found that the overall accuracy of most classifiers increased after the third day. However, integrating sentiment from both social media and financial news resulted in the least accurate predictions. Additionally, we examined the prediction algorithms employed and explored various features of the dataset.

We specifically examined how feature selection and filtering out spam tweets influenced the predictive accuracy of algorithms, finding that these two factors significantly improved most classifiers' performance. Through comprehensive analysis of each classifier, we identified that the Random Forest (RF) algorithm consistently delivered reliable results across all conditions, making it the preferred choice for predicting market trends.

Additionally, the behavior of selected stocks was analyzed using various methods. It was observed that NYSE and RHT stocks posed a greater challenge to predict due to their heightened volatility, while stocks like IBM, MSFT, and HPQ also displayed considerable unpredictability. The influence of news and social media on different stocks was further explored, revealing that news has a stronger impact on LSE and MSFT stocks, whereas NYSE, IBM, and TWTR are more affected by social media, with TWTR in particular showing susceptibility to both sources. The accuracy of neural networks in stock prediction improved with the application of deep learning techniques. Finally, the ensemble approach, which combines predictions from multiple classifiers through voting, led to an overall increase in prediction accuracy for individual classifiers.

In this paper[25]the experimental findings highlight the exceptional predictive performance of the ARIMA-LSSVM model, showcasing its ability to deliver high accuracy and minimal error rates across various datasets, including those related to motherboards, small and medium boards, and GEM data. These results clearly establish the ARIMA-LSSVM model's superiority over both RS-SVM and LS-SVM mod els in terms of prediction accuracy. This demonstrates the model's importance and represents a notable improvement in the predictive capabilities of existing approaches. Given the stock market's complex and nonlinear nature—driven by fundamental principles and significantly impacted by external factors such as trader behavior, political events, and macroeco nomic conditions—the ARIMA-LSSVM model proves to be a valuable tool in navigating such challenges.

This study employs the ARIMA-LSSVM hybrid model to predict upward and downward trends in the domestic stock market. To streamline the training process and enhance predictive accuracy, Principal Component Analysis is used to reduce the dimensionality of the input variables. The simulation results reveal that the model excels in short-term stock price forecasting. Its application in stock market predictions high lights its practical value and potential for further refinement. However, additional research is required to identify opportunities for optimizing the SVM kernel function parameters, which could further enhance the model's performance.

The ARIMA-LS-SVM model proves to be highly applicable to a range of stocks and stock indices in the financial market, offering significant marketing potential. To further assess the model's sensitivity and stability, various factors such as the stock, holding duration, and time period were substituted. The results indicate that the model's predictive performance remains consistently stable. Several insights were drawn from the stability analysis: 1) A larger training dataset results in better model fitting, higher prediction accuracy, and lower prediction error; 2) High-frequency data has a greater predictive effect compared to low-frequency daily data, providing more precise predictions. Therefore, when developing the model, it is important to use high-frequency data and ensure the training set is as comprehensive as possible to enhance model fitting and achieve higher prediction accuracy.

Jiazheng Li, Wenjie Lu, Jingyang Wang, Lele Qin [26], This study suggests that the CNN-BiLSTM-AM model can be effectively used to forecast the next day's stock closing prices. This method integrates multiple factors, including volume, turnover, opening price, highest price, lowest price, closing price, stock price fluctuations, and turnover volume, making effective use of the time-series nature of the stock data.

Convolutional Neural Networks are used to identify key features from the input data, while Bidirectional Long Short Term Memory models are employed to learn and predict using these extracted features. Attention Mechanisms are applied to highlight the impact of feature states at various time intervals within the time-series data, improving the accuracy of the predictions.

According to the experimental findings, Regarding prediction accuracy and performance, CNN-BiLSTM-AM performs better than MLP, RNN, CNN, LSTM, BiLSTM, CNN-LSTM, CNN-BiLSTM, and BiLSTM-AM. The MAE and RMSE of CNN-BiLSTM-AM are the lowest of all the approaches, while R2 is the closest to 1. It is difficult to attain high prediction accuracy with a single network; however, prediction accuracy can be raised by increasing network complexity. CNN-BiLSTM-AM is an effective stock price forecasting tool that may provide investors with relevant advice on how to maximise investment results. Furthermore, the CNN-BiLSTM AM proposal provides practical experience to those who are studying financial time series data.

K. Vijayakumar and M. Ananthi [27], They have employed k-NN regression in this work to forecast market trends. By analyzing the stock values of different companies, a set of technical indicators is predicted, showing a significant improvement in accuracy compared to other machine learning methods. Moving forward, comprehensive sentiment analysis will be integrated to further enhance market trend prediction results. The potential for predicting market trends is substantial, and in the future, trend analysis within specific industries can be explored. Additionally, machine learning could be used to forecast a company's revenue and performance, offering considerable benefits for a wide range of industries.

Jingyi Shen and M. Omair Shafiq [28] , They presented the three parts of their work: feature engineering, preprocessing and data extraction from the Chinese stock market dataset, and a long short-term memory (LSTM)-based stock price trend

prediction model. We collected, cleaned, and arranged data from the Chinese stock market spanning two years. We looked at several methods that actual investors frequently employ, created a new algorithmic component we called feature ex tension, and it has been shown to work. In order to create an efficient and successful feature engineering process, we used the feature expansion (FE) techniques in conjunction with recursive feature elimination (RFE) and principal component analysis (PCA). By combining the feature engineering process with an LSTM prediction model, the system is customised and achieves high prediction accuracy, surpassing the top models in the majority of related works. We also conducted a thorough assessment of this work. In the feature engineering section of our proposed system, we compare the most popular machine learning models with our suggested LSTM model and draw some heuristic conclusions that may be future research topics in the financial and technical research areas.

Unlike previous approaches, our proposed solution offers a distinct customization. Instead of simply presenting another advanced LSTM model, we developed a deep learning prediction system that is both optimized and tailored to the task. We also incorporated extensive feature engineering alongside LSTM to enhance prediction accuracy. By building on insights from prior research, we bridge the gap between investors and academics, proposing a feature extension method before applying recursive feature removal. This approach results in a noticeable improvement in the model's performance.

Hayati Yassin ,Zaharaddeen Karami Lawal , Rufai Yusuf Zakari [28] , In this research, they addressed the application of machine learning models to stock market forecasts, describing the supervised machine learning algorithms and techniques We studied the literature on the ideas and applications of classification and regression, and we looked at them using dimensions connected to current and new problems in stock price prediction. Classification and regression are used to make predictions in the stock market.

Deeksha Chandola, Mehar Vijh, Vinay Anand Tikkiwal, Arun Kumar [29], When it comes to predicting stock prices, the comparison analysis—which takes into account the values of RMSE, MAPE, and MBE—clearly shows that Artificial Neural Networks (ANN) beat Random Forests (RF). The results show that, in terms of RMSE (0.42), MAPE (0.77), and MBE (0.013), the ANN model performs well.

CONCLUSION AND FUTURE SCOPE

Conclusion

Conclusion Engaging in the stock market requires strategic decision-making rather than relying on luck. Our venture commenced with a deep dive into market behavior analysis, delving into the foundational aspects of Technical Analysis embedded within an API. We also explored significant market theories like Fibonacci and Gann theory to enhance our under standing. Leveraging extensive historical data and comprehensive datasheets, we're crafting customized solutions for both everyday investors and professionals in the field. Our strategy involves the utilization of advanced algorithms to rigorously evaluate tactics for both stock indices and individual stocks. In a manner akin to our collaboration with the Passive Investor, we've successfully obtained fundamental analytics, seamlessly integrating them into our API for practical implementation.

Table 1 Comparative Analysis

Year	Author	Purpose	Method Mentioned	Inference
2023	Vinay KM, Lalita Bhusal, Shwetakumari, Kem para, juvN, Gu, nasagari G S	Comparison of Machine Learning Methods for Predicting the Stock Market	LSTM, Regression	The pivotal reason for choosingthis particular algorithm lies in its versatility, being applicable and ef fective for both smaller datasets and extensive clusters of data. Moreover, the LSTM algorithm stands out for its notable accuracy, making it a preferred choice due to its high prediction precision re gardless of the data scale or com plexity.
2023	Shubhodh, Amar, avadi, Pulluri Anudeep, Yera malla Uttam, K Nagendra Chary	Stock Market Prediction using Long Short Term Memory	RNN, LSTM ,SVM, Re gression, ARIMA	As a result, the portfolio chosen byour LSTM network had a some what more consistent return than the ARIMA model.

2023	Mrs.Prasanna Pabba, S.Krishna Kiran, S.Sarthan Reddy, I. Sai Prakash, S V Sai Srikar	Stock, Mar, Ket Price, Pre Diction Using Machine Learning	LSTM and GRU models ,Net works,ANN, SVM Regression	In the realm of time series dataencompassing text, signals, stock prices, and similar domains, LSTM proves to be highly adept at captur ing temporal patterns within deep neural networks. Its proficiency in understanding and leveraging se quential patterns makes it particu larly well-suited for these kinds of data
2023	Akash Maurya, Aman Singh, Shivani Balani, Sujal Kumar Gupta, Amanjot Kaur	Stock Market Prediction using Machine Learning	LSTM, RNN, GRU	The findings of this study sug gest that the LSTM machine learn ing algorithm is a viable one for predicting stock values The model outperformed conventional stock market forecast techniques and at tained high accuracy rates
2021	Ernest Kwame Ampomah, Gabriel Nyame, Zhiguang Qin, Prince Clement Addo	Utilizing the Gaussian Na¨ıve Bayes machine learning algorithm for Predicting Stock Market Trends	GNB Algorithm, GNBLDA GNBP CA	Among the models utilizing theGaussian Na¨ıve Bayes (GNB) al gorithm, the one that integrated GNB with Linear Discriminant Analysis (GNBLDA) showcased superior performance. It surpassed all other GNB-based models for accuracy, F1-score, and AUC, three of the four evaluation measures.
2020	Anusha J Adhikar, Apeksha K Jadhav, Charitha G, Karishma KH	Survey on Stock Price Prediction Using Machine Learning	Two potent tools in the field of neural networks that are intended to handle and analyse sequential data are the Recurrent Neural Network (RNN) and (LSTM).	Based on the conducted research,it is evident that both RNN and LSTM libraries prove highly ef ficient in accurately identifying stock price trends in comparison to the real market trends

Table 2 Comparative Analysis

Year	Author	Purpose	Method Mentioned	Inference
2020	Polamuri Subba Rao, K. Srinivas, A. Krishna Mohan	Offers an examination and comparative assessment of diverse techniques employed in predicting stock market parameters.	ANN , TSLM , RN	The objective is to ex amine a fresh approach for enhancing stock re sult prediction. This en tails amalgamating multi ple methods to craft an innovative approach, ulti mately aiming to improve predictive accuracy

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A Vision IoT Framework for Smart Agriculture to Detect Motion and Malicious Activities in Farm

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ABSTRACT

Agriculture is most prominent occupation practised across India. Hence the GDP of the country is mainly dependent on Agriculture. To enhance the productivity and to ease the work of farmers modern technologies are being used in Agriculture. IoT has brought revolutionary changes in the practices of Agriculture. From measuring of moisture in the soil to detecting the diseases affected to the crops, everything is just a click of button away from farmers. Vision Based IoT has given a platform to monitor and control the farm at anytime from anywhere. The paper discusses about the framework for smart agriculture to detect motion and malicious activities in the farm. The security system detects motion in the farm environment, captures the scene information and notifies the user/farmer about the motion with scene image through email and sms notification. The frame work is devised using Raspberry Pi boards, Pi Cam and PIR sensors and the experiment is carried in the farm, the accuracy and consistency of the system are measured and tabulated. The results indicate that the system is highly accurate and consistent for detecting malicious activity.

KEYWORDS: *Vision IoT, Motion detection, Smart agriculture, Raspberry Pi board, Pi cam, PIR sensors.*

INTRODUCTION

Agriculture is one of the main occupations in India. 60% of total land of the country is utilised for Agriculture. Agriculture is mainly responsible for the significant growth of India's economy. The contribution of agriculture to the total gross domestic product of India is around 16%, and that to exports is around 10%[4]. In addition to providing crops and other raw materials, agriculture has also been the oldest known occupation to mankind. During the recent years agriculture has gone through many technological advancement.

Modern day agricultural operations and practices are far different from those of a few decades ago, mainly because of advancement in the technology. Over the past years, due to the introduction of information and communication technologies in agriculture, there has been an increase in food production. These technologies include deploying of sensors in farmland to measure climatic changes, monitor plant growth, maintaining moisture in the soil and many more. The way in which Internet of Things technology has brought changes in Agriculture is highly remarkable. Internet of Things is an emerging technology in which every day 'things' have the ability of communication and can send and receive data through wired or wireless communication. Internet of Things has provided a way to intelligent pest control, crop water management, precision agriculture, weed control, etc. This has made agriculture smarter. The scope for implementation of different sensors to measure different parameters in farm field is wide open with Internet of Things. One such major domain of IoT is Vision based IoT, especially for agriculture applications.

Vision Based IoT provides platform for Computer Vision with IoT, which provides an intelligent way to visualise the activities that happen in agriculture environment and also helps the farmers to monitor and control the activities in the farm. With the introduction of vision technology in IoT, a wide range of products, both new and enhanced, are becoming more intelligent and responsive than before, making them more valuable to users. Vision is one of the richest sensor modalities. When vision technology is coupled with IoT in Agriculture, the possibilities are endless in IoT in terms of surveillance, detection of malicious activities, controlling of agriculture environment etc.

Providing security to agriculture environment through surveillance, especially for the detection of rodents, animal invasion and other malicious activities, has always been an important aspect of Vision Based IoT. One of the significant challenges in providing security in agriculture is to interact between the devices which give security and provide the ability to control other sensors like camera, alarms etc, in order to enhance security. A Surveillance camera installed in farm cannot process information that is happening in the farm environment and it will be of no use until the recorded media is accessed. In addition to this it also doesn't provide alert to user/farmer whenever motion or any event happens.

In order to overcome the demerits of current surveillance systems, there is a need of a system which can be deployed in the farm environment and can detect motion and trigger camera to take images of the farm environment and send the notifications to user through email and sms. This paper aims at devising a framework for such a security system using IoT which detects motion in the farm environment, triggers PiCam to capture the scene information and notifies the user/farmer about the motion with the scene image through email and sms. The significance of this system is notification of real time information to the user through email and sms. The experiments carried out on the system gives much beneficial results with high accuracy of 97% and consistency of 100% which are discussed in the results section.

The paper is organised as follows, Section 2 gives the literature review, which deals with the contributions done in Smart Agriculture using IoT. Section 3 covers Vision IoT framework proposed for Smart Agriculture applications especially to detect motion and Malicious Activities in Farm and also further presents the Hardware and software components used in the framework. Section 4 deals with Experiments and result analysis and Section 5 concludes the work.

LITERATURE REVIEW

For developing an intelligent security device based on IoT, sensor network and database management systems are the foundation. The fields like data analytics and pattern matching also influence security devices. Researchers have been developing various IoT based security devices but a little work is done in agricultural area. The following are some of the prominent works reported on literature.

A smart security monitoring system for agriculture is designed in [34], to accentuate the methods to solve such problems like identification of rodents, threats to crops and delivering real time notification based on information analysis and processing without human intervention. In this device, the sensors and electronic devices are integrated using Python scripts.

An Agricultural Intrusion Detection system was deployed over an outdoor environment in[31], which generates alarm in farmers house and also transmits a text message to the farmers cell phone when an intruder enters into the field.

A WSN application for crop protection to divert animal intrusions in the agricultural land is presented in[35], for Crop Protection to divert animal intrusions in the crop field. The nodes in the crop field are equipped with PIR sensors, sound generating devices, light flashers and RF module. Animal entry at the farm boundary is detected by the nodes fixed at the boundary and is communicated to the central base station. On receiving this information the nodes in the vicinity of the animal activates the deterring gadgets and diverts the animal away from the field.

In [29], prevention of Monkey Trespassing in Agricultural Field Using Application Agricultural Specific Flooding Approach in Wireless Sensor Network is proposed, which is coupled with ultrasonic sound generator to ward off monkeys. The sensor node senses the movement of the monkey into the land and notifies the sink node by broadcasting alarm tones using the application specific flooding algorithm.

In [11], A Low Cost Wireless Sensor Network for

Rodents detection is designed in which a large number of devices connected in real time are deployed to monitor rodent pests mainly in food industries and agricultural activities.

An Internet of Things Approach for Motion Detection using Raspberry Pi is proposed in[1], which helps to monitor and get alarms when motion is detected and sends photos and videos to a cloud server.

In [24], Low Cost Smart Security Camera with Night Vision Capability Using Raspberry Pi and OpenCV is devised to be used inside a warehouse facility. It has human detection and smoke detection capability that can provide precaution to potential crimes and potential fire.

A Computer Vision Based Robotic Weed Control System for Precision Agriculture is designed in[21], to identify weeds and selectively spray right amount of the herbicide. The weed growth system is designed using plant growth monitoring sensors.

Different applications of WSN in agriculture are discussed in this section. However, the authors have overlooked the issue of theft in agricultural field due to unauthorized intruders. Here, we consider the entrance of an intruder as an important issue, and designed a prototype of the intrusion detection system.

VISION IOT FRAMEWORK FOR MONITORING OF AGRICULTURE FARM

The aim is to make a smart surveillance system which can be monitored by owner from remote location. It is required to develop and implement an affordable low cost web-camera based surveillance system. Authorized user can access their monitoring system remotely via internet with a mobile phone and monitor the situation.

The proposed Vision IoT framework consists of Sensor module, PiCam module, processing module, e-mail notifier module and SMS notifier module.

The sensor module has PIR sensor which is used to detect motion of the intruders and malicious activities in the farm. Passive infrared motion detectors (PIR) detect emitted infrared energy – given off by humans and animals in the form of heat. When the motion is detected by PIR sensor, it sends the information to the processing module.

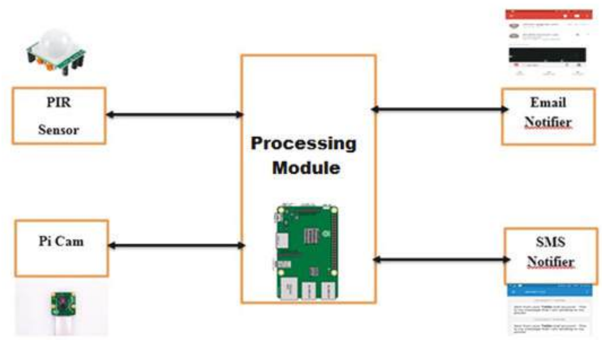

Fig 1. Vision IoT Framework for Smart Agriculture to detect motion and Malicious Activities in Farm

The processing module which in this case is Raspberry Pi board, will trigger the PiCam to take a picture of the environment. The PiCam captures the image and makes a local copy of the image in the Raspberry Pi and then transfers that information to the Email notification module.

The email notification module makes use of SMTP protocol and will be having the email id of the user, to which an email is sent with the image attached to alert the user. The SMS notifier module uses the services of TWILIO messenger and sends the security alert message to the registered user.

The working of proposed system can be divided into three phases, namely event detection phase, capture phase and notification phase.

1. Event Detection Phase: In event detection phase, the passive infrared sensor deployed in the field detects any malicious activities or motion if any and sends the signal information to the Raspberry Pi.
2. Capture Phase: The signal that is received by Raspberry Pi in the event detection phase triggers camera to capture image of the scene when motion is detected in this phase.
3. Notification Phase: The email and sms notification consisting of captured image is sent to the user regarding the detected motion in this phase.

The proposed system can be depicted using flowchart as shown in the fig 2.

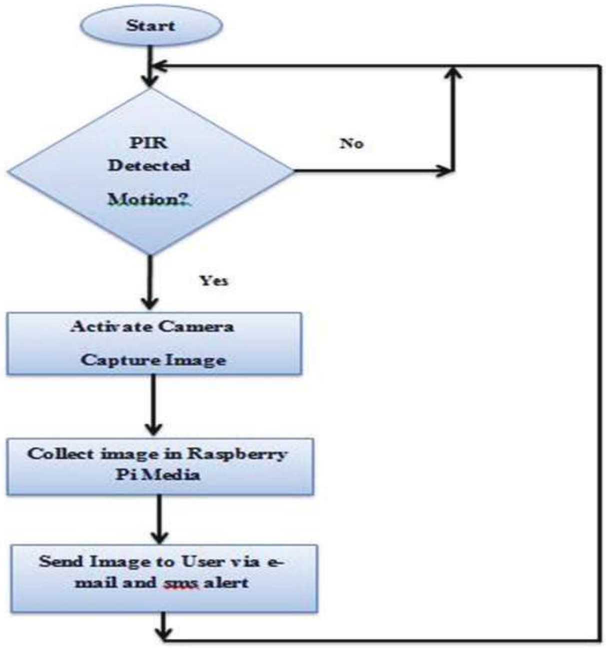

Fig. 2. Flowchart of the proposed methodology.

Architecture

The designed framework uses three interfaces for data transmission, data analysis and data collection. IoT architecture presented here can be viewed as a 3-layer architecture, these layers are,

1. The perception layer: can be viewed as physical layer, which is interface for sensors to sense and gather the information about the field. The layer is responsible for sensing physical parameters and report over the changes that happen in these physical parameters.
2. The network layer: This layer is responsible for connecting to different sensors and other networking devices in the environment. It is also responsible for processing and transmitting the sensor data.
3. The application layer: This layer is responsible for providing application specific services to meet user needs.

The perception layer has the interface for PIR sensor, it helps to gather information from sensor and processes it. The processed information is transmitted using network layer. The application layer is used to provide email and sms notifications to user.

Circuit Design

The PIR sensor and camera are connected to GPIO (general-purpose input/output pins) header. The connections are as shown in Table 1.

Table 1. GPIO Header Sensor Connection

Device	Port	GPIO
PIR sensor	VCC	
OUT		
GND		
	PIN 2	
GPIO 4		
PIN 6		
CAMERA	Camera/ CSI port	

Hardware and software components

This section discusses about the hardware and software components in the design of the framework.

Raspberry Pi Board

The Raspberry Pi board is a low cost, credit-card sized computer that can be connected to a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. The Raspberry Pi has the ability to interact with the outside world, and has been used in a wide array of projects.

Fig. 3. Raspberry Pi Board

Raspberry pi B+ GPIO header consists of 40 pins which include 5v, 3.3v, GND and 26 GPIO pins and 2 ID-EEPROM pins to provide connectivity to I/O devices. In the proposed frame work the monitoring of environment through PIR and camera sensor and presenting it to the user is programmed through Raspberry Pi.

PIR sensor

A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view.

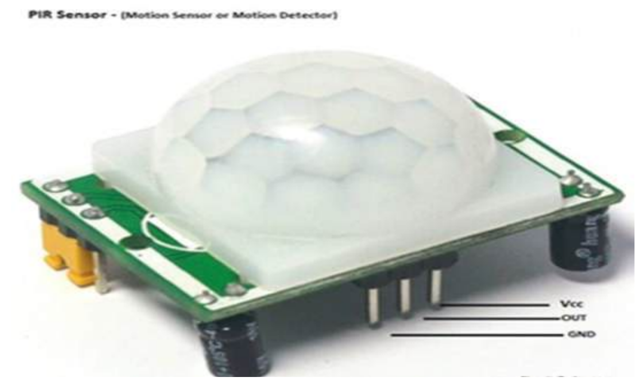

Fig. 4. PIR Sensor

PIR sensor has three pins namely Ground, Vcc and Out.

PiCam

The Raspberry Pi Camera Module is a custom designed add-on for Raspberry Pi. It attaches to Raspberry Pi by way of one of the two small sockets on the board upper surface.

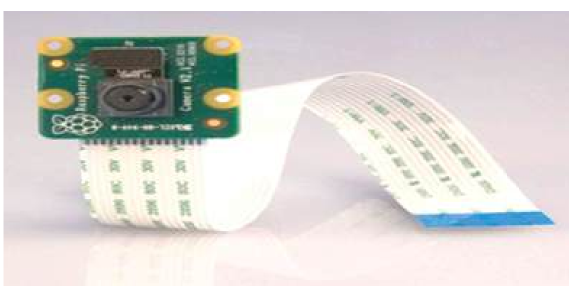

Fig. 5. PiCam

This interface uses the dedicated CSI interface, which was designed especially for interfacing to cameras. The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data.

Twilio SMS Service

Twilio is a cloud communications platform as a service (PaaS) company. Twilio allows software developers to programmatically make and receive phone calls and send and receive text messages using its web service APIs. Twilio's services are accessed over HTTP and are billed based on usage.

The motion of the intruder is detected by the PIR motion sensor and it triggers the Picam connected to Raspberry pi, and the captured picture or video will be transmitted to the authorised user through sms and email. The components are made to interact through the programs written in python programming platform.

EXPERIMENTS AND ANALYSIS ON AN AGRICULTURE FIELD

This section discusses how the framework is set up and how all the 3 phases discussed above interact with each other in order to devise a security system using IoT which detects motion in the farm environment and notifies the user/farmer about the motion with the scene image through email and sms. The experiment to test the system was carried in a land of 10000 sq ft area, which is rectangular in shape. The setup of the system is kept along the two diagonal corners of the rectangular farm land so as to get the best view of the image captured as shown in 6.

Fig. 6. Setup of the system in the Agriculture field

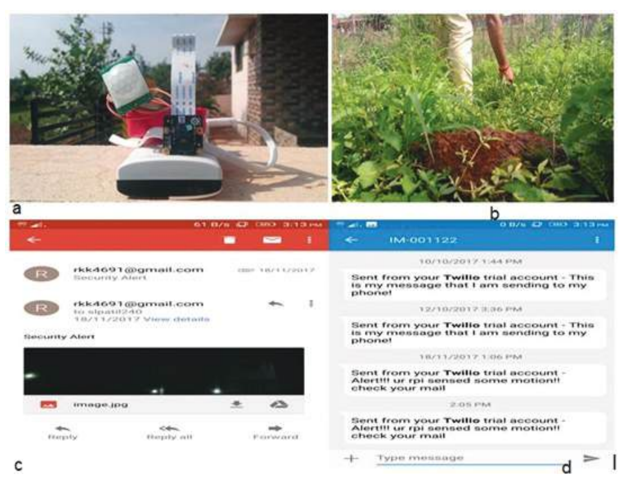

Fig. 7. a. Setup of the system for experimentation b. Captured scene image when motion detected c. Sample email alert sent d. Sample SMS alert sent

The setup of the system is as shown in the Figure 7. Figure 7a shows how all the hardware components of the system are setup, figure 7b shows the captured image when motion is detected in the farm land and figure 7c and 7d shows the sample email and sms alerts.

The PIR sensors used in the system can detect the motion within the range of 50 meters and triggers the camera to capture the image of the scene from where motion is sensed. The performance of the system is measured by accuracy factor, where in accuracy can be defined as the number of intruders detected by system, in percentage, over the total number of intruders who actually enter into the field.

Mathematically:

$$A = (ND/NE) * 100 \quad (1)$$

ND : Total number of detected intruders by the system.

NE : Total number of intruders entered into the field.

The following observations are made after running up the system for 5 hours. For ease of calculating the accuracy, every 60 minutes time span was taken as time unit. The results are tabulated in Table 2,

Table 2. Accuracy of the System Throughout the Experiment

Time (mins)	0-60	61-120	121-180	181-240	241-300	Total 300
ND	35	40	23	27	20	145
NE	36	42	24	29	20	151
A (%)	98	96	96	94	100	97

The results from Table II show that the system devised has an overall accuracy of 97% in detecting the intrusions into the farm. The PIR sensor triggers the PiCam to capture the scene information, an image is captured and stored in the Raspberry Pi storage unit and the same image is transmitted to alert the user about the intrusion through email and sms. Another performance factor to be considered here is the consistency, with which the system sends notification / alerts messages to the users for the detected intrusions, Table III provides summary of consistency of the system.

Table 3. Consistency of the System

Time (mins)	0-60	61-120	121-180	181-240	241-300	Total 300
ND	35	40	23	27	20	145
Ns	35	40	23	27	20	145
Consistency (%)	100	100	100	100	100	100

The consistency of the system is 100%, i.e, whenever an intrusion is detected it is reported to the user by the system. The time taken for user to get notification alert depends on the speed of the network and size of the image captured. The PiCam has a resolution of 5MP and can capture the images with size of 200KB to 2 MB. With this size, the image attached as the notification in email can be delivered to the user/farmer in 20-30 seconds of time and the sms alert will be delivered to the user in less than 30 seconds.

Altogether the system provides 97% accurate results with 100% consistency, which is better than the system devised in [21], where in the photos are sent to cloud and retrieved later on user request.

CONCLUSION

The proposed framework is implemented using Raspberry Pi and Python Programming language. The devices like Picam, PIR sensor and mailing/ sms service is governed using Python scripts. By improvising the capabilities of these technologies and integrating them the framework is devised with the hope of introducing motion detection in modern security systems for smart agriculture. The system detects the motion in the farm environment using PIR sensor and triggers camera to take picture of the environment at that moment. The picture is sent to the user through email and sms. System gives good results in all environmental conditions also. The framework designed can be used in Smart Agricultural applications such as detecting malicious activities in the farmland, preventing intrusion of wild animals and protecting crop from fire accidents. The frame work can also be used in the military applications to detect enemy intrusion and other malicious activities in military restricted areas.

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Issues, Challenges and Emerging Threats of Cryptography

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ABSTRACT

We all live in an advanced era where so many emerging technologies are connected to our daily lives using our data to perform several actions. With the usage of the internet 24/7 over so many social media platform and other media, data security becomes considerably less and thereby increase huge security threat. To overcome these, the usage of emerging technology cyber-security can be utilized where cryptography algorithms are used for protecting data takes place. This paper brings an overview of issues and challenges of cryptography for improving security as well as possible solutions to overcome them.

KEYWORDS: *Cryptography, Crypt-attacks, Digital technology, Security.*

INTRODUCTION

Network security is a crucial part of information security since it is responsible for protecting any data communicated between networked systems [1]. Network Security is in charge of offering a suitable security level for the hardware, software, and data in a system. It covers all elements, functions, and qualities of the hardware and software as well as the operational processes, accountability, metrics, access control, and administrative and management rules. The four basic issues in information security are secrecy, authentication, nonrepudiation, and integrity management. Confidentiality, also known as secrecy, refers to preventing unauthorized access to information. When people think about network security, they usually think of this. The purpose of authentication is to determine whom you are speaking with before disclosing sensitive information or entering into a business relationship. Signatures are the subject of nonrepudiation [2, 3].

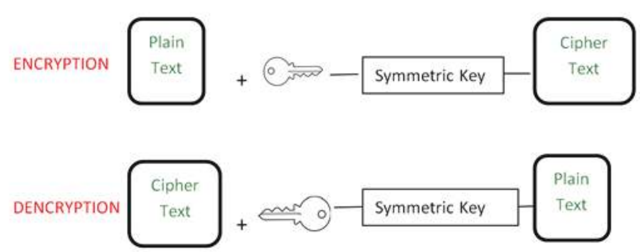

Fig. 1. Cryptography process

The integrity of Messages: senders and receivers should safeguard the integrity of their messages during transmission, even if they can authenticate each other. Protocol extensions are used for reliable transport and data links based on checksumming. In order to ensure network security, cryptography is an emerging technology [4, 5].Sensitive, priceless, and private data are more and more susceptible to unwanted access as data is collected, analyzed, and transported through computers. Businesses and individuals are increasingly using cryptographic methods, which were formerly only utilized by the military and diplomatic community, to protect their data in computer systems and networks as communications and eavesdropping technology continue to progress. All of it is protected by cryptography, including corporate e-mail, banking transactions, and internet shopping (Figure 1). Different mathematical methods are used in both classical and contemporary cryptography to restrict eavesdroppers from decrypting encrypted data. A computer system or network that stores, processes, or communicates sensitive information needs to be protected from such unauthorized access[6].

Security purpose of Cryptography

In order to provide four basic information security services, cryptography is used. Table 1 describes the goals of cryptography [7, 9].

Table 1. Goals of cryptography

Confidentiality	Cryptography provides confidentiality as a basic security service. The service protects the premises from unauthorized entry. Occasionally, it is referred to as secrecy or privacy. From physical security to the use of arithmetical algorithms for the encryption of information, confidentiality can be achieved in a variety of ways.
Data Integrity	The purpose of this service is to identify any data changes. Intentionally or accidentally, an illegal entity may modify the information. Services for maintaining data integrity check to see if all of the information was produced, sent, or saved by a legitimate user. Data can be processed, but integrity can state if the data has been changed unlawfully.
Authentication	Authentication allows the originator to be recognized. Data sent by an established and the recognized sender is verified as sent by the receiver.There are two types of authentication services:
	This type of authentication identifies the creator of a message regardless of whether the message was sent through a router or scheme.
	In entity authentication, data is pledged to have been received from a specific entity, such as an authoritative website, for instance.
	In addition to the source, authenticity may also reveal data about additional data-related factors, such as the date and time of data production and transfer.
Non-repudiation	Non-repudiation is particularly appealing when there is a chance that a dispute will arise regarding the flow of information. Once a purchase requisition is electronically submitted and non-repudiation repair is activated, the buyer cannot reject it.

Security Issues in Cryptography

- Accessing highly encrypted information, verified, and digitally signed might be challenging, even for authorized users. A network or computer system may be attacked by intruders and rendered inoperable.
- High availability, one of the core tenets of data security, is not something that cryptography can guarantee. Other techniques are needed to defend against a denial of service or a data system's total collapse.
- Additionally, cryptography cannot address the fundamental need for selective access control in information security. There must be administrative controls and procedures in place for this.

- Poorly designed systems, protocols, and procedures expose cryptography to vulnerabilities and threats. By setting up a defensive infrastructure, these problems can be solved.
- The cost of cryptography is high. Costs include both time and money-
    - o Information processing is delayed when encryption mechanisms are added.
    - o It requires significant financial investment to implement and maintain public key infrastructure for public key cryptography.
- Computational complexity of mathematical problems determines the safety of cryptographic approaches. A cryptographic approach can become vulnerable if the mathematical solutions to these problems or the speed of processing are improved.

Evolution

Khnumhotep II's tomb in the Egyptian village of Menet Khufu contains the oldest cryptographic text ever discovered. The life of Khnumhotep was depicted in his tomb around 1900 B.C. by his scribe. To obfuscate the meaning of the inscriptions, he drew the hieroglyphs using a variety of odd symbols. In this encryption method, one symbol or letter is swapped out for another, which is known as a substitution cipher. Hieroglyphic replacement increased in frequency as Egyptian society developed. For those who could read and write, it was rather simple to crack this encryption scheme [8][33].

The Spartans invented a mechanism known as secret communications around 500 BC. The message was then written lengthwise on the paper while the instrument, a cylinder, was still in use. After being unravelled, the message on the parchment strip was no longer legible. A similar cylinder was necessary to receive the message. The original statement would only appear once the letters were in the proper order.

For the very first time in history (2,000 years ago), Julius Caesar employed encryption in the military. Caesar, who was in charge of the Roman army, came up with an answer for the problem of encrypted communication with his soldiers. Caesar invented a substitution cipher method in which one letter was swapped for a different one. The secret messages were not revealed; only those who were aware of the messenger swap were caught. The Roman army greatly benefited from this during battle. A cipher disk-based encryption scheme was created by Leon Battista Alberti in the middle of the fourteenth century. This mechanical gadget had sliding disks that offered a variety of substitute options. This was the fundamental idea of poly alphabetic ciphers, a type of encryption that uses different substitution ciphers at various points during the encryption process. Alberti is referred to as "the father of Western cryptography" by author David Kahn in his book "The Codebreakers" (Kahn 1967). His idea for a cipher disk was abandoned by Alberti. Jefferson never created his encryption scheme, much like Alberti. Early in the 1900s, the US Army reimagined Jefferson's Wheel Cipher without knowing about Jefferson's innovation. According to Thinkquest.org (1999) [10–12], the US Army used this method from 1923 to 1942.

War Driver Cryptography: A German-encoded telegram was stumbled upon by British cryptographers at the onset of World War I in 1917.Zimmerman Communication is often used to describe this type of communication. As a result of their success in deciphering the messages, these cryptographers changed the direction of cryptology. Using this decoded telegram, they were successful in convincing the US to join the conflict. A secret communication known as the Zimmerman Telegram was given to Arthur Zimmerman by Heinrich von Eckardt, the German Empire's ambassador to Mexico. Mexico was given the chance to regain the states of New Mexico, Texas, and Arizona in exchange for its support for Germany, according to the telegram. Despite this proposal, Mexico came to the conclusion that annexing their previous territories would not be possible or even desired.

Choctaw Codetalkers: The absence of secure communication was a persistent issue in the United States throughout World War I. All of the allies' movements were known to the Germans because they nearly always intercepted telephone calls. A strategy using American Indian languages was developed by Captain Lewis, an army officer. He found eight Choctaw troops in the unit, using whom he used phone and radio to communicate. It is difficult to decipher codes and ciphers based on a single language, but protocols based on multiple languages can.

Modern Encryption-1

One-Time Pad: The early 1900s saw the creation of the "one-time pad" encryption technique, which has since been shown to be impenetrable. The Vernam Cipher, which bears Gilbert Vernam's name, served as the foundation for the one-time pad algorithm. The Vernam Cipher used a key that was read from a paper tape or pad along with a message. Before Joseph Mauborgne learned that cryptanalysis would be as tough as trying every conceivable key if the key were completely random, the Vernam Cipher was not impossible to crack (Kahn 1996). Even after evaluating each probable key, each decipherment effort would still need to be examined to see whether the correct key was used. For the one-time pad to remain intact, the key used must be completely random and used only once.

Pseudo-Random Number GeneratorA one-time pad is no longer impenetrable if it contains any non-randomness. There have been numerous attempts to use a key to produce seemingly random numbers. These number synthesizers are referred to as Pseudo-Random Number Generators (PRNGs) since they are still unable to provide a stream of completely random numbers. A PRNG can provide acceptable security when utilized appropriately, even though its security cannot be entirely assured to be impermeable. The Cryptographically Secure PRNG (CSPRNG) is a type of pseudorandom number generator (PRNG) designed specifically for use with cryptography. Certain traits that CSPRNGs have are absent in other PRNGs. Polynomial-time algorithms cannot accurately predict the (k+1)th bit based on the first k bits with a probability over 50%, if the first k bits are accurate. (Knuth 1981). Furthermore, CSPRNGs are subject to "state compromises." Even if a portion of the flow of random numbers were to be revealed, it should be impossible to duplicate it.

Symmetric Key Encryption (Private-Key):A distinct secret key must be generated in advance and kept in a secure location for each type of encryption that has been covered so far. Symmetric key encryption behaves in this way by default. Frequently called a private-key cipher, symmetric key encryption involves the use of keys that are indirectly related to each other. A standard mechanical lock serves as an analogy for this. The lock can be disengaged using the same key that activates it. The key must be safely distributed to each member in order to safeguard anything priceless concealed behind the lock. Unintentional access to the key would give the holder complete access to the items the lock is designed to secure.

Modern Encryption -2

Asymmetric Key Encryption (Public Key):With the advent of digital technology in the 1970s, a predetermined key encryption system was developed. For a message to be sent safely without first meeting the recipient, cryptographers of this era knew they would need a system that allows decryption. This technique would be comparable to a lock that requires a single key to engage and a distinct key to unlocking when compared to symmetric key encryption.

Future: Quantum Communication

Computers or processors that use quantum mechanics can perform quantum computation using quantum entanglement and quantum superposition. A "bit" is a unit of data storage used by modern computers that may store either a "1" or a "0" in binary code. Calculations are frequently carried out bit by bit in modern computers. To gather information, a quantum superposition of several states is created by the quantum computer. These various beneficial conditions are stored in quantum bits, or qubits. According to quantum architecture, each qubit can hold a certain amount of values simultaneously (Jones 2009).Compared to conventional transistor computers, this makes it possible to compute numbers much more quickly [26].

Key Highlights

This paper focuses on bringing an overview of cryptography in cybersecurity. Following are the objectives of the paper.

a. Overview of issues and Challenges of cryptography in cybersecurity.

b. Possible solutions to mitigate the threats in cryptography.

Organization of paper: The remainder of the paper maintains the format stated in Section 1 and is as follows: Sections 2 and 3 present difficulties to cryptography algorithms, dangers and developments in cryptography, and Section 4 depict the possible solutions for overcoming the challenges and threats and finally Section 5 ends with the conclusion.

CRYPTOGRAPHY THREATS AND TRENDS

For the Verizon 2021 Data Breach Investigations Report (DBIR), information from 29,307 events were analyzed, and 5,258 confirmed security breaches in 16 different corporations across four important global areas were discovered. Financial explanations were used in 86% of all breaches. The 3,950 validated breaches (out of 32,002 events) from the 2020 DBIR [15] show a considerable rise in comparison to that. According to the 2020 IDG Security Prioritizing Research, which surveyed 522 IT and security leaders, 49% of IT executives believe that safeguarding sensitive data is their most pressing security concern.

The Internet Crime Complaint Center (IC3) acquired over 28,500 complaints about COVID-19 in 2020, according to the 2020 FBI Internet Crime Report. A 69% rise over 2019 saw 791,790 complaints submitted to IC3 with losses exceeding $4.1 billion. According to IC3, Business Email Compromise (BEC) breaches were the most expensive attacks, resulting in 19,369 complaints and $1.8 billion in losses for victims. According to the 2021 Webroot Brightcloud Threat Report, the average ransom payment reached a peak in September 2020 at $233,817. The statistics show that phishing increased by 510% from January to February of 2020 alone and that 86% of malware is specific to a single PC. Figure 4 (a, b) depicts the increase incyber attacks per year and percentage-wise classification.

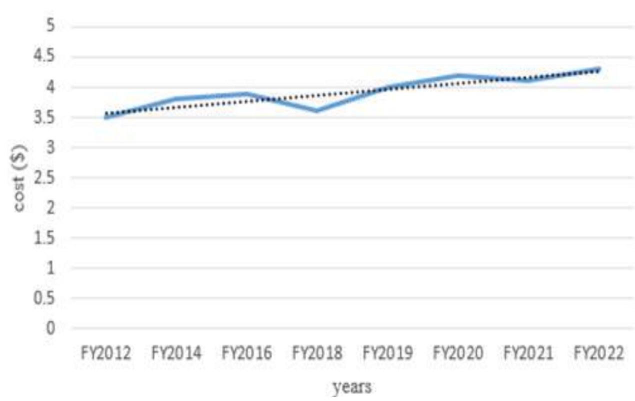

Fig. 4a. Global increase of attacks per year

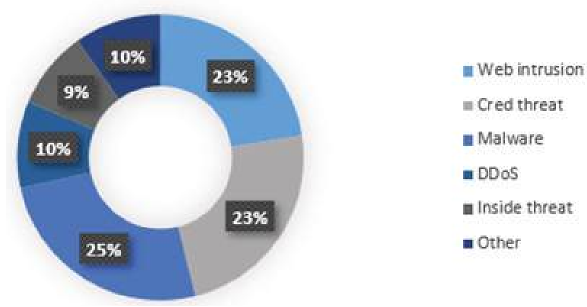

Fig. 4b. percentage-wise security threats

CHALLENGES OF CRYPTOGRAPHIC ALGORITHM

Here we describe the three main cryptographic categories and the possible challenges of each algorithm.

Symmetric Key Algorithm

Symmetric key cryptography methods encrypt and decrypt data using the same key. Instead, to decrypt the ciphertext and obtain the original plaintext, both the sender and the receiver must use the same key. The symmetry of the encryption and decryption processes gives rise to the name of this class of methods. Due to the need to maintain confidentiality and the fact that the key can only be understood by the sender and recipient, this type of encryption is also known as secret-key cryptography or private-key cryptography.

Drawbacks

- In symmetric-key algorithms, a secret key must be passed between two parties. The difficulty is that the sender and receiver must first agree on the key. This issue can be easily resolved by creating a private channel of communication that only the sender and the recipient can use, and using that channel to transmit the key. It makes reasonable to exchange the plain text directly if such a channel does exist. The Diffie-Hellman Key Exchange mechanism was proposed by Whitfield Diffie and Martin Hellman in 1976 as a feasible resolution to this problem [13].
- A separate secret key is needed for each pair of communication parties. One key is required if just 2 people are in communication with one another. However, three keys are required if there are 3 phases engaged. (n(n-1))/2 calculates the total

number of keys for n users. The number of keys is huge and impracticable for business transactions involving thousands of merchants and customers.

AES algorithm

In October 2000, Rijndael made the first appearance of AES (Advanced Encryption Standard). It was invented by Joan Daemen and Vincent Rijmen in Belgium. It is a symmetric block cipher that can handle blocks of 128, 192, and 256 bits in size. Basic division by key, substitution and transposition are the three major categories into which computations employed in encryption are separated. Four separate byte-arranged changes—Subbyte, Shift Row, Mix Column, and Add Round Key—combine to form the round function utilized by AES. According to the key's length, a certain amount of rounds must be utilized [14].

Drawbacks

- It has been demonstrated that a number of attack types, particularly those utilizing boomerang and rectangular assaults with associated key differentials [15], are vulnerable to AES.These attacks have lately witnessed advancements in hardware and computational power. [16] has specifics on how each of these algorithms functions within.

Blowfish algorithm

The block cipher used by the blowfish algorithm has a key size of 64 bits and a configurable length. Bruce Schneier discovered this in 1993 [17, 18]. The length of a blowfish key can range from 32 to 448 bits. This calculation employs a 16-round Fiestel figure with a big key ward S-box. Running blowfish uses roughly 5KB of RAM. Blowfish typically employs a certain style of key creation [19]. When a single key is expanded to 448 bits during the key expansion stage, a table (4168 bytes) of sub-keys is produced. Sub-key generation increases security. Blowerfish can produce longer keys to make key attempts more challenging.

Drawbacks

- It is quick, saving the time required to process each new key, which is roughly equivalent to encrypting 4 kilobytes of text. When compared to other block ciphers, this is quite sluggish.
- Because two people can use the same key, the blowfish algorithm is unable to provide confirmation and non-denial. The main schedule in Blowfish is a little tiresome. Compared to AES's 128-bit block size, Blowfish's tiny block size (64 bits) makes it more vulnerable to assaults [20].

DES Algorithm

Horst Feistel created the Data Encryption Standard (DES) at IBM in 1970. According to the National Institute of Standards and Technology [21], an encryption standard should be used. DES creates cipher text using the 64 bits of plain text that are provided as input. 64 bits make up the encryption text. The key length for this calculation is 56 bits, whether or not a 64-bit key is an actual input. The 16 rounds of DES operations involve substitution and permutation. To achieve this, key and data bits are permuted, XORed, shifted, and then passed through 8 boxes. The DES algorithm's fundamental step is to proceed from the lookup table. Reverse encryption is used during decryption.

Drawbacks

- DES's software implementation performance is not optimal.
- As hardware gets better and better, the possibility of cracking DES grows every day.
- In light of contemporary hardware and parallel computing, the 56-bit key is not thought to be long enough to guarantee adequate security.

Triple DES

Triple Data Encryption Standard (TDES), also called Triple Data Encryption Algorithm (TDEA), was initially proposed by IBM in 1998 and then standardized in ANSI X9.17 and ISO 8732 [27]. With this encryption technique, the faults of its predecessor, the DES, are meant to be fixed without necessarily needing the development of a new algorithm. Both of its two variants, the 2-key triple DES and the 3-key triple DES (K1, K2, and K3), use 56-bit keys (K1 and K3).

3.1.5 Hybrid Cubes Encryption Algorithm (HiSea)

Is a symmetric non-binary block cipher that employs integer numbers for its plaintext, ciphertext, internal operations, encryption and decryption keys. HiSea is a cryptographic technique that Sapiee Jamel developed in 2011 [28]. By combining and permuting numbers, these algorithms are created. Combining a part of a symmetric algorithm with the advantages of public keys results in a better cipher method. The difficulty in securely moving keys, which makes it necessary to exchange them through individuals, is a downside of the hybrid encryption algorithm, but it is still challenging.

RC4

It is both a stream cipher and a symmetric key. Wireless communication is made possible by using WPA and WEP. Due to its simplicity of use and quick speed, it is favoured. During the encryption method, the ciphertext is produced using key streams that are mixed with plain text. Only 256 bytes of RAM are required for the array because it employs byte manipulation. It is typically more effective because it uses less memory.

Tiny Encryption Algorithm (TEA)

A smaller number of lines of code make the Tiny Encryption Algorithm (TEA) simpler to develop and to use. The algorithm includes two 128-bit-long keys (k [0] - k [3]) and two 32-bit unsigned integer/code blocks, which can be created from a 64-bit block, to provide outputs in the form of w [0] and w[1]. To thwart attacks that depend on the periodicity of rounds, sets of magic numbers or constants are employed.

CAST

The CAST design approach was used to create CAST. It also has characteristics in common with other Feistel-based cipher techniques. Repetition removal has been made easier, thanks to this method, which also boasts robust keys. It is not very secure, though, and is vulnerable to attacks like timing attacks. Additionally, when compared to other products in the same class, it is regarded as being fast enough [29]. It is useful in other contexts, nevertheless, where its flaws do not compromise its efficiency.

IDEA Algorithm

IDEA is a block cipher using 64-bit blocks, similar to DES, but it employs a 128-bit key. There are eight rounds in all, and each one uses modular addition, multiplication, and the XOR function. The step of output transformation [22] comes after the eight cycles.

Drawbacks

- IDEA requires a license in order to provide security in business applications.
- Because DES has been in use for a far longer period of time than IDEA, it is more well-liked and broadly accepted.

Asymmetric Key Algorithm

Asymmetric key cryptography allows each user to create and retain their own secret, making it personal (unshared). Asymmetric key cryptography employs two keys, one for encryption and the other for decryption, as opposed to symmetric key cryptography, which only needs one key for both operations. The two keys that each individual owns are the public and private keys. User B’s public key must always be used to encrypt messages, and it is kept accessible to the public. Every time User A wishes to send User B an encrypted message, this is the situation. However, in order to decode the message, you’ll need B’s private key, which B alone possesses [23, 32].

Drawbacks

- The slowness of public-key cryptography is one disadvantage of encryption. More quickly than any widely used public-key encryption method are well-known secret-key encryption techniques.
- Public key authentication is advised or required. Everyone must confirm that their public keys are theirs because no one can be confident that a public key matches the person it claims to represent.
- More resources are used by the computer. It requires a lot more computational power than single-key encryption does.
- If someone gets their hands on a person’s private key and reads their full communication, there is a good chance that there will be a significant security breach.
- A lost private key might not be recoverable. All inbound messages cannot be decoded when a private key is lost.

RSA Algorithm

Ron Rivest, Adi Shamir, and Leonard Adleman created the musical piece RSA in 1978. The public key algorithm it uses is the most well-liked. Comparable open key cryptosystems don't compare to it [24]. The cryptosystem used by RSA is asymmetric. Two unique keys are available. Since one of them is shared by all parties, RSA is best known as a public key cryptosystem. The other key, which is kept a secret, is private

Drawbacks

- Its encryption time is the longest. It is challenging to achieve the criteria for c because it calls for identical lengths.
- Padding procedures are needed in this situation, which increases processing time.

Diffie Hellman

In 1976, Diffie-Hellman developed this algorithm. This algorithm divides the public key among the groups based on the key pair they come up with. Through a secured physical channel, this algorithm creates a shared secret between two parties. There is a secret key that is known only to each party. A secure exchange is enabled by the arrangement [30]. This method has the advantage of being secure, using a complex algorithm, and never transmitting the secret key over the Internet. The algorithm is costly, vulnerable to assaults, and unsuitable for most encryption scenarios because it lacks authentication, to name a few drawbacks.

Elliptic Curve Cryptography

The ECC algorithm encodes and decodes using asymmetric keys. In 1985, V. Miller (IBM) and N Koblitz (University of Washington) invented it. Based on finite elliptic curves over limited domains, ECC was based on algebraic structure.164-bit keys are effective enough to ensure security [31].To ensure security, that system requires a 1024-bit key. With the same bit size, ECC provides the highest level of security. Its disadvantages include increasing the size of the ciphered text and requiring highly complex equations. Lastly, encoding algorithms become more complex.

Hash Function

In contrast to the first two groups of algorithms, cryptographic hash functions do not encrypt or decode data using a key. It is difficult to determine the length or contents of the original plaintext from the hash since a hash value is instead calculated based on the characteristics of the plaintext. Passwords are frequently encrypted using hash algorithms.

Secure Hash Algorithm (SHA)

The Secure Hash Standard (SHS) was developed by NIST.A 160-bit hash value is generated by the SHA-1 variant. This version of SHA-2 includes 5 different SHA algorithms: SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512, which produce hashes with lengths of 224, 256, 384, and 512 bits, respectively.

Drawbacks

- Slowest hash function - For systems with high transaction rates, these hash functions can be very costly to the CPU.

POSSIBLE SOLUTIONS

To prevent counterfeit packets from entering your server, monitor the packets. Ensure your host's operating system is up-to-date with security patches. Make sure your server is not running very close to its capacity limits [25].

Secure usernames and passwords by enforcing strong authentication strategies. Keep passwords and usernames secret. Access should not be unnecessarily granted to users or employees.

An entertaining encryption strategy will keep you safe from eavesdroppers. The risk of eavesdropping attacks can be reduced by using encryption measures such as digital certificates (SSL certificates).Protect your network from eavesdropping and other attacks by segmenting it.

Spoofing can be prevented by filtering packets entering the network. Additionally, incoming and outgoing traffic should be filtered. By preventing falsified IP addresses from entering, ACLs help prevent Spoofing.

Authentication based on Public Key Infrastructures. Applications are not only protected from eavesdropping and other attacks but they are also validated as trustworthy. Authentication at both ends prevents a Man-in-the-Middle attack (MITM).Strengthening mutual authentication by setting up passwords and other high-level secret keys. By adding another layer of authentication when a login attempt is made, multi-factor authentication can help to avoid brute-force attacks.

CONCLUSION

From this paper, the basic understanding is to protect the data from various attacks using various advanced methods that is been populating daily. As the importance of securing every data from being hacked is getting an increase, the use of cryptography to double its performance for securing is also increasing. In this paper, we have gone through the overall view of cryptography issues and challenges in cryptography and its possible solutions to eradicate the barriers. Also, this will be helpful for other researchers to dig dive and bring such possible solutions by integrating it with other latest technology that is being emerged for improving security.

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Exploring Machine Learning Approaches for Effective Text Classification

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ABSTRACT

Text classification is a widely used technique for organizing text into predefined categories or groups, often referred to as text tagging or categorization. By leveraging Natural Language Processing (NLP), text classifiers automatically analyze text and assign appropriate labels or categories based on its content. This helps users quickly obtain relevant information related to their queries, ensuring faster and more accurate search results. Various methods and algorithms are employed for text classification, each with different accuracy levels. Convolutional Neural Networks (CNNs) are particularly effective for many NLP classification tasks. CNNs consist of one or more convolutional layers, also known as kernels, which slide over the input data in fixed-size matrices. Proper data dimensionality is crucial for optimizing algorithm performance. CNNs significantly enhance classification performance, with each class achieving accuracy levels above 94%. These results suggest that CNNs can be applied in defense systems where high-precision requirements are essential.

KEYWORDS: *Text classification, CNN, Natural language Processing, Kernels.*

INTRODUCTION

Language is one of the strategies for correspondence with the assistance of which we can talk, read and compose. For instance, we think, we simply decide, plans, and more in normal language; exactly, in words. Nonetheless, the central issue that defies us in this era of Artificial Intelligence is that could we at any point discuss in much the same way with PCs. As such, might people at any point speak with PCs in their normal language? It is really difficult for us to foster NLP applications since PCs need organized or structured information, yet human discourse is unstructured and frequently questionable. Normal Language Processing (NLP) is a part of Artificial Intelligence (AI) that empowers machines to grasp the human language. It will probably fabricate systems that can figure out text and naturally perform undertakings like interpretation, spell check, or topic classification.

Actually, the primary assignment of NLP is program PCs for examining and handling colossal measures of regular language information. Language is intended for conveying about the world. By concentrating on language, we can come to see more about the world. We can take advantage of information about the world, in blend with phonetic realities, to construct computational regular language frameworks.

It is helpful to separate the whole language handling issue into two discussions:

- Lexical, semantic and syntactic information is utilized to handle the composed text of the language as well as the necessary real world data.

- All the data required above in addition to extra information about phonology is utilized to process spoke language as well as sufficient added data to deal with the further ambiguities that emerge in speech.

Text Classification suggests examining the fundamental feelings of a given text victimization language process (NLP) and elective procedures to separate a significant example of information and choices from a given gigantic corpus of text. It examines the sentiment and point of the creator towards the topic of the subject referenced inside the text. This text is a neighborhood of any record, posted via web-based entertainment or from any data supply. Text is named unbiased or abstract, opposite or correlative, or adjusted.

RELATED WORK

This study proposes an approach of automated classification of articles submitted via an online submission system. There are many text classification algorithms. In this study, the algorithms used are KNN, Naïve Bayes, and SVM algorithms, of which classification performances are evaluated effectively.

Text classification: In the context of the rapid development of digital information, text mining techniques play an important role in information and knowledge management, attracting the attention of researchers. Automated text classification (or categorization) is the division of an input textual dataset into two or more categories, in which each text can belong to one or more categories. Text classification is carried out to assign a predefined label or class to a text. For instance, a new article posted in an online newspaper can be assigned one of the categories such as technology, sports, or entertainment; each article published in a journal can be automatically classified into the topics of information technology, environment, fisheries, etc.

Text classification algorithms

There are many text classification algorithms. In this study, the algorithms used are kNN, Naïve Bayes, and SVM algorithms, of which classification performances are evaluated effectively. Related studies on text classification: Many studies on text classification have been applied to solve problems in practice. For example, applied SVM and decision tree to solve text classification problems, and compared their effectiveness with that of the classical decision tree algorithm. In addition, the singular value decomposition technique was applied to the SVM algorithm to shorten the dimension of characteristic space and reduce noise, making the classification process more effective. With the dataset of 7,842 texts on 10 various topics, 500 texts of each topic were randomly chosen to train, the remaining texts were to verify independence. The results showed that the classification by SVM is better than that by the decision tree. Moreover, using singular value decomposition to analyze and shorten the dimension of characteristic space helped improve the effectiveness of the SVM classifier. The classification results with accuracy were greater than 90%. The second effective algorithm was Naïve Bayes with an accuracy was 87.6%. However, the kNN algorithm classifier implementation gave low accuracy with 46.7%. Normally, when compared with maximum number of features, KNN algorithm yields better results with minimum number of features.

METHODOLOGY

Classification using Natural Language Processing and Machine Learning:

Steps of article classification

The automated classification of articles is divided into two phases. In the training phase, relying on the collected dataset with machine learning algorithms, the classification model generated is described in Figure 1.

Fig. 1: Training phase

n a testing phase, based on the classification model generated at the training step, articles are classified in the testing dataset. This stage is described in Figure 2.

Fig. 2: Testing phase

Data pre-processing

File format conversion and word standardization:

Because the dataset used is .doc(x) files, it is necessary to convert them to plain text (.txt) for easy use in most algorithms and libraries serving automated classification. Converting format of an input article is based on Apache POI. Accordingly, Apache POI is used to perform read operations on the .doc(x) file, then write the readable content to the .txt file. After converting file format, word standardization is proceeded to convert all text characters into lowercase and delete spaces.

Word segmentation

In Vietnamese, space does not segment words but separate syllables. Therefore, the segmentation phase is quite important in NLP. Currently, many tools have been successfully developed to segment Vietnamese words with relatively high accuracy. In this study, the VnTokenizer segmentation tool by was used. The tool was developed based on the integrated methods of maximum matching, weighted finite-state transducer, and regular expression parsing, using the dataset of Vietnamese syllabary and Vietnamese vocabulary dictionary. This automated Vietnamese segmentation tool segments Vietnamese text into vocabulary units (words, names, numbers, dates, and other regular expressions) with > 95% accuracy. The process of word segmentation using VnTokenizer is described in Figure 3.

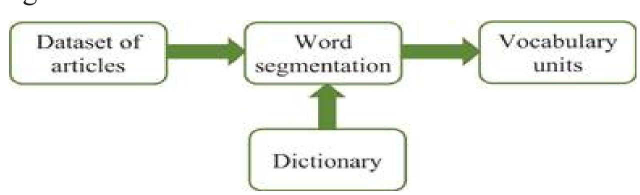


Fig. 3: Process of word segmentation using VnTokenizer

Text vectorization

There are several text representation models, i.e. vector space model based on the frequency weighting method, bag of words model, and graph-based model. In this study, the vector space model was applied. The vector space model can represent an unformatted text document as simple and formulaic notation. Because of its advantage, lots of research on the vector space model are being actively carried out. According to this model, each article is represented as a vector; each component of the vector is a separate term and is assigned a value that is the weight of this separate term.

CNN Architecture and methodology

Convolutional Neural Network(CNN) is a class of DNN and feed-forward artificial neural networks (where associations between hubs (nodes) don't frame a cycle). uses a variety of multi-facet perceptrons intended to require negligible preprocessing. These are roused by the animal visual cortex. It is an accurate method and performs so well in the classifications and Neural Networks. Here we are using Convolutional Neural Networks algorithm for Classification of text. Detecting multiple textures, edges, and corners are some of the features of convolutional layers. With this, all elements of a framework make CNN more sustainable to information of network structure. As the feature grows, we want to extend the element of the convolutional layer. Here we consider consecutive information of text data as data in time series and represented in one-dimensional matrix. To deal with one dimensional text data, we require a word embedding layer and an one-dimensional convolutional network.

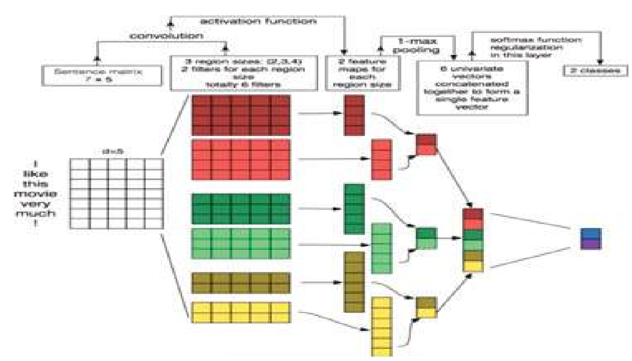


Fig. 4. Convolutional Neural Network Layers

RESULT AND DISCUSSIONS

Text Classification is quite possibly of the most fundamental pack in NLP categorizing text into organized groups. By utilizing Natural Language Processing (NLP), text classifiers can consequently anlyse text and afterward assign a set of pre-characterized labels or classifications in view of its content. By using CNN we are classifying tweets in a classified manner whether it is Positive, Negative, or Neutral. With help of the Tensor Flow Library, the tweets have been classified.

Firstly, the data have been cleaned up removing Emoji's and Special characters, and this data is Pre- Processed by taking a dataset this dataset will be Split into the train (80%) and test (20%). After all, it rejects the unknown characters or strings into a tokenizer and fits the text data, and converts it into sequence. These inputs are converted into embedding layers and these are inserted into 1D convolution and the training and testing accuracy have been shown. The total number of positive is 6985 with an accuracy of 0.90 and the total negative tweets is 6549 with an accuracy of 0.90 and negative-positive reviews are 941 and positive-negative reviews are 525 and the weighted avg of 0.90.

```
# take a peek at the data
dataset.head()
```

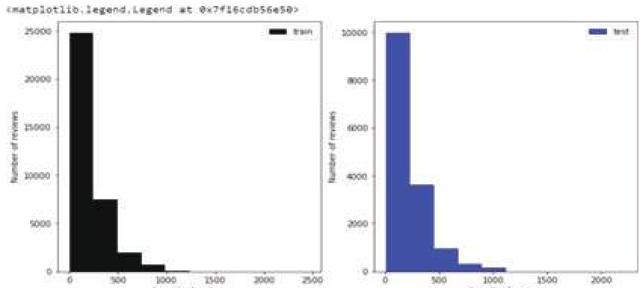
	review	sentiment
0	One of the other reviewers has mentioned that ...	positive
1	A wonderful little production. The...	positive
2	I thought this was a wonderful way to spend ti...	positive
3	Basically there's a family where a little boy ...	negative
4	Petter Mattei's "Love in the Time of Money" is...	positive

Fig. 5. Dataset took and modeled reviews

Graphical representation of the length of each review from training and testing datasets

```
import matplotlib.pyplot as plt
import numpy as np
%matplotlib inline

train_lens = [len(s) for s in train_sequences]
test_lens = [len(s) for s in test_sequences]

fig, ax = plt.subplots(1,2, figsize=(12, 6))
h1 = ax[0].hist(train_lens,color="black")
ax[0].set_xlabel('Length of review')
ax[0].set_ylabel('Number of reviews')
ax[0].legend(['train'], loc='upper right')


h2 = ax[1].hist(test_lens,color="blue")
ax[1].set_xlabel('Length of review')
ax[1].set_ylabel('Number of reviews')

ax[1].legend(['test'], loc='upper right')
```

```
<matplotlib.legend.Legend at 0x7f16cdb56e50>
```



Creating the model with the below code and followed by the output obtained.

```
# create the model
model = Sequential()
model.add(Embedding(VOCAB_SIZE, EMBED_SIZE, input_length=MAX_SEQUENCE_LENGTH))
model.add(Conv1D(filters=128, kernel_size=4, padding='same', activation='relu'))
model.add(MaxPooling1D(pool_size=2))
model.add(Conv1D(filters=64, kernel_size=4, padding='same', activation='relu'))
model.add(MaxPooling1D(pool_size=2))
model.add(Conv1D(filters=32, kernel_size=4, padding='same', activation='relu'))
model.add(MaxPooling1D(pool_size=2))
model.add(Flatten())
model.add(Dense(256, activation='relu'))
model.add(Dense(1, activation='sigmoid'))
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
embedding (Embedding)	(None, 1000, 300)	52738800
conv1d (Conv1D)	(None, 1000, 128)	153728
max_pooling1d (MaxPooling1D)	(None, 500, 128)	0
conv1d_1 (Conv1D)	(None, 500, 64)	32832
max_pooling1d_1 (MaxPooling1D)	(None, 250, 64)	0
conv1d_2 (Conv1D)	(None, 250, 32)	8224
max_pooling1d_2 (MaxPooling1D)	(None, 125, 32)	0
flatten (Flatten)	(None, 4000)	0
dense (Dense)	(None, 256)	1024256
dense_1 (Dense)	(None, 1)	257

Total params: 53,958,097
Trainable params: 53,958,097
Non-trainable params: 0

Training the model and evaluation of the created model following are the execution and outputs.

Model Training

```
# fit the model
model.fit(X_train, y_train,
          validation_split=0.1,
          epochs=EPOCHS,
          batch_size=BATCH_SIZE,
          verbose=1)
```

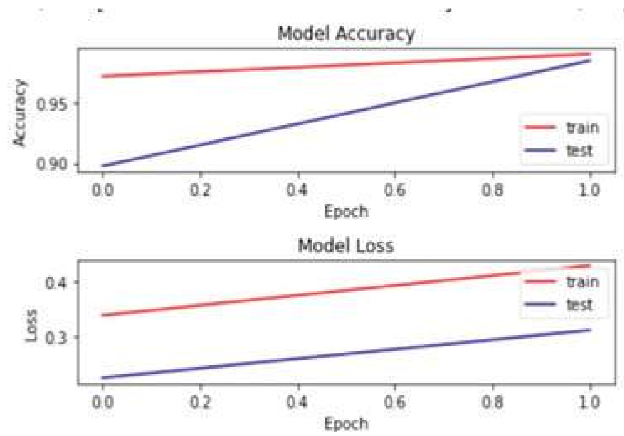
```
Epoch 1/2
247/247 [==============================] - 50s 198ms/step - loss: 0.4038 - accuracy: 0.7844 - val_loss: 0.2679 - val_accuracy: 0.8874
Epoch 2/2
247/247 [==============================] - 46s 187ms/step - loss: 0.1272 - accuracy: 0.9548 - val_loss: 0.2600 - val_accuracy: 0.8977
<keras.callbacks.History at 0x7f16cda87d90>
```

Model Evaluation

```
[22] predictions = (model.predict(X_test) > 0.5).astype("int32")
     predictions[:10]
```

```
array([[0],
       [1],
       [0],
       [1],
       [1],
```

```
[24] from keras.callbacks import ModelCheckpoint, EarlyStopping
     from keras.callbacks import EarlyStopping
     early_stopping = EarlyStopping(monitor='val_loss', patience=2)
     plt.subplot(2,1,1)
     history1 = model.fit(X_train, y_train, validation_split=0.1, epochs=2, callbacks= [early_stopping], verbose=1)
     history2 = model.fit(X_test, y_test, validation_split=0.1, epochs=2, callbacks= [early_stopping], verbose=1)
     plt.plot(history1.history['accuracy'], 'r', history2.history['accuracy'], 'b')
     plt.title('Model Accuracy')
     plt.ylabel('Accuracy')
     plt.xlabel('Epoch')
     plt.legend(['train', 'test'], loc='lower right')


     plt.subplot(2,1,2)
     plt.plot(history1.history['val_loss'], 'r', history2.history['val_loss'], 'b')

     plt.title('Model Loss')
     plt.ylabel('Loss')
     plt.xlabel('Epoch')
     plt.legend(['train', 'test'], loc='upper right')

     plt.tight_layout()
```



Finally, the classification report is as follows.

```
[25] # Final evaluation of the model
scores = model.evaluate(X_test, y_test, verbose=1)
accuracy=print("Accuracy: %.2f%%" % (scores[1]*100))

469/469 [==============================] - 7s 16ms/step - loss: 0.0361 - accuracy: 0.9895
Accuracy: 98.95%

from sklearn.metrics import confusion_matrix, classification_report

labels = ['negative', 'positive']
print(classification_report(test_sentiments, predictions))
pd.DataFrame(confusion_matrix(test_sentiments, predictions), index=labels, columns=labels)

              precision    recall  f1-score   support

    negative       0.93      0.87      0.90      7490
    positive       0.88      0.93      0.91      7510

    accuracy                           0.90     15000
   macro avg       0.90      0.90      0.90     15000
weighted avg       0.90      0.90      0.90     15000
```

	negative	positive
negative	6549	941
positive	525	6985

CONCLUSION

In view of natural language processing and deep learning algorithms, this study proposed a solution for text classification of articles/reviews to help authors/editors save time and effort when processing articles/reviews on the system. Data pre-processing steps are significant to making classification datasets in a standardized format for running the three algorithms of SVM, Naïve Bayes, and CNN. The results showed that the CNN algorithm gives better classification performance than the remaining classifiers. The rate of accuracy has been very consistent. This CNN is very elegant in handling larger datasets. Experimental outcomes demonstrate the way that our model can work on the performances of a group of related errands by investigating normal features. In future work, we might want to examine the other sharing systems of the undertakings.

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Secure and Reversible Data Embedding in Encrypted Images Using Deep Learning and Generative Adversarial Networks

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ABSTRACT

These days, pictures are shared on social media, and we have access to photo security. In order to conceal the important message within the image and vice versa, we would like to employ coding and steganography techniques. We tend to use a lossless reversible technique for information extraction and embedding in the planned system. By gently altering the pixel values, we can insert secret data into a conventional image via a technique known as reversible information concealment. In order to provide meaningful encrypted images for RDH, we tend to propose a replacement methodology in this study that combines models such as generative adversarial networks and convolution neural networks. The experiment is designed to use a four-stage specification along with the extraction, encryption/decryption, hiding, and recovery networks. The important information area unit was incorporated into the image using residual learning within the concealing network. The quilt picture is encrypted using a GAN to create a meaningful image known as the embedded image, which is then converted back to the decrypted image within the encryption/decryption network. In order to fully extract the concealed message on the receiving side, the original image must be recovered. There are numerous uses, such as social control, medical applications, such as protecting patient data, and military applications, where the ability to conceal information is highly valued. Additionally, this program aims to retrieve the original image without any damage. An alternative method is to determine the standard of image exploitation (SSIM) and compute the picture's embedding capability.

KEYWORDS: *Data diding, Deep neural networks, GAN model.*

INTRODUCTION

Digital images are widely used in a variety of industries, including publishing, journalism, healthcare, and the military. As a result, digital image integrity and copyright must be preserved. The image itself is not amenable to writing with the standard text encoding method because to its vast amount of knowledge, high correlation, and high redundancy between pixels. In addition to functionalities, a variety of technologies, such as watermarking and image authentication, are being developed for images. Knowledge concealing, a subset of digital watermarking technology, may be a crucial tool for ensuring counselling security.

To achieve the goal of useful embedding of hidden knowledge, knowledge concealment can be enforced in a variety of methods. Reversible and irreversible knowledge concealment are two categories of knowledge concealment that can be distinguished based on the receiver's ability to retrieve the quilt image. Once the encoded messaging unit of measurement—such as image data, labels, notations, or authentication information—is retrieved from the encrypted images, data concealment in the video may allow the original footage to be recovered without losing any of its original contents.

We suggest a framework for Reversible Image Transformation (RIT). RIT-based frameworks protect the privacy of the first image by shifting its content to that of the canopy image. Additionally, because they are changeable, they will be lossless reconditioned from the reworked image. As a result, RIT is frequently thought of as a unique secret writing topic called "Semantic Transfer secret writing (STE)". Since the camouflage image is a form of plaintext, it will evade outsiders' notation. As a result, outsiders will simply use antiquated RDH techniques for plaintext images to insert additional information into the camouflage image.

A lot of strategies are anticipated to optimize the technology known as reversible information concealing within the encrypted image (RDHEI). These techniques, however, are unable to provide robust embedding capacity. Therefore, we tend to suggest a complex RDHEI theme enabled lossless element conversion (LPC) in this study. In contrast to the earlier RDHEI algorithms, LPC is motivated by the coplanar map coloring question and uses a dynamic image division technique to split the original image into irregular regions as opposed to regular blocks. Elements are converted by region in the LPC approach, meaning that pixels in the same regions are reborn to equivalent conversion values that can occupy a reduced size, reserving the accessible area to include additional information. Since LPC could be a process, the original image is restored on the receiver side without loss.

RELATED WORK

In contrast to earlier methods that encrypt a target image into a cowl image, Weiming Zhang ET. Al seeks to improve the suggested methodology. Support for reverse image transformation allows the privacy of the initial image of the same size to be protected while transferring the original image's content to another image. Reversible image transformation and a very secure and lossless modified method of recovering the original image from the encrypted image. Two RDH techniques were used, together with PEE-based RDH and UES area unit, to add more data to the encrypted image in order to meet various requirements for embedding capability and image quality. [1]

Using dispensed supply coding, Zhenxing Qian et al.'s study suggests a method for concealing reversible records in encrypted images. To create space for the additional mystery records, the authentic photo portions of MSB planes are chosen and compressed after encryption.

On the recipient's end, the encryption key alone is used to recover the legitimate photo, and the embedding key alone is used to extract concealed records. It is possible to completely extract the concealed records and recover the authentic snapshot when the encryption and embedding keys are difficult for the recipient to decipher [2].

Xiaochun Cao et al. proposed a novel method in this study called the HC_SRDHEI, which inherits the reparability feature of RDH methods in encrypted images as well as the merits of RRBE. Are there considerably more vacant spaces for knowledge hiding using our technique than with more progressive alternatives? The knowledge information hider simply uses the element substitution to add more secret data in place of the supplied room. The area unit is error-free and can be separated from the information extraction and canopy image recovery area unit. Based on experimental results on three datasets, it is undeniable that our average MER will increase by 1.7 times compared to what the previous best method offered. According to the performance study, our suggested method has a great deal of promise for practical uses. [3]

With probabilistic and homomorphism qualities, Xinpeng Zhang suggested paintings that offer lossless, reversible, and mixed record concealment techniques for cipher-textual content images encrypted using public-key cryptography. In order to embed the additional records into the LSB-planes of the cipher textual content pixels, the values of the cipher textual content pixels are modified with new values in the lossless scheme. In this manner, the records embedding process no longer influences the decryption of the distinct plaintext image, and the embedded records can be instantly removed from the encrypted domain. A half of the cipher textual content pixel values are altered for records embedding in the reversible scheme, which preprocesses the histogram decrease before encryption. Data can be extracted in plaintext on the receiving end. [4]

Fashion is a stable reversible picture data concealing (RICH) topic that operates across the encrypted domain, according to J. Malathi. It demonstrates a public key modulation technique that enables the United States of America to plant data using clean XOR operations without requiring access to the crucial encoding key.

Applying a strong two-elegance SVM classifier to distinguish between encrypted and non-encrypted image patches is advocated at the decoder level. This will allow the active North American U.S.A. to jointly decipher the hidden message and, as a result, the unique picture sign dead. [5]

PROPOSED SYSTEM

The original image must be fully recovered without any loss and the hidden messages must be fully extracted on the receiving side without any distortion in order to create a system that uses camouflage images and enables users to embed additional data into the images without accessing the original contents.

Proposed Architecture

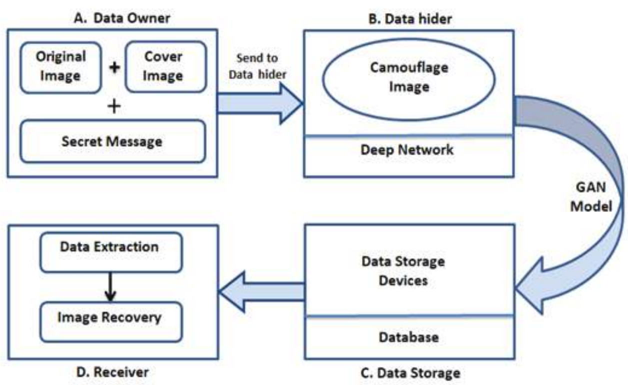

Fig.1. Proposed Architecture

Modules

The following modules are part of the system.

A. Data Owner

B. Data Hider

C. Devices for Data Storage

D. The recipient

Data Owner

The data owner section handles that.

Selecting the image as input: The original cover image is a color image.

Encrypt one image into another: A key is used to encrypt the original image into a different plaintext image. The camouflage image is generated and fed into the data hider.

Data Hider

The following features are available in the Data Hider section.

a. Data Encryption: A data-hiding key is used to hide the secret data that will be placed in the camouflage image. The data storage device receives a camouflage image that contains secret data. The data storage device module comes next.

Data Storage Device

The section on data storage devices covers a. Data Embedding: Any RDH display can be used to open text images and locate stored (perhaps external) extra information on camouflage images.

Data Removing: Any traditional flat RDH imaging technique can be used to add storage devices—possibly external ones—to camouflage photos. The data is added as input to the receiver along with the camouflage-formatted image.

Receiver

The key for decryption will be in the possession of the recipient, who may be the content's owner or someone with an approved key.

a. Image decryption: The receiver receives a camouflage image created by the data hider. The decryption key was used to recover the image.

Objective of the System

1. To reversibly and losslessly incorporate the extra data (text and audio) into the camouflage photos.
2. To enhance the camouflage image quality
3. To use a deep neural network to embed and extract the data from the image.
4. To create a Generative Adversarial Network (GAN) in order to accomplish real-time steganography.
5. To successfully restore the original plaintext picture.

Method of Implementation

Lossless Reversible Data hiding

The technique known as reversible data hiding (RDH) covers data and recovers the original data when the embedded data has been eliminated. It is a crucial technique that is widely applied in law enforcement, the military, and medicine. where it is unacceptable for the unique cover to be distorted. Since its initial presentation, RDH has drawn a lot of research interest.

RDH Embedding

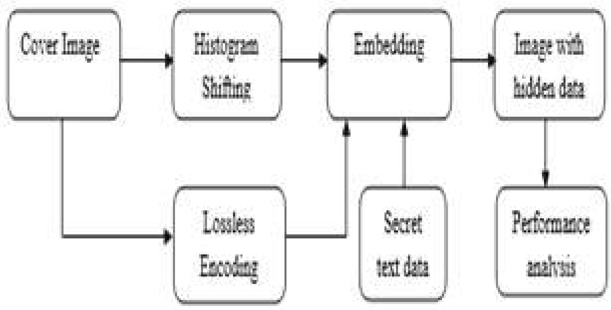

Fig.2. RDH Embedding

RDH Extraction

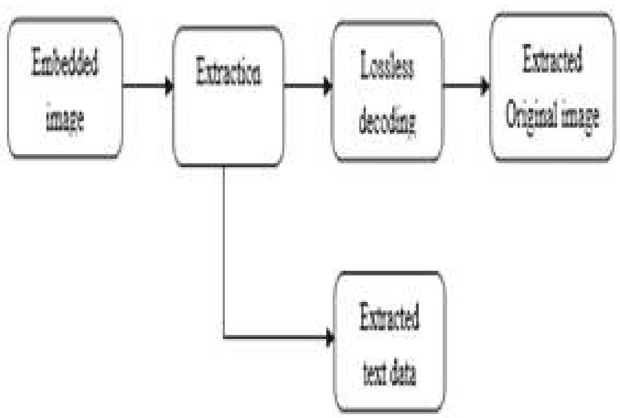

Fig.3. RDH Extraction

GAN(Generative Adversarial Network) Model

Information transmission has become strategic due to the quick development of information technology. Information security needs to be evaluated in order to avoid child information.

As a result, the skill of information concealment has gained popularity. In specifically, the symmetrical method of processing and conveying symmetrical data in the carrier envelope is used in the reversible data concealment (RDH) methodology. Not only is it possible to communicate fully acknowledged and undiscovered secret information, but the media envelope can also recover it without compromising its integrity. Additionally, the encryption methods can safeguard your private information and email service. The vector, on the other hand, is an encrypted version of ciphers, which is likely to draw in attackers. For RDH signaling, encrypted pictures are produced by counter-generative networks (GANs). A hidden network is part of the four-phase test that the network architecture is made for.

Pearson Correlation Coefficient

Correlation: The correlation coefficient is the ratio of the generated images to the original (uncompressed) images. The Pearson Correlation Coefficient (CSP) between pictures was computed as ρ.

Mathematical Formulation

Encoding Formula

Yi = Ek(Xi),

where Ek() is the encryption function and Yi is the corresponding cipher-text to Xi.

Sizes of Xi and Yi are identical.

Decoding Formula.

Xi = Dk(Y 0i) if σ(Dk(Y 0i)) < σ(Dk(Y 1i)) = Dk(Y 1i) else.

Showing Quality of Image with PSNR

Peak Signal Noise Relation (PSNR) is that the ratio between the utmost attainable power of a picture and also the power of corrupting noise that affects the standard of its illustration.

$$PSNR = 10\log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$

Mean square Error (MSE) or Mean square Deviation (MSD) of AN expert measures the common of error squares i.e. the common square distinction between the calculable worth's and true value. It's a risk operate, love the first moment of the square error loss.

$$MSE = \frac{1}{N}\sum_{i=1}^{N}\left(Y_i - \hat{Y}_i\right)^2$$

5.SSIM- Structure similarity (SSIM) index for grayscale image or volume A mistreatment referee because the reference image or volume. a worth nearer to one indicates higher image quality.

$$\text{SSIM}(x, y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

Pearson Correlation Coefficient

The Pearson method is widely used in statistical analysis, pattern recognition, and image processing. In this case, the applications include two images displayed in one image file.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Embedding Capacity

$$\text{Relative Capacity} = \frac{\text{Absolute Capacity}}{\text{Size of the Image}}$$

Dataset Used

http://www.vision.caltech.edu/datasets/

Caltech101 with 101 different types of object 50 images per class

Software requirement specification

Python

Spyder Software

Hardware requirement specification

Laptop

EXPERIMENTAL RESULTS

Main Option for Users

Fig. 4. Main Window of Project

The project's main window, which the data owner, data hider, and data receiver can use to continue working, is depicted in Fig. 4.

Calculation of Embedding Capacity

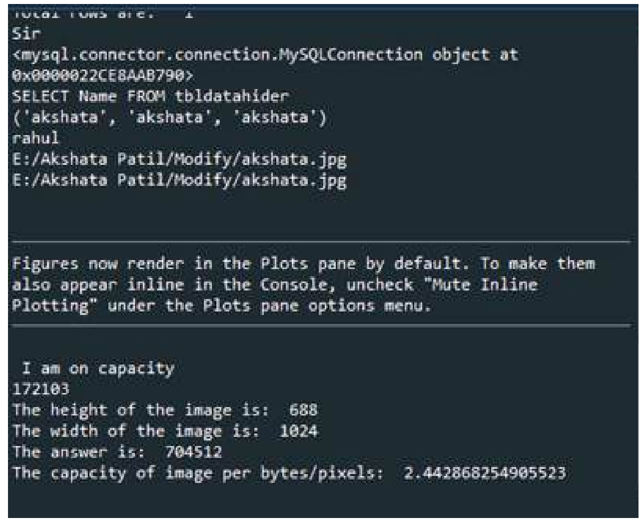

Fig. 5. Calculation of Embedding Capacity

Fig.5 Shows embedding capacity of image per bytes/ pixels.

Creation of Camouflage Image

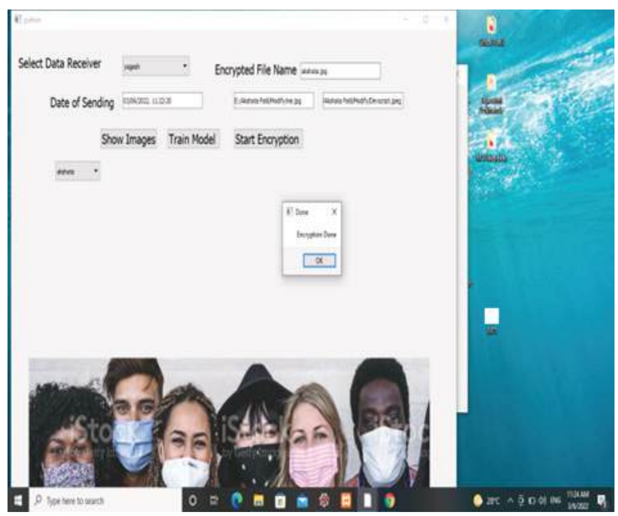

Fig. 6. Creation of Camouflage Image

Figure 6 illustrates how to create a camouflage image by combining cover and secret images and adding a data hider to the encrypted file name. We merge the two photos into a single image because the procedure is reversible.

Decryption of Information

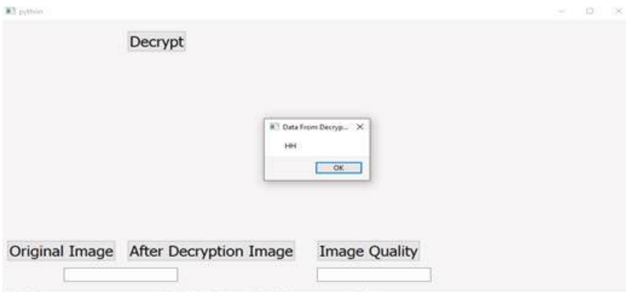

Fig. 7. Decryption of Information

The permitted file can be decrypted by the recipient, as shown in Fig. 7. Here, we decrypt using a network of encoders and decoders.

GAN Model Evaluation

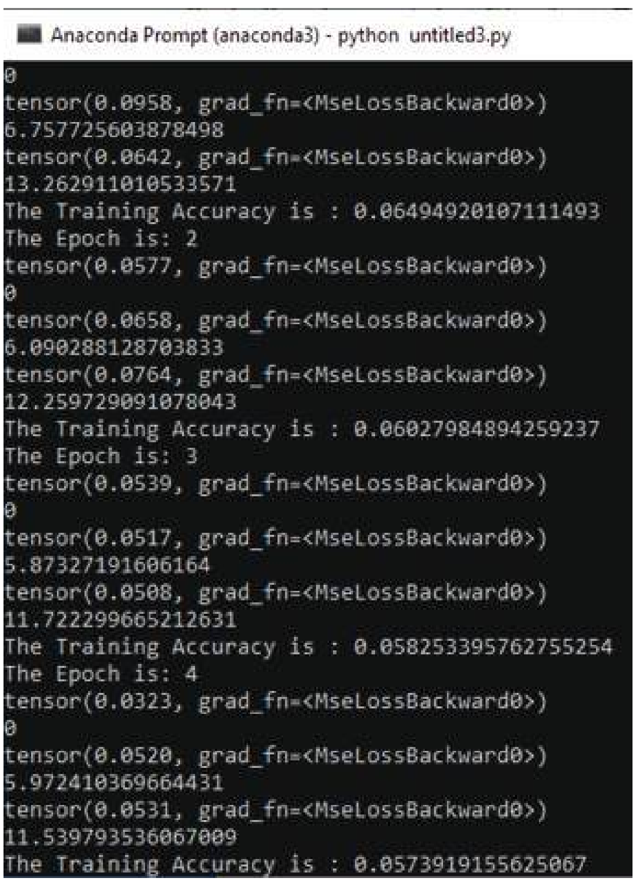

Fig.8. GAN Model Evaluation

The Fig.8 Shows the GAN Model evaluation and iteration

Image Quality- Evaluation Metrics

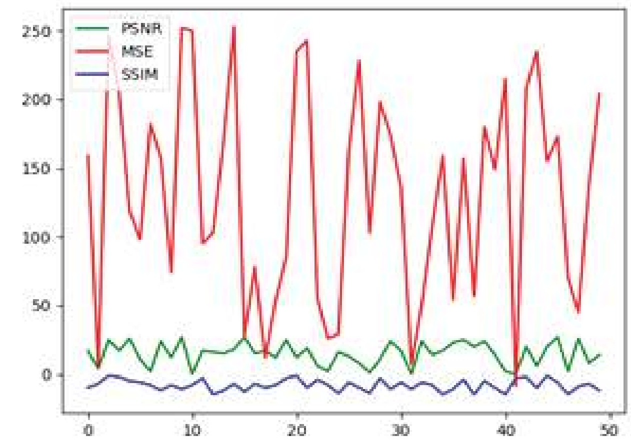

Fig. 9. Image Quality –Evaluation Metrics.

The Fig. 9 Shows the Image Quality- Evaluation Metrics of PSNR, MSE and SSIM.

Evaluation Metrics

Table 1. Evaluation Metrics

Image Name	PSNR	MSE	SSIM
Me.jpg	28.84	254.60	0.89
Devscript.jpg	30.37	178.83	0.86
Test.jpg	39.10	23.96	0.98
Test1.jpg	39.93	19.78	

Image Histogram before Encryption

Similar to alternative histograms, a picture's histogram concurrently displays frequency. On the other hand, a picture bar graph displays the intensity values and frequency of pixels. The grey level intensities are displayed on the x axis of a picture bar graph, and the frequency of those intensities is displayed on the y axis.

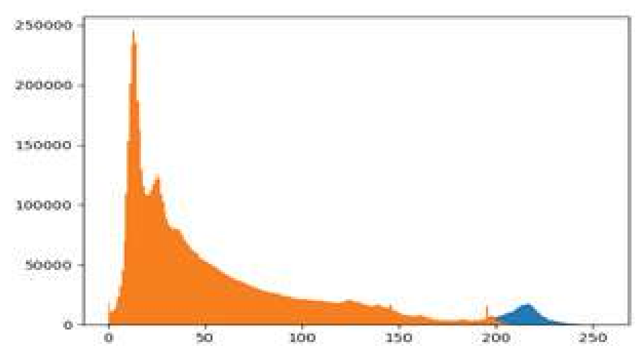

Fig. 10. Image Histogram before Encryption

The bar chart's x axis displays the range of pixel values. There are 256 levels of grey or reminder grey in the image because it is an associate degree eight bpp image. For this reason, the x-axis variation begins at zero and ends at 255 with a spot of fifty. In contrast, the count of those intensities is shown on the y axis. As you can see from the graph, practically every bar with a high frequency falls inside the darker half of the curve. indicating that our current image is darker. Additionally, the image may be used to test this.

Image Histogram after decryption

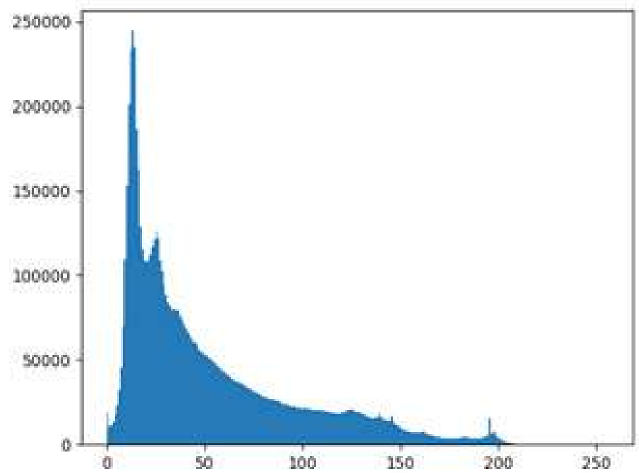

Fig. 11. Image Histogram after Decryption

Gray Scale Variance

There are two primary benefits to using the color image process: Foreground color can be a strong descriptor that facilitates item detection and extraction from a scene. Second, compared to 24 shades of gray, a man can distinguish thousands of hues and intensities. Each color is represented by its primary spectral components—red, neutral, and blue—in the RGB model. The Cartesian coordinate system serves as the foundation for this approach. Three-element images are included in images created using the RGB color model. These three phosphorescent screen images—one for each primary—combine to create a composite color image when they are put into the corresponding RGB screen. Element depth is the term used to describe how many bits each RGB package element represents. Examine a degree-assigned RGB image in which no blue image has ever been used on an 8-bit image.

Fig. 12. Gray Scale Variance

The Fig.12 shows the gray scale variance.

Co-Efficient Correlation

Fig. 13. Co-Efficient Correlation

The Fig 13 Shows the Co-Efficient relation between images.

CONCLUSION

In this paper, we have tested a novel framework for reversible image transformation (RIT) backed by reversible data concealment in the encrypted image (RDC-EI). It differs from earlier frameworks that converted plaintext images into a sort of ciphertext. In order to protect the image's privacy, it embeds one image into another. Consequently, some of the shapes of plain text images are also present in encrypted images. The data in this paper was encrypted and decrypted using the CNN and GAN Model with RDH method. We first determine the embedding capacity in this method. In order to increase accuracy and reduce iterations, the Self GAN model is employed.

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Machine Learning Based Traffic Accident Risk Prediction using Random Forest Algorithm

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ABSTRACT

We propose leveraging machine learning, specifically the Random Forest algorithm, to predict traffic accident risk. By analysing historical accident data alongside various relevant factors such as weather conditions, road characteristics, traffic density, and time of day, our model aims to accurately forecast the likelihood of accidents occurring at specific locations. Random Forest, known for its ability to handle large datasets and complex interactions, is utilized to construct a robust predictive model. Our research demonstrates the effectiveness of machine learning techniques, particularly Random Forest, in traffic accident risk prediction. These insights can be valuable for policymakers, urban planners, and transportation authorities in enhancing road safety and reducing the occurrence of traffic accidents.

KEYWORDS: *Machine learning, Road accident, Traffic accident, Geo-location.*

INTRODUCTION

Machine Learning

This creation units the level for exploring the function of gadget mastering in visitors' protection management, highlighting its cap potential to revolutionize twist of fate prediction, chance assessment, and proactive protection measures. By harnessing the strength of gadget mastering, we will paintings closer to growing more secure and greater sustainable transportation systems, in the long run saving lives and mitigating the societal and financial effects of visitor's accidents. The essence of gadget mastering lies in its cap potential to extract significant styles and insights from great and complicated datasets, hence uncovering precious understanding that won't be obvious via conventional analytical methods. By leveraging strategies along with supervised mastering, unsupervised mastering, and reinforcement mastering, gadget mastering algorithms can determine difficult relationships inside data, become aware of trends, and generalize from beyond reports to make knowledgeable predictions approximately destiny events.

Road Accident

Road injuries constitute an extensive worldwide public fitness and protection concern, inflicting great human suffering, monetary losses, and societal disruption. Every year, hundreds of thousands of lives are misplaced or completely altered because of avenue injuries, making it one of the main reasons of loss of life and harm worldwide. These injuries can arise because of a large number of factors, which include human error, inclusive of speeding, reckless using, and using below the have an impact on of alcohol or drugs; environmental factors, inclusive of damaging climate situations or poorly maintained roads; and vehicle-associated factors, inclusive of mechanical screw ups or defects

Traffic Accident

Traffic injuries, additionally referred to as street visitor's collisions or crashes, are incidents that arise on roadways regarding vehicles, pedestrians, cyclists, or different street users. These injuries can bring about numerous stages of harm to vehicles, accidents to individuals, or even fatalities. The effects of visitor's injuries may be intense, ensuing in accidents starting from minor cuts and bruises to intense trauma, everlasting disabilities, or fatalities. Moreover, visitor's injuries impose good sized monetary expenses on society, together with scientific expenses, assets harm, lack of productivity, and criminal fees.

Geo-Location

Geolocation, quick for geographic place, refers back to the identity or estimation of the real-global geographic place of an object, including a person, device, or place, the usage of diverse technology and techniques. Geolocation performs an important position in several programs and industries, which includes navigation, mapping, logistics, emergency offerings, marketing, and social networking. Overall, geolocation era has turn out to be a quintessential a part of contemporary life, allowing a extensive variety of programs and offerings that depend upon correct and well timed place information.

LITERATURE REVIEW

Tiwari P [6], et al. has proposed in this paper, in every nation, traffic and street coincidence are a serious challenge. Road coincidence effects on a variety of items, including property damage, unique damage stages, and a high death toll. Technological data knowledge can be used to investigate unique causes behind traffic and street coincidences, in addition to weather, street, time, and other variables. We presented novel class and grouping approaches for research data in this work. We used unique classifiers such Decision Trees, Lazy Classifiers, and Multilayer Perceptron Classifiers to categorise the dataset according to casualty classes. Additionally, we used k-way and hierarchical clustering algorithms to group the datasets. Initially, we used those classifiers to analyse the dataset, and we performed accuracy tests at several stages, followed by clustering strategies and class strategies on the resulting clustered data. When clustering algorithms were used to a dataset as opposed to one that was categorised without clustering, our accuracy stage increased at a few points.

Tarik Agouti [23], et al. has proposed in this paper, today`s ultra-related global is producing a big quantity of statistics saved in databases and cloud surroundings mainly withinside the generation of transportation. These databases want to be processed and analyzed to extract beneficial data and gift it as a legitimate detail for transportation managers for similarly use, consisting of avenue protection, delivery delays, and delivery optimization. The capacity of statistics mining algorithms is essentially untapped, this paper indicates large-scale strategies consisting of institutions rule evaluation, more than one standards evaluation, and time collection to enhance avenue protection via way of means of figuring out hot-spots earlier and giving threat to drivers to keep away from the dangers. Indeed, we proposed a framework DM-MCDA primarily based totally on affiliation policies mining as a initial challenge to extract relationships among variables associated with a avenue accident, after which combine more than one standards evaluation to assist decision-makers to make their desire of the maximum applicable policies. The evolved gadget is bendy and permits intuitive advent and execution of various algorithms for an in depth variety of avenue visitors subjects. DM-MCDA may be multiplied with new subjects on demand, rendering information extraction extra strong and offer significant data that would assist in growing appropriate regulations for decision-makers.

Tiwari [22], et al. has proposed in this paper, Street coincidence analysis can be of great importance because it can reveal the relationship between several specific types of features that contribute to the formation of a street coincidence. Street characteristics, environment, visitor, etc. can all influence the street coincidence rate. Street coincidence analysis can provide information on the role of these features in overcoming the chance of a coincidence rate. Data mining is one of the most popular ways of examining a street coincidence dataset. In this study, we have implemented street coincidence type based on the idea of a street consumer category.

After classifying the facts using the self-organising map and k-modes cluster technique, we have performed Support to classify the facts using decision trees, naive Bayes (NB) and support vector machine (SVM). We have applied type to facts with and without cluster. The final outcome shows that after fact segmentation with k-modes, better k-modes accuracy can be obtained.

R.E. AlMamlook [19], et al. has proposed in this paper, Traffic injuries are one of the most significant challenges facing the industry. They are responsible for thousands of lives, injuries and fatalities each year, not to mention the financial losses. It is a critical task for transit systems to accurately predict the visitor's coincidence severity. This research attempt identifies trends for choosing a set of hard and fast influential factors and constructing a version to categorise injury severity. These styles are generated using a wide range of device learning methods. The coincidence records of the visitors are tested using supervised gadget mastery methodologies, such as the AdaBoost method, Logistic regression method, Naive bayes method (NB) and Random forest rule (RF). To address record imbalance, we use the SMOTE rule set. The RF version could prove to be a helpful tool for estimating the severity of visitors' injuries. In terms of overall performance, the RF rule set outperforms LR rule (75.5%) and NB rule (74.1%) and AdaBoost rule (70.5%).

J.Y. Wang [26], et al. has proposed in this paper, the duration of visitor prognosis is incredibly long for the rapid handling of visitor injuries, especially for immediate rescue of injuries and elimination of risks to their safety. This study uses methods mainly based on Artificial Neural Networks (ANN) and Support Vector Machines (SVM) to predict the fate length spiral. A case study using data on approximately 235 injuries that occurred on highways between Dalian and Shenyang from 2012 to 2014 validates the proposed method. The performance of the two measures is evaluated using mean absolute error (MAE), root mean square error (RMSE) and mean absolute percentage (MAPE). The conclusions are as follows: Both ANN and SVM models were able to predict the fate of the visitor accurately within the length of the spiral. For long-term events, the ANN transformation achieves a better final result. The SVM version generally performs better than the ANN version in predicting the length of twists in the fate of website visitors.

EXISTING WORK

Vehicle injuries are a great challenge worldwide, main to lack of life, injuries, and monetary costs. Addressing this difficulty calls for powerful prediction fashions that may perceive cap potential dangers and mitigate them proactively. In latest years, gadget studying algorithms have proven exquisite promise on this domain, imparting the cap potential to examine significant datasets and extract significant insights to enhance street safety. In a latest have a look at carried out via way of means of researchers, Python turned into hired because the programming language to put into effect gadget studying algorithms for predicting car twist of fate dangers. The have a look at cantered on comparing the overall performance of various algorithms in diverse city street environments, which include situations concerning unique occasions including injuries and transient street controls.

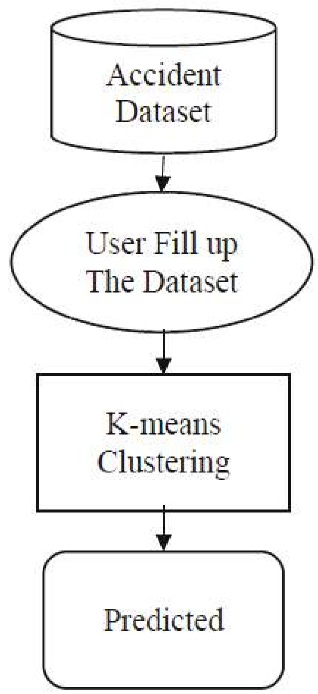


Fig. 1. Existing Workflow

Finally, the researchers used the educated prediction fashions to expect the real-time coincidence hazard of motors primarily based totally at the range of motors and the driver`s age band as category conditions. The consequences have been visualized the usage of color-coded regions and points, with blue indicating low coincidence probability, white indicating slight hazard, and crimson indicating excessive hazard. The visualization confirmed that because the newest release value (n) increased, the output of the prediction version become constantly optimized, main to clearer differences among extraordinary hazard levels.

PROPOSED WORK

Traffic injuries pose big threats to public protection and infrastructure worldwide. Addressing this problem calls for proactive measures, consisting of the prediction of twist of fate danger to mitigate their impact. Machine gaining knowledge of gives promising solutions, with the Random Forest set of rules status out for its effectiveness in coping with complicated datasets and imparting correct predictions. This precis outlines the important thing additives and standards worried in growing a system gaining knowledge of-primarily based totally machine for predicting site visitors twist of fate danger the use of the Random Forest set of rules, with a focal point on Python implementation.

Data Collection And Preprocessing

Collect applicable facts bearing on site visitor's accidents. This ought to encompass elements consisting of climate conditions, avenue type, time of day, ancient twist of fate facts, car sorts involved, etc. Pre-procedure the facts to address lacking values, outliers, and inconsistencies. This would possibly contain facts cleaning, normalization, and function engineering.

Feature Selection

Identify the maximum applicable capabilities that would have an effect on the chance of a visitor's coincidence. These capabilities may consist of street conditions, weather, visitors' density, time of day, etc. Select capabilities primarily based totally on their significance in predicting coincidence risk.

Model Training With Random Forest

Make use of the Random Forest method, an ensemble learning strategy that relies on selecting bushes. In order to increase accuracy and reduce overfitting, Random Forest constructs a few selection bushes and combines their predictions. Train the Random Forest version using functions identified as useful coincidence risk predictors on the pre-processed dataset.

Model Evalution

Use appropriate overall performance metrics such as accuracy, precision, recall and F1 score to evaluate the trained version. Ensure that the version is generalizable using methods such as cross-validation to confirm its overall performance.

Hyperparameter Tuning

You can maximize the overall performance of the Random Forest version by adjusting its parameters. This may include changing the number of trees, the maximum tree density, and the minimum number of samples required to prune a node. Use appropriate general performance criteria such as precision, accuracy, recall and F1 scores to evaluate the expert version. Ensure that the version is generalizable using methods such as cross-validation to confirm its overall performance.

Prediction

Once the version is educated and evaluated, it is able to be used to expect the probability of visitor's injuries primarily based totally on new enter data. Given a hard and fast of capabilities describing modern conditions (e.g., weather, street type), the version can expect the threat of a visitors twist of fate occurring.

Deployment and Monitoring

Deploy the educated version in a manufacturing surroundings in which it could offer real-time predictions. Continuously reveal the version`s overall performance and replace it as important with new records to make certain its accuracy and relevance over time.

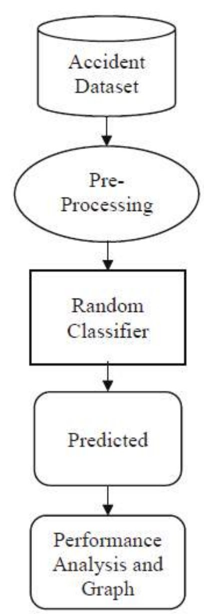
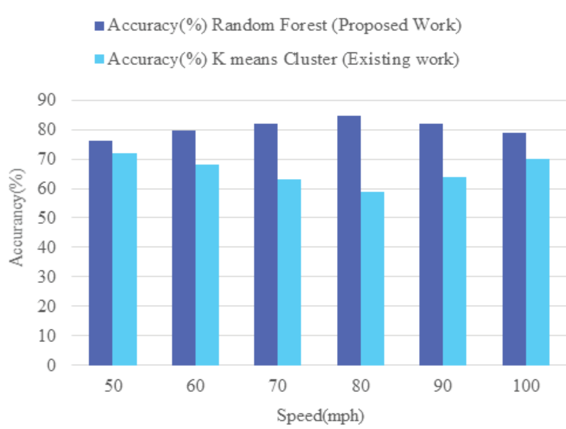


Fig. 2. Proposed Workflow

Result Analysis

Speed(mph)	Accuracy(%)	
	Random Forest (Proposed Work)	K means Cluster (Existing work)
50	76.2	72
60	79.5	68
70	82.1	63
80	84.6	59
90	81.8	64
100	78.9	70

In the proposed work utilizing Random Forest, the accuracy of predicting traffic accident severity increases with higher speeds. At 50 mph, the accuracy stands at 76.2%, climbing to 79.5% at 60 mph and reaching 82.1% at 70 mph. The accuracy peaks at 84.6% at 80 mph before slightly dropping to 81.8% at 90 mph and then to 78.9% at 100 mph. Conversely, in the existing work employing K-means clustering, the accuracy tends to decrease as speed rises. Starting at 72% at 50 mph, the accuracy diminishes to 68% at 60 mph and further to 63% at 70 mph. At higher speeds, the accuracy decreases even more significantly, with a drop to 59% at 80 mph, a slight recovery to 64% at 90 mph, and a subsequent increase to 70% at 100 mph.



ALGORITHM DETAILS

One well-known machine learning technique that falls under the category of supervised learning is Random Forest. It can be applied to any ML problem involving classification and regression. It is largely based on the concept of ensemble learning, which is a way of combining a number of classifiers to improve the overall performance of a model and solve a complex problem.

By description, "Random Forest" is a classifier that consists of selection trees from different subsets of a given data set and takes a join to improve the predictive accuracy of that data set. A random forest uses and largely depends on the prediction of each tree, rather than computing a single selected tree based entirely on the collective votes of the predictions, and it predicts the final product. A higher number of bushes in the forest area improves accuracy and removes overflow.

Random Forest Algorithm

The way Random Forest operates is in two parts: the first part involves creating the random woods by joining N selection trees, and the second part involves creating predictions for each tree that is formed in the first part.

Step 1: From the education set, choose K information factors at random.

Step 2: Construct the timber selection in accordance with the selected information variables (Subsets).

Step 3: Select the large variety N of wood that you need to build.

Step 4: Carry out Steps 1 and 2.

Step 5: Find each selection tree's predictions for new information factors, then allocate the newly discovered information factors to the class that receives the majority of votes.

Pseudo Code

```
class DecisionTree:
        def __init__(self):
        def fit(self, X_train, y_train):
def predict(self, X_test):
class RandomForest:
        def __init__(self, n_trees):
        self.n_trees = n_trees
        self.trees = []
def fit(self, X_train, y_train):
```

```
    for _ in range(self.n_trees):
X_subset, y_subset = randomly_select_subset(X_train, y_train)
        tree = DecisionTree()
        tree.fit(X_subset, y_subset)
        self.trees.append(tree)
def predict(self, X_test):
    predictions = []
    for tree in self.trees:
        predictions.append(tree.predict(X_test))
 final_predictions = []
    for i in range(len(X_test)):
        votes = [predictions[j][i] for j in range(self.n_trees)]
        final_predictions.append(majority_vote(votes))
    return final_predictions
def randomly_select_subset(X_train, y_train):
    def majority_vote(votes):
```

CONCLUSION

In conclusion, the utilization of machine learning techniques, specifically Random Forest, for predicting traffic accident risks presents a promising approach with significant potential for enhancing road safety measures. Through the analysis of various features such as weather conditions, road characteristics, and historical accident data, Random Forest models can effectively discern patterns and relationships that contribute to accident occurrence.

The benefits of using Random Forest for site visitors twist of fate danger prediction consist of its cap potential to address massive datasets with several enter variables, its resilience to overfitting, and its capability to offer insights into the relative significance of various features. Moreover, the interpretability of Random Forest fashions lets in stakeholders to apprehend the elements influencing twist of fate risks, thereby facilitating centred interventions and coverage decisions.

FUTURE WORK

Experiment with extraordinary hyperparameters of the Random Forest set of rules together with the variety of trees, tree depth, and minimal samples consistent with leaf. Additionally, take into account the usage of ensemble strategies like Gradient Boosting or XGBoost, which frequently outperform Random Forest in predictive accuracy. By specializing in those areas, destiny paintings can improve the todays in device learning-primarily based totally site visitors' coincidence threat prediction, main to extra correct fashions and in the long run enhancing avenue safety.

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Lung Cancer Detection using Machine Learning and Deep Learning: A Review

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ABSTRACT

Worldwide lung cancer is a fatal disease. Timely disease detection is vital for improving patient results and survival rates. Technological advancements have significantly impacted early disease detection by minimizing human error in the investigation of medical images. Recently, the employment of Computer Tomography (CT) scans for cancer detection has emerged as a prominent research area within medical imaging. Accurate identification of lung cancer locations and sizes is paramount for effective diagnosis and subsequent treatment. Though substantial advancement has been achieved, the performance of the deep learning approaches, mainly convolutional neural networks are worthier in analyzing lung CT or MR images for disease detection. Early detection of lung cancer facilitates more effective treatment options and improves the chances of successful disease management. This review paper explores various deep learning and machine learning methodologies employed for detection of lung cancer.

KEYWORDS: *Convolutional neural network, Computer tomography, Machine learning, Deep learning.*

INTRODUCTION

The lungs in human body are vibrant organs accountable for gas exchange, inhalation (absorbing oxygen) and exhalation (releasing carbon dioxide). Malignant lung cancer caused by multiplication and uncontrolled growth of lung cells. Worldwide, lung cancer is a major cause of mortality. As per World Health Organization, 10M fatalities, 2.21M new cases of lung cancer, and 1.80M related deaths in 2020 alone are reported [1,2]. The overlapping nature of cancer cells often delays early detection of cancer. Identification of cancer at initial stage is important as it considerably improves better treatment and survival rates. To detect the cancer, DL (Deep Learning), specifically Convolutional Neural Networks (CNNs), are established effectively in medical image processing, using CT scan or MR images [3]. For lung cancer identification, this study intentions to review the various deep learning and machine learning algorithms. It demonstrates latest accomplishments in lung cancer segmentation, classification, and detection of the disease. This review paper focuses state-of-the-art deep learning techniques for detecting lung cancer, and current achievements. The remainder of this paper is structured as follows. Section II elaborates Imaging Techniques, section III presents Literature Review, section IV gives Dataset, and Performance Metrics, section V presents Research gap and challenges, section VI gives conclusion and future scope.

Types of lung cancer

A malignant tumour initiates in the lung known as lung carcinoma or lung cancer. It is influenced by multiple reasons, comprising smoking, exposure to injurious airborne particles, genetic predisposition, aging, gender, and other environmental or lifestyle factors [4,5]. Smoking is a primary cause, not only for smokers but also for individuals exposed to second hand smoke. Common symptoms associated with lung cancer that can aid in its screening include yellowing of fingers, chronic fatigue, anxiety, allergic reactions, wheezing, persistent coughing (including coughing up small amounts of blood), hoarseness, breathing difficulties, chest discomfort, headaches, bone pain, and issues with swallowing [6,7]. In addition to smoking and passive smoking, other contributing factors include exposure to asbestos, silica, workplace chemicals, diesel exhaust, air pollution, radon gas, family's medical history of lung cancer, poor diet, and lack of physical activity [8]. Among these, prolonged smoking is the foremost cause of lung cancer [9].

Lung cancer is primarily categorized into two main types based on the microscopic appearance of cancer cells:

- Small Cell Lung Cancer (SCLC): This is the cancer that arises less frequently, approximately 10%-15% among all cases of lung cancer. SCLC is highly aggressive, spreads very fast and often recurs after initial treatment with chemotherapy[10,11].
- Non-Small Cell Lung Cancer (NSCLC): This is very common form of cancer than SCLC, comprising over 80% of cases but spreads slowly. NSCLC consists of three subtypes are adenocarcinoma, squamous cell carcinoma, and large cell carcinoma [10,11].

In 2018, GLOBOCAN reported around 2.09M new lung cancer cases and 1.76M demises attributed to the disease [12]. Globally, the occurrence and fatal rates of lung cancer have increased significantly [12]. Non-small cell lung cancer (NSCLC) reported in approximately 85–88% of cases, while small cell lung cancer (SCLC) makes up about 12–15% [13]. Fig.1 illustrates CT scans comparing normal lungs with cancerous lungs.

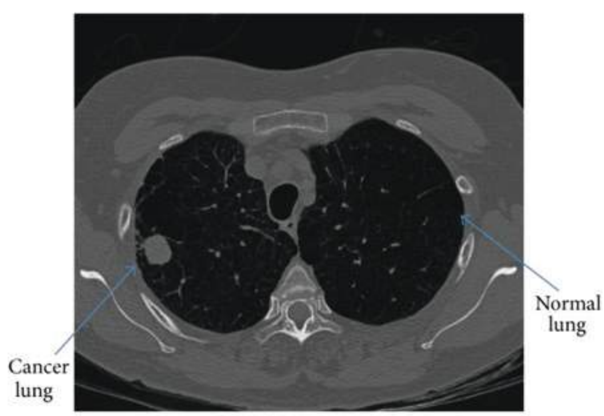

Fig. 1. CT image of Cancer and normal lung[14]

IMAGING TECHNIQUES

Various advanced screening approaches are employed to detect lung cancer, allowing medical professionals to examine internal body processes and evaluate organ functionality. These techniques play an important role in identifying lung abnormalities. Various imaging techniques include Positron Emission Tomography (PET), Chest Radiography (X-ray), CT scan, Ultrasound, and MR imaging, providing a comprehensive approach to diagnosis and assessment. Fig. 2. shows a few modalities utilized in identification of lung cancer[17].

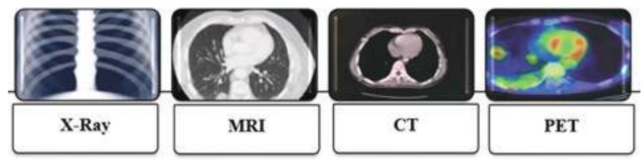

Fig. 2. Modalities in lung cancer detection[17]

For analysing lung cancer, MRI and CT scan modalities are broadly employed. Kalaivani et al. [18] proposed a DenseNet model using CT scans for detection of lung cancer. Similarly, to detect lung cancer, Rahane et al. [19] utilized CT scans and Joshua et al. [20] used both CT and MR images, Singh et al. [21] explored the use of X-ray, CT, and MR images, whereas Chaturvedi et al. [22] explored ML models with X-ray, MRI, and CT scans. Also, Riquelme et al. [23] concentrated on classification of lung cancer with CT scans.

LITERATURE REVIEW

DL(Deep Learning) and ML (machine learning) based models have been proposed to support clinicians for lung cancer detection. This paper presents an outline of the proposed methods for lung cancer prediction and highlight on their strengths, weaknesses, and challenges in the development and justification of such techniques.

Machine Learning Methods

Machine learning models are mostly used for recognition of lung cancer. Bansal et al. [25] projected an approach uniting Random Forest and XGBoost for examining CT images to identify lung cancer. Several machine learning models are evaluated by Radhika and Nair [26], consisting Naïve Bayes, Decision Tree, Logistic Regression, and Support Vector Machines (SVM). Pradhan and Chawla [27] proposed a new approach, Medical Internet of Things (MIoT) where a ML models is integrated with a novel architecture for disease detection. Rehman et al. [28] proposed a method using ML models with SVM and Artificial

Neural Networks (ANN) with CT scans to detect the disease Fatima F. et al. [29] proposed a hybrid approach combining ML, DL techniques, particle swarm optimization (PSO), and ensemble learning for cancer detection. The study highlighted that ensemble learning delivers superior accuracy in comparison with the traditional machine learning techniques. Bharathy S, P. R et al(2022)[30], lung cancer detection using machine learning typically involves training models on large datasets of chest radiographs (X-rays or CT scans). Common methodologies include convolutional neural networks (CNNs), segmentation using marker controlled watershed and threshold, for classification SVM, Naïve Bayes, Random Forest, KNN and Logistic Regression are used. Results have shown promising accuracy of 88.5% using Random Forest in identifying potential lung nodules and classifying them as benign or malignant. However, limitations include the potential for bias in datasets, the need for large and high-quality datasets, and the challenge of interpreting and explaining model predictions, which is crucial for clinical decision-making. Nageswaran, S.et al(2022) [31] proposed method for recognition of lung cancer with artificial neural network. Initially Preprocessing is done using geometric mean filter to enhance image quality, image is segmented using K-means technique. Machine learning classification methods such as ANN, KNN, and Random forest are used. Author proposed that ANN model gives more accurate results for detection of lung cancer. Kareem, Hamdalla F. et al (2021)[37]This study evaluated the performance of Support Vector Machines (SVM) in detecting lung cancer in a marked CT scan dataset. The methodology involved feature extraction techniques, such as texture analysis and shape descriptors, followed by SVM classification with different kernel functions. The SVM classifier attained high accuracy and sensitivity in differentiating between malignant and benign lung nodules. However, limitations include the potential for overfitting, the dependence on the quality of feature extraction, and the need for careful selection of kernel parameters and regularization techniques to optimize model performance.

Deep Learning Methods

Shah, A.A et al(2023) [32] proposed a DL model with 2D CNN consists of three neural layers, filters, and pooling techniques. This Deep Ensemble 2D CNN achieved 95% combined accuracy. Shimazaki et al (2022)[33] proposed a DL model with segmentation method to detect lung cancer. For the training and testing 629 radiographs, 151 radiographs respectively are utilized. This model achieved a lower sensitivity of 0.73 with 0.13 mFPI compared to the sensitivity of 0.87 of non-overlapped locations. The limitations of this work is that, dataset is collected from single hospital and it needed to evaluate the clinical usefulness of this system. Liangyu Li et al(2024)[34], this study investigated enhancing lung cancer detection by combining texture analysis features (GLCM) with deep learning-based auto encoder features. A hybrid feature vector was created and used to train a Support Vector Machine (SVM) classifier. Hyper parameter optimization techniques, such as grid search and cross-validation, were employed to fine-tune the SVM model. The hybrid methodology yielded significantly better performance However, limitations include the reliance on a specific dataset, potential for limited generalizability to unseen data, and the inherent interpretability challenges associated with deep learning features.

Yeh MC et al (2021)[35], this study used electronic medical records and proposed a deep learning neural network to predict lung cancer risk. In this study. This research utilised 11617 lung cancer patients and 1,423,154 control patients for evaluation. For overall population, the proposed method accomplished AUCs of 0.90 and 0.87 for patients having age more than 55 years. Khalaf Alshamrani et al(2024) [36], provides a DL model to identify lung cancer in chest CT images on limited dataset. While classification, the model illustrated a high level of performance, attaining 93.24% accuracy shows a considerable improvement over current state-of-the-art and provides early disease detection that potentially saves lives. Lakshmanaprabu SK, et al (2019) [24], explored an optimal DL model(ODNN) with 50 low dose CT images for lung cancer identification. Here, Linear Discriminative Analysis(LDA) is used for feature reduction. Proposed method classifies Normal, Benign and Malignant image with 94.56% accuracy, specificity of 94.2% and sensitivity of 96.2% compared to existing classifiers like KNN, NN, MLP, RBF, ANN, and DNN. As per author, proposed work does not predict the size of tumour, proposed work not evaluated on high dose CT images. Lanjewar MG, Panchbhai KG, Charanarur P (2023) [38], suggested a novel DL–based method with modification of DenseNet201 model on Kaggle dataset. This approach is evaluated usingROC curve, confusion metrx, Kappa score, 5-fold method, p-value, and Cohen's Matthews Correlation Coefficient. This method accomplished an average accuracy of 95%. Wang et al. [39] projected a DL model for image classification, with Fully Convolutional Network (FCN) to cancer diagnosis. Shin et al. [40], proposed a DL technique where features of exosome cells are explored and compared with human plasma for spectroscopic investigation for lung cancer diagnosis. Author demonstrated the accuracy of the model is 95% and can be benefitted for early stage cancer diagnosis. Avanzo et al. [41] suggested a method combining DL with radiomics to improve the efficiency of lung cancer detection. Liu et al. [42] investigated an approach with reinforcement DL approaches within the context of Medical IoT applications for recognition of lung cancer. Raoof et al [43] projected a ML framework consists of SVM and ANN for disease detection. Additionally, Kalaivani. et al [18] developed a CNN model and DenseNet model, utilizing CT scans for detection of lung cancer. Detailed literature survey is given in Table 1.

Table1. Literature survey

Author	Data base	Methodolo-gies	Observa-tion
Chaturvedi et al [19]	X-Ray, MR images, and CT images	ML	Machine Learning models using MRI, X-Ray, and CT-scan to detect lung cancer..
Joshua et al.[20]	CT images	ML	ML techniques with image processing techniques.
Fatima F.[29]	CT images	ML,DL, Ensemble learning,particle swarm optimization	Ensemble learning gives more accurate result than ML, DL,PSO.
Nageswaran, S.et al [31]	CT images	ML	ML model with ANN, KNN, and Random forest to detect lung cancer.
Raoof et al. [43]	CT images	ML	SVM, KNN is used to detect cancer
Wang et al[39]	CT images	DL	Fully Convolutional Network to identify lung cancer.
Shin et al[40]	CT images	DL	DL with SER Spectroscopy of exosomes for lung cancer detection.
Avanzo et al.[41]	CT images	DL	A novel architecture of DL with radiomics to identify lung cancer.
Shah et al.[32]	CT images	Deep learning	CNN model used to detect lung cancer
Liu et. al[42]	CT images	DL	DL approaches in presence of Medical IoT proposed for cancer detection.
Kalaivani.et al.[18]	CT images	CNN	DenseNet
Lanjewar et al [38]	CT images	DL	DL with DenseNet201

DATASET AND PERFORMANCE METRICS

For lung cancer detection, both publicly available and private datasets are utilized. The literature on this highlights the use of diverse datasets to evaluate the performance of DL systems. These datasets differ in terms of radiographic image, size, annotation precision, and the variety of lung cancer cases they cover. Such variations present the opportunities and challenges in developing ML and DL models that are accurate and generalizable. Commonly used performance metrics in deep learning and machine learning models for lung cancer detection includes Precision, Recall, Accuracy, and F1-score, as defined in their respective equations. Recall offers a qualitative analysis, while Precision delivers a quantitative analysis. The F1-score represents the harmonic mean of Precision and Recall, providing a balanced measure of both metrics [43,44].

$$Precision = \frac{TP}{TP + FP} \quad (1)$$

$$Recall = \frac{TN}{TN + FN} \quad (2)$$

$$Accuracy(\%) = \frac{TP + TN}{TP + TN + FP + FN} \times 100 \quad (3)$$

$$F1 - Score = \frac{2 * Precision * Recall}{Precision + Recall} \quad (4)$$

RESEARCH GAPS AND CHALLENGES

Recent progressions in deep learning methods have considerably enhanced the ability to detect, categorize, and analyse patterns in imaging data. Notably, developments in computer vision have driven its application in various medical imaging tasks, including image segmentation, computer-aided diagnosis, lesion detection, prognosis, and microscopic imaging analysis. Lung cancer, in particular, has been a major focus of research, promoting towards the progression of various deep learning-based approaches. However, there remains a need for more accurate early diagnosis of lung cancer. The varying appearances of lung nodules and the limited availability of existing datasets present challenges while training Deep Convolutional Neural Networks. Though some studies have aimed to predict mortality risks using CT scans of NSCLC patients, they have struggled to detect primary stage lung or lobe-specific malignant lesions.

CONCLUSION AND FUTURE SCOPE

This review paper presents a rigorous analysis of deep learning and machine learning approaches for lung cancer detection. This study explores existing methods, including ML, DL, and AI emphasizing their pros and cons while recognizing the research gaps. As per survey, DL algorithms given better performance for lung cancer detection. Still, performance of the ML, DL models using various pre-processing techniques, segmentation, feature extraction techniques can be improved. To achieve high accuracy class imbalance problem, need to overcome. Moreover, there is also a need to develop a lung cancer detection model capable of identifying among early benign nodules and small malignant lesions, that would significantly improves early detection and patient outcomes, and survival rate of the patient.

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An Ensemble Model for Cloud Workload Prediction Using LSTM-RNN and CNN

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ABSTRACT

Workload prediction is critical in cloud computing environments, as it accelerates resource allocation, system reliability, and performance. Most conventional approaches to workload prediction, based on traditional statistical methods and simple machine learning algorithms provide suboptimal predictions. The models do not handle temporal dependencies and pattern inheritance workload. To address these problems, there is a need to design a new approach for workload prediction that integrates advanced Machine Learning and Deep Learning algorithms. These algorithms will be able to capture the rich temporal and structural information contained in the workload time series data samples. This paper will designed and discussed a new ensemble model that would integrate Long Short-Term Memory Recurrent Neural Networks (LSTM-RNN) and Convolution Neural Networks(CNN) into a single model in handling workload predictions. It has been chosen to be LSTM-RNNs because they can very strongly capture long-term dependencies and temporal patterns from sequential data, which is an extremely special ability that makes the approach most suitable for any task in time-series forecasting. CNNs, while conventionally applied in image processing, have used detection features of fine patterns and anomalies through their convolutional layers, and these are applied effectively on samples of time-series data. In the ensemble model proposed, both the predictions of LSTM-RNN and CNN would be combined by techniques such as weighted averaging and stacking. In this way, the complementary strengths of each model can be leveraged. Such an Ensemble approach enhances not only prediction accuracy but also the robustness against some model-specific weaknesses. Preliminary numerical results indicate that the ensemble model outperforms other individual models of LSTM-RNN and CNN, reducing the MAE from 0.45 to 0.38, thereby making an improvement in prediction accuracy of around 10-15%. This work advances the state of the art in workload prediction by providing a more reliable and accurate forecasting tool that is important for the efficient management of computational resources. This represents a very promising scope of future research and practical applications. The results prove that this proposed model is an empirical framework useful for predictive analytics and system optimization.

KEYWORDS: *Workload prediction, LSTM-RNN, CNN, Ensemble model, Time-series forecasting.*

INTRODUCTION

In contemporary computing environments, the prediction of accurate workloads has long been a cornerstone of the optimization of resource allocation and stability in performance. To this end, it is expected that with the growth in complexity and scale of such systems will come a surge in the need for sophisticated prediction models that can handle large volumes of data, temporal dependencies, and intricate patterns. Classic statistical methods particularly ARIMA based methods are used for workload predictions by supplementing them with basic machine learning techniques[3]. However, all these methods usually lose the nonlinear and non-stationary properties inherent in workload data and, as a result, the accuracy of the prediction is reduced. In contrast especially Long Short-Term Memory with Recurrent Neural Network and Convolutional Neural Network, advanced neural network architectures have become very prominent tools in accomplishing time series forecasting. These models are suitable for capturing the temporal dynamics of workload patterns since, for these models, long-term dependencies in sequential data are specially cared for. On the other hand, CNNs, although originally designed for image processing, have proved extraordinarily fit for distinguishing and extracting relevant features from time series data through their convolutional layers[5]. The paper gives a novel approach towards workload prediction by integrating ensembles of LSTM-RNN with CNN[16]. This will help in utilizing the complementary strengths of the two models: the modeling efficiency of LSTM-RNN in temporal dependencies and that of CNN in the detection of intricate patterns and anomalies[7]. To enhance prediction accuracy, In this line, techniques like weighted averaging and stacking are proposed for combining models into an ensemble model, by which the prediction accuracy may be improved compared to the individual models.

The integration of LSTM-RNN and CNN into a unified framework for workload prediction. This paper not only complements the existing body of knowledge on workload prediction and consequently paves the way for further research and practical applications in predictive analytics and system optimization. It provides a new benchmark for predictive modeling in dynamic computing environments by incorporating all the advanced neural network architectures into an ensemble framework. The main contributions of this paper are given below.

To overcome the drawbacks of the traditional and simple machine learning algorithms, an ensemble model with the integration of LSTM-RNN and CNN is proposed.

This model captures the rich temporal and structural information contained in workload time series data samples.

The proposed model is evaluated with data collected from cloud simulated environment and calculated prominent performance metrics. The numerical results are compared with the three benchmark methods for identifying the efficacy of the ensemble model.

Analysis of the Numerical results is carried out and conclusions are drawn from it. Finally conclusions are drawn based on numerical results.

In this paper Section 2, discussed about the several approaches related to cloud workload prediction models. The architecture along with process flow of the ensemble model is explained in Section 3. The evaluated experimental results are analyzed and discussed in Section 4. The conclusions of the paper and future scope are presented in Section 5.

LITERATURE REVIEW

Workload prediction has been very well explored in the past few years, wherein several approaches have been put forward to improve the accuracy and efficiency of models related to such kinds of forecasting. This section reviews the relevant literature by pointing out advances and latest methodologies in the field. Sandoval et al. [1] presented a model for real-time team performance and workload prediction using voice communications. In this work, convolutional neural networks were applied for speech classification and cognitive load prediction demonstrating model's efficacy in monitoring team performance for better decisions. . Kim et al. [2, 3] proposed an ensemble prediction model using support vector machines and smoothing methods for cloud application workloads called CloudInsight, which significantly improved predictive resource management and autoscaling, thus enhancing performance evaluation in cloud computing environments. Seshadri et al. [4] designed a hierarchical characterization model of cloud workloads and a corresponding adaptive prediction model. Deep learning with graph embedding and Markov model for the realization of elastic cloud resource management and improving workload prediction accuracy with the use of a graph variational auto-encoder. Feng, Ding, and Jiang [5] proposed FAST, a forecasting model considering adaptive sliding window and time locality integrity for dynamic cloud workloads. The model in this paper focused on workload decomposition and adaptive sliding windows to optimize the accuracy of cloud computing workload prediction. Qiang Zhang et al. [6] have put forward a new hybrid model for workload prediction on Docker containers, which will combine LSTM Networks with triple exponential smoothing to compensate the nonlinear and seasonal characteristics of workloads inside containers, guaranteeing high accuracy in prediction.

Saxena et al. [7] contributed a performance analysis on machine learning-centered workload prediction models in a cloud environment. Various deep learning techniques have been surveyed in the current study for cloud workload prediction purposes using ensemble learning and evolutionary neural networks, in which hybrid learning strategies seem to be very promising. Li et al. [8, 9] proposed EvoGWP model that used deep graph-evolution learning toward long-term change predictions in cloud workloads. It utilized graph neural networks to capture the dynamic and interdependent nature of cloud workloads and greatly improved the accuracy of the long-term prediction. John et al. [10] examined some physiological correlates of changes in mental workload during tracking and collision prediction tasks. Through electroencephalography and other physiological techniques, valuable information related to the prediction of mental workload and its applications in human-machine systems is derived. Liu et al. [11] proposed a personalized trajectory-based risk prediction on curved roads considering driver turning behavior and workload. In this contribution, trajectory data is combined with workload prediction to improve vehicle dynamics in terms of safety and performance. Bi et al. [12] proposed a multi-application workload prediction model with the combination of ARIMA, wavelet decomposition and Savitzky-Golay filtering hybrid approach. It had better performance on cloud workload predictions for both short and long-term variations in different scenarios. Chen et al. [13] developed resource allocation of cloud-based software service models that enabled prediction by means of feedback control with reinforcement learning. It integrated the Q-value prediction with feedback control mechanisms for efficient resource management and quality of service levels. Kumar et al. [14] presented an autonomic workload prediction and resource allocation framework in fog-enabled Industrial IoT. Their technique integrated fog node resource allocation with workload prediction, using delay and execution time metrics to improve industrial IoT performance. Ding et al. [15] proposed COIN—a workload prediction model for containers that puts much emphasis on common and individual changes of workloads. This model made use of the similarity of containers and leveraged on-line learning to very good effect against dynamic changes in a containerized environment, thereby improving the accuracy of prediction with better resource management. These studies collectively underline the need for improvement in workload prediction methodologies that enhance the accuracy and efficiency of these predictions. The ensemble model presented in the paper builds upon these foundations of leveraging an LSTM-RNN for superior workload forecasting performance with the strengths of a CNN process.

ENSEMBLE MODEL FOR WORKLOAD PREDICTION USING LSTM-RNN AND CNN

The design of the proposed ensemble model is based on the strengths of Long Short-Term Memory Recurrent Neural Networks and those of Convolutional Neural Networks. The history related to workload data preprocessing will include metrics on levels, for example, those of CPU usage and memory usage. This data should be normalized to ensure uniformity and then divided into training set and test set. Subsequently, this LSTM-RNN model is then designed to capture the temporal dependencies existing in sequential data samples. Through the network of cells, this model processes the input data as X = {x1, x2, …, xt} sets. Each cell from the network maintains a cell state Ct and a hidden state ht in the process. The next equations update the states of the LSTM cell,

$$f_t = \sigma\left(W_f \cdot [h(t-1), x_t] + b_f\right) \quad (1)$$

$$it = \sigma(W_i \cdot [h(t-1), x_t] + b_i) \quad (2)$$

$$C{\sim}t = \tan h(WC \cdot [h(t-1), x_t] + bC) \quad (3)$$

$$Ct = f_t \odot C(t-1) + it \odot C{\sim}t \quad (4)$$

$$ot = \sigma(Wo \cdot [h(t-1), x_t] + bo) \quad (5)$$

$$ht = ot \odot \tan h(Ct) \quad (6)$$

Here, f_t stands for the forget gate, it for the input gate, C~t stands for candidate cell state, C_t for the cell state,

o_t stands for the output gate, and ht for the hidden state in this process. During training, the learned parameters are W_f, W_i, W_C, W_o; biases: b_f, b_i, b_C, b_o; activation functions σ sigmoid, tanh – hyperbolic tangent. These equations guarantee that the model preserves long-term dependencies and only updates its states selectively. On the other hand, CNN is used to look for the patterns of workload data through convolutional operations. The input data X will pass through some convolutional layers, after which each layer applies a set of filters to extract features from the data. The output of a convolutional layer is given by,

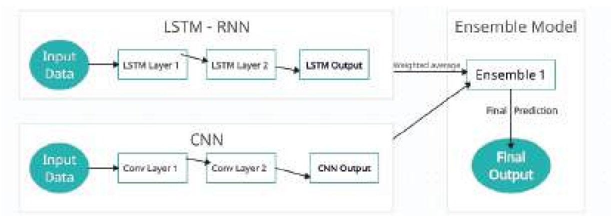

Fig. 1. Architecture of the Ensemble Model

$$h_i(l) = \sigma\left(\sum_{j=1}^{m}\left(h_i + j(l-1) * w_j(l) + b_j(l)\right)\right) \quad (7)$$

Where, $h_i(l)$ is the feature map at position i in layer l, $h_{i+j}(l-1)$ is the input feature map from previous layer, $w_j(l)$ are the convolutional weights, $b_j(l)$ are the biases, σ is an activation function and * represents the convolution operation. Consider y_{LSTM} and y_{CNN}, are predictions of LSTM-RNN and CNN, their predictions are given via the following equations,

$$y_{ensemble} = \alpha y_{LSTM} + (1-\alpha)\, y_{CNN} \quad (8)$$

Where α is a weighting factor, which is determined by cross-validation operations. Such combination exploits the temporal pattern recognition of the LSTM-RNN while exploiting the feature extraction capability of the CNN, hence leading to more accurate predictions. Equation 9 presents the Mean Squared Error used as the loss function for training the models.

$$L = \frac{1}{N}\sum_{i=1}^{N}(y_i - y_i')^2 \quad (9)$$

Where, y_i is the actual workload value, y_i' is the predicted value, and N is the number of observations. The models are trained using gradient descent, where gradients of the loss function w.r.t model parameters are computed and used to update the parameters & scenarios. The gradient ∇L is calculated as,

$$\nabla L = \frac{\partial L}{\partial W} \quad (10)$$

Where, W represents the model parameters in the process. The parameters are updated as follows,

$$W_{new} = W_{old} - \eta \nabla L \quad (11)$$

Where, η is the learning rate for this process. The reason behind selecting LSTM-RNN and CNN models in this ensemble framework can be attributed to their complementary strengths. While the LSTM-RNN is very effective in learning temporal dependencies, the CNN is efficient at feature extraction. Integrating them provides a strong model that predicts workloads accurately, mitigating the limitations of the prior approaches. This would enhance the accuracy of prediction and adaptability, making the model resilient to diverse workload scenarios.

RESULTS AND ANALYSIS

The experimental setting that evaluates the proposed ensemble model comprises three phases: data collection, model training, and performance evaluation. Workload data was collected from a simulated cloud environment over six months, capturing several workload metrics like CPU usage, memory usage, disk I/O, and network traffic. The dataset included 70% for training, 15% for validation, and 15% for testing. The proposed model was compared to three benchmark methods referred to as methods [5], [8], and [12]. For evolutionary process, Mean Absolute Error(MAE), Root Mean Square Error(RMSE), and computational efficiency metrics are chosen. Further scalability analysis and sensitivity of the hyper parameters are evaluated for comparing the performance of the ensemble model with the benchmark methods.

Table 1: Dataset Summary

Dataset	Training Samples	Validation Samples	Testing Samples	Features	Time Span
Workload Data	100,000	21,500	21,500	4	6 months

This table provides a summary of the dataset used in experiments, highlighting the number of samples in each subset and the features considered.

Table 2: Mean Absolute Error

Model	Training	Validation	Testing
Ensemble Model	0.035	0.042	0.038
Method [5]	0.048	0.056	0.050
Method [8]	0.052	0.060	0.054
Method [12]	0.045	0.053	0.047

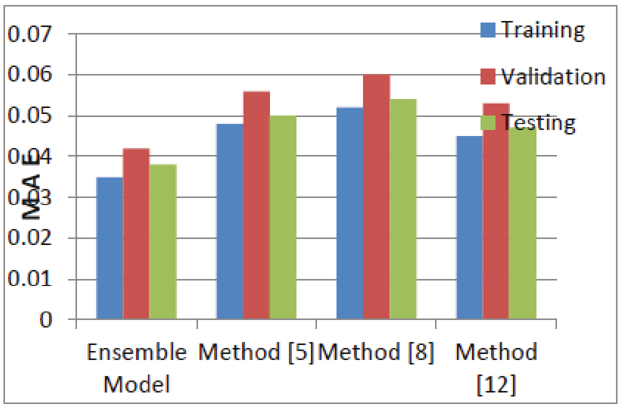

Fig. 2. MAE comparison for different methods

The table above presents the comparison of the mean absolute error of the proposed model with methods [5], [8], and [12] across the training, validation, and testing datasets & samples. The proposed model will perform better as it indicates a lower MAE in all cases.

Table 3: Root Mean Squared Error

Model	Training	Validation	Testing
Ensemble Model	0.045	0.052	0.048
Method [5]	0.058	0.065	0.060
Method [8]	0.062	0.070	0.064
Method [12]	0.055	0.062	0.057

This table presents the Root Mean Squared Error (RMSE) for each model, where the proposed model again outperforms the benchmark methods with the lowest RMSE.

The computational efficiency is contrasted through this table, in which time taken to complete the training phase of each model is recorded. The proposed model has quite efficient training times against methods [5],[8] and [12].

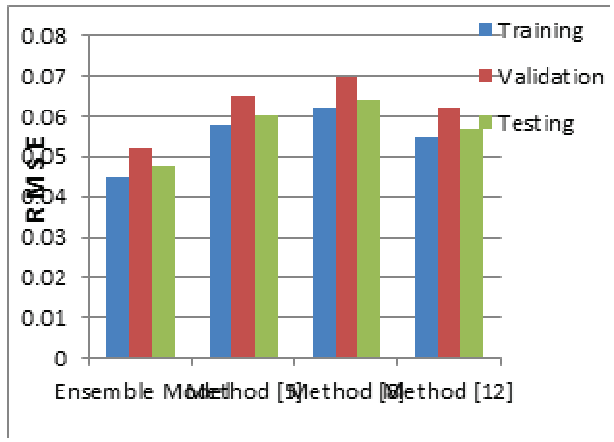

Fig. 3: RMSE comparison for different methods

Table 4: Computational Efficiency (Training Time in Seconds)

Model	Training Time (sec)
Ensemble Model	3600
Method [5]	4200
Method [8]	4800
Method [12]	3900

Table 5: Scalability Analysis

Dataset Size {samples)	Ensemble Model	Method [5]	Method [8]	Method [12]
50,000	0.042	0.055	0.059	0.051
100,000	0.038	0.050	0.054	0.047
200,000	0.035\	0.048	0.052	0.045

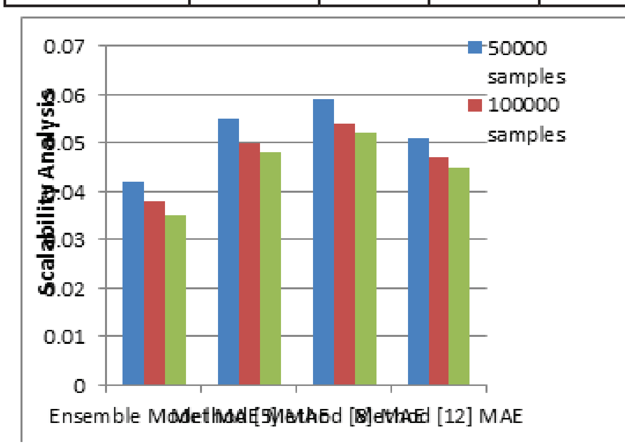

Fig 4: Scalability Analysis comparison for different methods

The scalability analysis is carried out with the evaluation of MAE on different sizes of datasets for ensemble and other benchmark methods. The dataset size is varied from 50,000 to 2,00,000 samples. The evaluated MAE values are presented in below table

By observing the above table and graph, it is noted that the MAE is decreases for all the methods when the dataset size is also increases. For all the dataset sizes the MAE of Ensemble model gets minimum values when compare with benchmark methods.

Sensitivity to Hyper parameters

The Sensitive analysis is performed for the Hyper parameters variations with different learning rates and batch sizes. For this purpose the MAE is calculated for the ensemble and different benchmark methods and presented in the following table.

Table 6. Sensitivity to Hyper parameters

Hyperparameter	Ensemble Model	Method [5]	Method [8]	Method [12]
Learning Rate 0.001	0.042	0.056	0.060	0.053
Learning Rate 0.01	0.045	0.058	0.062	0.055
Batch Size 32	0.042	0.056	0.060	0.053
Batch Size 64	0.043	0.057	0.061	0.054

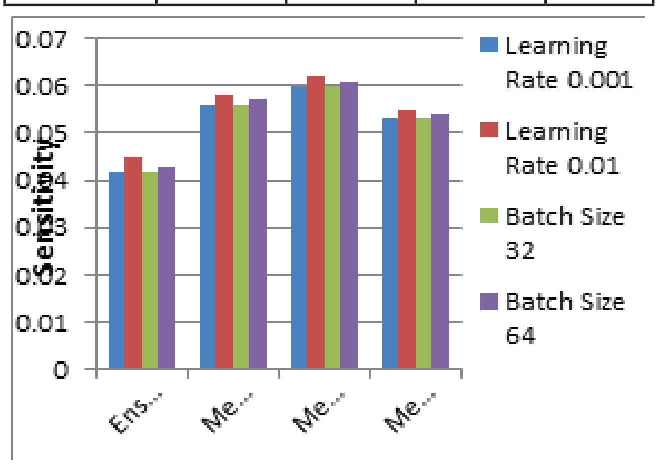

Fig. 5: Sensitivity comparison for different methods

The above results clearly indicated that the proposed model performed very stably across different settings, hence proving its robustness.

That is to say, the experimental results explicitly indicated that this new ensemble model had quite improvement in prediction accuracy, computational efficiency, scalability, and robustness to changes in hyperparameters as compared with benchmark methods. These results demonstrate the effectiveness of the proposed approach in workload prediction for dynamic computing environments.

CONCLUSIONS

In this study, a new ensemble model is proposed that combines LSTM-RNN with CNN, for predicting the workloads with a high degree of accuracy in computing environments. According to the experimental results the proposed ensemble model performed much better compared to the three benchmark methods referred to as methods [5], [8], and [12]. It significantly reduced MAE and RMSE across training, validation, and test datasets & samples. Specifically, the proposed model obtained a training MAE of 0.035, a validation MAE of 0.042, and a testing MAE of 0.038, thus showing a better performance compared to method [5] with a testing MAE of 0.050, method [8] with a testing MAE of 0.054, and method [12] with a testing MAE of 0.047. On the other hand, using RMSE as the evaluation criterion, the proposed model received a train RMSE of 0.045, validation RMSE of 0.052, and test RMSE of 0.048, against their higher respective RMSE values for benchmark methods. Notably, the proposed method also attained computational efficiency in terms of a training time of 3600 seconds, against methods [8] and [5], which took 4800 and 4200 seconds, respectively. The scalability analysis further proved the strength of the proposed model since it always returned a smaller MAE value as the dataset got larger. Sensitivity analysis results proved hat against all tuning parameters, this ensemble model consistently demonstrated stable performance thus proving its strength and adaptability. These results further manifest the competency of the proposed model in delivering workload predictions with accuracy. This is extremely important in any dynamic computing environment for resource allocation, system performance optimization, and reliability. This integration of LSTM-RNN and CNN into an ensemble framework is one step more up the ladder in advancing predictive modeling toward workload forecasting.

FUTURE SCOPE

Results from this study are promising for several avenues of future research and development within this area. This area includes further investigation of ensemble integration techniques that can utilize, for instance, more complex approaches such as boosting or bagging, which will further increase the accuracy in prediction. Another future direction could be toward the inclusion of other neural network architectures, like attention mechanisms and transformers, in this model for a better understanding of the temporal relationships and context in workload data samples. Further work may also be in the application of the proposed model in real-time workload prediction scenarios with respect to performance evaluation and adaptability testing in live environments. Further, generalizing the model to capture multi-variate and multi-step forecasting could enable capturing more comprehensive predictive capabilities by allowing simultaneous prediction of workload metrics and longer forecast horizons. The final proposed model can be modified for different domains and tested—for instance, in financial markets and energy demand forecast—and finally, logistics-based demand predictions to appraise its versatility and generalizability. All these future directions can help further increase the robustness of the results and hence the applicability of the proposed ensemble model in different fields of predictive analytics.

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Application of Recommendation System to Course Selection in Higher Education

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ABSTRACT

An artificial intelligence method called a recommender system assists customers or clients in making decisions by drawing on their prior selections or preferences. These days, it is utilized in many different sectors, such as online purchasing, healthcare, video browsing, online book reading, courses, college or university selection for students pursuing higher education, and many more. Such recommender system is taught in a way to recognize and record the user preferences, past decision and characteristics of goods and people using data acquired through their interaction. These days, machine learning and deep learning are popular methods for pre-training such systems. This paper primarily focuses on the fundamentals of recommender systems and the types of it, as well as an analysis of several machine learning and deep learning techniques that have been used in the past by researchers worldwide. It also addresses the usage, advantages, and disadvantages of recommendation systems in education within the perspective of shaping the future of individualized and egalitarian learning environments. This paper targets the people who are transferred to recommender systems for their better comprehension and rapid knowledge on the major work carried out on the data. It concentrates on various strategies used in course selection for students moving towards higher education.

KEYWORDS: *Higher education, Collaborative filtering, Content-based filtering, Hybrid, Machine learning.*

ABBREVIATION

Recommender System: (RS)

Content Based Recommendation System: (CBRS)

Collaborative Filtering(CF),Cosine Similarity: (CS)

Convolutional Neural Networks: (CNN)

INTRODUCTION

Increased internet services and emerging technologies have increased data access but at the expense of information overload. This is countered by recommender systems, which sift through content and suggest to users specific content based on behavior and preference. In the form of anticipatory relevant content, such AI-driven systems enable a better user experience and reduced searching time [1]. To meet customers' demands, they are leveraged to a large extent by various industries such as e-commerce, entertainment, travel, and learning. Recommender systems generate personalized recommendations by analyzing user-favorite criteria, which enables easy product, movie, song, and course discovery. With companies investing in increasing customer delight and engagement, their scope continues to expand [2].

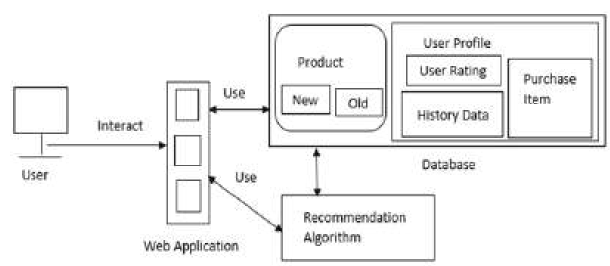

Fig. 1: Recommendation System

Issues of higher education include diversified curricula, competitive admissions, and rising enrollments. Basic support to students is still not to be anticipated from the administrators. Selection of the proper course is challenging everywhere due to more sophisticated educational options. Recommender systems provide intelligent assistance to help students select appropriate courses based on their interest and level of proficiency, saving time and enhancing learning[4,5,6].

Recommender systems avoid information overload and keep users up to date. They emerged in the late 20th century and manage content personalization using advanced algorithms[7]. Web usage data enhances recommendations, and recent advances improve accuracy. Sites with longer lifetimes have better results[8].

NRS delivers user-based news recommendation and contains “MovieLens” for rating-based movie recommendation[9]. Recommender systems in mobile avoid information overload for users by selecting reliable apps. Similarly, job-matching systems assist workers in finding a job[10-11]. Recommender systems strengthen customer loyalty and reduce customer acquisition cost in banking. But businesses must choose the most effective method among several [12,13].

LITERATURE REVIEW

Dhelim et al. (2023) used user interest mining and meta route-finding techniques to construct a personality-based product suggestion model [14]. In comparison, this approach performed better than deep learning and session-based models.

In 2021, Fan et al. [15] proposed an IoT-based recommendations system for cancer rehabilitation based on Beetle Antennae Search (BAS). It solved the patients' difficulty of determining the best diet regimen by using the objective function as the recurrence time.

In order to solve the problem, Havas (2022)[16] suggests a course recommender system that uses ant colony optimization and graph clustering. The suggested approach consists of four key steps: rating prediction, ant colony optimization for user weighting, graph clustering, and graph representation.

From item attributes, social knowledge, and customer opinions, an enhanced social media recommender system that combines CTR and SMF enhances suggestions. For providing enhanced suggestions, it uses real-time analysis of clickstream information through automatic web-usage mining[17,18].

Bhalse et al. [8] proposed a web-based collaborative filtering-based movie recommendation system to address the sparsity problems of the recommender systems. SVD, CF, and CS are combined to obtain the recommendation list, which was produced considering movie plot details.

Chen et al. [10] proposed a reinforcement learning-based dynamic goods recommendation system to solve the cold-start and sparsity problems. The proposed method may be able to learn in real time from a reduced entropy loss error on applications. Several methods will be combined, including item-level representation with user interest, neighbor-assisted presentation, latent representation with user interest, and category-level representation with user interest.

Using MaOEA, Chen et al. [12] presented a novel hybrid recommender model. The accuracy, diversity, and novelty of recommendations were all successfully maximized by the proposed model's methodology. JPEG coefficients were utilized in order to attain a precise prediction rate for the model.

Non-personalized RS are automatic because they do not remember users across sessions and do not require physical storage since their recommendations do not depend on user behavior, according to J. Ben Schafer, Joseph Konstan, and John [19].

According to Mladenic's text categorization survey [20], the system uses its algorithm to filter content to locate comparable things, then builds a model based on user interests. The suggestion is produced by this model.

Romero et al. have developed a mixture of multi-criteria recommendation system based on the student's academic performance, interests, and course selection.A Genetic Algorithm was used to construct the system, which was intended to help university students (GA). It combined data regarding students and courses to enhance system performance and recommendation accuracy [21].

Ullah et al. have developed an image-based service recommendation model for online shopping that is based on random forests and CNN [22].

In Walek, 2020 [23], a movie recommendation system based on user reviews gathered from social media and microblogs ispresented. Using the sentiment-aware association rule mining technique, it generatedrecommendations based onprogram view logs, program metadata similarities, and prior knowledge of typical program patterns.

For online shoppers, Wang et al. suggested a recommender model with a rough set association rule [24]. The program analyzed the expected behavioral variances of online customers and recommended product categories to e-commerce sites.

TYPES OF RECOMMENDER SYSTEMS

To further enhance item feature- and user taste-driven personalization of recommendations, recommendation systems have been created. They are also broadly categorized according to recommendation strategies and differ in application strengths, weaknesses, and best uses. Primary categories include content-based, collaborative filtering, hybrid models, deep learning, and reinforcement learning[16].

Collaborative Filtering

Collaborative filtering (CF) can be of two types: item-based and user-based. CF predicts based on the history of user interest. User-based CF suffers from the "cold start" problem with limited data, and suggests items rated by users with similar interests. Item-based CF is effective for large numbers of users and suggests similar users to similar items. Recent advancements, including neural networks and graph-based approaches, enhance accuracy and handle sparse data more effectively[25,26,27,28].

Content-based Filtering

For suggesting recommendations, Content-Based Filtering (CBF) takes into account the attributes of an item and compares them to the user's past choices, for example, movie choices by directors or genre. However, it exhausts diversity because it over-specializes. To better represent items and offer diversity of content, recent studies have leveraged deep learning techniques like transformers[29,30].

Hybrid Recommendation Systems

Hybrid recommender systems use various approaches to maximize efficiency and reduce problems. Switching Hybridization and Weighted Hybridization are two commonly applied techniques. Switching Hybridization chooses the best algorithm based on user profiles, items, or historical interactions. Weighted Hybridization combines algorithms such as Collaborative Filtering, Content-Based Filtering, Matrix Factorization, and Knowledge-Based Recommendations by assigning weights to their outputs[31,32].

Knowledge-based Recommendation Systems

Knowledge-based systems, particularly used in sophisticated domains like real estate, tourism, and specialty e-commerce, suggest based on domain expertise, for instance, product attributes and user tastes. More targeted and accurate recommendations are now possible because of natural language processing (NLP) advancements[31].

Table 1: Types of Recommendation System

Recommendation Technique	Machine Learning Algorithm	Application	Advantage	Disadvantage	References
Collaborative Filtering	Matrix Factorization (SVD, ALS)	Netflix, Amazon	Manage sparse matrices and huge data sets.	Faces issues with cold-starting.	7,8,36
	k-Nearest Neighbors	Last.fm, MovieLens	Easy to understand and suitable for small datasets.	Memory-intensive, not scalable for big datasets.	
	Support Vector Machines	Amazon, YouTube	Effective with categorization and sparse data.	Needs to hyperparameters be carefully adjusted.	
	Neural Networks	Netflix, Spotify	Captures intricate relationships between users and items.	Requires a lot of data and expensive computing power.	
	Association Rule Learning	Amazon, e-commerce	Beneficial for market basket analysis and cross-selling.	Unsuitable for recommendations that follow one another.	

Content-based Filtering	Decision Trees	IMDb, MovieLens	Simple to understand and useful for feature-based judgments.	If a tree gets too complicated, it may over fit.	7,8,24,35,36
	Support Vector Machines	News Recomme-ndation Systems	Effective with high-dimensional data.	Lots of feature engineering is needed.	
	Naive Bayes	News Aggregators, Personalized Ads	Effectively manages text data.	Features are assumed to be independent, which may not be the case.	
	k-Nearest Neighbours	Book Recomme-ndation	Easy and efficient for similar content.	Large datasets result in decreased performance.	
	Bayesian Networks	Health & Fitness apps, Travel apps	Manages uncertainty and draws conclusions based on probability.	Computationally costly when dealing with big data.	
Hybrid Recommender Systems	Matrix Factorization + Content-based Filtering	Netflix	Integrates content features and user preferences.	Computationally costly and difficult to implement.	31,34
	Ensemble Methods	Netflix, Amazon Prime	Makes use of several models to increase accuracy.	Can result in a significant level of time and computational complexity.	
	Neural Networks	Spotify, YouTube	Combines item and user characteristics to produce intricate forecasts.	Requires a lot of data and is challenging to comprehend.	
	Support Vector Machines	E-commerce	Integrates content-based and collaborative approaches.	Tuning is difficult and requires a lot of calculations.	
Knowledge-based Recommender	Case-based Reasoning	Travel Recommenders (TripAdvisor), Hotels.com	Depends on certain laws and user preferences to make decisions.	Restricted scalability and high user input requirements.	24,31,38
	Rule-based Systems	Financial Services, Health Recommenders	Makes explicit use of domain-specific rules.	When regulations change, manual adjustments are required; strict.	
	Constraint Satisfaction Problems	Job Recommenders (LinkedIn)	Effectively manages user-specific limitations.	Implementation is difficult, and it might not generalize well.	
	Decision Trees	Legal & Insurance Recommenders	Uses predetermined guidelines to recommend customized services or goods.	Overfitting is likely and trimming is necessary.	
	Ontologies	Personalized Learning	Deep personalization by organized domain knowledge.	Difficult to construct and needs domain knowledge.	

DIFFERENT APPROACHES USED IN THE RECOMMENDER SYSTEM

Machine Learning

Data quality and algorithmic thinking are the most crucial elements of machine learning deployments. Feature engineering, dimensionality reduction, clustering, regression, and reinforcement learning are the methods of improving data systems. Artificial neural networks that drive deep learning allow intelligent data analysis. Nevertheless, it is still difficult to choose the most suitable algorithm for an application[33,34].

K-Nearest Neighbour (KNN)

This machine learning algorithm guesses the class of the information being collected by using the labels of adjacent elements [36]. Every information element is kept, and freshly collected data is grouped using similarity metrics to previously recorded data. One popular application of the approach is to classify information elements based on the classification of nearby points.

Decision Tree

The decision tree is a guided learning technique used in machine learning. It is a graph-structured analyzer in which core nodes indicate data set attributes, branches represent decision rules, and leaf nodes reflect decision results [37]. It is a visual representation of each possible solution to a problem based on a specific option condition.

Linear Regression

The least squares approach finds the best-fitting line between elements of data, assuming that there is a linear relationship between input attributes and goal variable [38]. Linear regression aims to determine the optimal straight line to describe the relationship between input and output variables [39].

Apriori Association

Minimum support frequent item set discovery and rule generation from a confidence level are the two operations association rules use in finding associations between data items. Apriori association rules are utilized to find frequent pattern databases. Confidence (the ratio of the transactions which contain X and which also contain Y) and support (the ratio of transactions containing X and Y) are both measures of the strength of an association rule[40,41].

K-Means Clustering

Clustering is the process of identifying groups of elements that are similar to each other but different from any other group [8]. One of the most significant unsupervised learning strategies is clustering. A sort of unsupervised algorithm called the simple K-means algorithm moves items across the cluster set until the desired set is reached. As long as the number of clusters is known beforehand, this approach can be used to classify the data collection. The nature of this algorithm is iterative [23].

Classification-based AD Tree

Data mining classifies data into specified groupings, a process called "directed learning." With its decision nodes with conditions and prediction nodes with integers, the Alternating Decision Tree (ADTree) is an extension of decision trees. Summing values from travelled prediction nodes along actual decision pathways is how classification is carried out [36].

Table 2: Different Approaches used in Recommender System

Technique Used	Description	Dataset Used	Result	References
The K-Nearest Neighbor hybrid approach combines content-based recommendation systems and collaborative.	It establishes the correlation between student parameters and course types, categorizes similar students, and predicts for PG courses based on the KNN algorithm.	Final year graduate students details are used in which they take their curricular and non-curricular information are used.	94.23% accurate result is generated.	1

Deep Reinforcement Learning, Collaborative Filtering	The paper uncovers course completion delay issues and proposes a LINE chatbot algorithm to offer practice questions according to learners' performance.	Online website like Udemy, Coursera	Users of the system did 89.97% more exercises, and 90% wished to continue.	2
Linear Regression Model, Naïve Bayes, SVM,K-Nearest Neighbor, and Decision Tree Collaborative Filtering approach used.	This work aims to determine the most effective method of assigning courses to applicants without the need for human participation. A standard approach is adopted for the model.	The data set has 8,700 records from two institutions, including UTME number, UTME score, Post-UTME score, and Secondary School results, collected via an API.	The both naive Bayes and SVM models were shown to have the highest recommendation accuracy at 99.94%.	3
Linear Regression Model, Naïve Bayes, SVM, K-Nearest Neighbor, and Decision Tree	In this paper, author represent a comparative study of by using different combination of recommender type with different machine learning algorithm.	Lebanese High School Student Data. The dataset is more heterogeneous, including students' interests, career information, and demographic data.	Student feedback showed that the KB hybrid RS, combining CF and CB, produced 98% identical scenarios with 95% accuracy and personalization.	7
Random Forest (RF), the Gaussian Naive Bayes (GNB), Logistic Regression (LR), Decision Tree (DT), and K- Nearest Neighbour (KNN).	The proposed system receives data from 10th-grade and 12th-grade pass-out students along with academic achievements and It is the most appropriate academic path recommended.	Collected data of passing students from Hatgobinda- pur M.C. High School in West Bengal, India. There are 2996 samples accessible for this Proposed research.	Different algorithm are used for all the different courses in which KNN give better result.	9
Hybrid Technique: Collaborative filtering recommendation used as the primary and Content based recommendation used as supplement. K-Nearest Neighbour	This paper uses a 'transformation' hybrid recommendation algorithm to study and Analyse students' logical thinking ability, innovation ability, and operational ability based on their explicit and implicit data and constructs a course selection recommendation system for university students.	The student data set used in this experiment is from the College academic system and contains 352 items. These data are divided into students, and courses.	The algorithm helps match classes with students' learning capacities and minimizes uncertainty in the process of class selection, the experiment discovers.	11
XGBoost Algorithm, Decision Tree, Random Forest for analyzing Performance Matrix	This research aims to create a recommendation system to help graduate applicants choose the best university.	Through Yocket data is collected of GRE, TOEFL and IELTS	XGBoost was the best at 81%, followed by Decision Trees and Random Forests, both at 76%.	13

CONCLUSION

Every industry is going digital these days, and daily data usage from social media and telephones is increasing. It is tough for any of us to order the information and make sense of it. Recommender systems manage large amounts of heterogeneous data, do important microanalysis, give the data context, and assist businesses and consumers in making decisions based on user-specific preferences. From simple collaborative filtering techniques to complex deep learning and reinforcement learning-based models, recommendation systems have grown significantly. Though hybrid models that combine several strategies are becoming more and more common, each type of RS has its own strengths and limitations. Recommendation systems appear to have a bright future ahead of them, with the promise for more dynamic, personalized, and varied suggestions, thanks to the development of deep learning and context and social data integration. The recommender system is useful in a lot of sectors, including education. We'll show you how a recommender system helps with college course selection in the next sections.

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An In-Depth Study of Lumpy Skin Disease Virus and Its Impact on Livestock: A Data-Driven Analysis

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ABSTRACT

Diseases affecting animals are a subject of paramount concern for human welfare. Early detection and intervention for certain animal diseases are crucial for effective diagnosis and treatment. Lumpy Skin Disease is one such ailment with the potential for significant economic losses within the livestock industry if not managed diligently. The primary causative agent of this disease is Lumpy Skin Disease Virus (LSDV), belonging to the Poxviridae family. Given LSDV's close association with geospatial and climatic factors, arthropod vectors play a pivotal role in its epidemiology. The objective of this research is to study Lumpy Skin Disease and propose enhanced solutions for its diagnosis and management. While predictive models have been developed to identify the disease at an early stage, there remains room for improvement and refinement of diagnostic approaches. This study encompasses multiple facets. The first segment involves data preparation and the implementation of soft computing techniques. The second segment integrates Exploratory Data Analysis tools and various data visualization methods to enhance data analysis efficiency. Lastly, the third segment concludes the research findings and presents novel solutions for addressing Lumpy Skin Disease more effectively. Through this research, aim is to contribute to the development of advanced strategies for the early detection and management of Lumpy Skin Disease in animals, thereby minimizing its impact on both animal health and the livestock industry.

KEYWORDS: *LSD, Linear regression, Logistic regression, Decision tree, NaïveBayes, KNN, Support vector machine, Random forest classifier.*

INTRODUCTION

In Zambia, formerly known as Northern Rhodesia, the initial clinical observations of LSD were recorded in 1929 by Morris (1931). At that time, the symptoms of LSD were erroneously attributed to either poisoning or allergic reactions to insect bites. However, between 1943 and 1945, South Africa, Botswana, and Zimbabwe all experienced epidemics characterized by similar clinical symptoms, underscoring the contagious nature of the disease. This outbreak in South Africa alone affected eight million cattle, resulting in a significant economic crisis that persisted until 1949.

The presence of LSD was subsequently identified in Kenya, East Africa, in 1957. It further spread to Sudan in 1972 (as reported by Ali and Obeid in 1977) and West Africa in 1974. Its expansion continued, reaching Somalia in 1983 as documented by Davies in 1991 (both in Davies 1991a and 1991b). Subsequently, LSD proliferated across various African countries in a series of epizootics, as noted in recent studies by Davies (1991b) and House (1990). Instances of LSD were reported in Senegal, Mozambique, and Mauritius in 2001. Notably, the Middle East experienced LSD epidemics in Oman in 1984 and 2009. Kuwait witnessed outbreaks in 1986 and 1991, while Egypt reported cases in 1988 and 2006. Israel documented occurrences in 1989 and 2006, with Bahrain and Yemen witnessing cases in 1993 and 2002-2003, respectively. The United Arab Emirates also faced an LSD outbreak in 2000, and the West Bank reported an LSD invasion as well.

Lumpy Skin Disease is an inflammatory viral ailment caused by LSDV, belonging to the Chordopoxvirinae subfamily within the Capripoxvirus genus of the Poxviridae family. It goes by various names, including "exanthema nodularisbovis," "Pseudo-urticaria," "LSD," and "Neethling virus disease." The disease is characterized by distinct nodules on the skin, swollen lymph nodes, and fever, resulting in acute anorexia, reduced milk production, and infertility among affected animals. Overall, LSD significantly diminishes the economic value of animals due to its adverse effects on milk and meat production, hide quality, draught power, and reproductive efficiency, including increased risks of abortion and infertility. [1]

Background

The presence of LSDV, which induces severe or subacute illness in cattle and water buffalo populations, poses a significant threat to the livestock industry. All breeds of cattle are susceptible to infection, with calves and high-yield cows being particularly vulnerable. Clinical manifestations of the disease include fever, swollen lymph nodes, the formation of various skin and mucous membrane nodules, and swelling in the limbs. LSDV has gradually spread across Africa, the Middle East, Southeastern Europe, Central Asia, and more recently, South Asia and China. Several African nations and regions in the Middle East, including Iraq, Saudi Arabia, and the Syrian Arab Republic, as well as Turkey, are currently grappling with the endemic spread of the disease. [2]

Notably, LSD presents with early symptoms such as fever and distinctive nodular skin lesions on the animal's body surface. These skin lesions can appear in isolated spots or cover the entire body. Cattle affected by LSD may develop ulcerative sores on their oropharyngeal mucous membranes, along with ocular and nasal discharge, and lymphadenopathy. The economic impact of LSD can be accurately assessed based on factors such as vector presence, host susceptibility, and implemented preventive measures. Beyond a relatively low case mortality rate of less than 3% in uncomplicated cases, economic losses are incurred through reduced production, including sudden declines in milk production, and diminished performance in draught animals. Additionally, controlling LSD involves expenses related to agricultural quarantine, vaccination, treatment, labor, and may result in significant losses during international trade restrictions associated with disease transmission.

Fig.1 Infected cattle

In addition to Lumpy Skin Disease, several other skin ailments affect cattle, including Papillomatosis, Ringworm, Dermatophilosis, and Photosensitization. Papillomatosis is characterized by tumors in cattle and typically occurs in animals aged between 6 and 24 months which is shown in fig. 1. Ringworm, another cattle disease, presents as lesions on the neck and head, and it can be transmitted to humans. Dermatophilosis affects cattle of all ages and is exacerbated by close contact in wet conditions. Photosensitization, yet another skin ailment in cattle, leads to blistering, skin sloughing, and dryness.

Vulnerable host

The LSD virus primarily affects cattle. The LSD infection exhibits a notably higher specificity, which prevents it from causing clinical illness in domesticated animals such as pigs, sheep, horses, and goats. However, other domesticated animals, such as water buffalo and yaks, may also be susceptible. Although Asian water buffaloes (Bubalusbubalis) are considered to have a lower susceptibility to LSD, there have been few reported clinical cases in this species. It appears that animals that are undernourished, young calves, and lactating cows tend to experience more severe forms of the disease. This increased susceptibility may be attributed to compromised humoral immunity. In some instances, African buffalo from Kenya (Synceruscaffer) have been identified as potential reservoir hosts for the virus. Although infected buffaloes did not display any LSD symptoms, the presence of antibodies against the virus was detected.

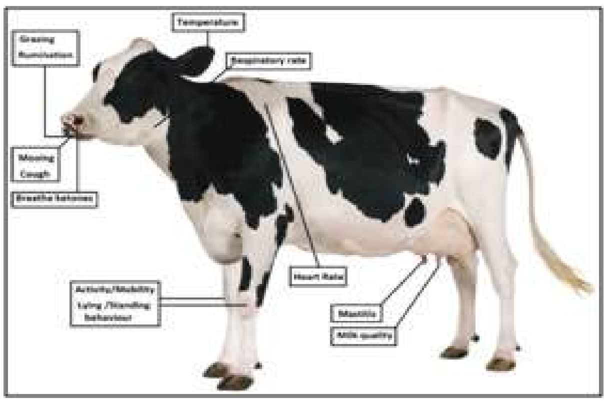

Fig. 2 Different monitoring parameters of cattle

As shown in Fig. 2, there exist various monitoring parameters those are very helpful in detection of various health issues and several diseases those generally occurs in all animals. In these parameters there exists some important attributes also like temperature, respiratory rate, heart rate, milk quality etc. For studying every health regarding issues doctors generally use these parameters which becomes helpful in diagnosis of cattle.

Can the viral outbreak jump to the humans?

As of presently, there's no prove of a zoonotic spread of the virus. Zoonosis could be a prepare in which an infection bounced from an animal on to humans. The COVID-19 pandemic is a prominent example of a zoonotic disease. However, there is no substantiated evidence to indicate that humans can contract Lumpy Skin Disease.

RESEARCH PROBLEM

A disease is a condition of illness that affects the functioning of various body parts. When a disease is present in cattle, it can lead to issues such as a decrease in milk production, which in turn impacts the country's economy. If the disease is contagious, the consequences can be even more severe, potentially leading to the loss of entire cattle populations. Early detection of the disease is crucial in mitigating these challenges.

In this research endeavor, diverse data mining methodologies are employed to prioritize the prediction of LSDV (Lumpy Skin Disease Virus) infection. These various algorithms utilize data mining techniques to analyze and forecast the occurrence of LSD virus infections effectively.

LITERATURE REVIEW

In research article [1], the author compiles a list of LSD epidemics that have occurred in Asian nations over the past decade. The epidemiological situation of this disease remains unclear in India. The study highlights the potential for disease control through vaccination, strict quarantine rules, and vector control measures. With a focus on transboundary dissemination, etiology, transmission, clinical manifestations, diagnostics, and disease treatment, the research describes the latest developments in epidemiology.

Article [3] discusses a severe cattle disease called lumpy skin disease (LSD) caused by the Capripoxvirus. The study, conducted in Ethiopia's central and northwestern regions from April 28, 2014, to February 1, 2015, aims to estimate the infection reproduction ratio in intensive commercial herds and mixed crop-livestock systems and calculate transmission among animals. The study suggests a low LSDV transfer rate among Ethiopian animals in general.

In the journal [4,5], the author explores LSD, a vector-borne disease caused by the genus CaPV, limited to sub-Saharan Africa. The review focuses on Agent Identification using various methods, including PCR, Electron microscopy, virus isolation, and immune response observation using VN and IFAT. The detrimental consequences of LSD include chronic debility, reduced milk production, weight loss, abortion, mortality, and infertility. These consequences can severely impact rural livelihoods that depend heavily on cattle, leading to decreased productivity.

The article [6,7] aims to predict the frequency of LSD transmission reports in Europe, Africa, and Asia, as well as identify trends and key transition points. Binary segmentation, NNAR (neural network auto-regressive), and ARIMA (auto-regressive moving average) models are used to forecast LSD report quantities. Time series models are also employed to predict LSD transmission reports in Europe, Africa, and Asia from 2022 to 2024, contributing to improved understanding of LSD epidemiology.

In research article [8], the study evaluates the current status of LSD on farms in Bangladesh's northwest region. Data collected through standardized questionnaires from NatoreSadar and Baraigram in the Natore district are used to diagnose LSD based on OIE principles. The study highlights the need for national awareness campaigns about the newly identified LSD epidemic in the dairy industry.

Current research frequently neglects the influence of specific environmental and climatic conditions, such as temperature, humidity, and cloud cover, on the spread and severity of LSD. There is a need for more studies that incorporate these factors into predictive models.

DATASET PREPARATION

Dataset is taken from online repository, which encompasses 19 attributes[9]. These attributes comprise diverse parameters, such as longitude, latitude, precipitation, and elevation data, among others. Additionally, the dataset incorporates a single dependent variable, representing the occurrence of Lumpy Skin Disease. In total, the dataset comprises 24,802 records.

Assessing Attribute Correlations

The fig. 3 illustrates the correlation of each attribute with the dependent variable attribute 'Lumpy'.

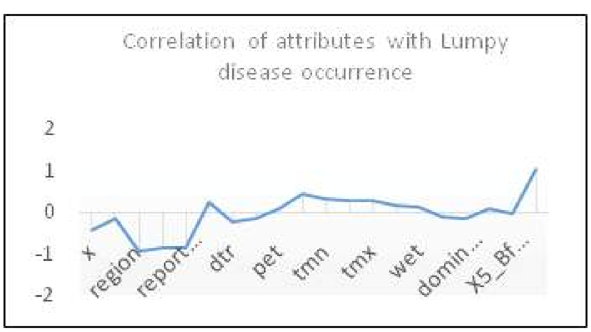

Fig. 3 Correlation of attributes

These findings contribute significantly to understanding of the factors influencing the occurrence of LSD in cattle populations. They provide a strong foundation for further research and model development in this domain.

Data Analysis

Based on the observed dependencies between attributes and the occurrence of LSD, selected specific attributes for in-depth analysis.

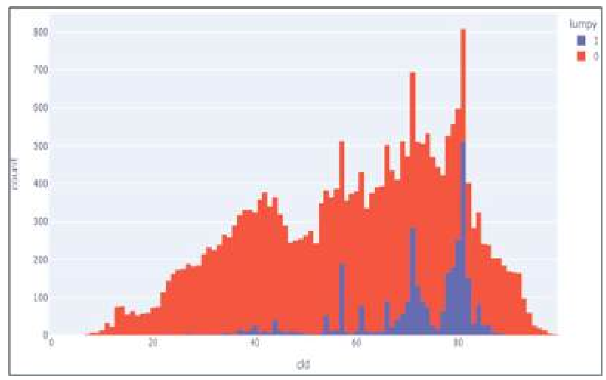

Fig. 4 Analysis of Monthly Cloud Cover

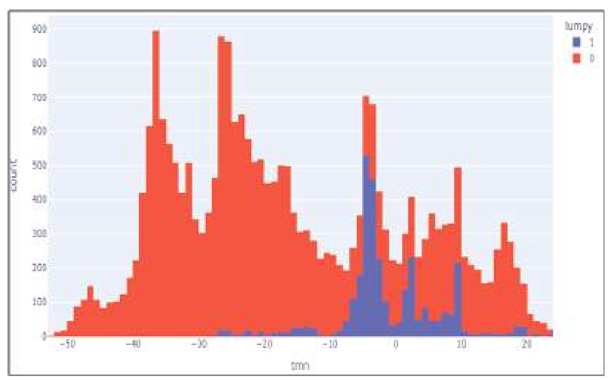

Fig. 5 Analysis of Monthly Average Minimum Temperature

The fig. 4 shows that the Monthly Cloud Cover values range from 26.6 to 88.6, with an average LSD occurrence rate of 9.37%. Notably, LSD is more likely when cloud cover is between 65 and 83.5, indicating a strong correlation between higher cloud cover and increased LSD risk.

Fig 5 shows that the Monthly Average Minimum Temperature ranges from -27.3 to 23.9, with extreme lows of -52.1. The average LSD occurrence rate is 28.99%.

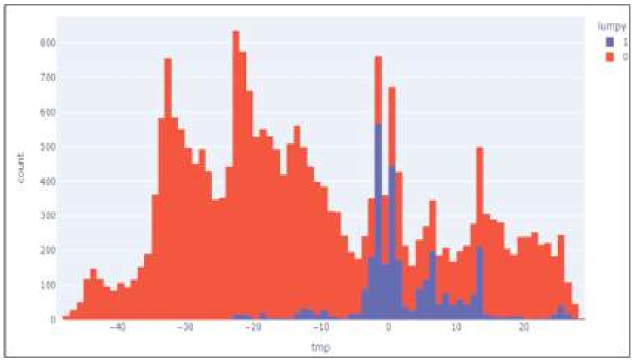

Fig. 6 Analysis of Daily Mean Temperature

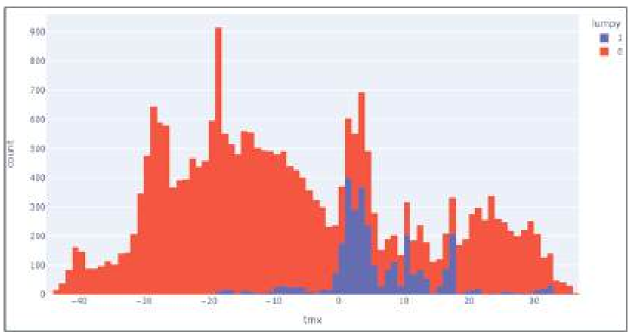

Fig. 7 Analysis of Monthly Average Maximum Temperature

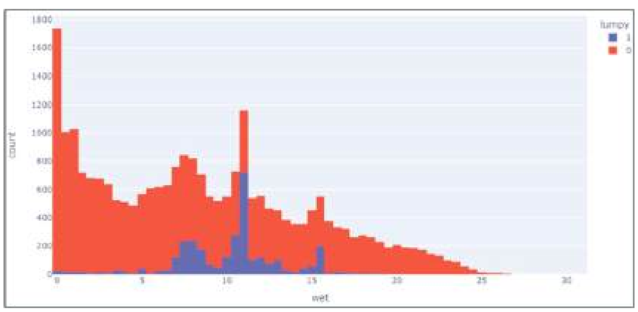

Fig. 8 Analysis of Wet Day Frequency

Fig. 6 illustrates that LSD occurs with an average frequency of approximately 28.71%. Additionally, when the attribute values fall within the range of -5 to 14, there is a significantly higher likelihood of LSD occurrence.

In Fig. 7 LSD occurs with an average rate of approximately 27.76%. Furthermore, when the attribute values lie within the range of -3 to 13, there is a notably increased probability of LSD occurrence.

Fig. 8 concluded that LSD occurs by 35.92%. Also, when the values of attribute lie in between 6.5 and 15, at that time there are higher numbers of chances of occurrence of the LSD.

IMPLEMENTATION

K-Nearest Neighbor Algorithm:

This algorithm is primarily employed to address classification problems. It creates a decision boundary to classify data points. When new data points are introduced, the algorithm tries to predict their classification based on their proximity to the decision boundary. By utilizing the algorithm, trained the model using historical data and used it to make predictions for future data points. As illustrated in Figure 9, it is concluded that the KNN algorithm achieved an accuracy rate of 95%.

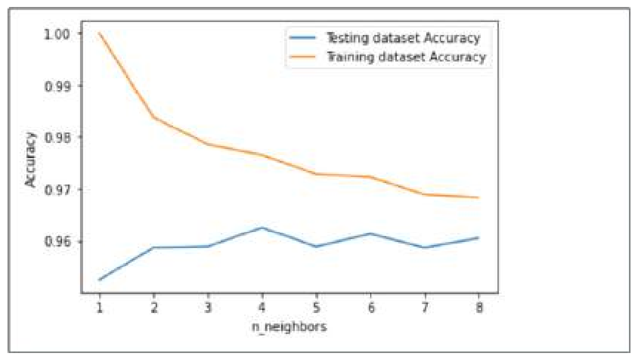

Fig. 9 KNN Train and Test Model Accuracy

Support Vector Machine Algorithm

It is a supervised machine learning technique used for both classification and regression tasks. It achieved an impressive accuracy of 96.37%. The results are further illustrated in Fig.10, which includes the accuracy score and confusion matrix.

```
Training confusion matrix
[[19338   249]
 [  454  1312]]
Testing confusion matrix
[[2142   35]
 [  51  145]]
training accuracy = 96.7077225682574
testing accuracy = 96.37589549093974
```

Fig. 10 Accuracy and confusion matrix of SVM

Decision Tree Classifier

As illustrated in fig. 11, the results obtained from the DT algorithm include a confusion matrix and a classification report, which confirm the accuracy score of 97%.

```
Confusion Matrix:

array([[4262,   63],
       [  78,  558]], dtype=int64)
```

```
Classification Report:
              precision    recall  f1-score   support

           0       0.98      0.99      0.98      4325
           1       0.90      0.88      0.89       636

    accuracy                           0.97      4961
   macro avg       0.94      0.93      0.94      4961
weighted avg       0.97      0.97      0.97      4961
```

Fig. 11 Confusion matrix & Classification report for Decision Tree

Linear Regression

It is a supervised machine learning algorithm that is primarily used for regression tasks. It models the target prediction value based on independent variables and aims to find the relationship between these variables. Different regression models can vary based on the type of relationship they consider between independent and dependent variables. When the Linear Regression algorithm was applied to the current dataset, it achieved an accuracy rate of 97%. However, the Root Mean Square Error score is 0.2549, which implies an accuracy score of 74.51%. Therefore, based on the RMSE score, it can be concluded that the Linear Regression algorithm achieved an accuracy of 75%.

Logistic Regression

It deals with discrete values for both input attributes and target attributes. This algorithm typically employs the sigmoid function to model the data. When the Logistic Regression algorithm was applied to the dataset; it achieved an accuracy rate of 93%.

Naive Bayes

Naive Bayes is primarily used for probabilistic analysis and is known for its simplicity. When the GaussianNB () technique was applied to the dataset, it achieved an accuracy rate of 92%.

Exploratory Data Analysis

Exploratory Data Analysis (EDA) tool that helps us visualize the frequency of longitude and latitude in each country, providing a comprehensive overview of disease patterns. As depicted in fig.12, the EDA tool applied to the current dataset allows us to visualize the distribution of latitude and longitude data in areas affected by LSD worldwide.

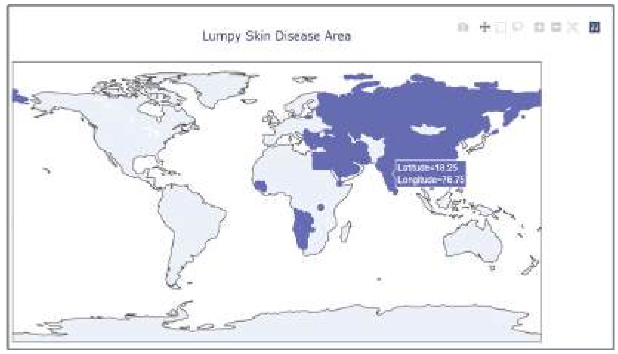

Fig. 12 Representation of latitude and longitude

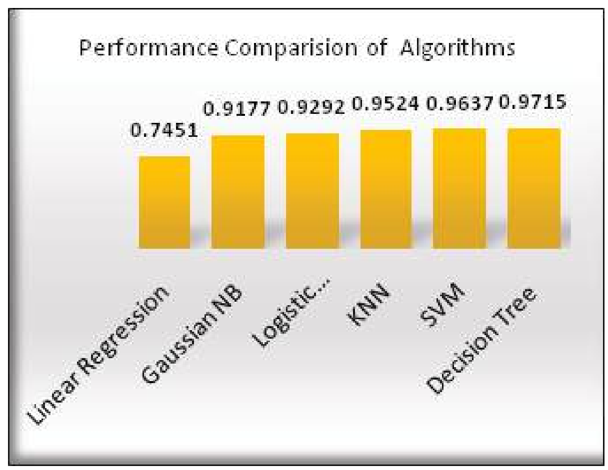

Fig. 13 Performance Comparison of Machine Learning Algorithms

From fig13, it is evident that the Decision Tree algorithm provides the best performance among the algorithms evaluated, closely followed by SVM and KNN. Linear Regression, on the other hand, yields the lowest performance, making it less suitable for this dataset or problem.

This comparison highlights the importance of selecting the right algorithm based on performance metrics to optimize the results for specific applications.

CONCLUSION AND FUTURE SCOPE

In this study, extensively analyzed Lumpy Skin Disease (LSD), a virus belonging to the Capripoxvirus genus within the Poxviride family. LSD primarily affects animals such as goats, sheep, cattle, oxen, and buffaloes, causing symptoms like skin nodules, fever, swollen lymph nodes, decreased milk production, infertility, and more. Various factors contributing to LSD which have been identified, including environmental influences, viral transmission, the immune response of the animals, and inadequate vaccination. Data analysis suggests that regular vaccination is the most effective preventive measure. Also, strict isolation of infected animals is crucial. Temperature plays a significant role in maintaining cattle health, and managing cattle based on temperature and weather conditions is essential if LSD occurs.To obtain meaningful insights, various data preprocessing and analysis techniques are applied, including measuring attribute correlations and dependencies, as well as implementing different soft computing algorithms for predictive modeling. Based on results, it is concluded that the Decision Treealgorithm outperforms other soft computing techniques, providing superior accuracy in LSD prediction. Exploratory Data Analysis has been performed, which simplifies the understanding of longitude and latitude frequency distribution across different nations affected by LSD. This tool can aid in gaining a comprehensive overview of disease metrics, facilitating tracking, awareness campaigns, and preventive measures, especially in regions where LSDV infection poses a high risk. For future research, plan is to delve deeper into feature extraction and propose more advanced prediction models to enhance understanding and management of LSD outbreaks.

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A Study on Packet Filtering and Network Traffic Management on Linux

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ABSTRACT

Packet filtering is crucial aspect of Linux operating system wherein the header of the packet is looked upon and based on the rules defined in net filtering hooks, some specific action can be applied. Packet filtering can be used for filtering traffic, rate limiting traffic and packets marking for managing quality of service of the traffic. It has a great usage in prioritizing traffic as well. Linux has many utilities that can be worked in integrated way to filter packets and manage network traffic, thereby it can provide better quality of service and improve user experience. The objective of the paper is to study different packet filtering methods and network traffic management methods.

KEYWORDS: *Packet filtering, Network traffic management, Linux.*

INTRODUCTION

This is an era of extensive communication of inter networks. We are using multiple applications and browse internet or consume music or watch videos over the network. In various scenarios, we want to prioritize the certain traffic, limit some other while restrain using some of the traffic. As an example, in a university, we want to allow the traffic that delivers education based contents that we want to restrict other traffic or make them less priority. So, there is indeed such a requirement in each type of network for better utilization and better quality of service for the intended traffic. Furthermore, it is indeed very affordable to use open source tools available in various linux version. There is a range of user space and kernel space applications that can be used to cater the above need i.e. limit certain traffic and restrict some traffic based on the types of communication protocol, servers and other protocol parameters utilized by the application or the network traffic. For such a usage, packet filtering and traffic management utilities are available in linux that indeed serves the need to allow or restrict the traffic and their usage of the network bandwidth.

Packet filtering is very important aspect that is used to filter the unwanted or unintended traffic. For packet filtering, there are various inbuilt linux tools that can serve the purpose of filtering the traffic based on various attributes of the packets and corresponding values. To have a better quality of service, packet filtering is very important. Rate limiting, ingress, egress filtering, black listing, whitelisting are important filtering methods. Likewise, traffic control and traffic management can be helpful to assign more or less bandwidth to the particular traffic and hence control and manage the overall bandwidth available for better quality of the service for important network traffic. Traffic management can be done using various tools that can be used to shape the traffic as per the network parameters supplied to the utilities. There is a need to prioritize the traffic as well. We have many mission critical application or live application that needs a better QoS like audio video streaming, youtube etc. It can provide better quality of service and better user experience by that. The research objective is to learn packet filtering methods, analyze them and propose a framework for its application. Packet filtering is a method that looks at the header of the packet and matches it with rules and attribute values supplied to decide the action to take on the same. It is a very useful to filter to packet to drop the unintended traffic and prevent the system resource consumption because of such a malicious traffic.

LITERATURE REVIEW

Linux based tools like net filter and features require to design a system that protects availability is described in [1]. It does filtering traffic and net filtering along with various chains. This paper discussed usage of iptables for filtering the traffic. How any networked component security needs to be taken care is elaborated in [2]. Many of the organization connected to internet deal with sensitive data and financial information, in such scenario measures of protections are must. This paper elaborates on network security threats and analyzes firewall as a component and iptables as an implementation technology. eBPF and TCP, UDP, ICMP filtering is described in [3]. The iptables can be used for defending TCP, UDP and ICMP flooding attacks [4]. SELinux is one of the access control methods that helps to manage an access in linux operating system [5].

Various packet filtering methods for Intrusion detection that includes Stateful Packet Inspection (SPI), Deep Packet Inspection (DPI), Medium Packet Inspection (MPI), Shallow Packet Inspection (SPI) are elaborated in [6]. Different traffic shaping techniques and traffic sharpers like hierarchical Token Bucket are described in [7]. The packet sniffing is illustrated and the framework is suggested for packet sniffing in [8]. TC for traffic shaping along with various qdisc are discussed in [9]. Iptables can be used to filter the packets by using various conditions. Iptables as an implementation mechanism has a least overhead in resource consumption [10]. The open source technologies for the filtering the traffic are compared in [11].

TCP SYN Flood is a type of Denial of Service (DoS) attack which overwhelms the server connections by sending SYN packets. Stateful packet inspection technique is utilized to counter and defend this type of flooding attack [12]. Packets can be allowed or blocked by using SPI. It can be done by setting up maximum connection from an IP Address, or a port and a rate of incoming SYN packet per second. The SPI mechanism blocks if the packets don't adhere to the rate configured for the supplied parameters [12]. The paper [13] utilizes and evaluates iptables as an implementation technology to filter packets by utilizing and defining various conditions. This paper discusses efficient scheme using packet filtering to mitigate DDoS. It uses iptables tool of linux to do packet filtering that prevents attack. Few iptables module like limit is used to limit the rate of packets.

PACKET FILTERING AND PACKET SNIFFING TECHNIQUES

Packet Filtering

Packet filtering is a technique to examine network packets and depending upon certain conditions appropriate action is taken. The action could indeed help to deny, accept or control the traffic cumulatively. The action could be DROP, ACCEPT or more complicated action. It is used for control, security and watchfulness on the network traffic. [14][19] Under linux, the packet filtering has been achieved since from the first generation. Kernel has netfiltering infrastructure to achieve this. There are various tools for implementation of it as below [19]: Ipfw, ipfwadm,ipchains, iptables ,and nftables.

As depicted in Figure-1, Packet filter works on network layer and transport layers that looks into the protocol headers and based on the conditions specified and target/action associated with the rule, it determines the action to be taken on the packet. It can be ACCEPT, DROP, SNAT, DNAT (changing source or destination address of the packet) or more complicated actions. The protocol type and its header fields like source port, source address, destination port, destination address, and connection status values can be utilized to specify condition to be matched with the packets and corresponding action to be performed once it matches. [20]

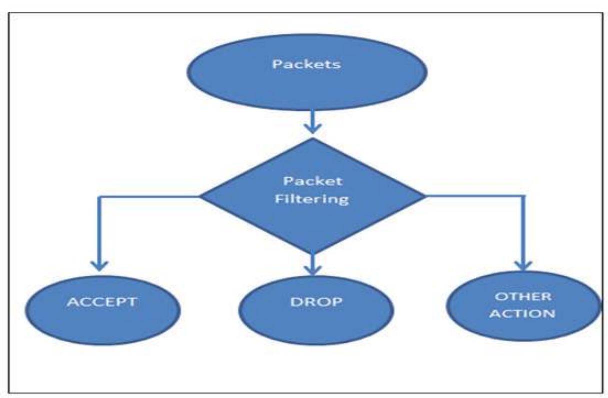

Fig. 1. Packet Filtering Actions

The packet filtering can work to defend the unintended traffic and filter it while allowing the intended traffic to pass by. Thus, it eliminates the malicious traffic passing the server and saving the valued network bandwidth [20].

As illustrated in Figure-2, the packet flow of netfilter goes through various chains and rules from built-in or user-specified chain. The packets enter into the linux system and passes through various PREROUTING chains i.e. raw, mangle, nat table chains. If the packet is addressed to the local system, then it enters to INPUT chains of mangle and filter tables of the iptables. If a packet is generated locally then it goes through the OUTPUT chains of raw, mangle, nat and filter tables.

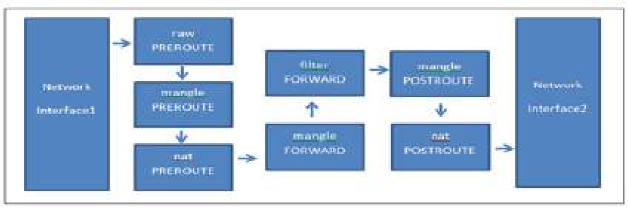

Fig. 2. Packet flow in the netfilter

Eventually, all the packets addressed to some other host passes through the POSTROUTING chains of mangle and nat tables. So, in all of these tables and buil-in chains, a user can enter a rule matches to the criteria and specifies an action to be performed or jump to a user-defined chain if a packet matches to those criteria. So, this mechanism provides an extensive application for packet filtering in the linux system. [1] There are several actions that indeed provides great flexibility for the packet processing i.e. ACCEPT target can be used to allow a packet, DROP can be used to deny a packet, SNAT can be used to alter the source address, DNAT can be used to modify the destination address, MASQUERADE can be used to modify the source address to the outgoing interface address and RETURN works to reject the packet with a message. So, all these targets provide great flexibility and extensive usage for packet processing in linux. [18]

Rate Limiting

As shown in Figure-3, rate limiting is a technique which restricts the packet rate with the configured parameters like source address, destination address or port or any combination of them. The packets that exceed the rate configured will be restricted to pass by thus controlling the packet rate. All the packets that exceed the rate can be dropped. This would help to control the rate of packets for some specified conditions like source port, source ipaddess, destination port, destination ipaddress or a couple of parameters taken together. This is indeed very important and effective way to ensure the packet rate is not more than the allowed specified rate and drop all the packets while overruns this limit. The rate limits help to prevent the congestion of the network and also helps to prevent the DDoS attach on the network host. [14]

Common methods involve the token bucket and leaky bucket algorithms that regulate the flow of packets through the network by controlling the rate at which they are permitted to pass.

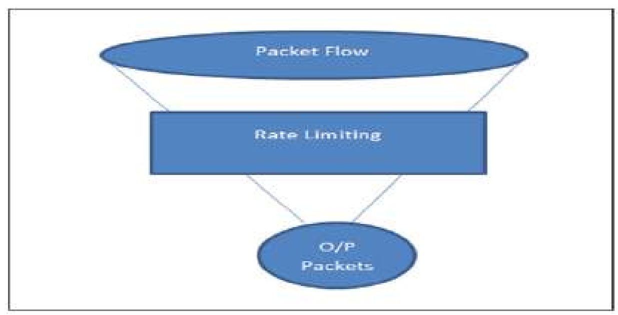

Fig. 3. Rate limiting

There are some key concepts around rate limiting as mentioned below:

Rate limiting mechanisms

The token bucket and leaky bucket algorithm are utilized to specify the rate at which the packets are allowed to pass though the rate limiting mechanism. [23]

eBPF (Extended Berkeley Packet Filter)

This technique is used for high performance packet filtering with specifying user programs on the netfilter hooks. eBPF is extensively used in high performance networking. It can be utilized as sandboxed programs to be utilized within the operating system with efficiency and safety in the execution environment. [24]

XDP (eXpress Data Path)

It is a part of eBPF, demonstrates path of the high performance in packet processing even earlier than the kernel point to leverage high speed throughput of packet processing. [24] There is several importance of rate limiting. It is indeed very important tool to control and manage the access of the network resources and control the availability of the server resources. Below mentioned are some key advantages of using rate limiting:

DDoS attack prevention

DDoS attacks prevents the legitimate users to consume the service by making the service overwhelmed with the fake requests. Rate limiting controls the incoming request to the available service at the defined rate and thus prevents the service overrunning the illegitimate service request and thus having the capability to consume the legitimate requests. [21][22]

Resource Utilization

Rate limit can be utilized to prevent the excessive usage of the resource by allowing only the requests at some preconfigured specific rate. Thus, it can help to utilize the resource properly and prevent starvation of the resources and improve the availability of the service. [21][22]

Abuse Prevention

Rate limit can prevent the abuse of resources of allowing the access to resources at only the specified rate thus preventing a user or a set of users consuming the entire availability of the service and it makes the service availability fair to all the users intending to consume the service. [21][22]

User experience Improvement

By rate limiting, we can improve the user experience of the real-time services because it prevents over usage of the application by some specific user and ensures the smooth quality of service delivery. [21][22]

Cost reduction

As discussed, it prevents the over usage of the resources which indeed helps to reduce the usage and thus the cost incurred based on the usage of the resource. [21][22]

Ingress and Egress Filtering

As shown in Figure 4, Ingress and Egress filtering is used to do filter the incoming and outgoing traffic which eliminates the packets from unknown sources and destination respectively. This is very important to identify and drop all the traffic which is unintended for the particular network. It helps to eliminate the unwanted traffic which could consume the valuable network bandwidth. [14]

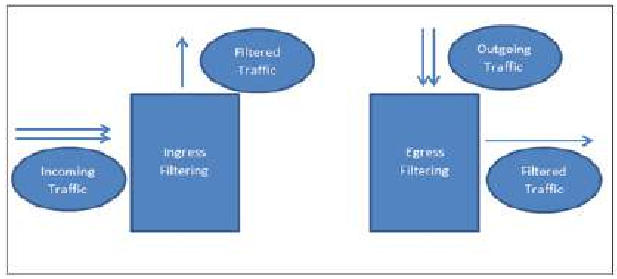

Fig. 4. Ingress - Egress Filtering

These techniques increase network security by controlling the incoming and outgoing packets. The explanations of individual techniques are as below:

Ingress Filtering

It is used to prevent the packets which are spoofed and not legitimate to enter in the interface as they don't fall within the range of the incoming network interface. This technique drops the illegitimate packets when they don't fall in the legitimate range. It helps prevent the IP spoofing attacks and avoid the illegitimate traffic entering into the network and thus saves the network bandwidth. [25]

Egress Filtering

It is utilized to prevent the illegitimate packets leaving network out of the network range. Here, the source address of the packet is checked to ensure the packet is coming from the legitimate network only belonging to the network of the host If it doesn't fall into the legitimate network, then it is dropped. The technique helps to prevent any ip spoofing attack from the network to any external network. [25]

Blacklisting and Whitelisting

In this technique, a list of ipaddresses are maintained that are allowed or denied to access the network. The technique is particularly very important when a new network node is identified to be malicious to be blacklisted or genuine to be whitelisted. It can be used for access control to a resource of the network and prevent unauthorized activities. [15]

Blacklisting

It is a process of identifying and maintaining a list of network hosts, ip addresses and domains that are to be prevented from accessing a network resource. The prime purpose of this activity is to prevent suspected entities to access the network resources. As an example, email server can block the list of emails that do spam emails often to prevent the network from any spam email. [26]

Whitelisting

It is a process of identifying and maintaining a list of network hosts, ip addresses and domains which are legitimate and they should have access to the network resources. It can be used to identify the legitimate users to consume or access the network resources. As an example, an organization might whitelist a set of legitimate users that are only allowed to consume some important business services or access to important business network resources. [26]

TRAFFIC MANAGEMENT

In this technique, traffic is queued to shape it using various in-built tools. It can be used to limit the bandwidth and quality of service using different attributes and values supplied for shaping of the traffic. Here iptables as a net filtering tool can play a vital role to control the traffic at the same time queuing like traffic control mechanism can also play a vital role in traffic management and shaping [4][10][11] Traffic management or traffic shaping ensures smooth and contiguous flow of the packet at some predefined rate. It incorporates limiting speed of data transfer and also reduces network congestion. There are a few key drivers in it as listed below [27]:

Traffic control tools

In linux, tc is a tool utilized to drive shaping of the traffic using various algorithms, queues and filtering mechanisms. [27]

Queuing mechanism

There are a few queuing mechanisms i.e. HTB, HFSC, FIFO, CBQ etc are utilized to manage the traffic traffic is to be prioritized and sent over the network. [27]

Rate limiting

It can be utilized to limit the rate of traffic that indeed can be used to fair delivery of the traffic and to prevent congestion in the network. [27]

Burst Handling

It can be used to treat how the burst of the traffic can be handled along with overall shaping of the traffic. [27]

EDoS Shield Mitigation

In this method, the whitelist and blacklist of the ipaddresses are created and maintained. Here, if a request comes from a new ipaddress, to start with a turing test is performed that identifies the request source to be a bot or a human request. If it is from a bot, it is added to the blocked list and denied the communication while if it is human, the rest of the communication is allowed then after.[18] The technique also protects the services hosted on clouds from attacks that exploit scalability as well as elasticity of the services offered by the cloud by usage monitoring and application of rate limit. [17]

Packet Sniffing

There are a few packet sniffing programs/softwares act to intercept and show the raw packet like tcpdump and some softwares like wireshark processes them. They are very useful to understand the packet structure and troubleshoot the network based communication in the real world. The tcpdump and wireshark use libpcap underneath to capture the traffic of interest as per defined criteria that are generally passed by the end user. [16]

There are few key concepts are packet sniffing as under:

Packet Sniffer

It is a software that can be utilized for packet capture over the interface. It has various control to capture the intended traffic by specifying various parameters and filter expressions. [16]

Promiscuous Mode

It is a mode by which the packet sniffer sniffs all the traffic over the network, not only the packets which are addressed to it. It is very essential concept for traffic capture because it enables to look into all the traffic passing by. [16]

Data

It is the data collected by the packet sniffer that can be utilized for troubleshooting of some issue or identification of some malicious activity over the service, host or the network. [16]

Protocols

There are various protocols like HTTP, FTP used to send and receive data over the network. The packet capturing can be used to look into such communication which can indeed help troubleshooting the issues or analyze behavior of some communication or identification of malicious activity over the network or the host. [16]

CONCLUSION

There are multiple packet sniffing, packet filtering and traffic management techniques to control and manage the traffic. Different packet filtering and traffic management techniques like rate limiting, ingress-egress filtering, traffic control and those techniques work to either filter or manage the traffic have been described in this paper. It is used in traffic filtering and traffic shaping that helps in fulfilling the overall objective of allowing intended traffic and dropping the unwanted traffic for better quality of service and less network congestion.

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An Adaptive Collaborative Filtering Model for College Recommendations: Leveraging User Preferences for Optimal Fit

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ABSTRACT

Every year millions of students in India apply for undergraduate and graduate programs in hundreds of universities across India and abroad. Each and every student applies for at least three different courses in various universities to secure his seat in his preferred undergraduate program. The universities have their own criteria of selecting and enrolling students including state level entrance exams, 12th board results and many a times their own entrance exams. Every year, India witnesses a major shuffle in the location of students, as they shift to their favourite destination of higher education within India and abroad, as per their economic status and merit. The universities witness a huge influx of applications in various departments, from all the states of India and also from abroad. It is a known fact that out of hundreds of applications in each department, only a few fortunate students are able to meet the criteria of admission every year. Here comes the importance of recommender system, an advance information filtering technology, currently used in various and varied areas, to recommend the desired data of students meeting the university criteria from different states and also to preserve the data of students for future reference. This research paper is focused to bring advancement in the precision and accuracy of a normal filtering process. Practically, many types of recommendation systems are in vogue. In this research paper we have preferred the algorithm which is inspired by K-NN plus K-NN Collaborative Filtering, which works upon collecting the data of the users, analysing the user's preferences, versions and recommends the most preferred results sought by the client. In the proposed algorithm, an improved cosine similarity is used as determination of cosine angle and enhanced accuracy has been attained in the recommendation results, aided by collaborative filtering technique.

KEYWORDS: *College recommender system, Cosine similarity, K-NN algorithm, Content-based filtering, Collaborative filtering, Nearest neighbours, Item-based collaborative filtering.*

INTRODUCTION

There are hundreds of universities in India offering different level of programs, including on-line, offline and distance learning, for each and every stream of education ranging from diploma to PHD. Every year the colleges spend a huge amount of time, money and effort to get the desired number of students in terms of merit and intellect. It is a common scenario in many universities in India that every year they get applications from the few common states, given the fact that the current students recommend the college to their juniors/relatives/friends, the affordable fees, the outstanding faculties and other facilities, the college is offering. Every year the process is same but expenses inflate every year due to various uncontrollable factors. The colleges need an efficient recommender system to assess the pattern of students applying to their college in terms of marks, the locality and the preferred courses from highest to lowest preference. This will give the university a fair idea to invest its precious time, money and effort, at right places. It will also help the university in making comparative analysis in different departments, in improving the quality of enrolments, the quality of departments which are less preferred by the students, to know the states where maximum and minimum budget is to allocated, in improving the other facilities to raise the bar etc. The recommender system will also help the universities to assess the change in program preferences of students, the spending capacity of students, the ratio of students enrolling form different states and a very fair idea regarding where to spend and where to save money in terms of expansion of infrastructure, introduction of new programs as per the changing demand, up-gradation of current programs, scrapping of programs with very less or no demand etc. The list of benefits is endless. An efficient recommender system can contribute towards increase in enrolments, increase in new preferred programs, increase in program up-dations, increase in an overall rating of the university and many other enhancements resulting in overall increase in the goodwill, reputation and revenue of the university.

Any recommender system contains a profile in which it stores the user information and then an algorithm is used which uses the information of the user as input and creates optimizations to return useful and good recommendations. In Recommender Systems, the machine learning algorithms can be classified into Collaborative filtering based, Content based and Hybrid based algorithms [2].

For example: While buying any product from Amazon, the users get recommendations under the section "People who purchased this also purchased these items". Conventionally, Recommender Systems have been associated as Content based filtering (CBF), Collaborative filtering (CF), Hybrid based and Demographic based recommender systems. The Collaborative filtering algorithms are based on similarity from interactions; whereas Content based algorithms calculate similarity between product attributes [3].

PROBLEM STATEMENT

Every year hundreds of man hours and resources are expended by the universities across India in advertisement of their courses, filtering of students who have applied for different programs and enrolment process. This exercise goes on year to year and the overall costs involved in this process of advertising and marketing escalates every year due to the rising competition among universities to attract maximum number of students and to keep up with the rising demand of new programs in technical faculties. This is unending process and this validates the grave need of a recommender system in all the colleges and universities.

RELATED WORK

Different modules and methods of filtering such as context based, deep learning techniques, hybrid techniques etc. are implemented in getting the desired results which are preferred in various fields. In [2], L. Uyangoda have applied the association of feature-scores resulting from user-item collaboration via ratings to enhance the input parameters of algorithm used in RSs to optimize the accuracy of recommendations with less number of past records of the user. In [4], F. Khawar and N. L. Zhang recommends a unique CF algorithm which clusters the users, which are agreeable towards different subsets of items, into taste clusters, employs those taste groups to identify the users and items to latent feature vectors and then deliver conclusions on the basis on the inner products of respective said vectors.In [7], The paper suggests a unique concept that creates user interest model along with knowledge points and learning aptitude assessment model by pulling out users' quantum of knowledge as their specialties and expertize, and also depending upon the idea of collaborative filtering algorithm. The paper[8] proposes a heightened recommendation algorithm founded upon the propositions of amended user-based collaborative filtering to solve the issues and difficulties and increase the recommendation quality. The improved algorithm was put in contrast to the traditional algorithm and its accurateness and performance by employing the Root Mean Square Error (RSME), Precision and Recall were assessed.

Problems of Recommender Systems

1. Sparsity: It is one of the key problems faced by recommender systems and data sparsity influences the quality of the system greatly. The foremost reason behind data sparsity issue is that most of the users do not give ratings to most of the products/ items and the ratings which are available are left sparse. [21].

2. Cold Start: It denotes a situation in which a new user or product enters the system. There are three kinds of cold start problems, namely: new item/ product problem, new user problem and new system problem. [1] [15].

3. Scalability: With massive growth of data and information over web, it is obvious to consider that recommender systems are having an outburst of data and therefore, it becomes very hard to handle continuously growing demands. [24] [13]

Different terminologies used in implementation of college recommender system are discussed below:-

Content-based Filtering

This recommendation system works on inputs based on the preferences, rejections and dislikes of the subjects depending on their previous behaviour, feedbacks and interests. For example, if a person watches action genre more multiple time than the horror genre, then the person will most likely watch the most-watched genre in the descending order.

A recommendation system was proposed by R. Van Meteren, and M. Van Someren wherein the comparison was carried out regarding users' profiles in respect of the preferences determined via users browsing history signifying the interest, tastes, preferences, likes and dislikes of the users which can be taken as various sets of the terms, symbolized as content of the document.

Collaborative Filtering (CF)

The Collaborative filtering and its variants are an exception among the other mostly used recommendation algorithms. [32] Certainly, recommender system researchers can also use it to build their customized movie or any other recommender systems. In order to recommend items to the users, the logic followed is to segregate the users having same interests, and then analyzing their actions and recommended products or items as shown in Figure 1. Generally, an 'AXB' matrix is used in collaborative filtering in which 'A' represents the users and 'B' represents the items or products. [35] The ratings given by the users are entered in the matrix and the users with the similar interests can be recognized using any mathematical resemblance measure like correlation. The history of the user is used in item-based K-NN collaborative filtering approach.[2]

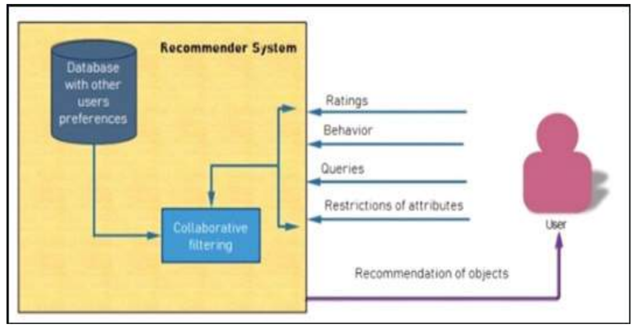

Fig. 1: Working of Collaborative Filtering

User-Based Collaborative Filtering (CF)

User based K-NN Collaborative filtering algorithm focuses on filling a user-item matrix and then recommending on the basis of users which are more similar to the active user. [31] This approach is basically memory based collaborative filtering approach in which the ratings of users are takes into account to calculate the similarity. This algorithm needs the following tasks to be done:

Step 1. It finds the K nearest neighbors of the user 'a', by using a similarity function 'w' used to measure the distance between each pair of users:

Similarity (a, i) = w (a. i). i € K

Step 2. The rating is predicted that the user 'a' will give to all items consumed by the K nearest neighbours and 'a' has not. Item (j) is looked for as it has the best predicted rating. Also, to predict the ratings on items, a user-item matrix is formed, based on other similar users present.

With respect to items or users, the scalability of the recommender systems must be dealt with. Nearest neighbour algorithm will contain calculations to scale with the items and users. [27] In User-based Collaborative filtering, the calculation time to generate the user-item matrix increases if the items and users increase and therefore, making a scalable CF algorithms are difficult.

Item-Based Collaborative Filtering (CF)

Item-based Collaborative filtering recommender system follows the idea of neighbourhood approach and is based on the idea that similar projects as well as similar users can be given priority shown in Figure 2.

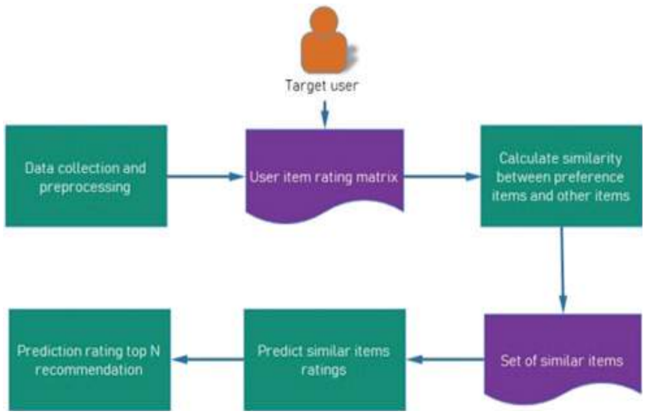

Fig. 2: The basic principle of item-based collaborative filtering algorithm

Item-based Collaborative filtering comprises of two main steps:

Step 1: The user project scoring matrix is used to determine the high-score projects of target users, and the pairs of these projects are then calculated.

Step 2: Here it calculates expected user scores for projects, generating a recommendation list for the top N, but users must be cautious when filtering out items or products already generated.

Recommendations are made based on user-purchased items, and recommender systems discover the count of items/users in a list and compare it to actual counts. They find similar items/users to antedate the user's score..[8]

In Table 1 given below, it can be deduced that item A is a preferred one by all the users and the same users have also shown inclination towards Item C. Item based do not change given that they are not dynamic by nature.

Table 1: Item-Based Collaborative Filtering

User/Item	Item A	Item B	Item C
User A			
User B			
User C			Recommended

The Hybrid approach: If we are looking for very precise and correct outcomes employing the collaborative as well as the content bases filtering, at the same time eliminating the minus points or let say drawbacks of the algorithm then this approach should be preferred.

PROPOSED RECOMMENDATION ENGINE

Collaborative filtering technique (item-based collaborative filtering) has been used in the proposed system. Item-based is more efficient as well as more accurate as it can be used offline and is non-dynamic in nature as compared to user-based collaborative filtering as it changes and is dynamic in nature. KNN algorithm has been used in the proposed approach in order to find the distance between the students and their rating from the past & the top k nearest similar students are ranked using cosine angle similarity. Various different techniques used in the proposed algorithm are mentioned below:-

KNN Algorithm- It is used to find clusters of same users on the basis of their common choices or ratings, and then the predictions are made using the top-k nearest neighbours' average ratings. KNN classifies any unlabelled class given to its respective class by predicting basis on a similarity factor or measure as shown in Figure 3.

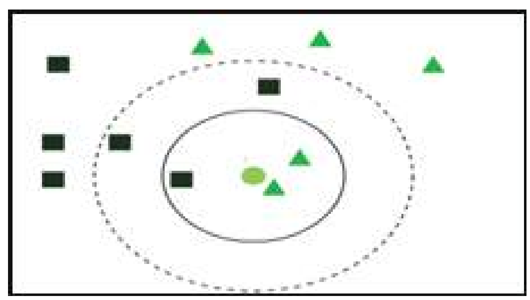

Fig. 3: Demonstration of the K-NN algorithm (value of K=3)

Cosine similarity- It is a metric which measures the similarity between two items. Mathematically, in this algorithm the cosine of the angle is measured which is between two vectors which are placed in a multi-dimensional space. It is used to calculate the distance between the ratings in the data and the target audience in the dataset. Regardless of how different the two measures are in size, the similarity can be measured using the cosine similarity algorithm and the cosine angle can be calculated between two vectors. The output value of this algorithm is between the range 0 or 1. 0 indicates there is no similarity and 1 indicates that there is 100% similarity between the items.

Eq. (1) is used to define the cosine similarity of the proposed model.

$$\theta = \frac{\vec{a}.\vec{b}}{||\vec{a}||.||\vec{b}||} \tag{1}$$

Item-based collaborative filtering- Item-based Collaborative filtering recommender system follows the idea of neighbourhood approach and is based on the idea that similar projects as well as similar users can be given priority. The recommendations are made on the basis of items bought by the user in the past.

Figure 4 explains the proposed collaborative filtering method. The objective here is to recommend the states in ascending order from which the respective University has accepted maximum number of students in the past few years. The recommendation is proposed using the item-based collaborative filtering technique. The acceptance criteria of students is based on their 12th and JEE marks.

First, the extraction of the dataset is performed in order to gather information about the students and their marks. Different ratings are given to different students on the basis of their marks for example: Rating 1 is given to those students whose 12th percentage is greater than 75% and JEE marks are greater than 150. Rating 2 is given to those students whose 12th percentage is greater than 60% or JEE marks are greater than 90. Rating 3 is given to those students whose 12th percentage is less than 60% and JEE marks are less than 90.

Second, the collaborative filtering algorithm is applied to format the rating dataset. The rating dataset is then processed using KNN model to solve huge dataset handling issues. According to the popularity, the sparse matrix is obtained by removing the noisy error problem and thus reducing the dataset. After the reduction of dataset, the cosine similarity is used and the distance between the students' states and students' ratings is calculated, giving the top k nearest neighbours in result. The list of recommended states is then displayed in descending order of distance. If the values of K=1 in KNN algorithm, then the respective item is assigned to its nearest neighbour of that class. A case in KNN algorithm needs the most majority number of its neighbours to be assigned.

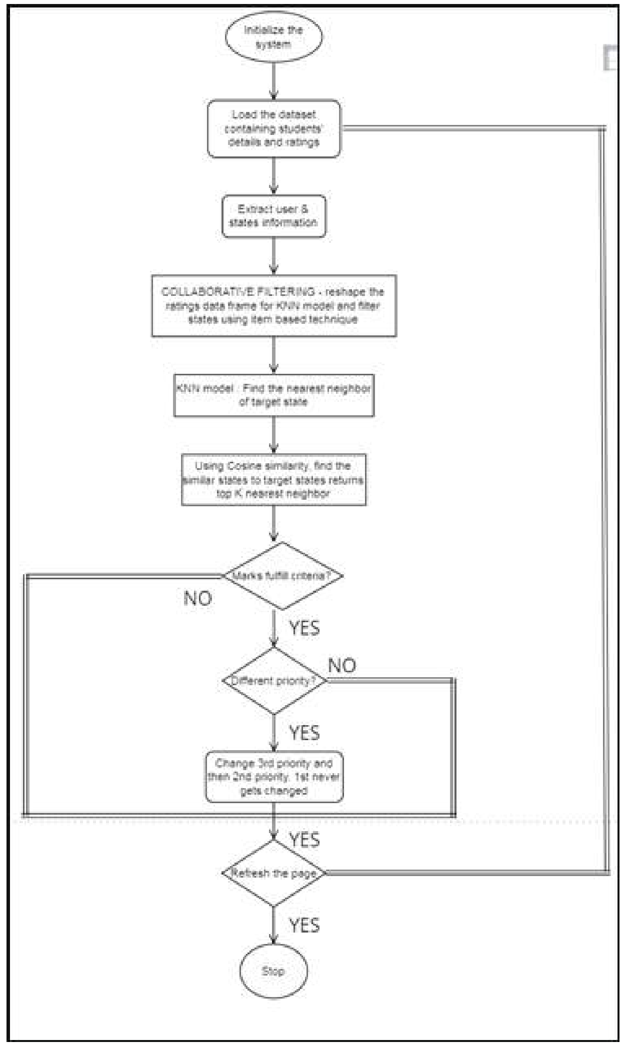

Fig. 4: Proposed Collaborative filtering

IMPLEMENTATION

Dataset Description: The dataset which used contains data of 1000,000 students and 1000,000 ratings. There are two inputs datasets:

1.Students.csv- This dataset contains Student Name, Student ID, Department Choice, Department Name, Student City, Student State, 12th Marks and JEE Marks. Figure 5 describes the students.csv dataset.

2.Ratings.csv- This dataset contains Student ID, Department Choice and Rating.

The filtering of the datasets is performed on the basis of popular ones by filtering the data frames to States only. Figure 6 describes the ratings.csv dataset.

	Student_Name	Student_ID	Department_Choice	Department_Name	Student_City	Student-State	12th Marks	JEE Marks
0	Mary	SID20131143	IDEPT7783	Computer Science	Agra	Uttar Pradesh	63	178
1	Annie	SID20131151	IDEPT6347	Information Technology	Satara	Maharashtra	98	289
2	Anna	SID20131171	IDEPT1836	Mechanical Engineering	Jaipur	Rajasthan	80	176
3	Margaret	SID20131176	IDEPT8473	Electrical Engineering	Gandhinagar	Gujarat	46	143
4	Helen	SID20131177	IDEPT5528	Aerospace Engineering	Adoni	Andhra Pradesh	58	113

Fig. 5: Students.csv

	Student_ID	Department_Choice	Rating
0	SID20131143	IDEPT7783	2
1	SID20131151	IDEPT6347	1
2	SID20131171	IDEPT1836	1
3	SID20131176	IDEPT8473	3
4	SID20131177	IDEPT5528	3

Fig. 6: Ratings.csv

Data Analysis: Data analysis is performed on the dataset using the python libraries. Insight is gained on the dataset to build the module. There are 1000,000 ratings present in the dataset. In the proposed approach, the libraries such as Pandas, NumPy, ScikitLearn and Scipy are used for efficient out on Jupyter Notebook. Figure 7 shows the libraries used in the proposed recommendation system. Every student is rated in the range of 1-3 (1 being the highest). Figure 8 shows maximum rating of 1 and 2 for the students in the dataset as compared to other students having rating 3.

```
import pandas as pd
import numpy as np
from scipy.sparse import csr_matrix
from sklearn.neighbors import NearestNeighbors
```

Fig. 7: Libraries Used

A sparse pivot matrix is developed as the dataset is huge and the data frame needs to be transformed into a proper data frame that can be further used with KNN algorithm and the ratings which are missing can be filled with 0's. The pivot table is analyzed using KNN and cosine similarity in order to find similarity between the students and their states and the result is displayed

Modules

There are three modules in the proposed system:

1. The student's input (Home)

2.The recommendation system (Analyses)

3.All Admissions

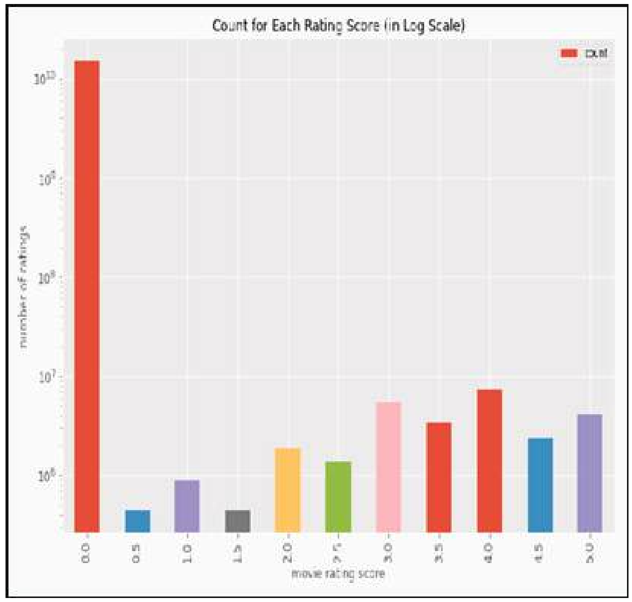

Fig. 8: Student Ratings in Dataset

The student's input: In this module, the students who are willing to apply in a University can check whether they are eligible or not in that respective University. The University will set criteria for that academic year in terms of marks. The University will enter how many marks in 12th are required for taking admission and how many marks in JEE are required.

Figure 9 shows the page where student will have to enter the details in order to check the eligibility. The student will enter details like name, contact number, email ID, address, education details such as 12th Board, school name, marks, city, state and JEE marks. After entering the details, the student is required to click on "Submit" button and then the entered details are compared with the criteria set by the University i.e., the 12th and JEE marks are compared with the criteria marks set by the University. If the student fulfils the criteria then the message is displayed that "Congratulations!! You are Eligible" otherwise the message "Sorry!! You aren't Eligible" is displayed.

The recommendation system (Analyses):In this module, the states from which highest number of students have taken admission in past few years in the University are recommended using the recommendation system.

The dataset is prepared which contains the student details such as Student Name, Student ID, Department Choice, Department Name, Student City, Student State, 12th Marks and JEE Marks, Date of Birth and Date of Admission. The dataset is taken as input as shown and then it is pre-processed. The dataset contains the ratings given to different students on the basis of their marks such as rating 1 is given to those students whose 12th percentage is greater than 75% and JEE marks are greater than 150. Rating 2 is given to those students whose 12th percentage is greater than 60% or JEE marks are greater than 90. Rating 3 is given to those students whose 12th percentage is less than 60% and JEE marks are less than 90. KNN algorithm and cosine similarity algorithm is then used on the dataset to find similarity between the students' states and the ratings. Then the states are recommended using the item-based collaborative filtering algorithm in ascending order.

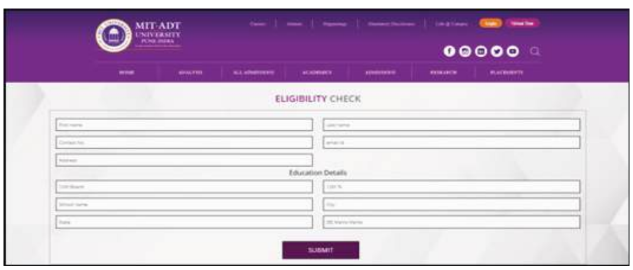

Fig. 9: Student's input

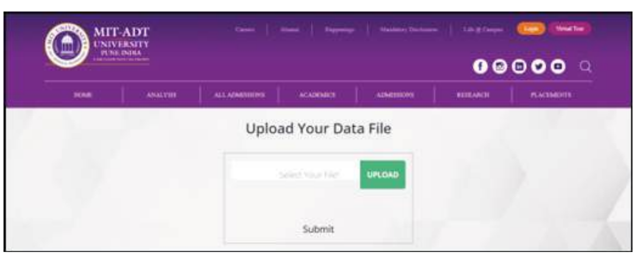

Fig 10: The recommendation system (Analyses)

All Admissions: In this module, the data of students who have checked eligibility in the first module has been stored. The University can use this data in future. For example, if in a particular academic year, the number of students who have taken admission is less, then the University can use the data to approach those students who are not eligible because of a very less factor (very less difference in their marks and the criteria set by the University). Figure 11 shows the dataset which is prepared by storing the students' details.

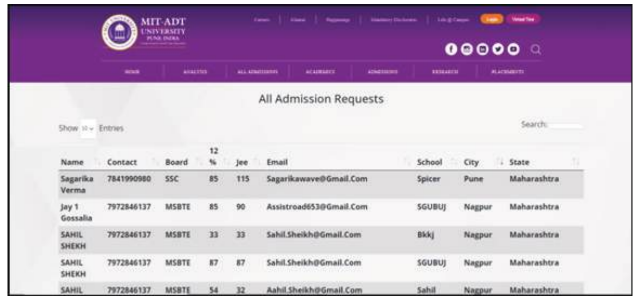

Fig. 11: All Admission Requests

RESULT ANALYSIS

The proposed system is used for recommending the top 5 states from which a particular University has got students fulfilling the eligibility criteria set by the University in the past few years. The recommendations are on the basis of two factors:

1. Based on the count of ratings.

2. Based on average rating.

Different ratings are given to different students on the basis of their marks for example: Rating 1 is given to those students whose 12th percentage is greater than 75% and JEE marks are greater than 150. Rating 2 is given to those students whose 12th percentage is greater than 60% or JEE marks are greater than 90. Rating 3 is given to those students whose 12th percentage is less than 60% and JEE marks are less than 90. Rating 1 and Rating 2 students are students of the University and Rating 3 students did not get admission in the University.

Figure 13 shows the recommendations made on the basis of the count of rating. As seen in the figure, Rajasthan is the top state containing students with Rating 1 and Rating 2. Similarly, after Rajasthan, Kerala becomes the second state containing students with Rating 1 and Rating 2.

Fig. 13: Top 5 states based on count of rating

Figure 14 shows the recommendations made on the basis of the average rating. As seen in the figure, Rajasthan is the top state containing students with Rating 1 and Rating 2. Similarly, after Rajasthan, Kerala becomes the second state containing students with Rating 1 and Rating 2.

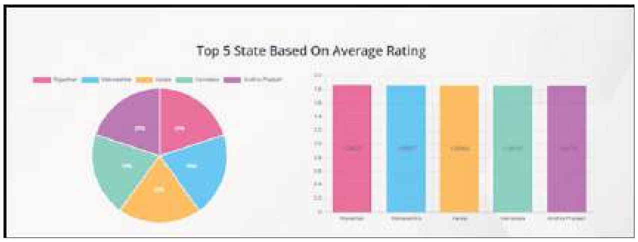

Fig. 14: Top 5 states based on average rating

The model can accurately recommend states by using the Ratings given to all students on the basis of their marks.

The similarity or distance between the students' states is evaluated between the distance parameter and the distance is displayed in ascending order.

Recommendations for Karnataka:

1: Rajasthan, with distance of 0.3035197854042053:

2: Kerala, with distance of 0.3638320565223694:

3: Andhra Pradesh, with distance of 0.38245856761932373:

4: Maharashtra, with distance of 0.3860310912132263:

5: Gujarat, with distance of 0.3874228596687317:

\Recommendations for Rajasthan

1: Rajasthan, with distance of 0.4035194857855404:

2: Kerala, with distance of 0.4638325678223694:

3: Andhra Pradesh, with distance of 0.48245856713572373:

4: Maharashtra, with distance of 0.4579810912132263:

5: Gujarat, with distance of 0.4875624596687317:

Recommendations for Maharashtra

1: Rajasthan, with distance of 0.2035194857855404:

2: Kerala, with distance of 0.3638325678223694:

3: Andhra Pradesh, with distance of 0.38245856713572373:

4: Maharashtra, with distance of 0.4579810912132263:

5: Gujarat, with distance of 0.3875624596687317:

Recommendations for Kerala

1: Rajasthan, with distance of 0.4035194857855404:

2: Kerala, with distance of 0.3638325678223694:

3: Andhra Pradesh, with distance of 0.48245856713572373:

4: Maharashtra, with distance of 0.3579810912132263:

5: Gujarat, with distance of 0.4875624596687317:

Recommendations for Andhra Pradesh

1: Rajasthan, with distance of 0.4035194857855404:

2: Kerala, with distance of 0.3638325678223694:

3: Andhra Pradesh, with distance of 0.58245856713572373:

4: Maharashtra, with distance of 0.3579810912132263:

5: Gujarat, with distance of 0.4875624596687317:

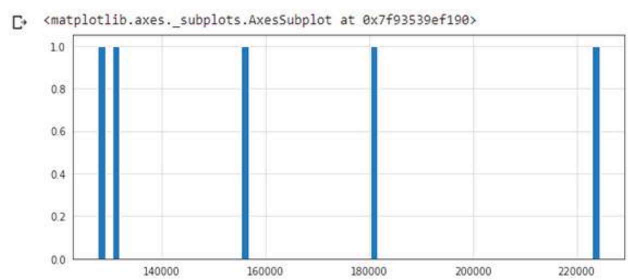

Fig. 15

Figure 15 shows the recommendation which is based on similarity is lesser than the distance having more similarity with the target state.

In order to evaluate and compare our recommendation system to provide better results, various experiments have been conducted by comparing our system with the already used recommendation systems on the basis of accuracy, quality, precision, time computation and recall.

The accuracy-numeric value determines the results of calculation. It fulfills to the standard or precise value. The metrics which are used are discussed from Eq. (2) to Eq. (5) below:

Precision: It is the ratio the recommended cases which are relevant to the total number of cases in the list [11] [12].

Recall: This factor basically describes the important and the most relevant prediction from the list of predictions.

F-measure (F1): F-measure is the score evaluated by calculating the harmonic mean of recall and precision.

Mean Absolute Error (MAE): It is also called as Mean Median Regression and is inversely proportional to the how the recommendation system performs. It measure the average magnitude of errors without taking the directions into count from the list of set of predictions.

The results in Table 2 represents that our proposed model works better and shows better results as compared to the content-based filtering approach. The value of TP rate being stronger as compared to content-based approach proves that accuracy has been improved. The MAE value of our proposed recommendation system is also lesser than other recommendation systems as shown in Table 3.

Table 2: Comparison between Content-based and Collaborative-based algorithms

Approach	TP rate	Precision	F1
Content-based	0.591	0.501	0.528
Collaborati ve based(Item-item)	0.761	0.782	0.772

Table 3: MAE values of different algorithms

Method	Algorithm	MAE
Content-based	TD-IDF	0.269
Collaborative	MODEL-BASED	0.265
Collaborative	USER-USER	0.258
Collaborative	ITEM-ITEM	0.248

CONCLUSION

In this paper, in order to avoid the use of content-based filtering and to get better results, item-based collaborative filtering approach has been used. KNN collaborative filtering along with cosine similarity recommendation system has been proposed by using it on a dataset containing 1000,000 rating over various students from different states. After comparing the proposed system with existing ones, it was found that the proposed system is more accurate and reliable. The increase in accuracy and efficiency of the system was tested by using it on different larger datasets. In the future, the dataset received in first module from student's input can also be used in the recommendation system to help University analyze that help many students wanted to apply in the University for that respective academic year. In case of shortage of admissions in that academic year, the University can also approach the students who were not eligible because of a very minimal difference in their marks and the criteria set by the University.

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Optimized Brain Tumor Prediction Model through Enhanced ImageNet Approaches and Fusion of Activation Functions with Batch Normalization

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ABSTRACT

Rainfall Health is seriously threatened by tumors, and effective treatment depends on early detection. Medical professionals rely heavily on magnetic resonance imaging (MRI) scans because they offer precise views of the brain that aid in tumor diagnosis, surgical planning, and research direction..However, accurately identifying brain tumors in MRI scans can be challenging due to factors like image noise and variations in brain anatomy.This investigation looks at the significant contributions deep learning (DL) makes to the identification and classification of brain cancers from MRI data.

DL is a kind of artificial intelligence that enables machines to recognize intricate patterns in enormous volumes of data.. In the field of medical imaging, DL techniques are showing immense promise in overcoming the challenges associated with brain tumor detection.

This paper specifically focuses on how DL is being applied to analyze MRI scans for both detecting and classifying brain tumors. It explores various DL approaches used for brain tumor classification (BTC) and how these techniques can assist radiologists in their work, ultimately leading to improved diagnoses and research. The survey also examines recent advancements in DL-based brain tumor detection, highlighting the current hurdles and future directions in this critical area. Additionally, it explores the use of standardized datasets for feature extraction and classification stages within the DL models.All things considered, this work provides an extensive analysis of recent developments in applying deep learning to solve the challenges associated with brain tumor diagnosis. This has enormous potential to improve patient outcomes and advance brain tumor diagnostics.

KEYWORDS: *Deep learning, Classification, Brain tumor diagnosis, Magnetic resonance imaging, Feature extraction.*

INTRODUCTION

Brain tumors are a major issue in medicine because of their variety and possibly fatal nature.

Recognized by the World Health Organization as a separate class of cancers of the central nervous system, these tumors exhibit a range of characteristics in terms of growth patterns, location, and aggressiveness. Common types, including gliomas, meningioma's, and pituitary tumors, collectively account for a substantial portion of brain tumor cases.

Early and accurate detection is critical to the best possible results for patients. Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans are two medical imaging modalities that have historically been used to detect brain tumors. Thanks to improvements in image resolution and contrast brought about by advancements in imaging technology, even small abnormalities can now be seen.

To enhance diagnostic efficiency and accuracy, automated diagnostic systems (CADS) have been developed. These systems leverage machine learning (ML) algorithms to analyze medical images and assist radiologists in identifying potential tumors. However, traditional ML approaches, which rely on handcrafted features, often encounter limitations when dealing with the complex and high-dimensional nature of medical image data.

A promising answer to these problems has been identified as DL, a subset of artificial intelligence. DL models do not require explicit feature engineering; instead, they may automatically pick up on intricate details and patterns straight from visual data by utilizing numerous layers of interconnected nodes. The analysis of medical images has experienced

a revolution thanks to this capacity to extract pertinent information from raw data, allowing for more reliable and accurate brain tumor diagnosis and classification.

Scope

- Model Creation and Instruction: Use CNNs and additional deep learning architectures that are appropriate for image processing. Use data augmentation to improve the training dataset and raise the model's generalizability.
- Gathering and preprocessingdata: Collect a diverse dataset encompassing various brain tumor types, sizes, and locations. Preprocess images for standardization (size, resolution, intensity) and apply normalization techniques to optimize model performance.
- Performance Evaluation:Use common metrics to assess the model, such as ROC AUC, F1-score, accuracy, precision, and recall. Perform cross-validation and independent testing to assess generalizability.
- During integration and deployment, make sure that all medical imaging workflows and systems are compatible. Provide a simple user interface so that medical professionals may interact with the model and get the results they need.
- Ethical and Privacy Considerations: Adhere to ethical standards and data privacy regulations. Implement measures to anonymize patient data and secure data storage/transmission throughout the process.
- Future Research: Explore the potential of combining combining deep learning with additional artificial intelligence methods (NLP, reinforcement learning) for improved diagnostics. Investigate the model's applicability to other medical imaging tasks.

LITERATURE REVIEW

The field of brain tumor analysis is going through a major change as a result of the growing application of DL. This powerful technology offers exceptional capabilities for analysing complex medical images like MRI scans, leading to advancements in brain tumor prediction and classification.

Key Objectives

Accurate Identification and Categorization: Achieve high sensitivity and specificity to minimize misdiagnoses (false positives/negatives).

Advanced Feature Extraction: Utilize deep learning techniques to automatically identify pertinent characteristics in brain images. Compare different methods to identify the most effective approach [26].

Enhanced Diagnostic Speed: Design a model for near real-time image analysis, assisting medical professionals in faster diagnoses [37]. Integrate the model seamlessly into existing medical imaging systems.

Clinical Validation: Train and validate the model using a comprehensive dataset of labeled brain images from various medical institutions [38] .The robustness and dependability of the model in practical situations are ensured by thorough testing.

- Explainable AI Solutions: Implement techniques to understand how the model makes predictions. Develop visualization tools to highlight tumor regions identified by the model [14].

Early Research and the Rise of Deep Learning:

Several studies have established the foundation for the present state of DL in brain tumor analysis. Arvanitis et al. [22]illuminated the complexities of brain tumors and the intricate interactions within them, highlighting the challenges associated with accurate diagnosis. Deeksha et al. [22] explored the potential of DL for overcoming these challenges, demonstrating its ability to accurately categorize brain tumors.

Building on this foundation, Nazir et al. [22] conducted a comprehensive review, outlining the significant strides made in DL-based brain tumor detection and classification between 2015 and 2020. Similarly, Amin et al. [22] delved into the broader application of machine learning techniques, providing valuable insights into Many techniques are used to identify and categorize brain tumors.

One noteworthy example is the study by Islam et al. [12]. In order to classify brain cancers in MRI scans, they devised a hybrid feature extraction technique employing Regularized Extreme Learning Machine (RELM). This approach resulted in increased classification accuracy and holds promise in assisting radiologists with more precise tumor identification.

In medical image analysis, transfer learning has proven to be an effective technique, particularly for problems like brain tumor classification. This technique leverages pre-trained models developed for one task and repurposes them for related tasks. By optimizing these current models, such as ResNet152, VGG19, DenseNet169, and MobileNetv3, researchers can significantly improve performance and achieve remarkable precision levels in brain tumor classification [2, 1].

Research conducted by Sandeep Kumar Mathivanan and colleagues [22] demonstrate the efficacy of transfer learning. Their research used deep convolutional neural networks (CNNs) like AlexNet, GoogLeNet, and VGGNet to classify brain cancers into different categories (meningioma, glioma, pituitary adenoma). Strong features from MRI scans can be extracted with ease by these CNN architectures. Moreover, the model performs better when transfer learning techniques like freezing and fine-tuning are included [22].

By making these existing models better, the importance of transfer learning is more clear. Researchers can diagnose brain tumors with extraordinary precision by utilizing the information gleaned from trained model, highlighting the potential influence of transfer learning approaches on improving diagnostic accuracy in medical image analysis [22].

Although categorization is essential for the investigation of brain tumors, precise identification is also necessary for early diagnosis and treatment strategizing. In order to improve brain tumor diagnosis from MRI scans, Appiah et al. [26] reported aa novel technique that combines deep learning networks with proper orthogonal decomposition (POD).

With this combination, medical professionals may be able to diagnose patients more quickly and with greater accuracy thanks to an automated and dependable tumor detection method [26].

Traditional methods for brain tumor segmentation, such as Fuzzy C-means, NN and SVM, often face limitations due to the intricate brain anatomical structures and the presence of noise and distortion in MRI images [37]. This highlights the need for more advanced techniques.

The study by Appiah et al. [26] offers a promising solution by integrating POD with convolutional neural networks (CNNs). This approach addresses the challenges associated with accurate brain tumor detection. Additionally, the study explores the use of cutting edge models for pre-trained transfer learning like MobileNetV2, Inception-v3, ResNet101, and VGG-19 to enhance the detection process, especially when dealing with limited training data availability [26].

Another crucial aspect is explainable AI, which sheds light onThe detection model's decision-making procedure. By providing hints on how the model generates its forecasts, explainable AI contributes to the transparency and trustworthiness of the results – essential factors in medical applications [26].

This paper introduces a novel deep CNN classifier for precise Parkinson's diagnosis through the application of transfer learning and data support techniques. The tasks involved the evaluation of two study variables (cold and conditioned) utilizing imagenet and mnist data. With the imagenet and pahaw datasets, the fine-tuning based technique resulted in a 98.28% network training accuracy[15]. This work classifies and detects brain cancers in MRI data using deep learning algorithms.

For radiologists, Brain tumor diagnosis is a time-consuming and labor-intensive procedure. They only use their own, frequently erroneous, personal knowledge and judgment to make these determinations. This project employs deep learning to accurately categorize brain tumor MRI images in order to address the growing challenge of accurately diagnosing brain cancers. CNN transfer learning model by Alexnet is utilized for this purpose. Our technology provides clinical accuracy, robustness, efficiency, and 99.62% accuracy for all diagnostic procedures[16]. The breadth of classification and diagnosis of complex disorders like brain tumors and other critical diseases is evolving as a result of the integrationof AI, particularly DL, into medicine.

Deep learning has demonstrated remarkable promise in the division and segmentation of brain tissue. This work offers a DL-based, publicly accessible data-driven method for classifying brain cancers using artificial intelligence. This dataset, which includes a set of 696 t1-weighted pictures, divides brain tumors into two categories.: malignant and noncancerous. With an accuracy of 99.04, our strategy has an amazing success record. These outcomes show that the suggested technique is successful in accurately categorizing tumor cells[19]. The goal of this research is to employ sophisticated categorization systems to detect and diagnose brain cancers. Nine pre-programmed transfer learning (tl) classes are compared in terms of performance: Inceptionresnetv2, Inceptionv3, xception, resnet18, resnet50, resnet101, shufenet, densenet201, and mobilenetv2. The public brain tumor segmentation (MRI) dataset is utilized in the analysis.

The suggested approach makes use of a multilayer algorithm built on learning metadata in conjunction with Using convolutional neural network (CNN) layers, brain MRI categorization can be made simpler. High-dimensional data is processed via sparse coding prediction, whereas metadata-based vector coding is employed as the method of encoding. This innovative method yields compelling outcomes in terms of categorization, both based on criteria and opinions. used two datasets for validation: brats and Rembrandt's brain MRI classification system performs better than the current approach[17]. This technique preprocesses MRI pictures using a multistage procedure to get rid of noise and artifacts. Using filters that are adaptable. Then, for picture analysis, enhanced fuzzy c-means clustering was used. Local binary gray-level joint motion matrix (lbglcm) for feature extraction comes after segmentation. extraction. At 98.79% sensitivity, this method produced the best categorization results. 91.3% precision, as well as.

After identifying edge pixels using the Kirsch edge detector, To enhance the brain image, contrast adaptive histogram equalization is utilized. Then, in order to acquire multiple resolution coefficients, the image enhancement brain is transformed using the ridgelet transform. Ridgelet transform coefficients are utilized to extract features, which are then optimized through pca. Next, the data is classified using the co-active adaptive neuro-fuzzy expert system classifier as either glioma or nonglioma. Achieving 97.6% sensitivity, 98.56% specificity, 98.73% accuracy, 98.85% precision, 98.11% fpr, and 98.185 fnr, this generalization demonstrated strong classification performance. Images are not required, although they can improve the content. In this instance, the updated sentence describes the plan and its effectiveness in a straightforward and succinct manner without the need for visual assistance.[46]

This work combines a unique algorithm with an SVM classifier to propose a revolutionary deep learning method for classifying brain tumors. We evaluate an adaptive learning-based method for diagnosing brain cancers using MRI data from figshare, which includes tumors with origins in the pituitary gland, meningioma, and glioma. With 99.61% accuracy using the resnet-50 architecture and adjusted parameters and 99.35% accuracy using the CNN architecture and SVM classifier, the deep learning approach has proven to be effective[14].

Using MRI data, an integrated a model is made to enhance brain tumor identification and categorization. The model integrates texture, intensity, and image feature extraction with MRI preprocessing. With a 0.984 auc-roc value, 0.94 precision, 0.93 recall, 0.94 f1 score, and 93.0% accuracy, the model performed well when tested on the Brats 2020 dataset. This method offers crucial resources for efficient treatment planning and early brain cancer diagnosis[15]. A brain segmentation technique for medical pictures that uses the u-net model architecture, which is well-known for its semantic segmentation performance, to train a data model dispersed across multiple hospitals. The government study is suitable for broad use in the field of medical imaging and is flexible.

The findings of the experiment indicate that specificity and dice coefficient grow with the number of clients.

This approach offers improved productivity, accuracy, and efficiency over cnn and rnn-based approaches. Without jeopardizing private data, the findings are anticipated to have broad implications in the medical field[16].

Neural networks and manual characteristics are combined in an integrated approach for brain segmentation in MRI data. The technique trains a CNN architecture to recognize items of interest by extracting information from MRI data. The brain tumor segmentation challenge dataset compares and surpasses standard approaches in terms of hybrid method performance. The objective of this study is to attain clinical application [17].

a cascade approach to brain segmentation that combines manually designed feature-based machine learning algorithms with convolutional neural networks (CNNs). The technique makes use of a global convolutional neural network (gcnn) and data from four different MRI modalities. With a dice score of 87%, the model outperformed the state average. This innovative method may help doctors identify and treat patients more accurately, enhance brain segmentation, and lower the expense, time, and mistake rates associated with manual segmentation [1].

The Broader Landscape of DL Techniques in Brain Tumor Analysis

The success of DL in brain tumor analysis extends beyond the approaches mentioned above. Several studies showcase the effectiveness of various DL models for brain tumor classification and segmentation from MRI scans.

- Mohsen [15] employed a DNN classifier to categorize brain MRI scans into four tumor categories.
- Siar&Teshnehlab[16] utilized a CNN to identify tumors in brain MRI images.
- Choudhury [19] demonstrated the use of CNN-based techniques for classifying MRI scans as “tumor detected” or “tumor.

Table 1: Summary of Literature Survey

Reference	Technique	Description	Performance Metrics	Dataset
Naseer, A.(2018)	Traditional Image Processing	Kirsch edge detection, contrast enhancement, Ridgelet transform, PCA, CANFES classifier	Sensitivity: 97.6%, Specificity: 98.56%, Accuracy: 98.73%, Precision: 98.85%, FPR: 98.11%, FNR: 98.185	Figshare
Badjie, B. &Ülker, E. D.(2022)	Deep Learning (CNN)	AlexNet for brain tumor classification	Accuracy: 97.62%	Kaggle
RajatMehrotra, M. A., Ansari(2020)	Deep Learning	AI-driven classification of brain tumors into malignant and non-cancerous	Accuracy: 96.04%	696 T1-weighted images
Ullah, N.(2022)	Transfer Learning	Comparison of nine pre-trained models for brain tumor classification	InceptionResNetV2 achieved highest accuracy (95.91%), precision (98.28%), recall (99.75%), F-measure (99%)	Kaggle brain tumor dataset
Saravanan, S.(2022)	Metadata Learning and CNN	Multilayer-based metadata learning with CNN for brain MRI classification	High classification performance, validated on BRATS and REMBRANDT datasets	BRATS and REMBRANDT
Srinivasan, S.(2023)	Hybrid Approach	Combination of hand-crafted features and CNN for brain tumor segmentation	Sensitivity: 95.79%, Specificity: 91.3%, Accuracy: 98.1%	Kaggle

Saravanan, S. &Tirumurugan(2020)	Cascaded Strategy	Integration of CNNs with hand-crafted features for brain tumor segmentation	Dice score of 87%	Four MRI modalities
Karim, P. J., Mahmood(2023)	Deep Transfer Learning	Fine-tuning pre-trained CNNs for brain tumor classification	Accuracy of 98.35% with CNN and SVM, 99.61% with ResNet-50	Figshare dataset
Ullah, F.(2023)	Ensemble Model	Combination of MRI preprocessing, feature extraction, and classification	Accuracy: 93.0%, Precision: 0.94, Recall: 0.93, F1 score: 0.94, AUC-ROC: 0.984	BraTS 2020 dataset
Nadeem, M. &Abrar(2024)	Federated Learning	U-Net based model for distributed training on brain tumor segmentation	Improved specificity and Dice coefficient compared to CNN and RNN	Multiple medical institutions
Ullah, F.(2023)	Hybrid Approach	Combination of hand-crafted features and CNN for brain tumor segmentation	Superior performance compared to conventional methods	Brain Tumor Segmentation Challenge dataset

ARCHITECTURE

High image contrast is crucial for effective visual interpretation, particularly in medical imaging where subtle anatomical or physiological details can significantly impact diagnosis. The contrast level within an image can be assessed by analyzing the distribution of pixel gray values in a histogram. Unfortunately, capturing images with the full spectrum of gray levels using standard commercial equipment is often challenging. Histogram modification is a common technique used to address this limitation in digital image processing. However, this method frequently introduces distortions into the image.

Steps of Digital Image Processing

Initial Image Processing

Brain tumor detection begins with MRI scans, which can be either color or grayscale images, standardized to a 220x220 pixel size for analysis. Color images are converted to grayscale using a numerical representation (0 for black, 255 for white). The subsequent process involves two primary stages: image segmentation and edge detection

The initial stage of analysis involves preparing MRI images for processing. These images, initially in colour or grayscale format, are standardized to a 220x220 pixel size. Color images are converted to grayscale for further analysis.

Subsequently, the image undergoes pre-processing to enhance its suitability for tumor detection. This includes noise reduction through techniques like median filtering, though noise in modern MRI scans is relatively minimal. Image smoothing is applied to simplify the image while preserving essential details, facilitating subsequent analysis.

Image registration is another critical step, aligning multiple images for comparison. In medical imaging, when images are frequently obtained at various periods or using several modalities, this is very crucial. (e.g., MRI and CT). Registration enables the comparison of images taken before and during surgery, despite potential differences in resolution and anatomical deformations due to the surgical process.

Splitting Images

Because the precision of image segmentation directly affects the succeeding steps in the analysis process, it is an essential step. Tumor boundaries can be difficult to define precisely because of differences in tumor size, form, color, and patient-specific characteristics including skin type and texture. Inconsistent tumor boundaries and instances of subtle transitions between the tumor and healthy tissue give rise to further difficulties.

Numerous segmentation techniques have been created to get around these problems. These methods can be roughly categorized into four groups.: supervised, unsupervised, region-based, edge-based, and thresholding classification techniques. These methods include, for example, fuzzy C-means clustering, gradient vector flow (GVF), thresholding, watershed segmentation, and K-means clustering.

Feature Selection and Extraction

A critical stage in image analysis is feature extraction, which entails locating the salient features in an image that best convey the most important information. These features act as a simplified representation of the original image data, facilitating subsequent analysis and classification tasks.By carefully selecting and extracting features, we aim to capture the essential properties of a lesion, such as its shape, size, and intensity variations. These extracted features are then used as input for classification algorithms, which assign the lesion to its corresponding category.

We concentrate on shape, intensity, and texture as the three main feature kinds in order to do this. Circularity, irregularity, area, perimeter, and shape index are examples of shape-related properties. Intensity attributes include factors such as mean, variance, standard deviation, median intensity, skewness, and kurtosis.. Texture features are composed of contrast, correlation, energy, entropy, homogeneity, cluster shade, and sum of square variance.

While these features collectively provide a comprehensive representation, they may contain redundant information. To address this, feature selection is employed. This procedure comprises removing superfluous or unnecessary features and carefully choosing the subset of features that are most pertinent for categorization. We increase the efficacy and efficiency of later learning models by decreasing the feature set. Among the advantages of feature selection are the reduction of the dimensionality curse, the improvement of model interpretability, the acceleration of learning, and the enhancement of model generalization.

Methods used in Detection

The remarkable depth of Microsoft Research's convolutional neural network (CNN) architecture ResNet-152, which has 152 layers, is one of its distinguishing features. The use of residual connections, also known as skip connections, in ResNet-152 is a significant advance. By allowing the learning of residual functions, skip connections make it easier to train incredibly deep networks. Because of its depth, this architecture can extract extremely complex characteristics and patterns from data, which makes it a good fit for applications like object recognition and image categorization.

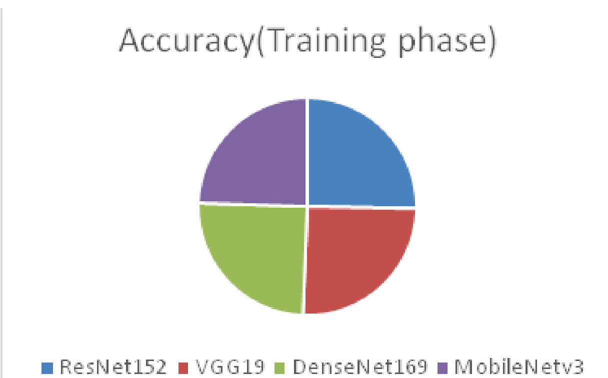
VGG-19 is a deep CNN architecture developed by the Visual Geometry Group. It is a 19-layer model with three completely linked layers and 16 convolutional layers that expands on the VGG-16 model.. Using 3x3 convolutional filters, VGG-19's deep structure enables it to capture complex picture patterns and characteristics.

To lessen computational effort and spatial dimensions, max-pooling layers are integrated. Completely connected, the last layers allow for predictions based on the high-level information retrieved by the convolutional stages. To add non-linearity, the network uses the Rectified Linear Unit (ReLU) activation function. Even while VGG-19 has been useful for image classification applications, ResNet and Inception, two more contemporary architectures, have outperformed it in terms of efficiency and performance.

A convolutional neural network called DenseNet-169 was created to overcome difficulties in deep network training. Because of its special structure, each layer is connected to every other layer, facilitating effective information flow and feature reuse. Bottleneck layers with 1x1 convolutions are used to control computational complexity.

The depth and feature extraction capabilities of the network are enhanced by dense blocks, which are made up of several densely connected layers. Transition layers control the spatial dimensions and growth of feature maps. Global average pooling is commonly used in DenseNet architectures to reduce parameters and enhance generalization. Due to its efficient parameter usage and strong performance in image classification, DenseNet-169 has become a prominent architecture in the field.A CNN called DenseNet-169 was created to solve problems with deep network training. Because of its special structure, which links every layer to every other layer, it facilitates effective information flow and feature reuse. Bottleneck layers with 1x1 convolutions are used to control computational complexity. Dense blocks add depth and feature extraction capabilities to the network by consisting of several densely connected layers. The growth and spatial dimensions of feature maps are controlled by transition layers. DenseNet topologies frequently employ global average pooling to lower parameters and improve generalization. DenseNet-169 has emerged as a leading architecture in the field of image classification because of its effective parameter usage and robust performance.

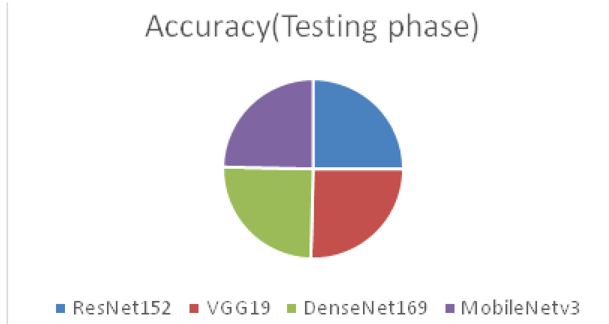
A neural network architecture called MobileNetV3 was created especially for gadgets with constrained processing power. It is the third version of the MobileNet series, with accuracy, speed, and efficiency as its top priorities. Specialized construction components, lightweight inverted residual structures, and two variations—MobileNetV3-Large and MobileNetV3-Small—are some of the key features. These design decisions maximize memory and processing capacity, allowing the architecture to run on hardware with limited resources. Inverted residuals enhance feature extraction while minimizing computational overhead. The two variants offer flexibility for different device capabilities, with MobileNetV3-Large targeting moderate resource constraints and MobileNetV3-Small designed for devices with stricter limitations.



Analysis

The pie chart illustrates the training time required for different deep learning models.

- ResNet152 demands the most training time, constituting the largest slice of the pie chart.
- MobileNetv3 requires the least amount of training time, represented by the smallest slice.
- VGG19 and DenseNet169 have intermediate training time requirements, with VGG19 generally taking slightly longer than DenseNet169.



CONCLUSION

Brain tumor identification has been transformed by deep learning, which has major benefits for patients and medical professionals alike.

By leveraging artificial neural networks, these models can rapidly and accurately analyze complex medical images. This technological advancement facilitates earlier detection, improved diagnosis, and ultimately, better patient outcomes. This study compares and surveys a number of automated MRI-based brain tumor prediction techniques. This is meant to highlight the numerous approaches to medical image processing that different people have proposed, along with their respective performances. Numerous techniques for image processing and tumor prediction have been proposed in the literature.

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Android-Based Assistant for Visually Impaired

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ABSTRACT

Visually impaired individuals encounter many difficulties in their daily lives. For the visually impaired, the daily routine can be daunting. The research introduces an Android-based system with a virtual assistant, designed to empower visually impaired individuals to independently perform routine tasks. The idea revolves around providing blind people with an Android-based system equipped with a virtual assistant, enabling them to perform some simple tasks independently. The purpose of the system is to provide voice assistance to visually impaired people to help them complete tasks such as reading, optical character recognition, object recognition, directional assistance and understanding the environment. By integrating cameras, mobile devices, and a sound system, the project seeks to comprehensively address the multifaceted challenges faced by visually impaired individuals. The ultimate goal is to enhance accessibility and promote independence, enabling visually impaired individuals to navigate the world around them with confidence and autonomy. By facilitating greater participation in daily activities, the development of such a device not only improves quality of life but also fosters social inclusion by empowering individuals with visual impairments to engage more fully with their surroundings. Through this research, we aspire to contribute to a more inclusive society where everyone, regardless of ability, can thrive and participate fully.

KEYWORDS: *Visually impaired individuals, Assistive technology, Virtual assistant, Android system.*

INTRODUCTION

Millions of people around the world suffer from low vision, making it difficult for them to understand their surroundings. One of the main problems that visually impaired people face is moving and understanding their environment. There are other problems, such as reading text written on the wall or desktop, unless auto reader is enabled on the desktop.

They have difficulty moving because they cannot evaluate the relative position of objects and people around them. They need help from others to navigate or understand their environment. Due to the limitations of traditional solutions, extensive research is used to provide effective and efficient tools to assist blind and visually impaired people. Android system that uses the mobile phone's camera to identify objects and text. Using TensorFlow's API, the application will recognize the environment and notify the user via voice about detected objects.

Visually impaired users can receive voice messages using audio devices such as headphones or speakers on their mobile phones. Since the system uses the phone's camera to perform these functions, an additional camera is not needed. This article provides an overview of Android applications, standards, and features for the visually impaired to explain how java and Kotlin-based applications support independence for the visually impaired.

LITERATURE REVIEW

In recent years, several studies have contributed to advancing technologies aimed at assisting visually impaired individuals.

In 2021 Kanchan Patil, Avinash Kharat, Pratik Chaudhary, Shrikant Bidgar, Rushikesh Gavhane published the article "Guidance System for Visually Impaired People" which proposed a wearable virtual assistive system aimed to help visually impaired people in their regular activities. This technology is meant to handle the primary issues faced by visually impaired users, such as environmental awareness, location, facial recognition, and text reading. This new system has five essential features, each of which contributes to functionality and usability. Utilizing advanced deep learning and the core libraries of the Python language, the project aims to simplify the day-to-day activities of visually impaired individuals and provide effective solutions to common challenges.

In 2020 Vinayak Iyer, Kshitij Shah, Sahil Sheth, Kailas Devadkar published the paper "Virtual assistant for the visually impaired" which addressed the challenge of internet accessibility for visually impaired individuals by developing a software solution enabling interaction with websites via voice commands. The authors propose a software solution designed to increase Internet accessibility for visually impaired users by providing voice commands to interact with web pages. Their software incorporates speech-to-text and text-to-speech modules, along with automation capabilities using Selenium, thereby enhancing usability and providing summarized content.

In 2023 Prof. Supriya Gupta, Divya Wandhare, Harshal Jodangade, Aayushi Pandit, Bhargavi Chendke published the paper "Voice Assistant For Visually Impaired People" which describes an application catering to the needs of visually impaired individuals, offering features such as reading printed text, a talking calculator, weather information, object detection, and a voice-based payment system. The main objective of the project is to improve the daily lives of the blind through the use of voice recognition techniques, which have become increasingly important with the rapid development of wireless communication.

In 2021 Sulaiman Khan, Shah Nazir, And Habib Ullah Khan published the paper "Analysis of Navigation Assistants for Blind and Visually Impaired People: A Systematic Review" and conducted a systematic review focusing on navigation assistance for blind and visually impaired individuals. Their study identified various navigation devices and highlighted the need for improved guiding mechanisms to mitigate limitations such as limited object detection ranges and potential user harm. By analyzing primary studies from 2011 to 2020, their research aims to inform future improvements in navigation assistance technology.

In 2022 Xuhui Hu, Student Member, Aiguo Song, Hong Zeng, and Dapeng Chen published the paper "Xuhui Hu, Student Member, Aiguo Song, Hong Zeng, and Dapeng Chen" explored the use of spatial audio reasoning (SAR) to assist blind amputees in conveying environmental information. Their study developed a virtual scene and sound source to simulate three-dimensional motion, coupled with a prosthetic control system to enhance daily activities. The findings demonstrate the potential of SAR in improving information transfer rate and reducing completion time for blind amputees.

Overall, these studies contribute valuable insights into the development of assistive technologies for visually impaired individuals, highlighting the importance of innovation and interdisciplinary collaboration in addressing the diverse needs of this population.

SYSTEM OVERVIEW

Mobile Application Interface

- This serves as the user-facing part of the system, running on an Android device, providing an intuitive interface for interacting with the app.
- This component aligns with the objective of creating an Android-based assistant for visually impaired individuals.

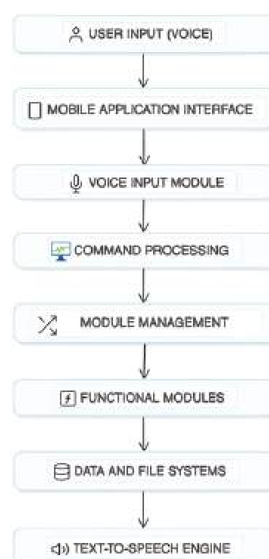

Fig. 1: System Workflow

Voice Input Module

- Responsible for capturing voice commands from the user and converting spoken words into text format.
- This component is crucial for enabling users to interact with the application hands-free, which is essential for individuals with visual impairments.

Command Processing

- Receives the recognized voice command from the Voice Input Module and analyzes it to determine the intended action or module switch.
- This component facilitates the seamless execution of user commands and navigation between different modules.

Module Management

- Utilizes Android's Intent system to navigate between different modules based on the user's command. Launches the appropriate module based on the user's request.
- This component ensures efficient management and coordination among the various functional modules of the application.

Functional Modules

- These include modules such as Object Detection, Navigator, and OCR.
- Object Detection Module: Utilizes image processing techniques to identify and classify objects present in the environment.
- Navigation Module: Utilizes GPS data and mapping algorithms to provide real-time directional guidance and route planning for navigation purposes.
- Optical Character Recognition (OCR) Module: Analyzes images to extract and convert text into machine-readable format, enabling text recognition and reading capabilities.

Data and File System

- Manages the data and files used by different modules, including images and textual data.
- This component ensures proper storage and retrieval of information required for the operation of the application.

Text-to-Speech (TTS) Engine

- Converts textual information into speech output, providing audio feedback to the user.
- This component is essential for delivering information and instructions to visually impaired users in an accessible format.

Data Flow

The system begins with the user issuing a voice command, which is captured by the Voice Input Module. Subsequently, the recognized voice command undergoes analysis within the Command Processing module to discern the user's intended action, such as object detection. This information is then relayed to the Module Management component, which utilizes Android's Intent system to transition to the appropriate functional module. Upon activation, the selected functional module executes the requested task, such as performing object detection, while relevant data is managed within the Data and File System. Once the task is completed, the results are synthesized into speech using the TTS engine, enabling the system to provide audible feedback to the user.

PROPOSED SYSTEM

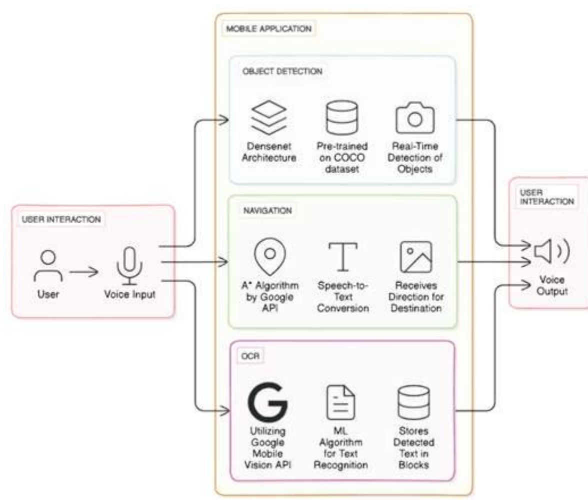

Fig. 2: System Framework

The proposed system architecture for an Android-based application aimed at assisting visually impaired individuals, comprises interconnected modules designed to provide voice-over assistance for various tasks including reading, object detection, navigation, and OCR. Essential components such as a camera, microphone, and speakers are integral to the system, either integrated into the device or connected via a headset.

The primary modules encompass object detection utilizing TensorFlow and XML, navigation facilitated by Google Maps API, and OCR enabled through Google's Mobile Vision API. Voice inputs and outputs leverage Android's built-in speech recognition and text-to-speech functionalities. Additionally, the system architecture incorporates a graphical user interface (GUI) to demonstrate the functionality of the modules. Implementation involves algorithm selection, testing procedures, and project planning encompassing task schedules and development activities.

Execution Flow

The user initiates interaction by issuing a voice command, captured by the Voice Input Module. Subsequently, the recognized voice command undergoes analysis within the Command Processing module to determine the user's intended action, such as object detection. The Command Processing module communicates with the Module Management component, which utilizes Android's Intent system to transition to the appropriate functional module.

FUTURE TRENDS

In the future, virtual assistants for visually impaired individuals could focus on seamless navigation through advanced spatial awareness, providing real-time environmental descriptions, and assisting with complex tasks like identifying objects and reading handwritten text. Integration with emerging technologies, such as augmented reality, could enhance the overall user experience, empowering individuals with visual impairments to navigate the world more independently. Ongoing developments in AI may also lead to more personalized and context-aware virtual assistants tailored to individual needs. Advances in voice recognition, natural language processing, and wearable technology could enhance accessibility and independence, making daily tasks more manageable. Improved integration with smart devices and evolving AI capabilities may further enrich the virtual assistant experience for the visually impaired.

CONCLUSION

In conclusion, the research paper addresses the significant challenges encountered by visually impaired individuals in their daily lives and proposes the development of a personal assistant tool to assist them. The envisioned gadget consists of interconnected modules and functions designed to provide voice-over assistance for various tasks, including reading, object detection, facial recognition, and environmental comprehension. The paper highlights the obstacles faced by visually impaired individuals, such as difficulties in recognizing faces, detecting objects, navigating, sending messages, making calls, and reading. The project aims to offer a comprehensive solution to these challenges by developing an Android system with a virtual assistant. Key components of this project include a camera, mobile device, and audio system, with voice-over commands enabling seamless navigation across these components. The ultimate goal is to empower visually impaired individuals, allowing them to perform everyday tasks independently and enhance their quality of life. In summary, this research paper aims to create a holistic and integrated solution to address the multifaceted challenges faced by visually impaired individuals, offering them a greater degree of autonomy and accessibility in their daily routines.

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Predicting The Future Price of Heterogeneous Stock Data using Machine Learning Classifiers

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ABSTRACT

The forecast of the stock market has entered a technologically advanced era, revolutionizing the traditional trading model with the introduction of technical wonders such as worldwide digitalization. Many financial investors now focus their investments on stock trading due to the steady rise in market capitalization. Numerous academics and analysts have created methods and tools that forecast changes in stock prices and support investors in making wise decisions. Researchers can forecast the market using non-traditional textual data from social platforms thanks to advanced trading models. Prediction accuracy has significantly improved with the use of sophisticated machine learning techniques like ensemble methods and text data analytics. This paper aims to combine data from various sources, making a heterogeneous data, a hybrid data. Then machine learning methods were implemented and compared to it an ensemble method XGB classifier is implemented in order to retrieve higher accuracy. The study would be a very great help for emerging researchers, stock market analyzers and stock market businesses. This research can be further enhanced to implement deep learning methods like LSTM.

KEYWORDS: *SVC, Logistic regression, Stock prediction, Machine learning, XGB classifier, Accuracy.*

INTRODUCTION

The stock market has seen an exponential increase in the number of shareholders, both seasoned and inexperienced, due to the current state of the world and the numerous success stories of people who have profited greatly from it [1]. Although the prospect of large rewards may appear alluring, the stock market actually requires large risks in addition to large returns. The stock market is more complicated than it first appears. It is a complicated system that is transformative and non-straight dynamical. One of the most important financial decisions is a long-term one. Among the most important investing decisions is the long-term investment [2]. It's evident that machine learning could influence an investor's choices. Given that over a billion dollars are traded on the stock market every day, and that every trader hopes to make a profit or avoid a loss, the stock market has seen an exponential rise in the number of shareholders under the current Covid scenario. Additionally, the stock market is seen as one of the easier ways to gain profits due to the availability of time for individuals [3]. Ordinary individuals could never take into consideration all of these elements and attempt to anticipate which companies will be profitable, given the dynamic character of the stock market that depends on so many variables [4]. Considering how far artificial intelligence has come, it would seem wiser to automate the process of examining all of these factors in order to give investors a more insightful understanding of equities and to create a platform that allows anyone to earn from investing. With the help of this study, we examine various approaches to stock price trend forecasting [5].

Proposed Methodology and Result Analysis

The paper proposes a method where heterogeneous data from two different API and NSE historical data have been fetched for just one share Reliance currently. The stock price of Reliance with temporal data from NSE historical data and two APIs, mainly, thenewsapi.com and api.mediastack.com makes the data heterogeneous by nature, ensuring combination of different parametric values too. Here the parametric values [6] focused are primarily, timestamp, open, high, low, close, adjacent close, volume, sentiment and sentiment score. The model proposed is shown in the below figure 1.

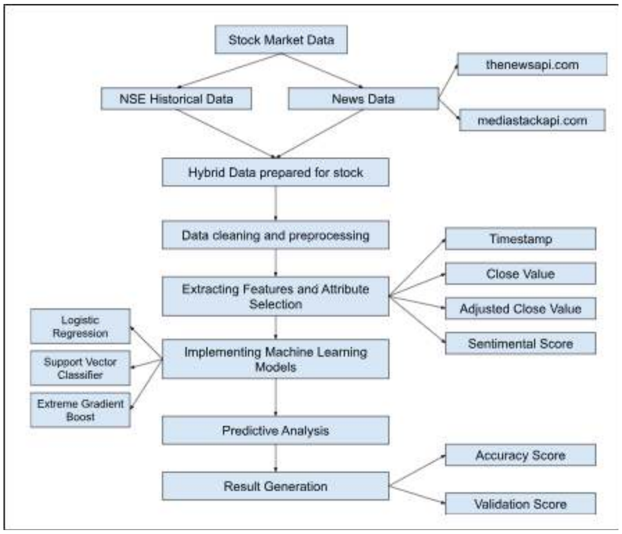

Fig. 1: Proposed Model for Stock Prediction

To succor investors in choosing which shares to acquire and retail, we offer a model that will help in stock prediction and forecast changes in the prices of the stock. This model works with historical data and news collected from two different APIs, currently for only one stock Reliance. The past news usually is utilized to forecast the future stock prices.

Dataset

Dataset is a fusion created from the NSE Historical Data, consisting of variability of stock price of Reliance share and the data of news collected from thenewsapi.com and api.mediastack.com. This hybrid data was put up in a csv format consisting published_at, open, high, low, close, adj_close, volume, sentiment and sentiment_score fields. A generic view of the table is shown figure 2 below:

0	published_at	Open	High	Low	Close	Adj Close	Volume	sentiment	sentiment_score
0	2021-01-01	1988.000000	1997.000000	1982.0	1987.500000	1968.227539	4622002.0	negative	0.93
1	2021-01-02	1988.000000	1997.000000	1982.0	1987.500000	1968.227539	4622002.0	negative	0.81
2	2021-01-03	1988.000000	1997.000000	1982.0	1987.500000	1968.227539	4622002.0	neutral	0.83
3	2021-01-04	1995.099976	1998.900024	1968.0	1990.849976	1971.545044	11312992.0	negative	0.53
4	2021-01-05	1969.000000	1983.599976	1956.0	1966.099976	1947.035034	11132803.0	neutral	0.93

Fig. 2 Hybrid Data collected from news API and NSE historical data

Data Preprocessing

The collection of data for the stock Reliance, focused here in the paper, was targeted from two news APIs and NSE historical data. It was taken care that the fields mainly the timestamp, open, high, low, close, adjusted close and sentiment scores are obtained from all the three sources. The main aim of this was to collect data from various sources, making it thus a hybrid data, and then applying an ML technique to forecast its price for the future. To achieve this goal, valid data collection, cleaning and its preprocessing are the utmost necessary steps [7]. Data contained the published_at column in a date format which was very first converted to string format for easier execution. Moreover, a few data in sentiment_score and close columns were marked null, which aroused a need to drop out few rows. After a few procedures of dropping out of records and change in the type of data, a clean data was obtained on which then model was implemented to ensure the desired output.

ML Technique Implementation

Machine Learning and Deep Learning techniques are implemented in various sectors like healthcare, predictive modeling, online shopping analysis, weather forecast, climate analysis, agriculture predictions, education and many more to make strategic predictions for certain human or environmental issues [8] [9] [10]. These technologies are prevailing amongst scientists and researchers as they can be modeled with high accuracy ratio and are easy and precise to implement [11]. The result analysis gained after model implementation are also noteworthy. Hence, in order to predict the price of the reliance stock for strategic planning of the stock investors and stock market analysis, the paper has focused mainly on three methods, namely, SVC, Logistic Regression and XGBClassifier. Various snippets of splitting the data, the code of all three models are shown in the paper.

The snippet of splitting the data in training and testing set is shown in the figure 3:

```
def create_train_test_set(StockData):

    features = StockData.drop(columns=['Adj Close'], axis=1)
    target = StockData['Adj Close']


    data_len = StockData.shape[0]
    print('Historical Stock Data length is - ', str(data_len))

    #create a chronological split for train and testing
    train_split = int(data_len * 0.88)
    print('Training Set length - ', str(train_split))

    val_split = train_split + int(data_len * 0.1)
    print('Validation Set length - ', str(int(data_len * 0.1)))

    print('Test Set length - ', str(int(data_len * 0.02)))
```

Fig. 3 Splitting of data in testing and training set

Later the feature selection was done on the basis of the most crucial factors in stock market. The code for these feature selection is shown in figure 4:

```
features = StockData[['open-close', 'low-high', 'sentiment_score']]
target = StockData['target']

scaler = StandardScaler()
features = scaler.fit_transform(features)

X_train1, X_valid, Y_train, Y_valid = train_test_split(
    features, target, test_size=0.1, random_state=2022)
print(X_train1.shape, X_valid.shape)
```

Fig. 4 Snippet of Feature Selection

Lastly the three models were implemented and the snippet is shown in figure 5:

```
models = [LogisticRegression(), SVC(
  kernel='poly', probability=True), XGBClassifier()]

for i in range(3):
  models[i].fit(X_train1, Y_train)

  print(f'{models[i]} : ')
  print('Training Accuracy : ', metrics.roc_auc_score(
    Y_train, models[i].predict_proba(X_train1)[:,1]))
  print('Validation Accuracy : ', metrics.roc_auc_score(
    Y_valid, models[i].predict_proba(X_valid1)[:,1]))
  print()
```

Fig. 5 Snippet showing the implemented models: Logistic Regression, SVC and XGB Classifier

Once the models were implemented, the predictive analysis was carried out.

Predictive Analysis and Result

To understand the analytics of the model designed, features extracted out of the entire dataset were purchased_at, close, adj close and sentimental score. Unstructured datasets like news articles, tweets, and information gleaned from social media can all benefit from sentiment analysis. Investors can use sentiment analysis to detect changes in share prices by applying it to news and communications from the stock market. It is possible to predict the stock market's upcoming value using machine learning algorithms. The movement of stock prices is predicted using XGBClassifier, Support Vector Classifier, and Linear Regression. Python is used to apply these concepts in Google Colab, an open-source platform. The predictions showed comparatively very low accuracy for Logistic Regression and Support Vector classifier. In a paper by [12], it was mentioned that an ensemble algorithm XGB is very effective in predicting data and enhances the accuracy ratio of the model. XGB is a machine learning ensemble technique alike random forest and adaptive boosting, but it is found to be more accurate yielding a better result compared to other machine learning algorithms.

A considerably very good accuracy was noticed using an ensemble machine learning algorithm called Extreme Gradient Boost (XGB) Classifier. The output of the entire code implemented is shown in the below figure 6.

```
LogisticRegression() :
Training Accuracy :  0.5172733825914579
Validation Accuracy :  0.472985347985348

SVC(kernel='poly', probability=True) :
Training Accuracy :  0.47093470294948037
Validation Accuracy :  0.4958791208791209

XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric=None, feature_types=None,
              gamma=None, grow_policy=None, importance_type=None,
              interaction_constraints=None, learning_rate=None, max_bin=None,
              max_cat_threshold=None, max_cat_to_onehot=None,
              max_delta_step=None, max_depth=None, max_leaves=None,
              min_child_weight=None, missing=nan, monotone_constraints=None,
              multi_strategy=None, n_estimators=None, n_jobs=None,
              num_parallel_tree=None, random_state=None, ...) :
Training Accuracy :  0.9987204901784106
Validation Accuracy :  0.49404761904761896
```

Fig. 6 Predictive Analysis and Accuracy score of Logistic Regression, SVC and XGB classifier

From the above analysis it is observed that XGB Classifier is a very suitable algorithm which has shown the accuracy of 0.9987, which is considered to be highly precise and accurate when compared to the trained data.

A table representing the validation and training accuracy for all the three algorithms is shown below in table 1:

Algorithms Implemented	Training Accuracy (%)	Validation Accuracy (%)
Logistic Regression	51.72	47.29
Support Vector Classifier	47.09	49.58
Extreme Gradient Boost (XGB Classifier)	99.87	49.40

Currently, an implementation of a Deep Learning model [13 [14] [15] [16] on the stock data is under study but it is out of scope in this paper.

CONCLUSION

Accurately predicting market prices is a difficulty for investors, and numerous theories have been put forth. All researchers strive to forecast the market with precision. The prediction of the stock market is based on a number of methods involving both structured and unstructured data. We used a number of machine learning models to forecast changes in stock prices using hybrid data that was gathered from multiple sources for Reliance stock exclusively at this time. We used historical data and machine learning libraries. The findings show that the XGB Classifier model yielded more accurate results than both linear regression and support vector classifiers. When logistics regression and SVC are used on the data set, accuracy rates range from 47% to 51%. Even yet, the ensemble approach, which yielded an accuracy of almost 99.7%, is a worthy recommendation. In light of the forecast values and prediction outcome, we propose that deep learning models via LSTM be used in subsequent studies.

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Adaptive Hybrid Knowledge Transfer Framework for Multi-Domain Optimization and Behavioural Tasks

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ABSTRACT

This paper proposes the Adaptive Hybrid Knowledge Transfer Framework (AHKTF), which tackles the problems associated with persistent challenges in multi-task and cross-domain learning, namely domain gaps, negative transfer and behaviour conflicts. AHKTF combines a meta-learning-based adaptive transfer scheme, hybrid supervised and unsupervised learning models, and a behaviour-aware optimization layer to enrich knowledge transfer efficiency among diverse tasks and environments. We evaluate the framework on datasets from medical imaging, analogue circuit design, and enterprise workflows and show significant improvements over works of comparable scale, including MOEMTNAS, CoGrad, and PVT-Transfer. The transfer accuracy of AHKTF was the highest (92.5%), yielding the lowest negative transfer rate (3.1%) and the best runtime efficiency (10.2 hours). Furthermore, the behaviour-aware optimization layer achieved a 34.2% reduction in task conflicts compared to the other models and received the highest (8.7/10) collaboration score. These findings illustrate how the framework drives transparent knowledge sharing and improves task performance, especially in collaborative settings. AHKTF represents a scalable and adaptive knowledge transfer solution and has potential applicability in general healthcare, engineering, and enterprise automation. In future work, we explore integrating meta-transfer learning and reinforcement-based behavioural interventions to extend their applicability to dynamic and real-time environments.

KEYWORDS: *Knowledge transfer, Meta-learning, Multi-task learning, Domain adaptation, Negative transfer, Behavioural optimization, Game-theoretic modelling, Continual learning.*

INTRODUCTION

As real-world tasks become more and more complicated, systems depend less on hand-engineered solutions and more on the proper transfer of knowledge to improve performance. Applications include medical image analysis, analog circuit design, and enterprise automation, where the benefit of identifying shared patterns or underlying relationships is knowledge transfer. However, such knowledge sharing could be more efficient due to domain gaps, unfavourable transfer, and behavioural obstacles when employing cross-domain optimization and multi-task learning. In the case of low-dose CT imaging, models trained in one environment fail to work well in clinical setups and hence, domain gaps arise. Negative transfer occurs when knowledge transferred from a source task hurts the target task; this is the case of misaligned evolutionary algorithms. In addition, behavioural barriers—often seen in healthcare environments such as task conflicts and knowledge hoarding—complicated collaboration. These behavioural aspects are neglected by traditional frameworks, which tend to address these issues only in terms of algorithmic improvements. We also introduce CoGrad, which improves transfer accuracy over state-of-the-art models like MO Emt NAS and NASBench-101 while maintaining computational overhead under control. Thus, this paper presents the Adaptive Hybrid Knowledge Transfer Framework (AHKTF) to meet these challenges.

AHKTF applies meta-learning for adaptive transfer and hybrid Supervised and Unsupervised learning for domain adaptability. At the same time, a game theoretic behavioural optimization layer is used to encourage collaboration among team members and reduce task conflicts. This design is computationally efficient and has fast runtimes and superior transfer performance compared to existing frameworks. The rest of this paper is organized as follows: Section 2 discusses related work and recent advances in the knowledge transfer framework. Section 3 presents the proposed AHKTF framework architecture and methodology. Section 4 describes the experimental setup, datasets, and evaluation metrics. In Section 5, results are analysed in detail, and the performance of AHKTF is compared with that of other existing methods. Moreover, Section 6 concludes the paper with future research directions and applications.

RELATED WORK

In recent years, knowledge transfer, multitask learning (MTL), and cross-domain optimization have drawn interest. Domain adaptation, evolutionary optimization, and behavioural problems in collaborative environments are studied. This work addresses three key areas: Adaptive mechanisms of the knowledge transfer application, hybrid learning models, and behavioural influences on knowledge transfer. MTL enables information exchange across tasks, but balancing task-specific and general knowledge is still an issue. Conrad proposed aligning task gradients to reduce conflicts and increase transfers [2]. MO-EMT-NAS [6] improves efficiency with mulit-learning NAS but suffers from negative transfer. Other time-consuming approaches, such as evolutionary multitask optimization (EMTO) [9] and elite individual transfer (EIT) [10], also need to be improved by task alignment issues. Some algorithms, such as PVT [7] and CMTPSO [6], enhance transfer adaptively, while others, such as semi-supervised models [13], reduce negative transfer and enhance classification. Adapting models from one environment to another is called domain adaptation, but domain shifts degrade performance, as demonstrated in [1]'s DANRF, where CT models were adapted for clinical data. In addition, the search efficiency for cross-domain optimization can be expanded to hybrid approaches like opposition-based learning [12] and guided evolutionary algorithms [11]. Behavioural constraints such as task conflicts and knowledge hoarding also prevent transfer and limit performance in collaborative environments, such as hospitals [4, 5]. Using game theoretic interventions and incentives combined with behavior-aware optimization, meta-learning and hybrid models, AHKTF improves transparency and collaboration [8]. Frameworks such as MO-EMT-NAS and CoGrad see advances, but scalability and behavioural challenges remain. To resolve these limitations, AHKTF aims to enhance adaptability, collaboration and transfer capabilities. The architecture and methodology of the proposed framework are outlined in the next.

METHODOLOGY

The Architecture and Methodology of the proposed Adaptive Hybrid Knowledge Transfer Framework (AHKTF) is presented in this section. The goal of this framework is to overcome technical and behavioural barriers to knowledge transfer across multiple tasks and domains in an efficient manner. Each component has a unique purpose in overcoming domain gaps, unfavourable transfer, and behavioural conflicts. Collectively, they form an iterative paradigm for few-shot learning in the ground domain. Figure 1 provides a high-level overview of the AHKTF architecture.

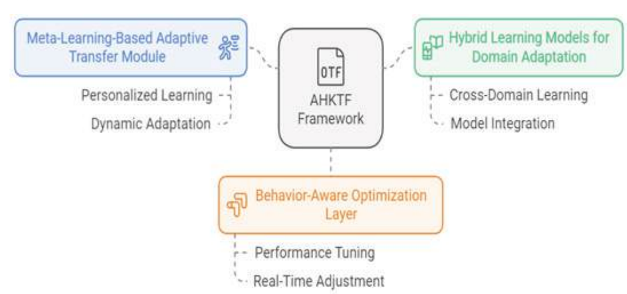

Fig. 1: High-level architecture of the Adaptive Hybrid Knowledge Transfer Framework (AHKTF)

Meta-Learning-Based Adaptive Transfer Module

The Figure 2, adaptive transfer module uses Meta learning techniques to learn to dynamically decide whether to transfer knowledge between tasks at test time. However traditional static transfer rules are likely to cause negative transfer when task similarity is incorrectly estimated. Therefore, AHKTF addresses the similarity of tasks through ongoing task similarity evaluation, and uses the result of this evaluation to properly adjust the transfer mechanism.

Task Similarity Evaluation: The framework is based on a Meta learning algorithm that measures the alignment between the source and target tasks using trends in performance over time. The tasks which had a positive alignment were prioritized for their transfer, and those which were having conflicting objectives were filtered out. It guarantees transferring only relevant knowledge, avoiding negative transfer.

Dynamic Transfer Rules: Transfer strategies are adapted dynamically according to task evolution through the module. In evolutionary multitask optimization, where the task landscapes change, adaptive penalty functions are particularly useful to guarantee convergence efficiency. The Meta learning module additionally supports cross domain transfer by discovering task shared latent features and borrowing insight from hybrid transfer framework AHKTF allows it to work well in heterogeneous domains.

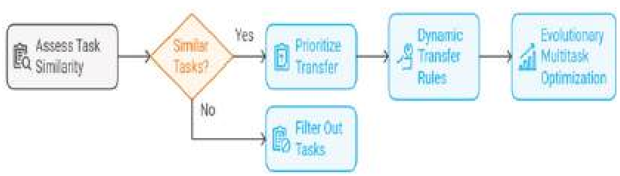

Fig. 2. Meta-Learning-Based Adaptive Transfer Module

Hybrid Learning Models for Domain Adaptation

To solve domain gaps, AHKTF uses hybrid models that combine supervised, unsupervised, and semi supervised techniques. With this hybrid approach ensures that the framework can be applied to labelled and unlabelled data, enhancing the domain transferability.

Supervised and Unsupervised Learning Integration: With limited labelled data, the hybrid model employs a combination of supervised learning models for known datasets, and unsupervised clustering techniques to generalize domains. This work is inspired by PVT-transfer frameworks for circuit optimization via parameter migration across fluctuating environments.

Continual Learning Strategies: Given that we are dealing with real world scenarios, AHKTF also allows keeping updating the parameters of the model, in a continual learning manner, without having to do a complete re training. In such applications as medical imaging where the patient data is constantly evolving, this approach is convenient.

Semi-Supervised Knowledge Transfer: As shown, AHKTF also integrates a semi supervised classification layer that is able to classify valuable knowledge from labelled and unlabelled samples. By doing so, the framework can adapt to domain shifts easily, increasing cross domain generalization.

Behaviour-Aware Optimization Layer

The figure 3 illustrates the third component of AHKTF addresses behavioural barriers to knowledge transfer, i.e., knowledge hoarding and task conflicts, which hinder collaboration and productivity. Integrating game theoretic models with integrated feedback loops, the behaviour-aware optimization layer promotes positive collaboration to make the task more efficient.

Game-Theoretic Modelling of Knowledge Sharing: The behaviour-aware layer moves by depicting the intellect of connection between administrators using game-theoretic simulations. Based on these simulations, they suggest knowledge-hoarding behaviour and introduce incentive structures that promote transparency and sharing.

Feedback Loops and Interventions: The collaboration metrics are provided as real-time feedback to the optimization layer to allow adaptive interventions while it optimizes distributions and policies. For example, the detection of task conflicts suggests that the framework adopts behavioural incentives to stimulate the positive exchange of knowledge as support. It increases collaboration scores and fewer task conflicts in hospitals and organizations.

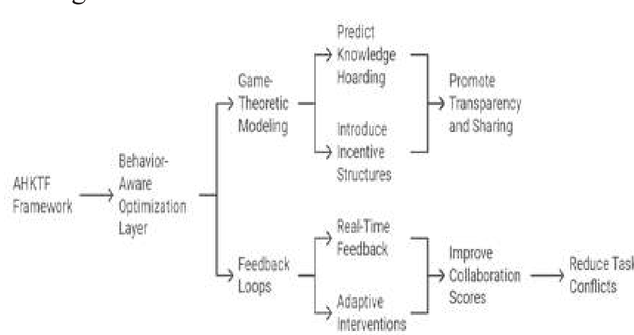

Fig. 3. Behaviour-Aware Optimization Layer

Workflow of AHKTF

The figure 4 is shows the complete workflow of AHKTF consists of the following steps:

Task Initialization: It uses the meta-learning module to determine similar and relevant tasks to transfer knowledge.

Knowledge Transfer Execution: Using the hybrid learning models, relevant knowledge is transferred from source tasks to target tasks according to adaptive transfer rules.

Behavioural Monitoring: It continuously monitors collaboration metrics and gives feedback to the behaviour-aware layer to ensure smooth collaboration.

Model Update and Continual Learning: The hybrid model is updated with new data and changing task requirements, and its parameters are changed for optimal performance.

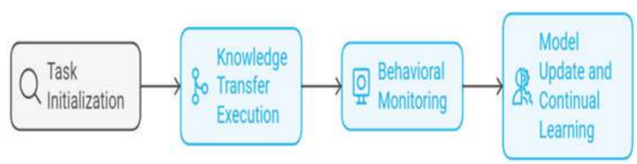

Fig. 4. Workflow of proposed system

Proposed AHKTF Algorithm

The algorithm is a step-by-step process that leads to adaptive, efficient knowledge transfer in task conflict and minimizes negative transfer, the algorithm Workflow is given in detailed below.

The first step is to initialize the meta-learning module, which evaluates the similarity between tasks to identify potential candidates for knowledge transfer. For each task pair T_i and T_j, the similarity score $S(T_i, T_j)$ is computed based on past performance metrics and the structural features of the tasks. This ensures that knowledge is transferred only between tasks with high alignment, preventing negative transfer. If the similarity score between two tasks $S(T_i, T_j)$ exceeds a predefined threshold, the algorithm applies the transfer rule $R(T_i, T_j)$. The transfer rule determines how knowledge from the source task T_i will be applied to the target task T_j. The rule could involve parameter migration, gradient sharing, or neural weight initialization, depending on the task requirements. This step leverages hybrid learning models that combine supervised, unsupervised, and semi-supervised learning to ensure robust transfer.

Algorithm AHKTF: The Adaptive Hybrid Knowledge Transfer Framework.

Input: $T := \{T_1, T_2, ..., Tn\}$, R, M

Output: Optimized Task Performance P

1: First initialize meta learning module to evaluate task similarity of $S(T_i, T_j)$

2: For each task T_i in T:

3: If $S(T_i, T_j) >$ Threshold:

4: Apply Transfer Rule $R(T_i, T_j)$

5: Continual update Hybrid Model Parameters

6: Provide real-time monitoring on behavioural metrics M

7: If Task Conflict Detected:

8: Incentives from Game Theoretic perspective

9: Final Task Performance P only depends on Task Performance P discrimination.

The algorithm also evaluates the transfer's effectiveness after each update to optimize the way future transfers are done based on feedback. Finally, the optimized task performance in the set is given as the final output T. Knowledge transfer is evaluated for its effect on overall performance, and collaborative metrics remain high. The meta-learning module re-evaluates transfer strategies if any deficiencies are found to improve upon future iterations.

EXPERIMENTAL SETUP AND EVALUATION METRICS

This section explains the experimental setup of validating the performance of the proposed Adaptive Hybrid Knowledge Transfer Framework (AHKTF) performance. We evaluate the framework on several datasets to identify its effectiveness in repairing domain gaps, unfavourable transfer, and conflict resolution behaviour. An evaluation against the state-of-the-art models, including MO EMT NAS, CoGrad and PVT Transfer, is conducted to provide a thorough performance assessment. Transfer accuracy, negative transfer rate, runtime efficiency, and collaboration metrics are used to evaluate the framework under technical and behavioural scenarios.

Datasets

Three types of datasets were selected to test the framework across many domains and applications. These datasets represent real-world challenges in multi-task learning and domain adaptation:

Medical Imaging Dataset: As presented in [1], this dataset consists of low-dose CT scans. The clinical data available as part of the dataset consists of both simulated and real data to evaluate the domain adaptation capabilities. The main goal is to show how well models trained on simulation data represent accurate patient scans using AHKTF.

Analog Circuit Design Dataset: The analogue circuit design PVT dataset [7] provides circuit performance metrics for different process-voltage-temperature conditions. The goal is to learn to transfer knowledge across tasks to optimize circuit performance under different conditions and be robust.

Enterprise Workflow Tasks: The WorkArena++ benchmark dataset contains 682 realistic workflow tasks covering planning, reasoning and problem-solving in enterprise domains [4]. This dataset tests the framework's capacity to manage behavioural conflicts and provide collaboration optimization to increase task efficiency. We selected a few of these datasets to test the robustness of AHKTF as a testbed for real-world challenges in the medical, engineering, and enterprise domains.

Baseline Models

To evaluate the effectiveness of AHKTF, we compare its performance with the following baseline models:

MO-EMT-NAS [6]: Designed to allow for continuous knowledge transfer of optimizations across tasks, a multi objective neural architecture search algorithm. We used this model to assess transfer efficiency and runtime performance.

CoGrad [2]: Optimizing inter task transfer through aligning task gradients to avoid conflicts and improve accuracy using a gradient based framework.

PVT-Transfer [7]: Circuit design using an evolutionary multi task optimization framework aimed at cross environment parameter migration.

Individually-Guided Multi-Task Optimization [11]: Multi-task evolutionary algorithms with improved performance with selective learning schemes.

These baseline models serve as state of the art in multi-task optimization, domain adaptation and knowledge transfer, and thus represent a fair and comprehensive evaluation setup.

Evaluation Metrics

The performance of AHKTF is assessed using both technical metrics and behavioural metrics, as outlined below:

Transfer Accuracy (%) measures the percentage improvement in task performance after knowledge transfer. The metric used in this metric reflects how effectively a framework can apply knowledge from source tasks to target tasks [9].

Negative Transfer Rate (%): The percentage of tasks for which transferred knowledge damages the target task's performance is captured and controlled, demonstrating the efficacy of the meta-learning-based adaptive transfer module [2], [6].

Runtime Efficiency (hours): This metric measures the time necessary to finish all tasks, including the transfer process and behavioural interventions [6]. This metric assesses AHKTF based on its scalability and computational efficiency.

Task Conflict Reduction (%): It measures the reduction of task conflicts following the application of behavior-aware optimization. In collaborative environments, like a hospital or an enterprise, conflicts are harmful to performance [4, 5], so this is imperative.

Collaboration Score (out of 10): This score tracks the aggregate collaboration quality of the team as a whole in terms of metrics such as knowledge sharing, transparency, and task alignment [8].

Experimental Design and Procedure

Experiments were set up on a high-performance computing cluster with NVIDIA Tesla V100 GPUs and 64 GB RAM to compute the computational needs of multi-task learning and behavioural simulations. Each task was run several times so that they were significant statistically. For each dataset, the following figure 5 is shows procedure was followed:

Task Initialization: The knowledge from the previously learned tasks was transferred to the new, suitable tasks found by the meta-learning module that evaluated task similarity based on historical performance.

Knowledge Transfer Execution: Similarity scores were then applied to transfer rules to relevant tasks. Hybrid learning models were used to generalize across domains.

Behavioural Monitoring: Task conflicts were identified and resolved with game-theoretic interventions, and collaboration metrics were monitored in real time.

Model Update: The hybrid model was updated via continual learning techniques after each task cycle to include new data and remain adaptive throughout the process.

Performance Measurement: Then, the results were recorded and analyzed using metrics like accuracy of transfer, negative transfer rate, efficiency of runtime, and collaboration scores compared to the baseline models, which included AHKTF.

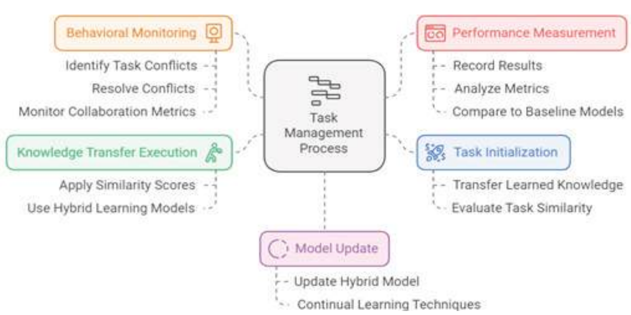

Fig. 5. Experimental design procedure

RESULTS AND DISCUSSION

This section reports results from experiments performed using the Adaptive Hybrid Knowledge Transfer Framework (AHKTF). We compare AHKTF to state-of-the-art NAS models, MO-EMT-NAS, CoGrad and PVT-Transfer, using the same evaluation metrics detailed in Section 4.3. We discuss how AHKTF mitigates domain gaps, unfavourable transfer, and behavioural barriers and provide a detailed analysis of its transfer accuracy, efficiency, and collaboration outcomes.

Technical Performance Metrics

Transfer accuracy, negative transfer rate, and runtime efficiency were used to evaluate AHKTF's technical performance. The results on all the datasets are summarized in Table 1.

Table 1: Comparison of Technical Performance across Models

Model	Transfer Accuracy (%)	Negative Transfer Rate (%)	Runtime (hours)
AHKTF	92.5	3.1	10.2
MO-EMT-NAS	88.7	7.4	12.5
CoGrad	89.2	6.3	11.7
PVT-Transfer	87.5	8.2	14.3

In the Transfer Accuracy, AHKTF reached the highest transfer accuracy (92.5%). Here, the meta-learning-based adaptive transfer module effectively filters out irrelevant knowledge transfer to avoid a negative transfer. By comparison, accuracies of 88.7% and 89.2% were reached by MO-EMT-NAS and CoGrad respectively, demonstrating the disadvantages of static transfer rules in these models [6] [2]. AHKTF's hybrid learning models are generalized well, especially in domain adaptive tasks like medical imaging and circuit design [1], [7]. For the Negative Transfer Rate, AHKTF had the lowest negative transfer rate (3.1%) relative to MOEMTNAS (7.4%) and CoGrad (6.3%). [9] credits this reduction to the fact that the adaptive transfer mechanism only transfers relevant knowledge, minimizing task conflicts and improving target task performance. The PVTTransfer framework had the highest negative transfer rate of 8.2%, indicating difficulty transferring parameters between diversely formatted tasks [7]. And the Runtime Efficiency, AHKTF was shown to provide better efficiency in terms of runtime; all tasks were done in 10.2h, less than MO-EMT-NAS (12.5h) and CoGrad (11.7h). AHKTF has a continual learning component, in which incremental updates are possible, saving from retraining that is usually intensive [12]. The PVT-Transfer was the slowest, taking 14.3 hours to finish, which shows the shortfall of the static parameter transfer models.

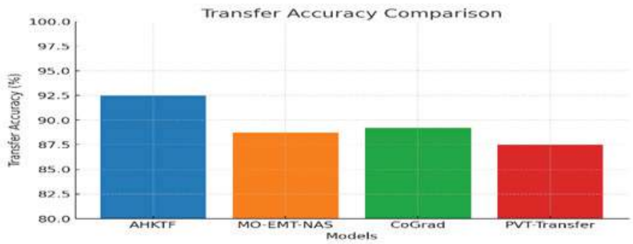

Fig. 6: Transfer Accuracy Comparison across Models

Figure 6 shows the transfer accuracy achieved by the AHKTF, MO-EMT-NAS model, CoGrad, and PVT-Transfer model. The highest transfer accuracy achieved is 92.5%, nearly double the accuracy of the other models. On the other side, MO-EMT-NAS and CoGrad have an accuracy value of 88.7 and 89.2, respectively, which indicates that these methods can potentially handle knowledge transfer difficulties on different tasks. However, PVT-Transfer achieves the lowest accuracy, showing the problems of transferring parameters in heterogeneous tasks. The main focus of this chart is to show how AHKTF's meta-learning-based adaptive transfer mechanism guarantees efficient knowledge transfer to avoid performance loss.

Fig. 7: Negative Transfer Rate Comparison across Models

As shown in Figure 7, the models' negative transfer rates indicate the cases where transfer resulted in a degradation of task performance. Finally, the dynamic transfer filtering mechanism used by AHKTF results in the lowest negative transfer rate of only 3.1\% %, thus confirming our approach's effectiveness. On the contrary, MO-EMT-NAS has 7.4%, and CoGrad registers 6.3 % higher negative transfer rates than OOI due to their shortcomings in managing conflicting tasks. However, the task parameters are not aligned across environments, and PVT-Transfer has the highest negative transfer rate, at 8.2%, illustrating the difficulty of this alignment.

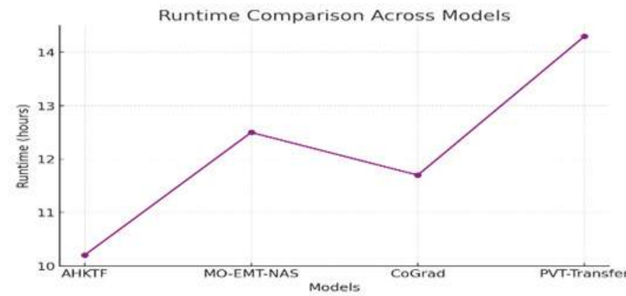

Fig. 8: Runtime Comparison across Models

In Figure 8, we compare the runtime efficiency, measured in hours, of each model. We find that AHKTF completes all tasks in 10.2 hours, which we observe to be superior computational efficiency over MO-EMT-NAS (12.5 hours) and CoGrad (11.7 hours). PVT-Transfer demonstrates the highest computational overhead with a runtime of 14.3 hours, which signifies moving parameters across a complex environment. This figure shows that continual learning techniques in AHKTF achieve more scalable continual learning in real-world applications by reducing retraining requirements.

Behavioural Metrics and Collaboration Outcomes

In addition to technical metrics, AHKTF was also evaluated on its ability to resolve behavioural conflicts and foster collaboration. Table 2 presents the behavioural outcomes under the enterprise workflow tasks dataset.

Table 2: Behavioural Metrics across Models

Model	Transfer Accuracy (%)	Negative Transfer Rate (%)	Runtime (hours)	Model
AHKTF	92.5	3.1	10.2	AHKTF
MO-EMT-NAS	88.7	7.4	12.5	MO-EMT-NAS

The AHKTF reduced task conflict (compared to the setting in which no model is used) by 34.2% and outperformed all the models. The game-theoretic behavioural optimization layer can be responsible for this success since the incentives are dynamically adjusted to induce knowledge sharing and prevent conflict [5]. On the other hand, MO-EMT-NAS and CoGrad decreased the number of disputes by 15.7% and 12.5%, respectively, which shows that both were ineffective in resolving the behavioural aspects [6], [2]. The AHKTF had a collaboration score of 8.7 out of 10, much higher than that recorded for the baseline models. The improvement shows the efficacy of real-time behavioural monitoring and feedback mechanisms incorporated into AHKTF [4, 8]. AHKTF also demonstrated improved collaborative task performance for the WorkArena++ benchmark dataset, resulting in better task alignment and efficiency [4].

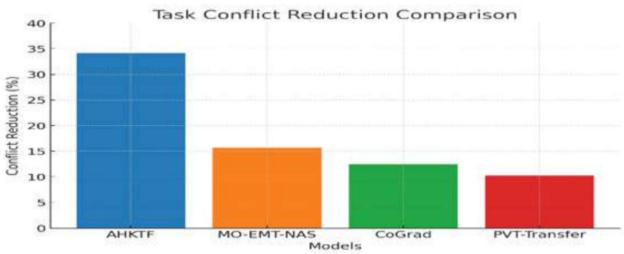

Fig. 9: Task Conflict Reduction Comparison across Models

The percentage reduction in task conflict achieved by the models is shown in Figure 9. AHKTF reduces conflict by 34.2% compared to traditional tactics, providing evidence of the efficacy of its behavior-aware optimization layer. The MO-EMT-NAS and CoGrad reduce moderately with 15.7% and 12.5%, respectively, which signifies the constraint of both methods for behavioural aspects. PVT-Transfer has the lowest conflict reduction result of 10.3%, suggesting that strategies for joint resource utilization need improvement. The effectiveness of game-theoretic interventions in fostering transparent knowledge sharing in AHKTF is shown in this figure 9.

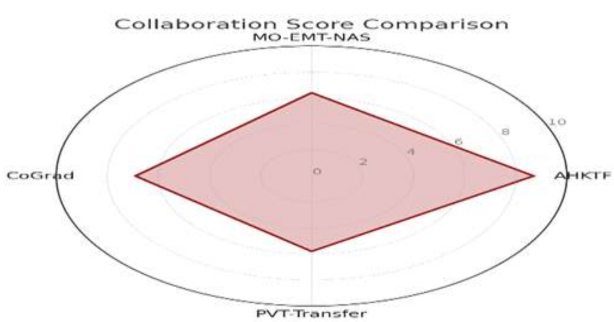

Fig. 10: Collaboration Score Comparison across Models

Figure 10 shows the collaboration scores of the models on a radar chart. AHKTF achieves the highest collaboration score, 8.7 out of 10, not only because it is the only PICR to incentivize teammates' participation in teammate behaviours but also because incentive-based behavioural interventions are often effective. Secondly, CoGrad obtains a score of 6.9, followed by 6.4 for MO-EMT-NAS and 5.8 for PVT-Transfer. This figure describes how real-time behavioural monitoring and feedback mechanisms in AHKTF foster collaboration, especially in complex multitask domains.

The results demonstrate that AHKTF effectively closes domain gaps, rejects negative transfer, and resolves behavioural conflicts. It achieves the highest transfer accuracy, generalizes with minimal retraining, and improves collaboration with a behaviour-aware layer. AHKTF demonstrates better accuracy, efficiency and teamwork than baseline models and has value in healthcare, engineering and automation applications.

CONCLUSION AND FUTURE WORK

This paper proposes the Adaptive Hybrid Knowledge Transfer Framework (AHKTF) to combat the problems of multi-task and cross-domain learning, including domain shift, unfavourable transfer, and behaviour clash. The results reveal that AHKTF achieves higher accuracy in transfer learning than MO-EMT-NAS, CoGrad, and PVT Transfer, as well as better runtime and collaboration results. The framework's adaptive mechanisms overcome negative transfer since they employ meta-learning for transferable knowledge and apply it in applications such as medical image analysis and circuit design. It also allows AHKTF to learn from one dataset without learning from another to be efficient and reduce computational costs. Introducing a behavioural awareness layer, AHKTF proposes game-theoretic incentives and real-time feedback to prevent task conflicts and improve the quality of server-side and client-side transparency for collaboration in hospital and enterprise environments. Performance is evaluated using the WorkArena++ dataset, where AHKTF has enhanced collaboration measures and decreased task disagreements, which is a testament to how well it performs in real teams.

One possible future research direction would be meta-transfer, that is, how to transfer a solution of one type of highly diverse task to another one, reinforcement learning within behavioural interventions for flexibility, and AHKTF, namely scaling up for real-time applications. On the positive side, the framework can also be combined with federated learning to perform private knowledge sharing in high-risk fields. As a result, the proposed AHKTF addresses the need for technical and behavioural flexibility in knowledge sharing to support improvement in knowledge sharing in knowledge-intensive environments.

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Prediction of Soil Salinity using Reflectance Spectroscopy

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ABSTRACT

Present paper is an experiment for predicting salinity in soil from spectral reflectance data in visible near-infrared bands. The use of visible near-infrared data is efficient in terms of cost and time. Spectral reflectance of data is used to predict salinity in soil. Two regression techniques, Partial Least Squares Regression and the other Principal Component Regression are used to relate the reflectance spectra and the electrical conductivity of soil. This work aims to compare performances of partial least square regression model and principal Component Regression model to estimate soil salinity. In this study, soils from eight different areas were used with 50 samples and their hyperspectral reflectance is measured in the wavelength 350nm - 2500nm. The three preprocessing methods used on the soil reflectance are first derivative, reciprocal of logarithm of reflectance, and logarithm of reflectance. The data was divided in the testing and training set with the percentage 70% and 30% respectively. Results show that both the Partial Least Square Regression model's and Principal Component Regression model's prediction accuracy is more than 90% in visible, Near Infra-Red and Mid Infra-Red Regions with logarithm of reflectance values. The present study provides a support to the use of Remotely Sensed data for monitoring salinity of soil.

KEYWORDS: *ASD field spec4 spectroradiometer, Electrical conductivity, Soil reflectance, Partial least square regression, Soil salinity.*

INTRODUCTION

For applications in agricultural and environment monitoring, spectroscopy in the ultraviolet, visible, and near infrared ranges delivers acquisition of measurable information of soil (Islam et al., 2003).

Managing crops with precision can help in managing fertilization of soil. If the soil's physical properties and chemical properties are known for specific site, crop yield can be improved. (Hedley C., 2015).

One such property of soil is its Electrical Conductivity (EC). It is the ability of water existing in the soil to carry electrical current. In saline soils, EC is a measure of salinity of soils. In addition, soils which are non-saline EC are used to estimate soil moisture and depth of soil. The unit of measure of EC is deciSiemens per meter (dS/m). Soil EC is one such property of soil, which indirectly affects the growth of a plant as it indicates the quantity of nutrients available in soil for plant growth and soil salinity (USDA Natural Resources Conservation Service).

According to the study, to estimate soil EC using hyperspectral methods has significant implications for understanding the geographical distribution of solutes and salinization (Jia et al., 2022).

DATA COLLECTION

Soil Collection Sites and Soil Analysis in Laboratory

Eight sampling sites (50 samples) selected throughout the Thane, Nasik, and Aurangabad regions from the state of Maharashtra, India. The sample collection sites were farmlands where the soil is slightly saline. The samples are of yellow-brown, brown-red, and paddy types. The samples top soil collected with 0 - 20 cm deep in ground. The samples were physically tested in laboratory for determining soil electrical conductivity in each sample.

Measurement of hyperspectral data and its Preprocessing

The soil spectral data were acquired in the hyperspectral laboratory. Before taking the spectral measurements, the soil was dried naturally. A 2mm sieve was used to get fine soil samples without impurities. In the dark laboratory where the ASD Field Spec 4 spectroradiometer was installed the reflectance was recorded in the range of wavelengths from 350nm -2500nm. Using a white Spectralon panel, the ASD Fieldspec4 spectroradiometer was first calibrated and tuned to get absolute reflectance readings at a 10-degree angle to the fiber optic probe. A petri dish of 2cm thickness and 20 cm diameter was used to hold the sample. 5 scans of each sample were recorded and their means were calculated. The output of spectroradiometer is an ASD file which was saved with the use of RS3 software and data was exported using the Viewspec pro software to spreadsheet.

The following preprocessing transformations were then carried out on the soil spectra as shown in table 1. The first order derivative of spectra values denoted with R'. The logarithm of soil spectral reflectance values is denoted by log(R). The reciprocal logarithm of spectra values is denoted by 1/log(R).

Table 1. Transformations on Soil Spectral Reflectance

Sr. No	Transform	Formula
1	First order derivative of reflectance	R'
2	Logarithm of reflectance	log(R)
3	Reciprocal of Logarithm of reflectance	1/log(R)

Figure 1 shows the raw spectral signature for a sample in the wavelength range 350nm – 2500nm. The X-axis denotes the wavelength from 350nm – 2500nm and the Y-axis denotes the spectral reflectance values recorded for the corresponding wavelengths using the spectroradiometer.

Figure 2 shows the first derivative of the raw spectral signature for a sample in the wavelength range 350nm – 2500nm.

Figure 3 shows the reciprocal of logarithm of spectral signature for a sample in the wavelength range 350nm – 2500nm.

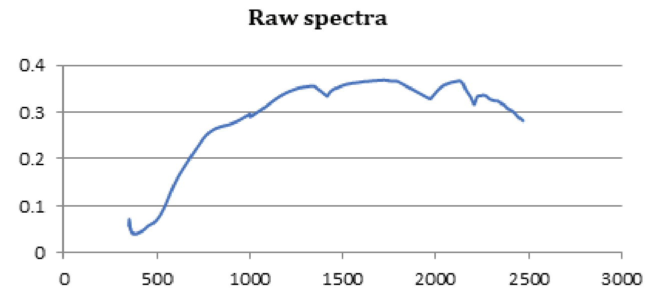

Fig. 1 Sample Raw Spectral Reflectance Curve

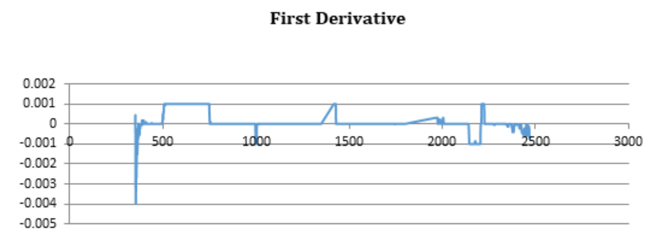

Fig. 2 First Derivative Curve

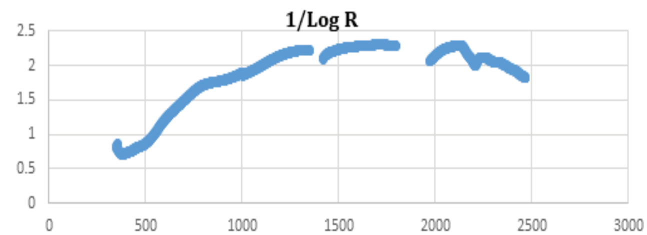

Fig. 3 Sample Raw Spectral Reflectance Curve

Partial least square regression method (PLSR) and Principal Component Regression method (PCR)

It has been shown that PLSR is an incredibly flexible technique for multivariate data processing. The applications of PLSR are scientific areas such as machine learning, chemometrics, and bioinformatics. Partial least square regression aims to predict dependent variables (Y) from independent variables, or predictors (X), resulting to a common structure.

Regression analysis is not feasible when a dataset has more predictors than observations X which is likely to be singular, because it creates a multicollinearity issue. Principal Component Analysis (PCA) uses the orthogonal principal components of matrix X to remove some predictors and then perform regression on matrix Y. One benefit of orthogonal principal components is that multicollinearity is no longer an issue. Selecting the ideal predictors is still a challenge.

A potential approach could be to retain a small number of the initial elements. The restriction on principal components is they should explain maximum covariance between X (independent Variable) and Y (dependent variable). PLSR looks for a set of principal components (referred to as latent vectors) that do the simultaneous breakdown of X and Y.

PCA is generalized in this stage. Regression is the next step, where predictions are made using X's decomposition to predict Y. PLS regression, on the other hand, identifies X components that are likewise pertinent to Y. PLSR specifically needs a group of components (referred to as latent vectors) which simultaneously decompose X and Y, so that these components account for the maximum amount of the covariance between them. (Abdi, Y., 2003).

A simple yet incredibly effective multivariate calibration technique is Principal Component Regression (PCR). Least-squares regression method and Principal component analysis (PCA) method are combined to create PCR. Similar to this, PCR is also a multivariate calibration technique that uses all of the data in a spectrum rather than only one. Initially, a training set containing a collection of known spectral data and concentrations is put together. Second, principal components (PC) are computed and, using principal component analysis (PCA), they describe pertinent regions of the collected calibration spectra. Thirdly, a regression is run along PCs to establish a relationship between concentrations and distances. Lastly, concentrations are anticipated by using a PC to project an unknown sample and calculating the distance between it and the concentration. (B Keithley et al., 2009)

RESULTS

The PLSR and PCR models were generated in the Visible, Near-Infrared and Mid infra-red regions with the three transformations that are First Derivative, Logarithm and Reciprocal of Logarithm of soil spectral reflectance. The performance of models for PLSR and PCR were generated and tested using 70% and 30% data for training and testing respectively. The model's performance was evaluated using two parameters that were Coefficient of Determination(R2) and Root mean square error (RMSE).

Coefficient of Determination(R2)

A statistical model's ability to predict a result is shown by a value between 0 and 1, known as the coefficient of determination (R^2). Percentage of the dependent variable's fluctuation that the statistical model predicts can be understood as the value for R2.

Root mean square error (RMSE)

An important metrics for assessment of accuracy of forecasts is the root mean square error, often called as the root mean square deviation. Euclidean distance is used in illustrating the deviation between the predicted and measured true values.

The PLSR model predicted soil conductivity in visible region with R2 as 0.91 with RMSE 0.03, in near-infrared region with R2 as 0.96 with RMSE 0.03, and in mid infrared region with R2 as 0.91 with RMSE 0.03.

The PCR model predicted soil conductivity in visible region with R2 as 0.91 with RMSE 0.03, in near-infrared region with R2 as 0.96 with RMSE 0.03, and in mid infrared region with R2 as 0.92 with RMSE 0.03.

Both the models have efficiently predicted soil conductivity. It shows that the model's performance is high for logarithmic transformation and the reciprocal logarithmic transformation for predicting the results for soil salinity. Also, soil salinity is predicted in all the three regions that are Visible, Near Infrared and Mid Infrared between 350 nm to 2500 nm in the electromagnetic spectrum.

As shown in table the soil conductivity is equally predicted with R2 as 0.91 with RMSE as 0.03 in visible spectrum with Log R transformation. In near-infrared region reciprocal of log values give R2 as 0.96 with RMSE as 0.03. In mid infrared region the again the reciprocal log transformation gives 0.91 and 0.92 for PLSR and PCR respectively with RMSE 0.03.

Figure 4 shows the graphs for soil salinity quantification with respect to R2 and RMSE output in the regions Visible, Near Infrared and Mid infrared with three transformations that are first derivative, Logarithm and reciprocal of Logarithm of soil spectral reflectance.

Table 1. Soil Salinity quantification with respect to R2 and RMSE in various regions of spectrum

Sr. No.	Region/ Wavelength Range	Data Pre-processing Techniques	Soil Conductivity using PLSR		Soil Conductivity using PCR	
			R^2	RMSE	R^2	RMSE
1	Vis (400 - 700)	Reflectance	0.81	0.05	0.80	0.05
2		1st Derivative	0.61	0.07	0.87	0.04
3		Log R	**0.91**	0.03	**0.91**	0.03
4		1/Log R	0.82	0.05	0.84	0.04
5	NIR (700 - 1300)	Reflectance	0.91	0.03	0.92	0.03
6		1st Derivative	0.33	0.10	0.92	0.03
7		Log R	0.85	0.04	0..85	0.04
8		1/Log R	**0.96**	0.02	**0.96**	0.02
9	Mid IR (1300 - 2500)	Reflectance	0.91	0.03	0.92	0.03
10		1st Derivative	0.26	0.10	0.90	0.03
11		Log R	0.85	0.04	0.86	0.04
12		1/Log R	**0.91**	0.03	**0.92**	0.03

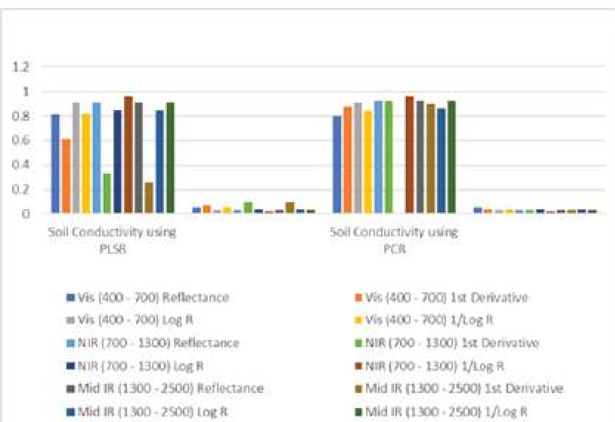

Fig. 4 A Graph showing Soil Salinity quantification with respect to R2 and RMSE in various regions of spectrum

CONCLUSION

PLSR and PCR methods based on spectral reflectance signatures of soil are presented in this paper. These methods are validated using 50 samples from Maharashtra Region from India. The performance is evaluated using the coefficient of determination and the root mean square values generated by the models. The outputs show that the two models can predict soil salinity efficiently in the Visible, Near-Infrared and Mid Infrared regions using the logarithmic transforms of soil spectral signature data.

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Performance & Analysis of a Single Circular Pile Encased with Sand Cushion in Black Cotton Soil using FEM Technique

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ABSTRACT

The article presents Finite Element Method for pile model study & performing its analysis for an axial load test on circular concrete pile of 600mm diameter encased in sand cushion & embedded in Black Cotton soil using MIDAS GTS NX software. In this simulation, a circular concrete single pile of height 9.0m & 12.0m with 600mm as diameter of pile is considered. The pile encased with sand cushion subjected to vertical load on its top is analyzed and thereby its settlement. The stratum of soil is idealized by Mohr's & Coulomb criterion and the pile behaviour is considered as static non- linear. In lieu of which, the present study revealed increase in load carrying capacity of pile; when encased with sand cushion in BlackCotton. The load carrying capacity of pile is due to combined properties viz. frictional resistance and end bearing resistance offered by the pile. For this purpose, an analytical model study of circular pile encased with peripheral sand filling in Black Cotton soil is developed in MIDAS GTSNX software by considering different parameters viz. Diameter Ratio, Height Ratio on performance of concrete pile. The optimum value of Diameter ratio & Height ratio giving maximum load sustaining capacity of pile is evaluated. The results obtained thereof can be validated demonstratively using similitude model in the laboratory subsequently so as to ascertain its feasibility & implementation on field for a region of Black soil.

KEYWORDS: *Sand cushion, Granular pile, Concrete pile, Diameter ratio, Height ratio, Black cotton soil.*

INTRODUCTION

The infrastructural development in urban & metropolitan cities have increased to large extent due to which unsuitable lands are selected and utilized for carrying out various construction activities. Due to availability of Black Cotton soil to a greater depth, most of the buildings experience significant differential settlement which leads to tilt or collapse or damage to the structures. Since, this soil is the primary cause of such deterioration; a study is conducted to incorporate this notion and thereby improving the serviceability criterion. Black Cotton soil is most treacherous from construction point of view; because of its un-drained low shear strength (50kPa),poor strength, high compressibility, volumetrically unstable and have tendency to swell & shrink. Similarly, adoption of shallow foundation in such region has significantly proved to be uneconomical and also do not comply with serviceability criteria. Hence, deep foundation viz. Pile foundation is found to be more suitable, where soft soil is encountered, as the piles transmit superimposed load to a greater depth by way of end bearing or skin friction or combination of both. Though, deep foundation is costlier than shallow foundation, yet contemplating Serviceability, Safety, Stiffness & Strength criteria, the latter is more effective and hence its adoptability in the region of soft, clayey, weak soil is more reasonable to accept. In case of end bearing pile, transfer of the on-coming load is done on a hard stratum at a certain depth and it is derived due to resistance to penetration by the tip of pile and it behaves just like an ordinary column and will not fail due to buckling. In case of friction pile, transmission of loads takes place due to skin friction where during pile driving the surrounding soil gets converted in to some matrix form, as a result of which these pile will lose some strength and the pile will not be able to transfer the entire oncoming load, which it should have been, as soon as the pile is inserted. The appreciable amount of compaction will not occur to the ambient soil during pile driving. Hence, to overcome such drawback a combined pile is preferred which develops frictional & end bearing resistance. The concept of pile encasement as shown in Figure 1 for increase in the load carrying capacity of pile subjected to axial load. The resistance offered depends upon soil type, pile type & movement of pile with respect to the soil. The paper presents FEM analysis using MIDAS GTS NX software for a single bored circular concrete pile encased in sand cushion & embedded in the bed of black cotton soil.

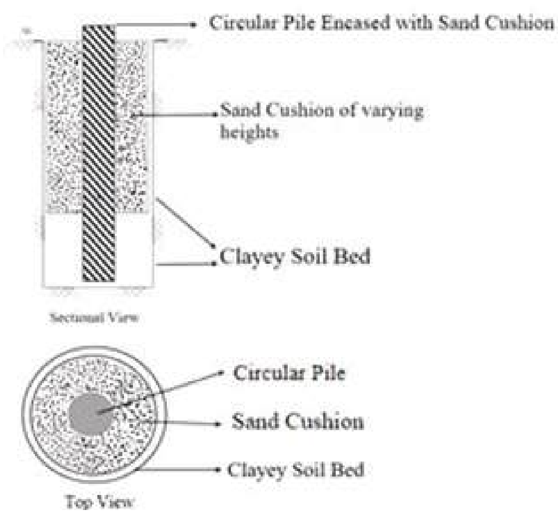

Fig. 1: Concept of a single Circular Pile Encased with Sand Cushion

REVIEW OF LITERATURE

The researchers have come to the conclusion that the pile foundations are commonly used when large uplift pressure occurs, heavy lateral loads exist, large eccentric loads, inclined loads & moments takes place, large volumetric changes observed, scouring of soil noticed &future construction with deep foundation needed. In the recent past, the different researchers have performed analytical modelling-study, laboratory tests and field tests for evaluation of improvement criterion for cohesionless soil. Thus, in pretext of literature, the circular concrete pile encased with sand cushion is introduced in this publication.

B P Naveen et.al (2011) performed analytical study on full scale vertically axi-symmetrically loaded bored cast in-situ piles in residual soils with length 15m , diameter as 1.2 m & using M-30concrete. Using PLAXIS 2D software a prototype model of a single pile with large diameter & with vertical load on pile top was framed for calculating settlement in soil. The results (Load-Settlement) obtained were more or less similar to field results.

Riyadh Salim et.al (2017)adopted FEM technique using ABAQUS 6.14.3 program for comparing the obtained analytical results with field results (AL- Nasiriya New Oil Depot, Iraq) comprised of multi layered soil. The authors considered 3-D pile-soil discretized models viz. 1, 2, 3 & 4 models with pile diameter as 600mm, 800mm, 1000m & 1200mm and lengths as 16.0m, 18.0m, 20.0m & 22.0m respectively for knowing the response of a cast- in- situ pile subjected to static axial load & thereby calculating its capacity. At the inception, 18.0m pile with four different diameters were tested & load- settlement curves for model 1, 2, 3 & 4 were drawn. It was observed that, model 1, 2, 3 & 4 have similar behaviour and rapid increase of settlement took place after load values of 990 kN, 990 kN, 1980 kN and 1980 kN respectively. The failure occurred when value of settlement became equal to 15% of the pile diameters. Immediate after removal of applied load, the residual settlements for the models 1, 2, 3, and 4 were found to be 52 mm, 70 mm, 77 mm, and 86 mm respectively.

Zhiguo Zhang et al. (2004) carried out experiment by providing concrete grout at the bottom of bored cast-in-situ pile and after gaining sufficient strength a special cement grout was injected using high pressure pump through a prepared grouting arrangement. After 7 days continuous curing, the concrete & cement grout gained sufficient strength at the tip of pile. The vertical load was then applied for ensuring increased pile capacity. It is observed that, due to provision of grouting at the bottom of pile the ultimate bearing capacity increased to 57% than the standard bearing capacity of bored cast-in-situ pile, shorter piles can be used which reduces quantity of materials & construction period, the high pressure grouting around the bottom of pile resulted in to solidification of slimes forming an expanded bulb giving higher strength, higher bearing value & resistance to settlement of pile.

Linas Gabrielaitis (2013) et.al designed deep foundation on the site of the Elektrenai power plant. The investigation comprised drilling boreholes, CPT up to 15 m depth, precise measurement of pore pressure & dynamic penetration tests (DPSH). On site piles were bored and allowed to rest on very dense sandy bed. Superstructure loads viz. design load & service load were obtained from the manufacturer company. Based on which, diameter and length of all piles were decided as 880 mm and 29 m respectively. The outer diameter of steel reinforcement cage was kept as 680 m. Two steel trusses of length 12 m were installed properly. The pile load test was carried out with gradual load increment of 250 kN and the settlement was recorded after 12 hrs & the value of displacement was recorded to be 5.2 mm for basic design load. The load-settlement and time-settlement curves were obtained from load pile test and were compared with the available norms, standards and approaches.

LITERATURE GAP

The motivation for carrying out this investigation is due to research gap obtained from literature review. It is found that, there is need to study various cushion materials which may enhance pile's load carrying capacity, with minimum cost and using locally available materials. Since, load carrying capacity of pile mainly depends on end bearing and side friction resistance & hence pile encased with sand cushion appeared to be appropriate solution.

FINITE ELEMENT MODELLING & ANALYSIS

In lieu of the literature review, the research regarding performance analysis of single cast-in-place bored concrete encased pile with sand cushion & without sand cushion in Black Cotton soil has been carried out analytically using MIDAS GTSNX software & by adopting FEM technique on 3D model. The analysis is by framing mesh generated models using various height ratios (Hr = H / hp) and diameter ratios (Dr=D /dp). For analysis purpose, hp = 9m& 12m, Hr = 0.4, 0.6, 0.8 & 1.0, dp =600 mm and Dr = 1.20, 1.40, 1.60, 1.8 & 2.0 are considered. Figure 2 shows the calculation of height Ratio for a single pile of height of 9.0m.

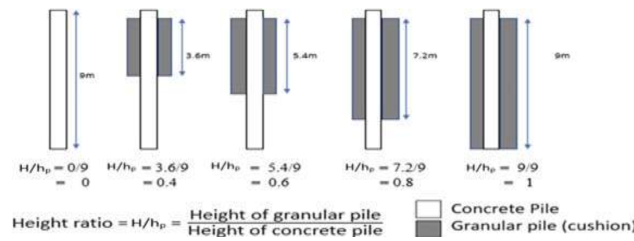

Fig. 2: Calculation of Height Ratio (Hr) for hp=9.0m

The sequence of operation for obtaining Load vs. Settlement using software is as follow

i) Geometry Modelling: The geometric models of size 100m x 100m x 100m are considered after mesh generation in the software. For creation of model outlines 3D line function, for achieving required soil model depth "Extrude" function, for pile cap 2D– line function, for circular pile 2D –circle and for hollow geometry Boolean operation are used.

ii) Assigning Properties: The properties assigned to soil viz. Sand & Black soil are obtained according to laboratory test results and for concrete pile according to IS 456:2000. The model selected for analysis of encased pile is an "Elastic model"and for soil, it is "Mohr-Coulomb" model. It is because, the assumptions of "Mohr-Coulomb" model are appropriate when the combination of concrete structure and sandy soil deposits occurs.

iii) Mesh Generation: Mesh generation is done on earlier created geometrical model. For accurate result of analysis, use of hexahedron or quadrilateral element & finer meshing with more number of elements are recommended. For foundation and soil model separate mesh is provided using 'Auto Mesh function'. For mesh generation the number of elements varies with dimension variations. Using MIDAS GTX NX geometry modelling is done followed by generation of mesh, for different height ratios as shown in figure 3.

iv) Applying Load: Vertical loads are applied at a particular node selected on structural element provided above foundation. For a given load intensity "Force"as a type of load is used where, ground support & self-weight with boundary conditions are provided for geometry. For the sake of validation value of interface element factor shall be kept as 0.5, so that the result variation may not vary more than 10%.

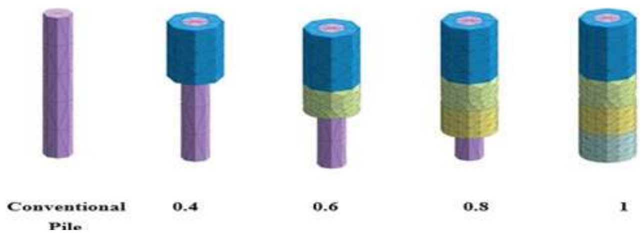

Fig 3: Geometry Modeling of a Pile Encased with Sand Cushion

v) Non-Linear Analysis: MIDAS GTS NX provide various analysis features such as time history, Eigen value, static, transient seepage, construction stage, steady-state seepage, and response spectrum analyses. In Non- Linear analysis lesser number of steps is involved for solving the pile geometry. For creating geometry the mesh is set by activating at once and the self-weight is considered to have linear variation along the depth.

vi) Analysis of Problem: The generated model is analyzed as described in non-linear analysis of vertical pile.

vii) Result Evaluation: The software organizes complex graphical result, animation, display of large scale models & complex construction activities & provide the post data result evaluation for the process of designing.

PARAMETRIC STUDY

The parameters considered for the analysis of pile are Diameter ratio (Dr) and Height ratio (Hr) subjected to vertical loading. The density, source & type of Sand are kept constant during analysis. The parameters selected are given in Table 1.

Table1: Parameters under consideration

Parameters	Values
Diameter of pile (dp)	600mm
Height of pile,(hp)	9.0m&12.0m
Diameter Ratio(Dr =D/dp)	1.0,1.2,1.4,1.6,1.8,2.0
Height Ratio (Hr=H/hp)	0.4, 0.6,0.8,1.0,1.2

DISCUSSION AND INTERPRETATION OF RESULTS

For analysis purpose, diameter of pile is kept constant and other parameters are kept varying. At inception, the analysis is carried out on a single circular concrete pile without sand cushion i.e. conventional pile & then with sand cushion i.e. encased pile.

PERFORMANCE OF CONVENTIONAL CIRCULAR PILE (I.E. WITHOUT SAND CUSHION):

The obtained results of ultimate loads are presented graphically in Figure 4 & 5 respectively.

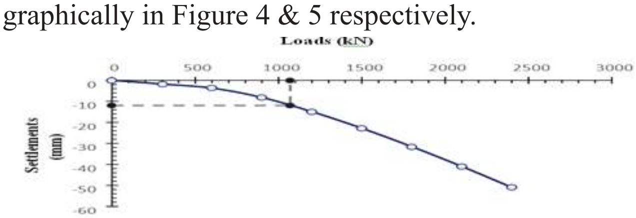

Fig. 4: Load-Settlement curve for Conventional Circular Pile-without sand cushion (hp=9m)

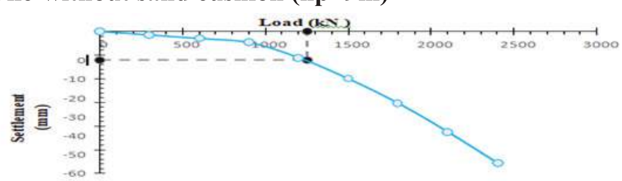

Fig. 5: Load-Settlement curve for Conventional Circular Pile-without sand cushion (hp=12m)

PERFORMANCE OF A PILE ENCASED WITH SAND CUSHION

The graphical results are as shown from figure 6 to 15.

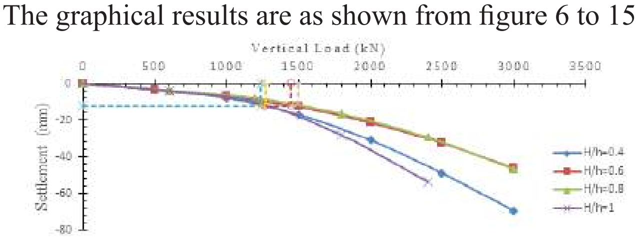

Fig. 6: Load-Settlement curve for hp= 9 m& Dr = 1.2 (dp = 600mm, D =720mm)

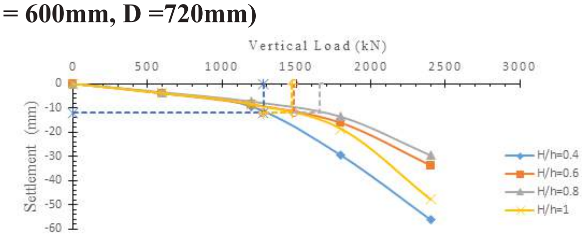

Fig. 7: Load-Settlement curve for hp = 9 m & Dr = 1.4 (dp = 600mm, D =840mm)

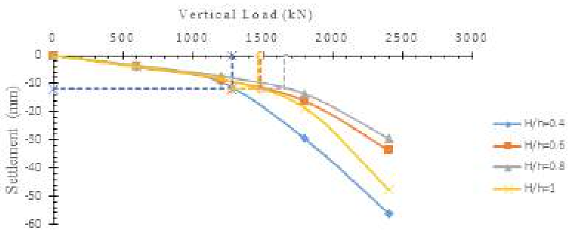

Fig. 8: Load-Settlement curve for hp = 9 m &Dr = 1.6 (dp = 600mm, D = 960mm)

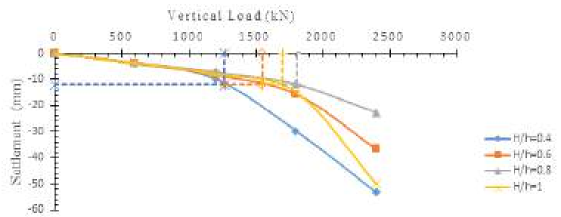

Fig 9: Load-Settlement curve for hp = 9 m & Dr = 1.8 (dp = 600mm, D = 1080mm)

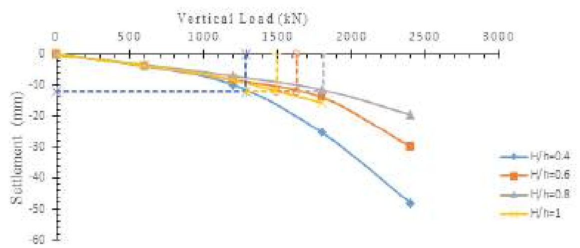

Fig. 10: Load-Settlement curve for hp = 9 m &Dr = 2.0 (dp = 600mm, D =1200mm)

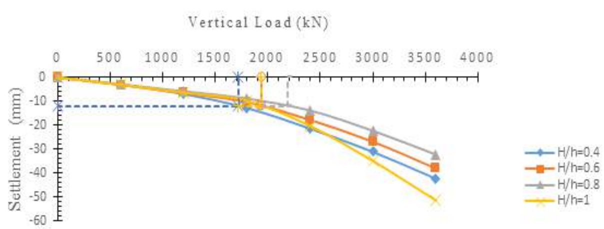

Fig. 11: Load-Settlement curve for hp = 12&Dr = 1.2 (dp = 600mm, D =720mm)

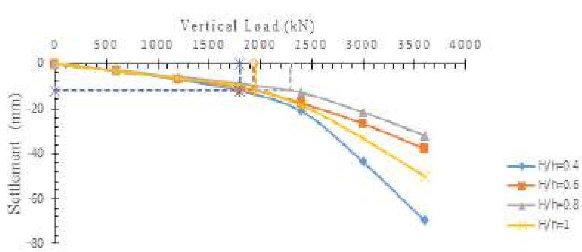

Fig. 12: Load-Settlement curve for hp = 12 m & Dr = 1.4 (dp = 600mm, D =840mm)

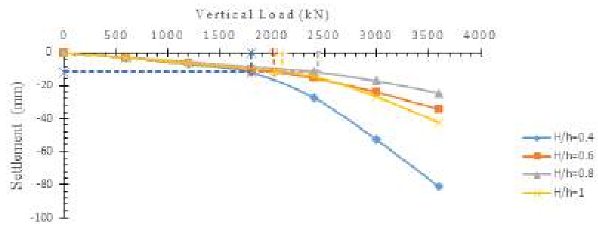

Fig. 13: Load-Settlement curve for hp =12 m &Dr = 1.6 (dp = 600mm, D =960mm)

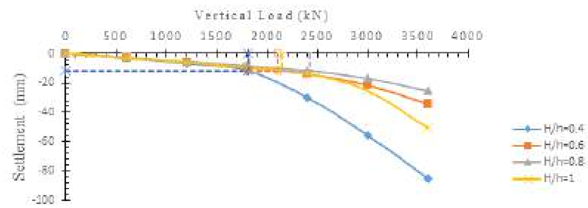

Fig. 14: Load-Settlement curve for hp = 12 m & Dr = 1.8(dp = 600mm, D = 1080mm)

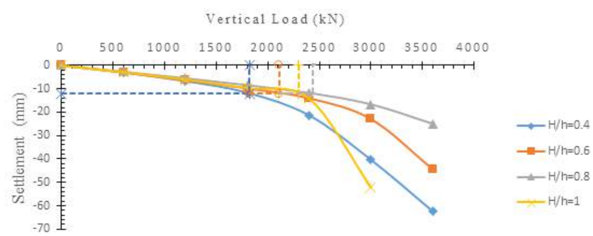

Fig. 15: Load-Settlement curve for hp = 12 m & Dr = 2 (dp = 600mm, D = 1200mm)

CONCLUSIONS

After performing Finite Element Analysis using MIDAS GTS NX software it is concluded that,

- The Ultimate load carrying capacity of pile encased with sand cushion increases with increase in height ratio up to certain limit.
- When the height ratioHr=0.8, the ultimate load carrying capacity of a single pile increases significantly i.e. 44% for hp = 9m, 75% for hp = 12m. It is due to more development of frictional resistance offered by pile encased with sand cushion.
- As the diameter ratio (Dr) of encased pile increases, its ultimate load carrying capacity increases in black cotton soil. This is due to the effect of confinement of frictional material around the periphery of pile surface.

- The percentage increase in load carrying capacity of pile is more when Dr = 1.6 for hp= 9 m &12 m. It is the optimum diameter ratio beyond which ultimate load capacity does not increase significantly.
- It is not a soil stabilization technique in black cotton soil bed; rather it is a method where load carrying capacity of pile increases with encased sand cushion with different diameter ratio viz. 1.2, 1.4, 1.6, 1.8 & 2.0.
- Around 35% reduction in diameter of pile is observed for optimum value of Hr & Dr; when the pile is encased with sand cushion as compared to conventional pile i.e. without sand cushion .e.g. for minimum Hr = 0.4 & Dr =1.2
- Table 2 suggests the diameter of a single pile Encased with Sand cushion i.e. 600mm against which the recommended size of a conventional Pile for carrying the given loads.

Table 2: Recommended size of conventional Single Pile Encased with Sand cushion

Height of pile; hp(m)	Diameter of pile considered for analysis dp (mm)	Load carrying capacity of conventional pile(kN)	Load carrying capacity of pile encased with sand cushion (kN)	% increase in load carrying capacity of pile encased With sand cushion	Then, recommended size of a conventional Single pile(mm)
1	2	3	4	5	6
9	600	1070	1238	15.70 %	695
12	600	1250	1720	37.60 %	830

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Comprehensive Guide on Numerical Analysis of Plate Anchors in Clay

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ABSTRACT

Foundation systems known as anchors are made up of a central steel rod and several plates welded around it. These rods and plates are typically constructed from steel. The central rod is responsible for transferring torque during the installation process and for distributing the load to the plates. This study aims to compare the maximum pulling force and lateral load-bearing capabilities of four types of anchor systems: circular, square, helical and star plate anchors, all set in clay deposits with various structural arrangements. The analysis is conducted using FEA MIDAS GTS NX. The study considers various configurations of the anchor systems, including plate's numbers, upper and lowermost plate's depth and the distance between the plates relative to the plate's diameter. The results include the load–settlement curves of each configuration, followed by the determination of the maximum pulling force and lateral load capacity for each setup. The behavior of the soil is modeled under the Mohr–Coulomb failure criteria.

KEYWORDS: *Circular, Square, Helical and star plate anchor, Maximum pullout capacity, FEA study, MIDAS GTS NX.*

INTRODUCTION

Anchor piles are constructed from a variety of materials, including steel plates, wooden sheets, reinforced fiber, and precast. Anchor piles are designed to withstand vertical and horizontal, as well as slanted forces across different geotechnical projects. The specific type of soil anchor selected also plays a role in its ability to resist backfill resistance and thermal stress. Tension members are affixed to the structure and then sunk deep into the ground to withstand uplifting forces. Essentially, soil anchors act as foundation systems that transfer structural load to the ground, enabling them to counteract moments and forces that could endanger the stability of the structure. The research on the performance of soil anchors for homogeneous soil has been both analytically and experimentally conducted by numerous scholars to forecast their pullout resistance. Ghosh. P., et al. (2019) performed numerical analyses to determine the ultimate uplift capacity (Pu) of helical anchors in soil of homogeneous nature [1]. Mittal. S., et al. (2015) conducted experiments on the behavior of helical screw anchors under vertical compressive loads [2]. Bhattacharya. P., et al. (2019) conducted an experiment on the load-settlement behavior and uplift capacity of horizontal plate anchors in layered sand deposits [3]. Stability of plate anchors in undrained clay (2001) was studied by Merifield, R. S., Sloan, S. W., et al. [5].

Merifield, R. S., and Smith, C. C. (2010) studied the ultimate capacity of multi-plate strip anchors in undrained clay [6]. The ultimate uplift capacity of foundations was examined by Meyerhof, G. G., and Adams, J. I. (1968) [7].

PROBLEM STATEMENT

Models of isolated circular, square, helical and star plate anchor having different plates of diameter "D", length "L" for square and width "a" for star plates, is set into the ground. This is done with a plate embedment ratio "λ= H/D","H" represents the plate embedment depth of the highest plate among all the anchors being examined, as illustrated in Fig. 1, Fig. 2, Fig. 3 and Fig. 4.

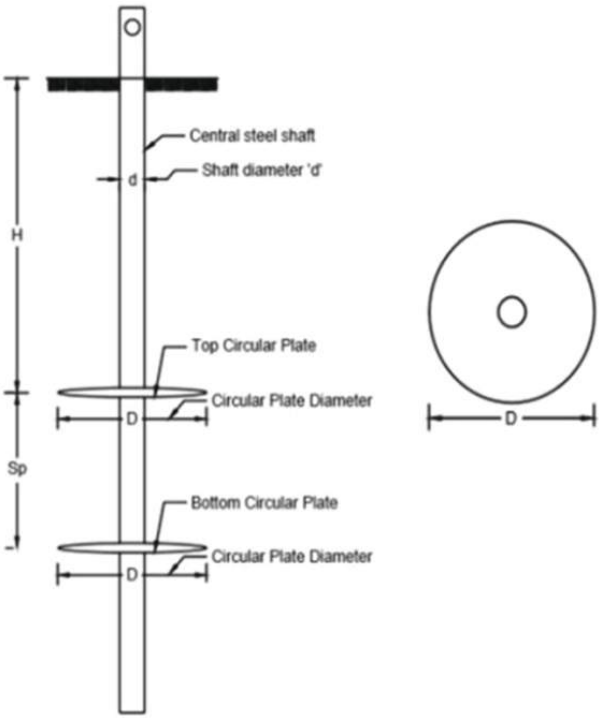


Fig. 1 Elevation & Cross section of Circular Plate Anchor

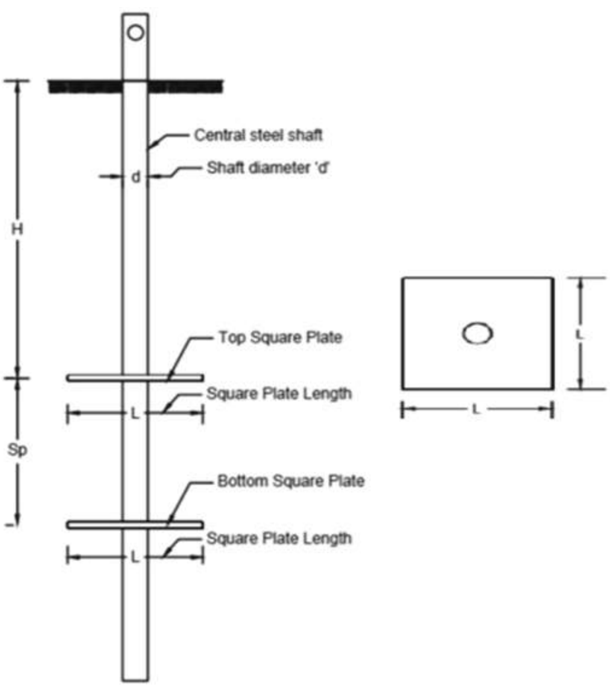


Fig. 2 Elevation & Cross section of Square Plate Anchor

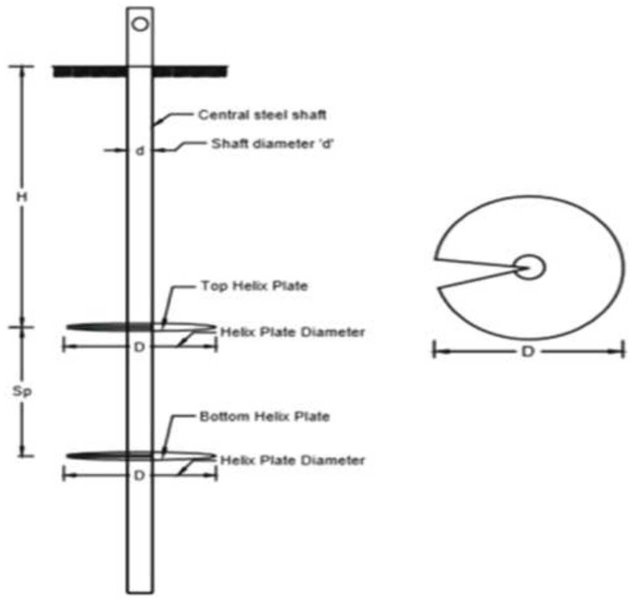


Fig. 3 Elevation & Cross section of Helical Plate Anchor

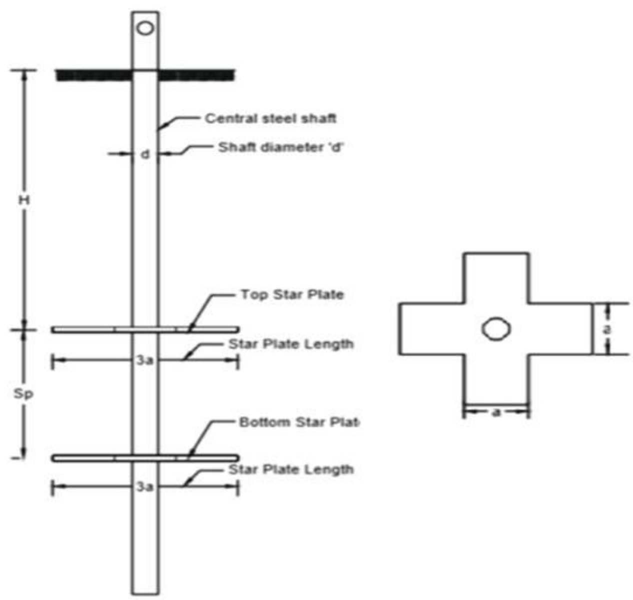


Fig. 4 Elevation & Cross section of Star Plate Anchor

Every anchor is constructed from steel with extremely rough surface. The dimensions of the plate and the core shaft for both circular and helical plate anchors are set at 2.4 m and 0.4 m, respectively. The area of the plate for sqaure and star plate anchor is equal to the area of the cross-sectional area of the circular plate. The pitch of the helical anchor is measured at 0.46 m. The plate thickness is considered to be 0.1 m, which is deemed insignificant when compared to the diameter and length of the plate.

Anchors considered for examination are taken from Wang et al. (2013) and are mentioned in Table 1. A variety of anchor model are considered for the examination as illustrated in Figure 5. The specifications of the anchor model selected for examination are detailed in Table 2. Configurations C-1, C-2 and C-3 are comprised of three plates, while C-4 and C-6 consist of double plates. Configurations C-7 and C-8 are single plates with varying depths of plate embedment for each type of anchor. Within all group of anchors, the spacing between two plates (Sp) remains constant, except for configuration C3, where the distance between plates varies.

Table. 1 Attributes Assigned to Anchors for Examination (Wang et al. 2013)[4]

Sr. No.	Attributes	Values	Units
1.	E	2.1×10^8	kN/m^2
2.	ρ	76.5	kN/m^3
3.	υ	0.25	

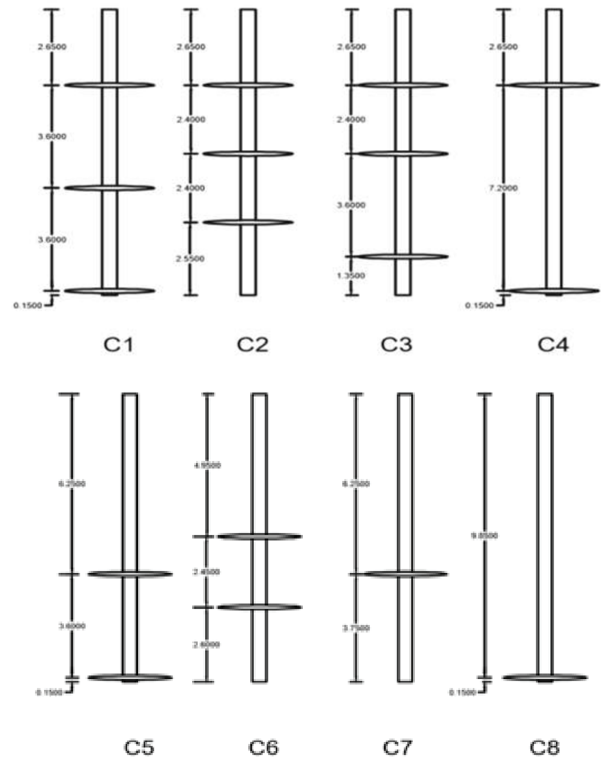


Fig. 5 Configurations of Anchors for Examination

Table. 2 Configurations of Anchors used for examination

Configurations	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8
Plates	3.	3.	3.	2.	2.	2.	1.	1.
Upper-most plate, H(m)	2.6	2.6	2.6	2.6	6.2	5.0	6.2	9.8
Lower-most plate, h (m)	9.8	7.4	8.6	9.8	9.85	7.4	6.2	9.8
Spacing of plates, S_p(m)	3.6	2.4	2.4,3.6	7.2	3.6	2.4	-	-
(S_p/D)	1.5	1	1,1.5	3	1.5	1	-	-
(λ=H/D)	-	-	-	-	-	-	2.5	4

To calculate the maximum uplift and maximum lateral load strengths of the areas, we are focusing on clay soil deposit. The characteristics of soil are sourced from Wang et al. (2013) and are detailed in Table 3. For the purpose of this analysis, a Mohr–Coulomb failure criterion is considered. The soil layer under consideration is assumed to be in an undrained state.

Table .3 Characteristics of soil examined for study (Wang et al. 2013)4

E(kN/m^2)	Cu(kN/m^2)	Ɣ(kN/m^3)	υ	ϕ°
12.75x 103	12.75	16	0.4	0

Analysis

The goal of the study was to find out the maximum Pullout and Lateral support abilities of plate anchors. To do this, each anchor was subjected to a step-by-step increase in force upwards to measure its lifting strength and a step-by-step increase in lateral force to measure its lateral support strength. This current study was carried out using FEA software MIDAS GTS NX. The process of creating the finite element model involved using four tetrahedral nodes. The anchors and soil constructed in finite element model are illustrated in Figure 6, 7, 8, 9 and Figure 10.

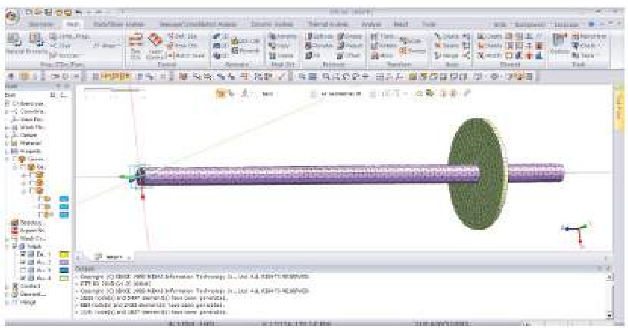


Fig. 6 Geometry of Circular Plate Anchor embedded in soil after Mesh Generation in MIDAS GTS NX 3D

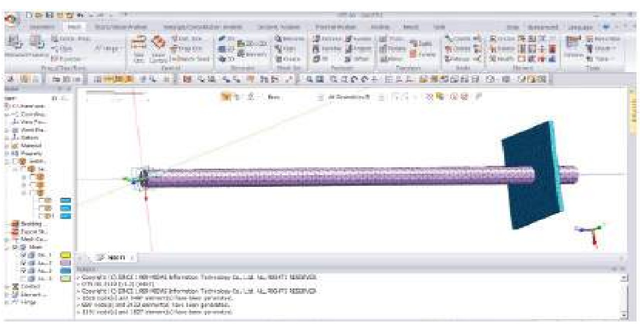


Fig. 7 Geometry of Square Plate Anchor embedded in soil after Mesh Generation in MIDAS GTS NX 3D

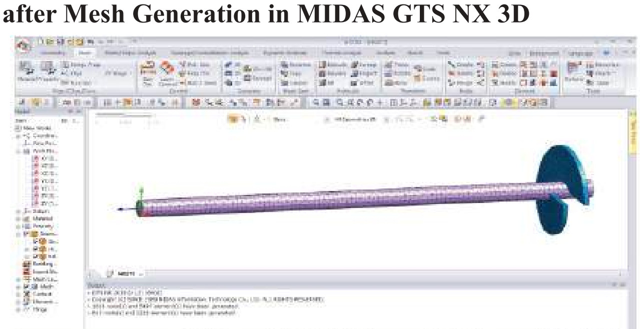


Fig. 8 Geometry of Helical Plate Anchor embedded in soil after Mesh Generation in MIDAS GTS NX 3D

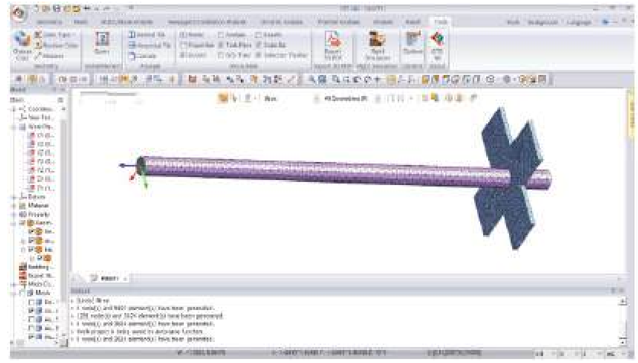


Fig. 9 Geometry of Star Plate Anchor embedded in soil after Mesh Generation in MIDAS GTS NX 3D

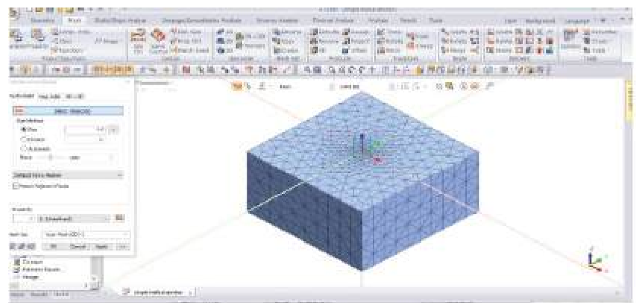


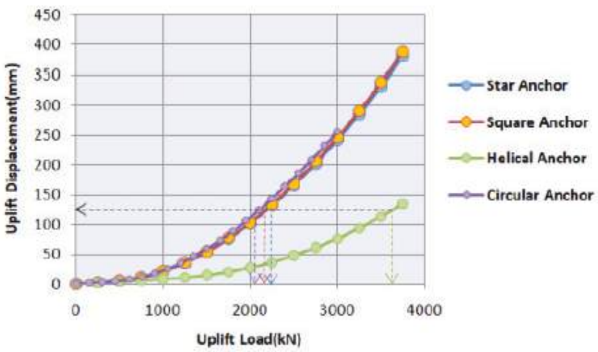
Fig. 10 Geometry of soil after Mesh Generation in MIDAS GTS NX 3D

In the study, the basic materials properties for general contact are utilized to model how all surfaces interact. The following conditions for the study are taken into account. For X-axis movements, the displacement ux is set to "0" at the vertical edges that are parallel to the YZ plane. For Z-axis movements, the displacement uz is set to "0" at the vertical edges that are parallel to the XY plane. All movements are set to "0" at the base, meaning ux = uy = uz = 0. At the start of the study, the ideal size of the domain was determined. To achieve this, models C-1 and C-8 from all set of anchor points were selected. The primary aim for choosing these configurations was that C-1 anchor configuration featured three plates with a consistent spacing between them in all type of anchor, and the lowest plate was placed at a depth of 9.85 m, which represented the maximum depth of the plate considered in the current study. On the other hand, C-8 anchor configuration had a sinusoidal plate with a depth of 9.85 m for all type of anchor. Through this analysis, the optimal depth of the clay deposit was identified as 12.5 D, with a depth of 7.5 D in the horizontal direction from the anchors center

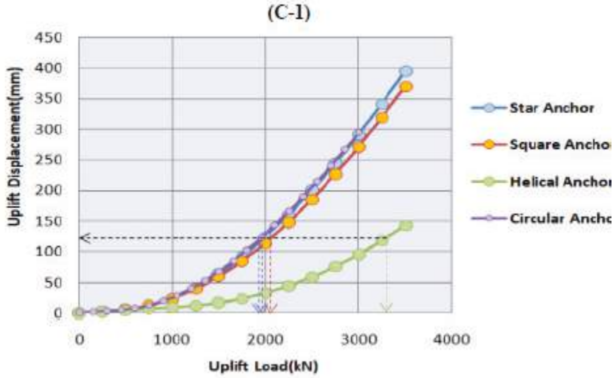
RESULTS & DISCUSSION

Pullout capacities of anchors

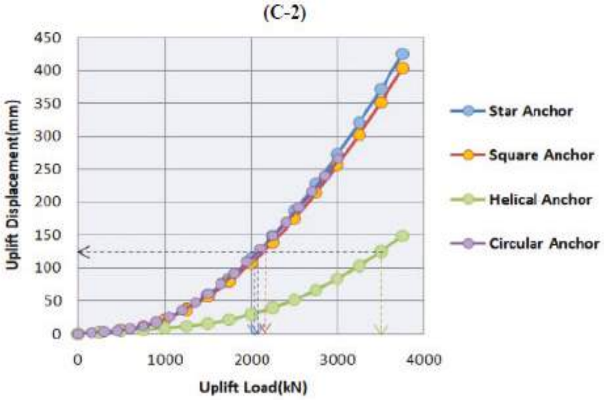
Figure 11 displays the adjusted uplift load–settlement curves for each anchor set in a clay deposit, categorized by model from C-1 to C-8. The maximum uplift load capacities (Pu) of the anchors were determined by selecting the pullout displacement that equaled 5% of the plate diameter. Figure 12 illustrates the percentage increase in pullout load capacities for all anchor configurations with respect to circular plate anchor.



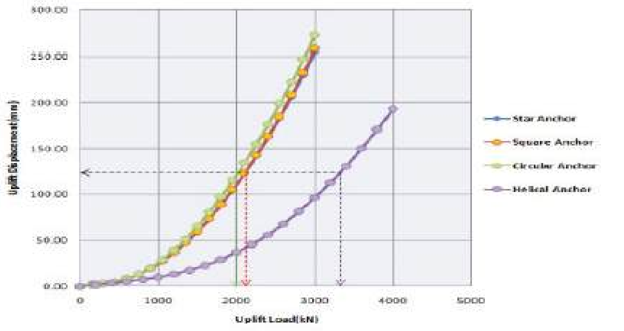
(C-1)



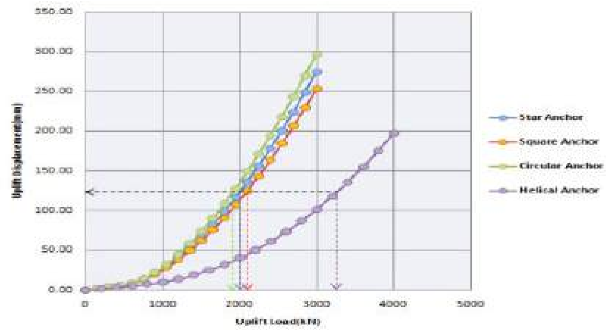
(C-2)



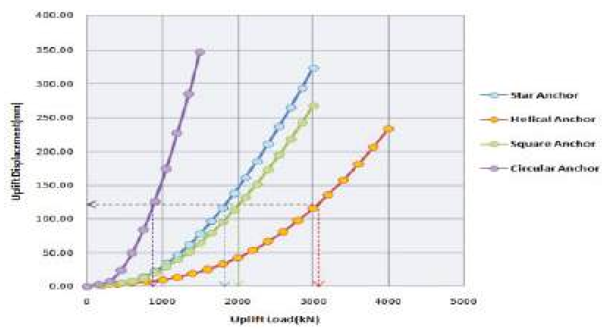
(C-3)



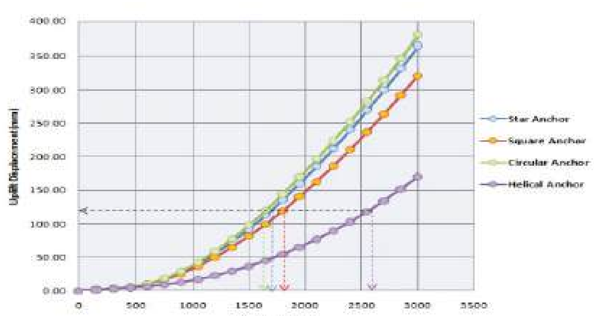
(C-4)



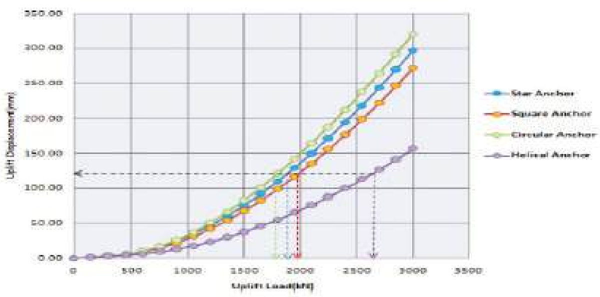
(C-5)



(C-6)



(C-7)



(C-8)

Fig. 11 Pullout Load Vs Pullout Displacement Curve of All Anchor Configurations

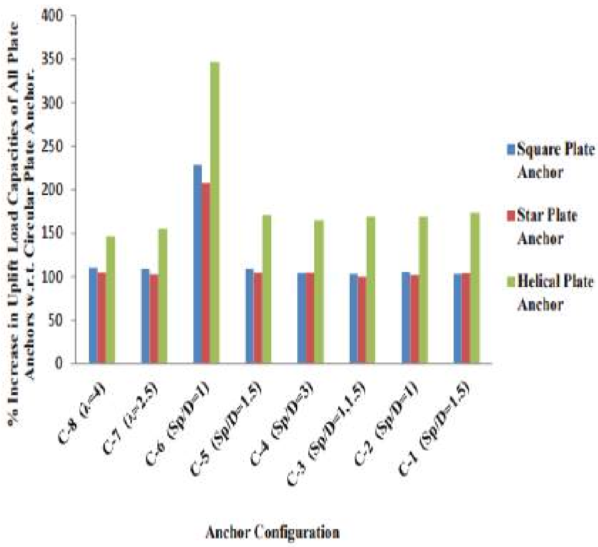
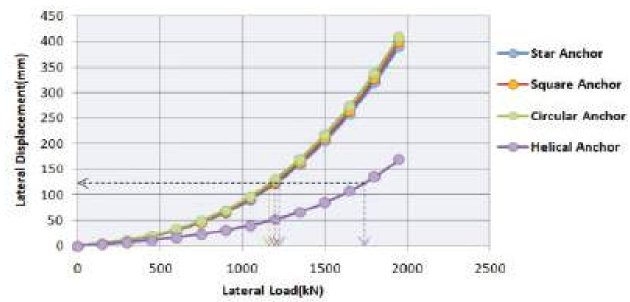


Fig. 12 Percentage Increased in Uplift Load Capacities of all anchors with respect to Circular Plate Anchor

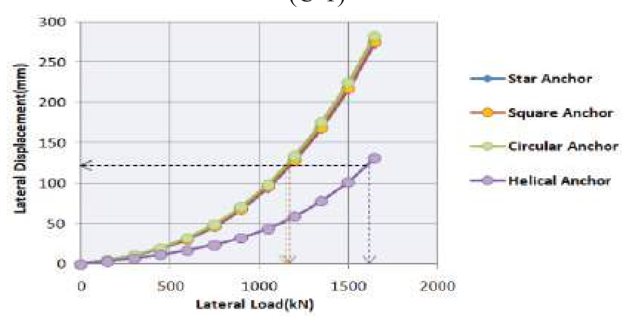
As illustrated in Fig. 12, when comparing the anchor with three plates to those with two or one plate, the latter offer less support due to their lower embedment depth. However, it's noted that with an equal number of plates, the support capacity grows as the distance between the plates and their diameter increases. This is demonstrated in Fig. 5, where it's observed that the support capacity also rises as the ratio of embedment depth to diameter (λ = H/D) increases for single plate anchors. Furthermore, the pullout capacity of the anchor increases with a higher ratio of plate spacing to diameter (Sp/D) and a deeper the depth of the lowermost plate. The helical plate anchor is found to have a higher support capacity than that of circular, square, and star plate anchors. According to Fig. 6, the support capacity of all anchors is shown to increase more with circular plate anchors. Specifically, the helical plate anchor configuration C-6 achieves the highest increase in ultimate support capacity when compared to circular plate anchors of a similar design.

Lateral load capacities of anchors

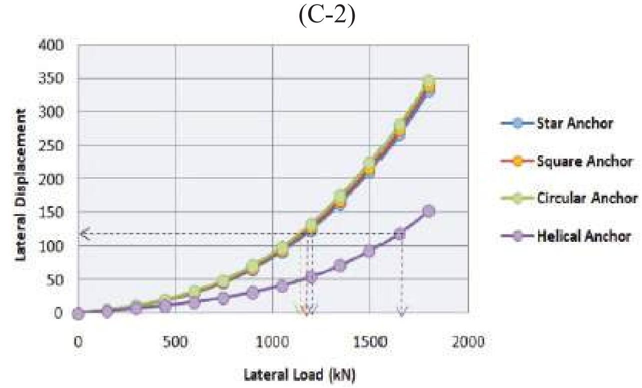
Figure 13 displays the standard lateral load-settlement curves for each anchor installed in a clay layer, across various setups ranging from C-1 to C-8. The maximum lateral load bearing abilities (PL) of the anchors were calculated based on the lateral displacement that is 5% of the plate diameter. Figures 14 illustrate the percentage increase in lateral load bearing abilities for all anchors with respect to circular plate anchors.



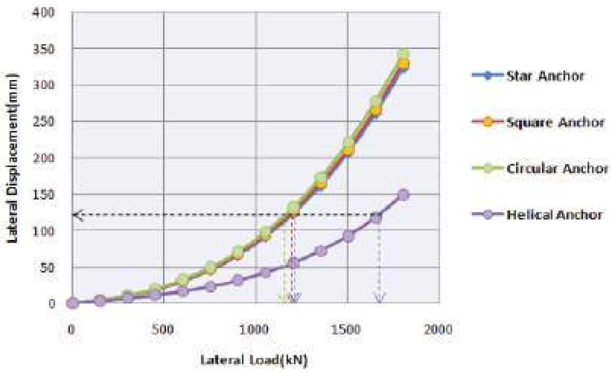
(C-1)



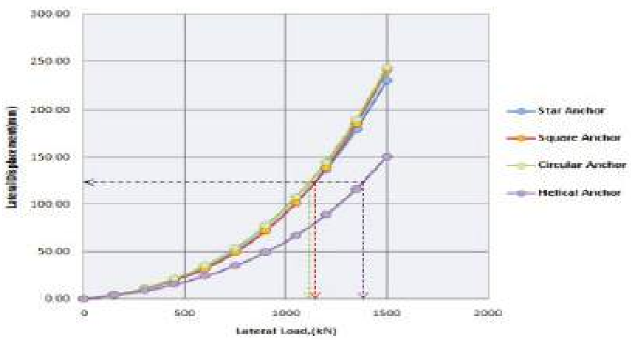
(C-2)



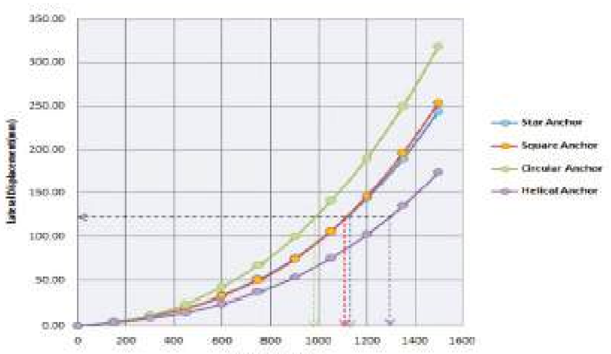
(C-3)



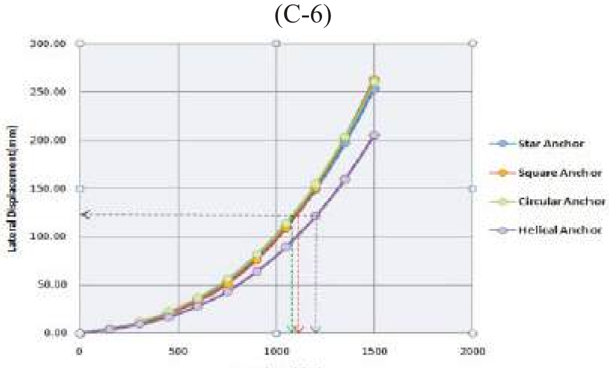
(C-4)



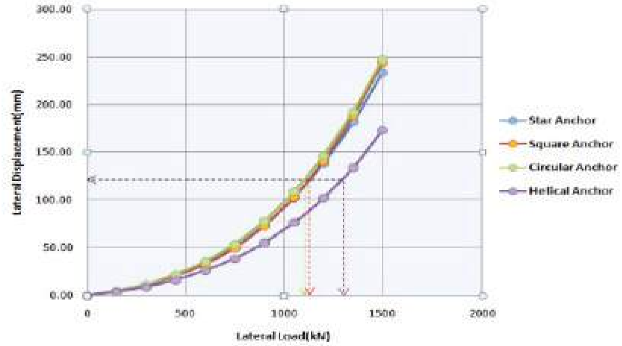
(C-5)



(C-6)



(C-7)



(C-8)

Fig. 13 Lateral Load Vs Pullout Displacement Curve of All Anchor Configurations

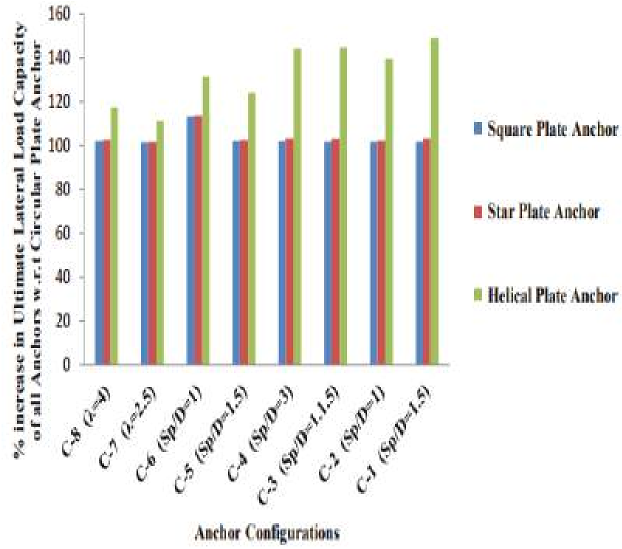


Fig. 14 Percentage Increased in Lateral Load Capacities of all anchors with respect to Circular Plate Anchor

According to Figure 14, it's observed that the load-bearing capacity of anchors slightly rises as the ratio of the depth at which the plate is embedded ($\lambda = H/D$) increases, especially for anchors designed with a single plate. Additionally, the size of the plate itself increases when the ratio of spacing to depth (Sp/D) is higher and when there's a greater depth to the lowest layer of the plate. The helical plate anchor demonstrates a higher lateral load capacity than its circular, square, and star counterparts. Figure 9 illustrates how the lateral load capacities of all anchor types differ from those of circular plate anchors. Specifically, the helical plate anchor with configuration C1 (when Sp/D is 1.5) achieves the highest percentage enhancement in its ultimate lateral load capacity relative to similar circular plate anchor configurations.

CONCLUSIONS

Based on a detailed numerical study of various types of plate anchors, including single, double, and triple ones, the following key findings are observed. The maximum pullout & lateral support capacity of single plate anchors increase as the depth ratio of embedment of the plate "λ=H/D" is raised. Both the maximum uplift & lateral load support capacity of double and triple plate anchors, as well as those of single plate anchors, improve with an increase in the ratio of plate spacing to diameter "Sp/D". The maximum uplift & lateral support capacity of all anchors tend to go up with the number of plates involved. Double and triple plate anchors offer slightly higher maximum uplift & lateral support capacity than single plate ones. The maximum uplift & lateral support capacity of anchors with square, star, or helical shapes are generally greater than those with circular shapes, particularly when the cross-sectional area is the same. At plate spacing by diameter ratios of 1, 1.5, or 1.67, the maximum uplift & lateral support capacity of double and triple plate anchors with specific shapes (square, star, or helical) exceed those with circular shapes. Triple plate square, star, and helical anchors exhibit higher maximum uplift load and lateral support capacity in cohesive soils with plate spacing by diameter ratios of 1.5 or higher compared to single plate anchors. In comparison to each other, helical plate anchors show the highest maximum uplift load and lateral support capacity for anchors of similar cross-sectional areas. Furthermore, the configuration with a depth ratio of embedment of the plate set at 4 and plate spacing by diameter ratio of 1.5 has been found to be the most effective for resisting uplift and lateral forces.

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Utilization of Sustainable Sea Shell Powder and Alccofine in Concrete Production

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ABSTRACT

In this study, potential of substituting cement with Alccofine and seashell powder in concrete production is explored. Employing a standardized methodology, experimental trials of M30 grade concrete was conducted with a consistent 10% Alccofine and varying seashell powder proportions up to 30%. These mixtures were evaluated against conventional concrete standards. The experimental procedures adhered to IS 588 for mixing or casting and IS 486 for specimen testing are explored. The performance of concrete was assessed through measures of compressive strength with 3,7- and 28-days. Evaluations with split tensile strength, scanning electroscope and rapid chloride is also carried out. Comparative analysis extended to the cost effectiveness of traditional materials versus sustainable alternatives. The findings suggest that the M1 mix with up to 20% partial replacement of cement by seashell powder provides a viable and effective solution, recommending practical and environmental benefits. Findings underline the importance of integrating sustainable materials in the construction industry, potentially inducing significant ecological and economic impacts.

KEYWORDS: *Sustainability, Concrete microstructure, Optimization modeling, Cost analysis.*

INTRODUCTION

Concrete is widely used as a structural material across the globe, with cement as a key component. Global warming is contributed by exponential expansion of infrastructure due to increase in carbon dioxide emissions. To produce enhanced sustainable concrete, researchers have explored various additives, such as Alccofine, fly ash, sea shell powder, and silica fume [1]. Out of these, incorporating fly ash into concrete is gaining popularity due to its ability to reduce both environmental and technical issues related to coal-fired power plants. This helps in decreasing greenhouse gas emissions from industries while conserving natural resources. However, delayed pozzolanic activity of fly ash in concrete can hinder early strength development and causes its detrimental effect. To mitigate this, admixtures like Alccofine 1203 and Sea Shell, exhibiting high glass content and high pozzolanic reactivity [2] is used. It is observed that the use of these materials improves the flow of concrete and its workability apart from increasing its compressive strength [3]. Throughout history, humans have utilized seashells for various purposes, including musical instruments, medical and pharmacological uses, arts, and construction materials. Seashells have been incorporated into concrete mixtures as replacements for both fine and coarse aggregates, as well as supplementary cementitious materials (SCM) [4]. Previous research has examined cement replacement with seashell powder in proportions ranging from 5% to 30%, revealing improvements in setting time but reductions in both compressive and flexural strength. Type of shell, their collecting place, minerals of surrounding waters, contribute to the chemical composition of shell. Despite of variations, raw seashells are predominantly composed of calcium carbonate ($CaCO3$ – 95.95%) along with trace organic compounds and minerals [5]. By using byproducts from seashell production as cement, certain properties of concrete can be enhanced.

Fig. 1. Sea Shell Powder

Fig. 2. Alccofine Powder

Sustainable Materials

Alccofine is an extremely fine material, with ground granulated blast-furnace Alccofine being particularly fine. The use of non-metallic materials, such as ground granulated blast furnace slag, often consists of calcium along with other key silicates and aluminates. When molten slag is rapidly cooled in water, it forms a granular material that resembles glassy sand. Alccofine size of particles are smaller than cement but larger than micro silica. It is commonly understood that the fineness of cementitious material directly affects strength. The incorporation of Alccofine enhances the durability of concrete due to optimized particle size distribution. Alccofine particle size range is between 0.1 to 17 microns, with an average size of 4 microns. Alccofine 1203 is processed with high glass content and significant reactivity is achieved by controlled granulation [7]. The primary materials involved are low-carbon silicates.

METHODS

Components of concretes for sustainability tests are evaluated and analyzed.

Crushed Sand

Crushed sand with a fineness modulus of 2.88 and zone I (± 3% tolerance) is utilized in the concrete mixing process.

Coarse Aggregate: It uses aggregate from 20 mm to 10 mm in size. As per IS 383-1970, aggregate has an angular shape, while flaky and elongated aggregate is not used. The coarse aggregate test is the specific gravity test is necessary equipment includes a weighting a scale, an oven with a temperature range of 100^0C-110^0C, a wire basket with a maximum mesh size of 6.3 mm [11].

Water

Water chemically interacts with cement to create cement gel giving strength to the concrete. It requires to evaluate quantity and quality of water precisely by curing and mixing the concrete specimens.

Design Mix for Alccofine and Sea Shell based M30 Grade

Grade Designation: M30, Grade of Cement: 53 Grade (Birla Shakti Cement), Max nominal size of aggregate: 20mm, exposure conditions: saver [IS 456 T-3], minimum cement content: 320 kg/m3 as per IS 456 T-5, 100 mm workability in terms of slump, Transportation time: 30 mins, Standard Deviation: 5 N/mm2 as per IS 10262T-2, course aggregates of crushed angular aggregate, maximum cement content: 0.45 as per IS 456 T-3, Fine aggregate (Crushed Sand): Zone I, Admixtures: Polycarboxylate Ether (PCE) used as a super plasticizer at a 1% of dosage, specific gravity of cement: 3.15 kg/m^3.

Mix Calculations

Total Volume = 1 m^3, Volume up interrupted air in wet concrete: 0.01 m3

$$\text{Volume of Cement} = \frac{438.16}{\text{Specific Gravity}} X \frac{1}{1000} = \frac{438.16}{3.15} X \frac{1}{1000} = 0.139 \text{ m}^3 \quad (1)$$

$$\text{Volume of Water} = \frac{197.16}{\text{Specific Gravity of water}} X \frac{1}{1000} = 0.197 \text{ m}^3$$

Aggregate Volume=[Total Vol–Entrapped air volume]–[Vol of cement + Vol of water] = [1-0.01] – [0.139+0.197] = .01654 m^3 (2)

Mass of coarse aggregate = (Volume aggregate)*(coarse aggregate volume)*(specific gravity)*1000 = 0.654 x

$0.634 \times 2.64 \times 1000 = 1094.639$ kg/m^3 (3)

Mass of fine aggregate = (Volume aggregate)*(fine aggregate volume)*(specific gravity)*1000 = 0.654 x 0.366 x 2.6 x 1000 = 622.346 kg/m^3 (4)

Mix Proportions

Cement = 438.134 kg/m^3, Fine aggregate = 622.346 kg/m3, Water Content = 197.16 kg/m^3.

Cement: Fine aggregate: Coarse aggregate

428.134: 622.346 : 1094.64

1 :1.42 :2.5

Cement Content = 438.134 kg/m^3

Sea Shell

10% = 43.813 kg/m3, 20% = 87.626 kg/m3, 30% = 131.440 kg/m^3

Cement + 10AL + 10SS = 350.508+43.813+43.813 = 438.134 kg/m^3 (5)

Cement + 10AL + 20SS = 306.695+43.813+87.626 = 438.134 kg/m^3 (6)

Cement + 10AL + 30SS = 262.881+43.813+131.440 = 438.134 kg/m (7)

Weight basic proportion for cube

Volume of mould = (0.15*0.15*0.15) = 0.003375 m^3 (8)

Design Volume = 1.52*0.003375 = 0.0513 m^3 (9)

Table 1: Mix Portion of Cube

Sample Code	Cement	Crushed Sand (Kg)	10 mm (Kg)	20 mm (kg)	Water (Kg)	Alccofine 1203 % Kg	Sea Shell Powder %
CC	3.078	4.135	2.037	4.753	1.39	-	-
MI	2.62	3.72	2.037	4.753	1.39	0.4t	0.41(10%)
M2	2.62	3.31	2.037	4.753	1.39	0.46	0.83 (20%)
M3	2.62	2.9	2.037	4.753	1.39	0.46	1.24 (30%)

Weight basis proportion for cylinder

Volume of mould = (3.14*0.05*0.05*0.2) = 0.00157 m^3 (10)

Design volume = 1.52*0.00157 = 0.00238 m^3 (11)

MATHEMATICAL MODELING

Calibration model to measure effects of incorporating Alccofine and sea shell powder into concrete production will involve establishing, how admixtures affect properties like compressive strength, setting times and durability.

x% = Percentage of cement replaced by sea shell powder, y% = Percentage of cement replaced by sea shell powder

CS (MPa) = Compressive strength of concrete

IST (min) = Initial Setting Time of concrete

FST (min) = Final Setting Time of concrete

DI (%) = Durability Index of Concrete

Compressive Strength (CS)

$CS = CS_0 - \alpha x - \beta y$ (12)

CS0 = Compressive Strength is without replacement,

α, β = Negative impacts percentage increase in Alccofine and sea shell powder

Setting Times

$IST = IST_0 + \gamma x + \delta y$ (13)

$FST = FST_0 + \varepsilon x + \zeta y$ (14)

IST_0 and FST_0 = Setting times for standard mix

γ, δ, ε, ζ = Factors that increase setting time per percentage increase in admixtures

$DI = DI_0 + \eta x + \theta y$ (15)

DI_0 = Durability Index for baseline η and θ are improvements in durability per percentage increase in Alccofine and sea shell powder.

Table 2: Data Table

Mix	% of Alccofine	% of sea shell powder	CS (MPa)	IST (Min)	FST (Min)	DI
A	0	0	32	100	200	80
B	10	0	30	105	205	82

C	0	10	31	102	202	81
D	10	10	28	107	207	83

Applying these Data in model predict compressive strength

CS = 32 – α, 10 – β * 20 (16)

Assuming from calibration

A = 0.2, β = 0.1, CS = 32 – 0.2 * 10 – 0.1 *20 = 32 – 2-2 = 28 MPa

Predict Setting Times

LST = 100 + γ*10 + δ*20 (17)

FST = 200 + ε * 10 + ζ * 20 (18)

Assuming

γ = 0.5, δ = 1, ε = 1, ζ = 1.5

LST = 100 + 0.5 * 10 + 1 * 20 = 100 + 5 + 20 = 125 min

FST = 200 + 1 * 10 + 1.5 * 20 = 200 + 10 + 30 = 240 min

Predict Durability Index

DI = 80 + η * 10 + θ * 20 (19)

Assuming η = 0.2, θ = 0.1, DI = 80 + 2 + 2 = 84%

Validation Model

x = Percentage of cement replaced by Alccofine, y = Percentage of cement replaced by shell powder

Properties Vector is represented by P

P = [■(Compressive Strength (CS)@Initial Setting Time (IST)@Final Setting Time (FST)@Durability Index (DI))]

$$P = \begin{bmatrix} Compressive\ Strength\ (CS) \\ Initial\ Setting\ Time\ (IST) \\ Final\ Setting\ Time\ (FST) \\ Durability\ Index\ (DI) \end{bmatrix} \quad (20)$$

Coefficient of Matrix

Column A presents admixtures, and each row corresponds to effect on a particular concrete property

$$A = \begin{bmatrix} a11 & a12 \\ a21 & a22 \\ a31 & a32 \\ a41 & a42 \end{bmatrix} \quad (21)$$

Where, a11, a12 are effects of Alccofine and sea shell powder on compressive strength, a21, a22 are effects on initial setting time, a31, a32 are effects on final setting time and a41, a42 are effects on durability Index

Admixture vector is represented by X

$$X = \begin{bmatrix} x \\ y \end{bmatrix}$$

The model equation can be expressed by matrix equation, P = A * X + B

B = Baseline properties vector without any admixtures, P = Properties of vector with admixtures

$$B = \begin{bmatrix} 30\ MPa \\ 90\ Min \\ 180\ Min \\ 75\ \% \end{bmatrix}$$

Coefficient of matrix A can be

$$A = \begin{bmatrix} 0.3 & -0.2 \\ 1.5 & 2.0 \\ 3.0 & 2.5 \\ 0.1 & 0.15 \end{bmatrix}$$

Admixtures proportions for a specific mix a 10% Alccofine and 15% sea shell powder

$$X = \begin{bmatrix} 10 \\ 15 \end{bmatrix}$$

Concrete Properties will be

P = A * X + B (22)

$$= \begin{bmatrix} 0.3 & -0.2 \\ 1.5 & 2.0 \\ 3.0 & 2.5 \\ 0.1 & 0.15 \end{bmatrix} * \begin{bmatrix} 10 \\ 15 \end{bmatrix} + \begin{bmatrix} 30\ MPa \\ 90\ Min \\ 180\ Min \\ 75\ \% \end{bmatrix} = \begin{bmatrix} 30 \\ 135 \\ 24705 \\ 78.25 \end{bmatrix}$$

Durability Index = 78.25

RESULTS AND DISCUSSIONS

Numerous combinations are tabulated and result from various testing is compared to regular concrete. Graphical representations are used to compare results. These test findings include slump, compressive, split tensile and rapid chloride penetrations tests to optimize sustainable properties.

The strength test values in every type of modified concrete are presented in following graph Fig 1 and 2

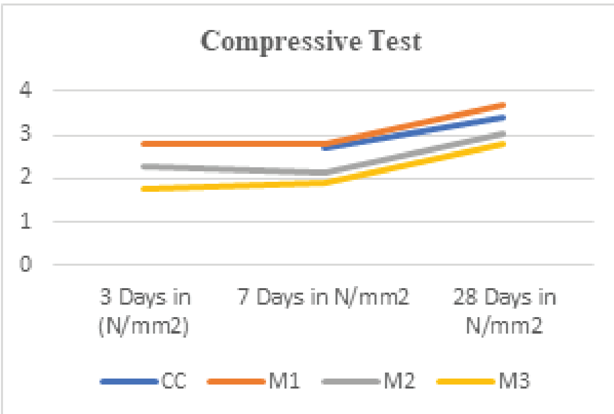

Fig. 1: Compressive Strength Test

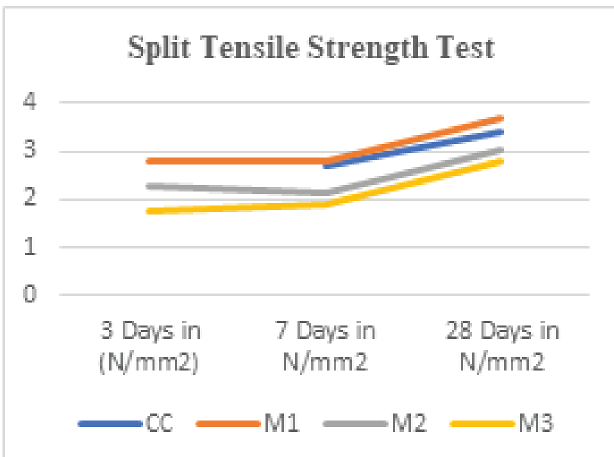

Fig. 2: Split Tensile Strength Test

It is concluded that for 7 days, it should be more than 2.47 and for 28 days it should be more than 3.43

4.1 Scanning Electron Microscopy (SEM) All mixtures were scanned under Scanning Electron Microscopy (SEM) (Fig 3 to 6) at 28 days of curing time at various magnification, including 2μm and 1μm. As shown in figure 6, the calcium hydroxide that comprises the binders' solid phase at the start of the hydration process is primarily in the form of portlandite.

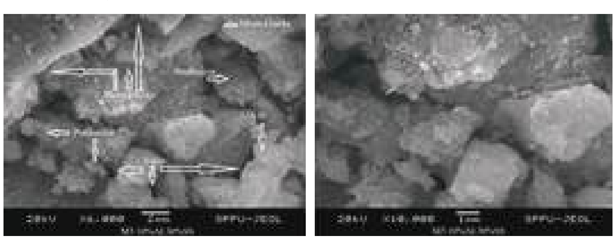

Fig. 3: Traditional Concrete Sample

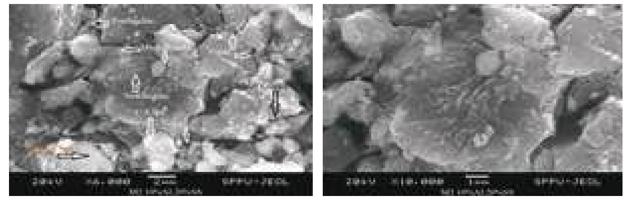

Fig. 4: M1 mix (10% AL, 10% SS)

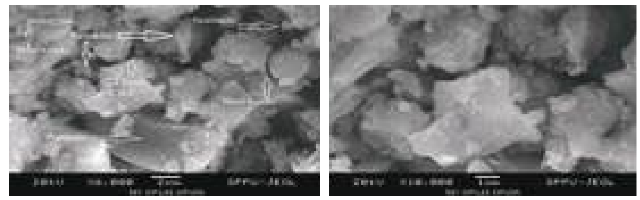

Fig. 5: M2 Mix (10% AL, 20% SS)

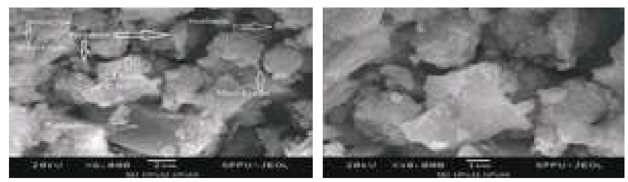

Fig. 6: M3 Mix (10% AL, 30% SS)

CONCLUSION

The utilization of Alccofine and seat shell powder, as supplementary cementitious materials (SCMs), in concrete offers a sustainable approach to construction. The experimental results demonstrate that a 20% partial replacement of cement with these materials in the M1 mix (10% Alccofine + 10% Sea Shell Powder) enhances the compressive and split tensile strengths of conventional grade M30 concrete. Notably, the M1 mix achieved a compressive strength of 45.33 N/mm2, which is approximately 4.83% higher than that of conventional concrete at 43.244 N/mm2. Furthermore, the M1 blend exhibits improved durability characteristics, as evidenced by favorable results in Rapid Chloride Penetration Tests (RCPT) and reduced occurrences of micro fractures and voids, as observed through SEM studies. The increased formation of C-S-H get, particularly with higher sea shell replacement levels, contributes to these strengths and durability enhancements. Cost effectiveness in the construction industry is demonstrated with the difference between conventional concrete and M1 mix. Reduced cement usage not only reduces cost of concrete production but also mitigates environmental impact to reduce carbon footprint. Research work founds that, M1 mix with 10% Alccofine and 10% Sea Shell Powder is practically significant for sustainable alternative. M1 mixed with 20% partial replacement of cement will be more sustainable and cost-effective approach to development of infrastructure. This research work advocates to explore long term effects and the scalability of Sea Shell Powder and Alccofine mix in concrete for more sustainable approaches.

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Hydroponics –Future of Farming

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ABSTRACT

As per FAO by 2050 the global population is projected to reach 9.8 billion with 66 percent of the population living in urban areas. An agricultural area of 593 hectares of land is required to feed the population. Present agriculture faces the huge task of satisfying the demand and it can nowhere match reaching the demand for food worldwide in future decades. The challenges in basic practices are climate calamities, soil fertility issues, excessive water, and nutrient requirements. Hence Technology must permeate in Agricultural sector to explore innovative alternative sustainable methods as solutions against food insecurity resource conservation and to mitigate the negative impacts on the Ecosystem. Hydroponics is a new sustainable method of soilless farming in controlled Environmental conditions producing high-quality yields of crops.

KEYWORDS: *Food security, Sustainable, High yield, Soil fertility, Water saving, Optimum fertilizer, Industry 4.0.*

ABBREVIATIONS

DWC: Deep Water culture.

NFT: Nutrient Film Technique.

CEA: Controlled environment agriculture

DFT: Deep Flow Technique

CELSS: Controlled Ecological life support system.

IoT: Internet of things.

AI: Artificial Intelligence.

GPS: Geographic positioning system.

INTRODUCTION

This article discusses scope, methods, advantages, limitations, potential and possibilities, setup factors, challenges, costs vs benefits, and future research in the field of Hydroponics. Basically, it is a subset of horticulture which is based on hydroculture, HYDRO means water and pono means labor. This unique innovative grow system controls the balance of nutrition, humidity, and temperature and uses a ten percent fraction of water than conventional methods, producing a High qualitative yield. The plants grow faster and healthier since the nutrients are delivered to their roots through water in the form of an aqueous solution. The major risk of climate calamity in unconventional farming is mitigated by controlled environmental conditions for plant growth.

Methods

Elements of photosynthesis like Sunlight, water nutrients, and Carbon Dioxide are artificially substituted by tailor-made LEDs and soil-free mediums like coco peat, rice husk perlite, sand, gravel, vermiculite, rock wool, etc. Proper drainage, aeration, and water-holding capacity provide moisture to plants and facilitate nutrient movement to roots. Multiple forms of hydroponic methods are emerging as media culture and solution culture. Circulating and non-circulating methods like NFT, DFT, DWC, Floating methods, Aeroponics, and Aquaponics, sandponics has taken new sustainable eco-friendly approaches with promising future.

Advantages

High-yield, healthy, clean, and pest-free, eco-friendly crops are produced with less labor and space. Since the roots do not take up much room, more crops are produced on a given surface. Seeds do not need to make their way through the soil mechanically hence allowing for faster maturation and crop development leading to short cultivation cycles. Ensure food security in extreme drought areas and areas of low soil quality. Abandoned lands can be reverted as natural ecosystems, food parks, and vertical gardens. As against conventional farming, they use fewer resources and reduce greenhouse gas emissions, carbon footprint, and minimize agricultural waste. Organic farming is the prime outcome of CEA without the application of fertilizers.

Limitations

Lack of Educational awareness and training in the agricultural sector in India. Heavy investments may lead to intense risks. Maintenance and monitoring of sensors and digital systems need expertise, skill, and support. Financial support from governments and subsidies given is too less for the set-up costs. Technical know-how standards, and knowledge are the roadblocks of this promising urban farming. Plumbing systems and automation, such as sensors, controllers, water pumps, lighting, Consultant's fees, and equipment to control temperature, and purify water all need installation and maintenance costs. Generating plant nutrition and integration of Artificial Intelligence, Data Analytics is a real challenge.

POTENTIAL AND POSSIBILITIES

Hydroponic modular farming can be used to grow the following.

Table 1: Types of crops

Vegetables	Carrots, cucumber, tomatoes, peas, onions, Beans, bell peppers, cantaloupe
Cereals	Rice, maize
Flowers	Marigold, roses, chrysanthemum
Herbs	Parsley, mint, chives, sage, basil
Greens	Lettuce, spinach, basil, celery
Fodder	Barley
Fruits	Strawberries, bananas, cherries, blueberries,
Cash crops	Ginger, turmeric, saffron

Countries like Japan, Indonesia, Africa, Israel, Canada, the US, and Singapore are proactive with this fastest-growing sector for overall economic development. In India Hydroponics is walking ahead with infantry stages but significant growth is seen to happen in the near future. Researchers, scientists, and urban planners, agronomists have noted the crucial role of these modular farming methods to manage domestic demand in cities. A key innovation drive is emerging as vertical farming in urban landscapes. The food demand of the local population is satisfied and has economic perspectives along with ample Job opportunities.

Setup Type

Table 2: Setup details and suitability Analysis

Method	Suitability
DWC-Roots supported in media.	Used in tropical climates, a simple setup, pump with a timer is used to supply solvents.
NFT -Roots dipped in nutrient solution	Stacked as Vertical gardens, lightweight, with less space. Clogging issues.
Media-based Roots supported by media	Flood /drain method Large spaces are required.
Aeroponics-Roots hung in the air	The solution is Misted in frequent time intervals, used in drought areas.
Aquaponics-fish and plants are grown together	Used in coastal areas with saline water.
Sand phonics	Large and industrial cultivation, new system.

Data and Discussion

Soil-based farming in India grows 10 - 20 tons of tomatoes, greens, and 20 -25 tons of berries and leafy greens per acre. The hydroponic systems can grow 180-200 tons of tomatoes,50 tons of berries, and 300 to 400 tons of leafy greens per acre.

Operational costs for one acre in a year include the following. poly bag costs Rs 24000, pesticides Rs 30,000, coco peat Rs 1,35,000, thread clips Rs 25,000, seeds Rs 1,44,000, Salary and electricity Rs 3,00,000, nutrient cycle costs as Rs 1,00,000 accounting to be Rs 9,00,000 per acre.

Considering land cost as zero drip Irrigation charges as Rs 5,00,000 Greenhouse establishment is Rs 15,00,000 summing up to around Rs 30,00,000 for 5 years and annually Rs 6,00,000.

It is observed approximately a total cost of Rs 9 Lakhs plus Rs 6 Lakhs i.e., Rs 15 Lakhs is required to set up a system of hydroponics in one acre.

Profit analysis for tomato plant

5 kg/plant * 12000 plant/acre* 2 yield /year* 100 Rs / Kg

costs around Rs 1.2 crore in the present scenario of the high cost of tomatoes.

Profit per year is 1.2 crore -15 L around 1,00,000 crores.

In a normal case of 50 Rs per Kg the profit is half the above value.

Set Up -Factors

LIGHTING: The site selected should have the highest natural light levels. Led allow the modulations in intensity of spectrum enabling effective plant growth.

TEMPERATURE: The temperature should be maintained in summer without the use of fans and winters are to be managed with porous polyester to reduce night heat loss. For maintaining temperatures, the elevation of the site should be optimum.

HUMIDITY: The optimal relative humidity during the clone's rooting can be 70-80%. During the transition from germination to the vegetative phase the RH value is 40-60% and during the blossoming phase the RH is 40-50 %

ELECTRICAL CONDUCTIVITY: EC meters which are highly influenced by temperature adequately tested across several EC treatments, prove the photosynthesis effect on leaves is higher between 1.8- 2.4 EC.

ENERGY: Natural gas, propane, fuel oil, and electricity are types of energy sources.

WATER QUALITY: Chemical parameters of water like PH, alkalinity, calcium, magnesium, and chlorine salts concentration should be checked. plant growth depends on the pH range in soilless agriculture 5.5 and 6.5

GREENHOUSE: Polyethylene sheet roofs for greenhouses prove better than glass, fiber PVC sheets.

Facts and Future Scope -Analysis

1. Hydroponics in India requires greenhouse building, trays, and lighting systems that may cost 70,000 rupees per 1000 Square feet Area.
2. It is expected to reach a global market of 25 billion US $ with a CAGR of 15.6% in 2027. In India, it is expected to reach a 13.53 % CAGR.
3. Closed systems of NFT and Media based hydroponics can save 90 percent water, 85 percent fertilizer, and 250 percent increase in productivity.
4. Crops produced by NFT systems are of high quality and productive.
5. NASA is researching extensively on CELSS during space missions as an Ecological support system for astronauts in zero gravity environments using Aeroponics.
6. Pharma and Nutraceutical industries planning for clean, toxin-free herbs (ginger, turmeric, Shatavari, ashwagandha) in CEA approaches
7. In 2023 budget Agricultural Accelerator fund is announced to boost agriculture startups with innovative solutions.
8. Punjab agricultural university gets a national patent in hybrid hydroponic technology for growing tomatoes.
9. NUTRIFRESH is a startup yielding 1100 MT of fruits and veggies in 10 acres satisfying the food needs of Mumbai and Pune cities.
10. Green rush organics is an aquafarm that grows 6000 plants in an 80 square feet area under the BETTER INDIA program.
11. Some success stories of hydroponics farming can be considered as the confidence booster of any grower who is willing to set up this innovative hydroponic system.
    1. Aqua Farms, Chennai: Rahul Dhoka,
    2. Letcetra Agritech, Goa: Ajay Naik,
    3. Urban Kissan, Hyderabad: Vihari Kanukollu, Dr. Sairam, and Srinivas Chaganti .
    4. Future Farms, Chennai: Sriram Gopal,
    5. Rise Hydroponics patel vivek Shukla, Ahmadabad
    6. Nutrifresh Farm Tech , Pune
12. Singapore City plans to reach the 30 by 30 goal using GO GREEN towers to satisfy the country's

30 percent nutritional needs by using a vertical garden Hydroponic system in 2030.

Agriculture 4.0

Hydroponics fits perfectly within the frame of Agriculture 4.0, as large companies are investing in indoor vertical farming, artificial intelligence, and Plant Biology to grow an extensive line of products in commercial agriculture, pharmaceutical industries, and automotive industries. With the support of advanced and disruptive technologies and sound scientific knowledge, a new mode of precision agricultural practice is soon to emerge globally. Steps for the integrated approach need a wide understanding of the need of the project, analysis of the market, self-need or entrepreneurship, and choosing the automation level in the future to design the same. proper Technology and processing units should be procured, tested, and made available to end users. Agriculture 4.0 aims to implement AI and IoT in regular practice, as shown in the key plans below.

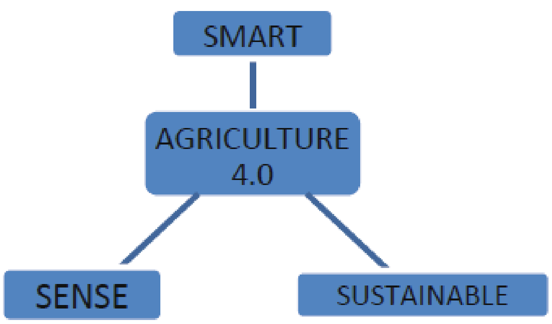

Fig. 1 Concepts of Agriculture 4.0

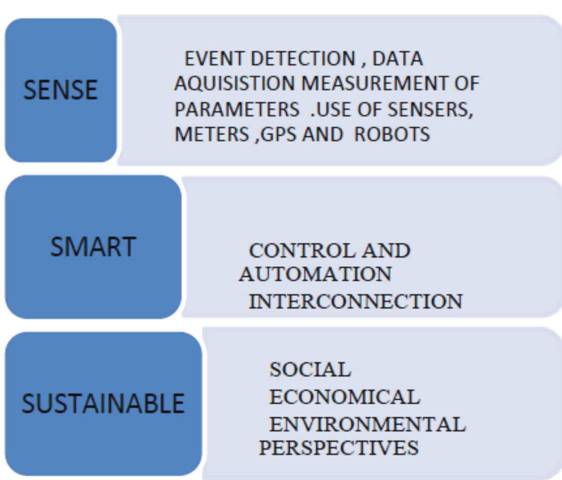

Fig. 2 Modernization concepts towards Sustainability

With all these means of precision modernization, Hydroponics has the ability to support the Food Security Strategy now and in the future. Several organizations have explored coming out with Food Processing Computers technologies to improvise automation and control the environmental parameters in closed/open systems that can affect plant growth.

SUMMARY

Hydroponics is essential agricultural technology to be focused especially in urban areas as they offer investment stability, pioneering ideas, and research strategies. The progress of this system is only possible through the collaboration between the Government, policymakers, scientists, and agriculturalists, private sectors, industrialists to involve young entrepreneurs in planning strategies, performing surveys, and creating practical knowledge among youth farmers to bring about farming on a large scale.

Finally, Agriculture is not cropping and cultivation for food security, but it should sustain to conserve resources. Every drop of water should be efficiently utilized, and soil degradation towards the decline of arable land sources should be avoided. Hydroponics Farming has dual benefits, it is not far when people will understand the importance of Fresh & Nutritious Food in their daily lives.

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A Stabilization of Expansive Soil using Industrial and Plastic Waste: A Review

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ABSTRACT

Expansive soil is also called as a black cotton soil in India. Its nature is highly expansive due to the high affinity to water and shrink when water squeezes out. Due to this alternate expand and contract behavior of black cotton soil repetitive stresses are acting on structure and various damages cause such as cracked foundation, floors and basement walls are typical types of damages done by swelling of soil. Problems associated with expansive soil are low bearing capacity, high compressibility, swelling and swelling pressure and shrinkage. The research papers that we are studied suggest and proved that the use of plastic and industrial waste is effective in stabilization of expansive soil. The plastic waste and industrial waste such as saw dust, rice husk, sugarcane bagasse, waste tires, incineration ash, fly ash, ceramic dust, glass fiber, broken bricks, agricultural waste, sawdust ash and lime give significant improvement in geotechnical properties of expansive soil which are Maximum dry density, Optimum moisture content, Plastic limit, Liquid limit, Shear strength, Specific gravity, swelling potential, California Bearing Ratio etc. The test conducted for determination of these properties are Standard proctor test, Atterberg's limit, Specific gravity test, Unconfined compressive strength test, California bearing ratio test, Free swell test etc. This review paper highlights the optimum content of wastes to be added in soil for effective improvement in geotechnical properties of soil.

KEYWORDS: *Expansive soil, Stabilization, Industrial and plastic waste, Geotechnical properties.*

INTRODUCTION

Expansive soil is the type of soil which is expand when water is added and shrink when water is dry out. This soil is greatly experiencing volume change under the moist condition. In India expansive soil cover vast areas of Maharashtra, Karnataka, Andhra, and Gujarat, Natural causes to change moisture in the soil are rain, change in temperature, poor drainage and leakage through conveyance system etc., this results in subsurface moisture which has adverse effect on structures such as houses, buildings, roads, pipelines and other structures. expansive soil is highly accommodated with montmorillonites which have tendency to absorb water, for that purpose many stabilization techniques are in practice for enhancing the properties of soil. The important geological properties that are need to improve are strength, swelling potential, compressibility and durability. These studies aim to stabilize the black cotton soil using plastic and industrial waste. The study involves a detailed evaluation of the soil's geotechnical properties including Atterberg limits, unconfined compressive strength, shear strength, swelling potential, maximum dry density, optimum moisture content, and bearing capacity. These properties are assessed in both the natural state of the soil and after mixing it with varying proportions of waste materials. By reusing the plastic waste, it helps to reduce the landfill space taken up by the plastic. Reducing plastic is an important part of reducing waste, conserving resources and protecting the environment, only 9% of plastic waste has been recycled which is not enough to solve the plastic crisis. Using plastic waste as a soil stabilizer can be economical and environment friendly way to reuse plastic and dispose of it. Plastic can improve soil properties such as its bearing capacity, density and shear strength. Recycling industrial waste helps to produce less waste and consequently release less waste content into the environment. Industrial wastes such as saw dust, rice husk, sugarcane bagasse, waste tires, incineration ash, fly ash, ceramic dust, glass fiber, broken bricks, agricultural waste, sawdust ash and lime.

LITERATURE REVIEW

The study regarding the stabilization of expansive soil using plastic and industrial wastes had been carried out experimentally and analytically by various researchers.

S. Almuaythir et al. (2024)1: This experimental study investigates the use of various industrial waste material such as silica flume, cement kiln dust, calcium carbide residue, rice huck ash, ground granulated blast finance slab (GGBS) to stabilize the expansive soil. The mixing proportions of waste is as 3%, 6%, 9% of GGBS. Unconfined compressive strength value increases from 114.64 Kpa to 1582.91 Kpa after 30 days of curing. liquid limit reduces up to 37.66%. At 9% of GGBS value of shear strength increases. Finding suggest that industrial waste material is effective and sustainable alternative for soil stabilization.

D.T. Melese et al. (2024)2: Expansive soil is the soil which expand when water is added and shrink when water is dry out due to change in moisture content. The municipal solid waste fly ash is used as stabilizer to improve index properties of expansive soil. The percentage of fly ash added in soil to get optimum content of fly ash was 5%, 10%, 15%, 20%, 25%, 30%. The experimental analysis shows improvement in engineering properties of expansive soil when municipal solid waste fly ash is mixed. The optimum content of fly ash was 25% which gives optimum results.

S. Ahmad et al. (2024)3: Expansive soil exhibits drastic volumetric and compressibility changes due to moisture variation. This research highlighted the Behavior of expansive soil when treated with industrial waste pozzolanic fly ash. As fly ash is the residue left after the burning of coal in power plant which is considered as a solid waste. This paper reviews on the efficiency of fly ash as soil stabilizer in enhancing the mechanical behavior of expansive soil.

The geotechnical properties determined in this study was Atterberg's limit, Unconfined Compressive Strength, California Bearing Ratio, Swell potential to investigate the behavior of soil with varying proportion of soil. The optimum content of fly ash was found to be between 25-40% at which there is improvement in plastic behavior up to 32%, compressive shear strength 42-48%, penetration resistance 52-55%, and compressibility 36- 40%. So, study has proven that fly ash is effective in soil stabilization.

Manish Kumar Mishra & Prof. Mohit Varma (2023) [4]4: This study highlights the use of polyethylene waste material to stabilize the expansive soil on respect to increase the Geotechnical properties of the soil. The orientation of study was mainly focuses on the parameter unconfined compressive strength of soil by adding plastic waste. Generally plastic bottles as a soil stabilizer in the proportion of 0.5-1% of the soil, with the addition of 0.5-1% of plastic the UCS gradually increases as follows:

Table 1. Results of UCS with varying proportion of plastic waste than 20% as per IRC 37-2001. hence these four samples can be used without any additives

Sr No.	Plastic Waste(%)	UCS (kg/cm2)
1	0.0	11.08
2	0.5	13.12
3	1.0	15.17

Kamble et al. (2022) [13]6: The study examined the stabilization of expansive soil (Black Cotton Soil) with the help of plastic waste i.e. plastic bottle strips. This process is carried out to improve the engineering properties of the soil and make it more stable. The study focuses on the reduction of unqualified characteristics of soil such as consolidation potential and permeability and to increase the shear strength with plastic waste by providing alternative solution as plastic recycling. The cold drink bottles are collected and cut down into the soil with different proportion as 0%, 0.2%, 0.4% and 0.6% of dry weight of soil samples are free swell index, liquid limit, plastic limit, and specific gravity of soil. The paper concludes that this method is appropriate for sustainable foundation and improvement of soil by plastic bottles.

Adamu Beyene, Yada Tesfaye, Damtew Tsige (2022)7: This study highlights the use of natural lime and waste ceramic dust to stabilize the expansive soil which is act as a subgrade in pavement construction. Due to its insufficient workability and capacity to carry the imposed traffic loading. In this study both the separate and combined results of lime and ceramic dust were

O Bhojaraj, R Prasad (2023) [4]5: This paper aims to identify the use of industrial waste such as steel skin, broken bricks, coir waste rice husk ash, ground nut shell ash and lime as a soil stabilizer. These wastes help to improve the shear strength of the soil along with bearing capacity. It also helps to provide more stability in case of slopes or other similar places. From the experimental analysis out of five samples four samples get CBR value less

investigated. According to results obtained, the optimum content of natural lime was 6% and waste ceramic dust 20% which give effective results in improvement of expansive soil.

Mantu Kumar et al. (2022)8: This Paper conclude that the black cotton soil used has plastic index 35%, Shrinkage index 39.2% and free swell index as 49.8% hence, the soil taken may be categorized as the expansive soil with high degree of expansion. the sample soil was reinforced with waste plastic bag strips of size 1 cm x 3 cm, 2 cm x 3 cm, 3 cm x 3 cm were added in soil at the rate in percentage to the weight of soil as 0.1, 0.4, 0.7 and 1.

The results highlight the influence of plastic strips by improving Compaction characteristics, California bearing ratio and Shear strength of black cotton soil.

Niyomukiza, Wardani and Setiadji (2021)9: This examination has analyzed the most recent trends in the stabilization of expansive soils through the utilization of waste materials, specifically focusing on waste tires, sawdust, sawdust ash, and fly ash as stabilizing agents. The identified waste materials have been shown to enhance the index properties, compaction characteristics, strength, and compressibility of expansive soils. Furthermore, employing these waste materials as stabilizing agents could potentially decrease the volume of waste disposed of in the environment or sent to landfills, thereby alleviating health and environmental issues associated with improper waste disposal. The optimal content of these waste materials for soil stabilization is contingent upon the specific properties of the soil in question. Consequently, it is advisable to prioritize the practical application of these waste materials in the field rather than solely concentrating on laboratory studies. Several research gaps have been identified, including the need for further investigation into the microstructural characteristics of soils stabilized with waste materials. The use of shredded waste tires helps to improve the load carrying capacity and reduce plastic limit of the soil with optimum waste tire of 20 % by weight. The paper stated that more studies are needed to know the exact size and optimum content of the waste tire used to stabilized the soil. The saw dust is used in the proportion of 3 % of weight of the soil which is found to be effective in increasing Unconfined Compressive Strength (UCS).

Garg et al. (2021)10: They studied that addition of Sugarcane bagasse ash (SBA), Ceramic dust (CD) and Glass fiber into the black cotton Soil has changed the maximum dry density swelling of soil, optimum dry density, swelling of soil optimal moisture content, California bearing ratio (CBR) and Unconfined compressive strength (UCS). The study was carried out by the varying content in percentage of SBA (0-20), GF (0-4) and CD (0-20) in Expansive soil. At the content of SBA -15, CD- 10 and GF- 3 the soil mobility is observed low and controlling swell behavior. the addition of 1-3 Glass fiber was result in reduction of liquid limit and the CBR value increase in the content of Sugarcane bagasse ash (15), Ceramic dust (0-15).

R. B. Kassa et al. (2020)11: The study highlights the use of Waste plastic material as a soil Stabilizing agent. the plastic strips were prepared in there different mixing rates (5 mm *7.5 mm, 10 mm *15 mm, 15 mm *20 mm) and added at three different mixing ratios (0.5%,1% and 2%) by weight. the result shows improvement in shear strength parameters, reduction in swelling and optimum moisture content, increase in maximum dry density. The optimum moisture content decreases at a strip size 5 x 7.5 mm with 2% addition by 31%, 30% deduction in swell observe at strip size 5 x 7.5 mm with 2% addition. The shear strength increases from 49.83 Kpa to 62.67 Kpa which is 26% improvement at the same strip size also, at strip size 5 x 7.5 mm with 2% addition the Unconfined strength obtained is

307.4 KN which is for natural soil is 151.8 KN.

Arunav Chakraborty et al. (2016) [4(1)]12: This study aims to investigate the use of sugarcane straw ash (SCSA) as a soil stabilization. In developing countries plastic crisis is the biggest problem. In this paper, sugarcane straw ash is used at various varying percentage. The test conducted for analysis are free swell test, unconfined compression test, California Bearing Ratio (CBR) test to check the geotechnical

properties of soil. the optimum content of sugarcane straw ash was found to be 10% with

with cost effective stabilization method with

environmental concern for sustainability.

increasing UCS and CBR.

Meron Wubset e t a l . (2014)13: This study highlights the use of bagasse ash and lime for stabilization of expansive soil the test conducted on soil by adding 3% of lime, 15% bagasse ash and combination of 15% and 3% of bagasse's ash and lime respectively. The plasticity index decreased with addition of lime, bagasse ash: only addition of bagasse ash shows minor effect on plasticity index ,maximum dry density decreased significantly with addition of lime and bagasse ash it also increases the CBR of the soil combination of bagasse ash lime can strongly improve the strength of the expansive soil. Thus, combining bagasse ash and lime can effectively improve the properties of expansive soil.

3. CONCLUSION

From the above review it can be concluded that many studies have been carried out experimentally and analytically to mitigate the stabilization of soil using various industrial and plastic waste. The use of plastic and industrial wastes helps to enhance the geotechnical properties of expansive soil. The optimum content of various wastes found as for plastic was 2% of strip size 5mm x 7.5 mm where Optimum moisture content decreased by 31%, shear strength increases by 26%. For shredded waste tire it was 20% which is effective in improving the bearing capacity of soil. For sawdust it was 3% which helps to increase Unconfined compressive strength and decrease swelling potential. For fly ash it was about 25-30% that improve properties of soil. The other wastes such as rice husk, sugarcane bagasse, incineration ash, ceramic dust, glass fiber, broken bricks, agricultural waste, sawdust ash and lime also improve the geotechnical properties of soil such Specific gravity, Maximum dry density, Atterberg's limit, California bearing ratio. so, it provides solution for waste reuse along

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Strength and Durability Properties of Concrete with Cold-bonded Lightweight Aggregates and Mineral Admixtur

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ABSTRACT

This manuscript aims to produce M20-grade lightweight aggregate concrete (LWAC) by adding Cold-bonded Lightweight aggregate (CLWA) and Alccofine (AF) powder. The CLWA pellets were manufactured using cement (20%) and fly ash (80%) in a laboratory Disc Pelletizer machine and hardened by the Cold bonding treatment which can prepare more lightweight, affordable, and sustainable concrete. The various LWAC mixes were prepared by replacement of natural coarse aggregates with CLWA pellets in different percentages such as 0%, 25%, 50%, 75%, and 100%. The slump cone test, compressive strength, splitting tensile strength, water sorptivity, Chloride ion permeability and Water permeability were performed on various LWAC mixes. The findings demonstrated that the round shape of CLWA pellets improves the workability of LWAC mixes over Normal Weight Concrete (NWC). Results also revealed that Alccofine (AF) powder enhances the mechanical and durability properties of various LWAC mixes. Moreover, it was observed that concrete properties decline as the percentage of CLWA pellets increases in the LWAC mixes. However, all LWAC mixtures reached their desired strength at various ages. Our studies thereby protect the use of natural coarse aggregates, which promotes the sustainable growth of the concrete industry, and helps to minimize the environmental issues related to FA powder.

KEYWORDS: *Cold bonded lightweight aggregates, Disc pelletizer machine, Transport properties, Micro-structural enhancement, Preserve natural resources.*

INTRODUCTION

In India, the development of utilization of natural coarse aggregates and reduces the environmental issues caused by FA powder. Various methods exist to prepare and harden the Artificial lightweight aggregate (LWA). The LWA can be prepared by a Disc Pelletizer machine and hardened by different hardening methods (sintering (S), autoclaving, and cold bonding (CB)) [1]. Among the various hardening methods, the CB technique utilizes the least energy. By aiming to produce the least energy LWA pellets, the cold bonding technique has been selected in the present experimental work to harden the CLWA pellets.

Various factors influence the physical and mechanical properties of LWA pellets during the production phase such as duration of pelletization, water content, speed of the pelletizer, angle of the pelletizer disc, and their interaction effects [2].

Various literatures presented the possible utilization of CLWA pellets in concrete widely. Recent research showed that the production of concrete (along with micro silica (MS) and fly ash (FA)) by using the Calcined attapulgite (80%)-cement (20%) cold bonded aggregates presented the enhancement in thermal conductivity up to 46.9% [3]. Also, it proved that the addition of MS and FA minerals improved the transport properties of concrete [4]. Literature revealed that the cold-bonded aggregates produced with different fibers (glass fiber, polystyrene, and polypropylene) enhanced aggregates' physical and mechanical properties [5].

Researchers reported that increasing the W/C ratio and volume of LWA pellets increases the value of the transport properties of concrete [6,7,8,9,10]. Many researchers exhibit that adding Silica Fume (SF) and FA powder in LWAC mix enhances concrete's mechanical and transport properties [11,12].

Moreover, the physical properties of CLWA pellets can be enhanced by adding various activators (such as NA2SO4, NaOH, and Styrene-butadiene rubber (SBR)). These activated CLWA pellets also boost the mechanical and durability properties of LWAC mixes. However, the cost of activated CLWA pellets also increases [13,14,15,16].

The Alccofine is a micro-fine mineral additive derived from slag that is utilized as an additional cementitious material in mortar and concrete. The study found that adding AF powder (4–10%) in place of cement enhanced the properties of the concrete [17]. In the literatures, it was observed that various LWA pellets are produced by different waste materials that are available easily with economy and manufactured concrete with their aims.

To accomplish the aims of the present study, to produce sustainable cost-effective M20-grade lightweight concrete, fly ash powder (80%) is selected to produce CLWA pellets as a base material (along with 20% cement) that is available in bulk quantity. Moreover, the CLWA pellets were hardened by a cold-bonding technique that is also cost-effective. Additionally, to enhance the mechanical and durability properties of LWAC mixtures, the AF powder was added confirming to IS 12089–1987 [18]. This study will motivate the value-added utilization of fly ash to make the CLWA pellets, which minimizes the environmental problems associated with FA powder and preserves the use of natural coarse aggregates. Additionally, the production of CLWA pellets using the cold-bonding process also exhibited their energy-saving benefit which consumes less energy.

THE PROCESS OF MAKING LIGHTWEIGHT AGGREGATES AND THEIR CHARACTERISTICS

The CLWA pellets are prepared by a Disc pelletizer machine and hardened by a CB technique. A specially designed disc pelletizer was fabricated and used in this experimental work (Fig. 1).

Fig. 1 Manufacturing procedure of CLWA pellets

The various features of a Disc pelletizer and their factors affecting the quality of pellets were discussed and optimized in previous literature [13, 15]. The Class F FA [19] powder and OPC53 grade cement [20, 21] were used to prepare the CLWA pellets. For a maximum of 28 days, the CLWA granules were allowed to solidify at room temperature inside the plastic bag. In this experiment, CLWA granules with diameters ranging from 20 mm to 4.75 mm were chosen.

The formula for determining an aggregate's crushing strength was established by Kockal & Ozturan [22]. The various properties of concrete ingredients are carried out as per IS standard [23, 24] and presented in Table 1.

Table 1 Properties of concrete ingredients

Properties of concrete ingredients	CLWA Pellets	Sand	Coarse Aggregate	References
loose bulk density (kg/m3)	905	1605	1502	IS: 2386
Specific gravity	1.75	2.66	2.85	IS: 2386
Absorption of water (%)	15.82	1.5	0.8	IS: 2386
Strength of Pellet Crushing (MPa)	4.14	---	---	Kockal &Ozturan (2010)
Fineness Modulus	2.65	2.65	6.55	IS: 383

Figure 2 shows the microstructure of CLWA Pellets. It could be observed that more voids at the outer shell of CLWA pellets can promote higher water absorption and open porosity.

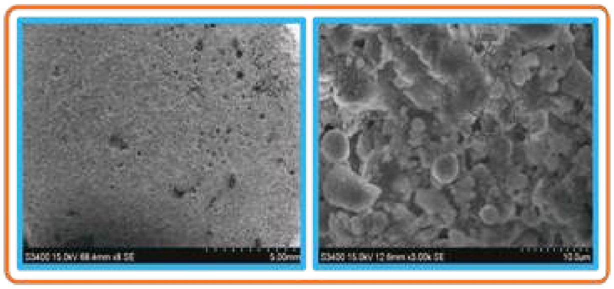

Fig. 2 Microstructure of CLWA Pellets

PRODUCTION OF VARIOUS CONCRETE MIXES

Ingredients consumed in the concrete mixture

The PPC cement [25] used in various concrete mixes confirms the Requirement as per IS-1489. The properties of Alccofine (AF) as a slag powder [18] have been presented in Table 2. The Natural Sand (NS) and natural coarse aggregate (CA) were selected from local quarries (Gujarat). The different physical and mechanical properties of various aggregates are exhibited in Table 1. The CLWA pellets were partially replaced with CA particles in concrete mixes. The tap water was chosen to produce concrete mixes. The superplasticizer was used in concrete mixes to accomplish the required slump value.

Table 2 Properties of Alccofine

Physical Characteristics				
Bulk Density (Kg/m^3)	Specific Gravity	Fineness (cm^2/gm)	Particle Size Distribution	
			d10	d50
700-900	2.88	>12000	1.5 micron	5 micron
Chemical Characteristics				
CaO	SO_3	SiO_2	AL_2O_3	Fe_2O_3
61-64%	2-2.4 %	21-23 %	5-5.6 %	3.8-4.4 %

Proportioning of the concrete mixture

Concrete was made in accordance with Indian specification BIS: 10262 (BIS, 1982) [26]. The different concrete mixture is exhibited in Table 3. The different concrete mixtures were designed by partially replacing natural coarse aggregates (CA) with CLWA pellets at different percentages such as 0%, 25%, 50%, 75%, and 100%. For every mixture, the ratio of water to binder was 0.50. To enhance the properties of lightweight concrete (mix M2-M5) and target strength of concrete mixture, Alccofine powder is partially replaced (around 6%) with cement. The dosage (0.4%) of superplasticizer has been selected in such a way as to get the required slump value. The other ingredients were equal in weight.

Table 3 The concrete mixture's proportions

Mix No	Mix ID (A-B)	W/B ratio	Cement	Alccofine	Natural sand	Replacement of CA with CLWA		CA	CA/TA (vol.%)	Water + SP	SP (%)	Slump (mm)	28 days density (kg/m^3)
						Kg/m^3	In %						
M1	CLWA-00	0.50	320	0	754	0	0	1212	60	161.3	0.4	90	2431
M2	CLWA-25	0.50	301	19	754	186	25	909	60	161.3	0.4	105	2307
M3	CLWA-50	0.50	301	19	754	372	50	606	60	161.3	0.4	115	2182
M4	CLWA-75	0.50	301	19	754	558	75	303	60	161.3	0.4	130	2065
M5	CLWA-100	0.50	301	19	754	744	100	0	60	161.3	0.4	140	1942

Mix proportion represents the blend as A-B, where A is the lightweight aggregate and B (00 to 100) is the percentage that CLWA pellets replace CA, CA= natural coarse aggregate, CLWA=cold-bonded lightweight aggregate, TA= total aggregate, SP= Superplasticizer.

Procedures for testing concrete blends

The concrete ingredients were mixed in a laboratory concrete mixture and placed in various molds. The vibration was applied to these concrete specimens as prescribed in BIS: 516 (BIS,1999) [27]. The CLWA pellets were mixed in concrete in pre-socked condition. After 24±1 hours, specimens were placed in a water tank for different curing periods. The slump value on fresh concrete was carried out as presented in BIS: 1199 [28]. The compressive strength was found as per BIS: 516 [27] at various ages (7-day, 28-day, 56-day, and 90-day). The splitting tensile strength test was carried out as per IS: 5816-1970 [29] at 7 and 28 days. The water sorptivity on LWAC mixes was conducted as guided in ASTM C1585-13[30] at 28 and 90 days. At 7 and 28 days, the chloride permeability test (RCPT) was conducted on LWAC mixes by ASTM C1202 [31]. The LWAC mixtures' water permeability was measured as per IS: 3085 (BIS, 2002) [32].

4. RESULTS AND DISCUSSION

Workability and density of concrete mixes

The slump value of various concrete mixes was obtained in the 90mm to 140mm range as presented in Figure 3. The slump value of LWAC mixes (CLWA-25 TO CLWA-100) was increased by 15-55% compared to the CLWA-00 mix (control mix). The rising trend in slump value is due to the round shape of CLWA pellets.

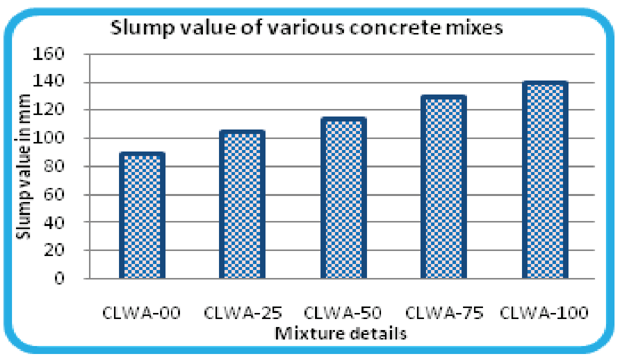

Fig. 3 Slump value of various concrete mixes

The slump value of the concrete mix was increased gradually as increases the CLWA pellets. The (0.4%) was used to keep the desired slump value. The density was observed at 1942-2431 kg/m3 in various concrete mixes. The density of LWAC mixes (CLWA-25 TO CLWA-100) was decreased by 5-20% compared to the CLWA-00 mix (control mix). This positive result is due to CLWA pellets' lower density than natural coarse aggregate.

Concrete's compressive strength

Figure 4 displays the compressive strength (CS) of various combinations at various ages (7-day, 28-day, 56-day, and 90-day). The maximum CS values (at 90 days) for CLWA-00, CLWA-25, CLWA-50, CLWA-75, and CLWA-100 were found 34.8 MPa, 33.4 MPa, 32.1 MPa, 30.80MPa and 29.5 MPa, respectively. As the replacement of CLWA pellets rose, the CS of LWAC mixes decreased as well. As noted, the LWAC mixes containing CLWA pellets obtained less strength than the CLWA-00 mix for the similar water-binder ratio due to the higher porosity and lower strength of the CLWA pellets.

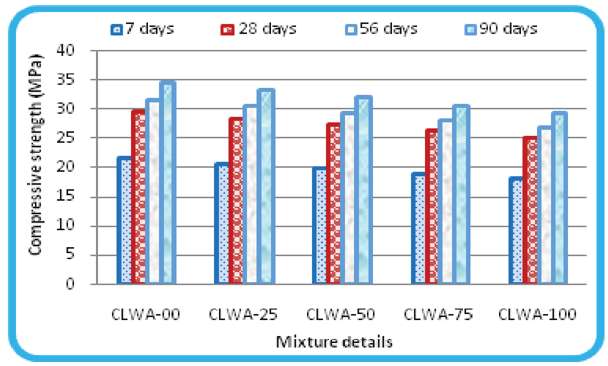

Fig. 4 Compressive strength of various combinations

Moreover, it can be observed that replacing the amount of cement with Alccofine improved the CS of LWAC mixes. This positive result could be obtained by Alccofine refining the pores between the cement particles to make them finer. To form the pozzolanic link and improve the paste matrix's performance, AF itself functioned as the pozzolanic substance [17]. Furthermore, the rough texture of the CLWA's outer shell was observed, strengthening the interaction between the paste matrix and aggregate. It was demonstrated that the CS for all combinations grows gradually over time by extending the curing period, regardless of the w/b ratio and aggregate type.

Concrete's Split Tensile strength

Figure 5 displays the Split Tensile Strength (STS) results for different concrete mixes. When comparing CLWA-00 to LWAC mixtures (containing CLWA pellets), the STS value is higher for the same w/b ratio. A higher modulus of elasticity of CA particles is the cause of a higher STS value in the CLWA-00 mix. The plane of failure surface was seen to pass from the CLWA pellets in broken cylindrical specimens. This meant that rather than aggregates, the paste matrix's strength determined the STS of the CLWA combination.

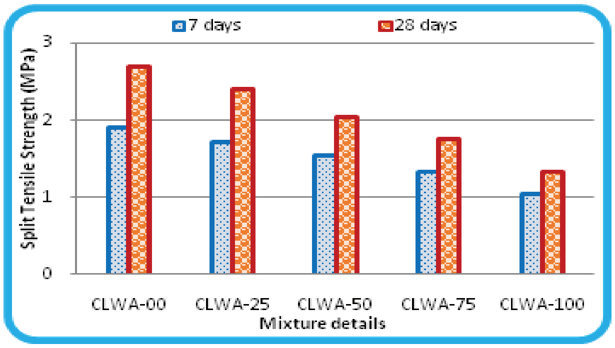

Fig. 5 Split Tensile Strength of Concrete Mixtures

According to earlier research, the STS decreased as the volume of cold-bonded aggregate increased [33] Additionally, it can be noted that replacing Alccofine with cement enhances the paste matrix, which improves the STS characteristic [17].

Chloride Ion Permeability of Concrete Mixtures

The chloride ion permeability of various blends is displayed in Figure 6. By ASTM C1202, the CLWA-00 mix showed small RCPT values at 28 and 90 days.

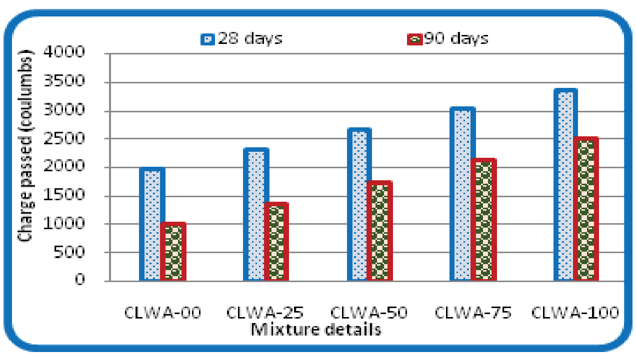

Fig. 6 Chloride ion permeability of various combinations

At 90 days, the CLWA-25 and CLWA-50 obtained small values whereas CLWA-75 and CLWA-100 presented moderate values respectively. At 90 days, there was a noticeable improvement in the RCPT value across all combinations due to pore refinement's enhancement of the concrete's structure.

Additionally, it could be seen that as compressive strength increased, the RCPT value dropped. For a similar water/binder ratio, CLWA-00 displayed much less chloride permeability than LWAC mixtures (including CLWA pellets) due to the decreased water absorption and reduced open porosity of the CA particles. While the open porosity of the concrete paste regulates fluid flow in the samples, overall porosity determines the CS value [15]. The uncertain path was created as a result of the erratic behavior of the CLWA's outer shell and increased paste diffusion into the CLWA pores. This could be the factor influencing the RCPT value's trend.

Water Sorptivity of Concrete Mixtures

The water sorptivity (WS) of different combinations is shown in Figure 7. At 90 days, the sorptivity value in the CLWA-00 mix was much lower than that in LWAC mixes (which contained CLWA pellets) for the similar w/b ratio. This can be because the natural aggregates have less open porosity. LWAC mixes including CLWA pellets showed considerable improvement at 90 days because adding Alccofine increased the amount of CSH gel that was formed [17].

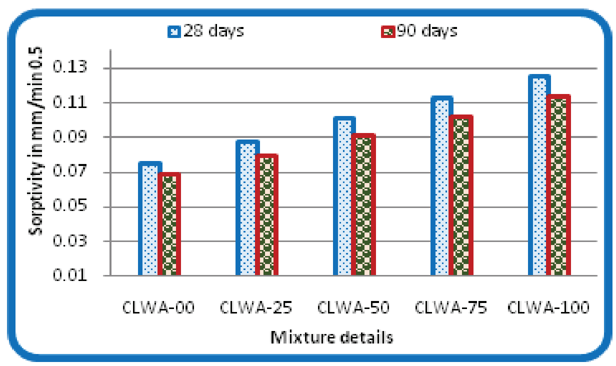

Fig. 7 Sorptivity of Various mixtures

It was observed that altering the type of coarse aggregate in LWAC mixes (which contain CLWA pellets) greatly affected the sorptivity of the concrete. Results show that the particles' porosity and the matrix's quality are both important factors in water absorption through capillarity in concrete [15].

Water Permeability of Concrete Mixtures

Figure 8 exhibits variations in each mix's water penetration (WP) depth. At 90 days, water penetration ranged from 22 to 34 mm in all of the concrete. It demonstrates that the M1 mix's water permeability was significantly smaller than that of the M2-M5 mixtures. This is because CA particles have a denser structure. Extending the age from 28 to 90 days resulted in a steady improvement in LWAC mixtures. This might be because adding AF powder increases the volume of hydration products, reduces porosity, and decreases water permeability [17].

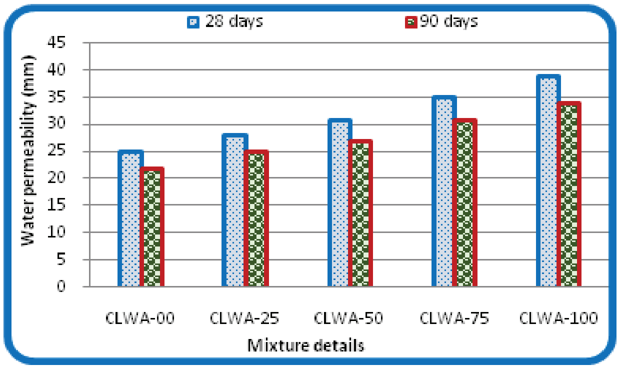

Fig. 8 Water permeability of different mixtures

CONCLUSIONS

This experimental attempt aimed to investigate whether CLWA pellets and Alccofine powder would work together to make M20-grade lightweight aggregate concrete (LWAC) sustainably and economically. The results showed that at various ages, all of the LWAC mixtures reached their target strength. The following conclusions could be made in considering the study's findings:

- When comparing the CLWA-00 mix to LWAC mixes, the round shape of CLWA pellets showed greater workability at the similar w/b ratio. The density of the different concrete mixtures (M1-M5) progressively decreased from 2431 to 1942 kg/m3. When compared to the CLWA-00 mix (M1), the density of LWAC mixes (M2-M5) was gradually dropped by 5–20%.
- The maximum compressive strength was obtained at 34.8MPa and 33.4-29.5MPa for the CLWA-00 and LWAC mixes respectively at 90-day. However, each LWAC mix reached its target strength at a different age.
- The CLWA-00 mix was able to attain a higher STS value than the LWAC mixes due to the higher modulus of elasticity of the CA particles. As a result, the paste matrix strength and CLWA pellet MOE have a major influence on the STS of LWAC mixtures.
- For a given w/b ratio, all LWAC mixtures, performed lower transport characteristics than the CLWA-00 mixture. The formation of porous ITZ in the concrete mixture, the existence of linking pores, and the generation of the porous exterior wall in the CLWA pellets may be the cause of inferior outcomes in LWAC mixtures. However, the inclusion of Alccofine could enhance the transport qualities of LWAC mixes.
- According to test results, when combined with Alccofine powder, CLWA pellets can be utilised to produce concrete with a compressive strength of 20 MPa. The FA powder was utilized largely to make the CLWA pellets, which minimizes the environmental problems associated with FA powder and preserves the use of natural coarse aggregates. Additionally, the production of CLWA pellets by using the cold-bonding process also exhibited their energy-saving benefit which consumes less energy. As a result, this research encourages the concrete sector to grow sustainably.

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Employment of Dolochar in Lead Remediation of Industrial Waste Water

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ABSTRACT

This study delves into the green solution of using dolochar, an industrial waste, to purify lead-contaminated water. Through a comprehensive analysis, the composition of dolochar was examined using diverse analytical techniques. Various kinetic models were compared to elucidate the rate at which dolochar captures lead. The findings highlight that lead adsorption adheres to a specific kinetic pattern, particularly the pseudo-second-order model, demonstrating exceptional precision ($R^2 = 0.999$). The research delves into how three key variables—dolochar quantity, initial lead concentration, and water pH—affect lead removal efficiency. Total 15 numbers of experiments were performed to determine the optimal conditions for lead removal employing dolochar. A predictive model was developed to estimate lead removal based on these parameters, yielding highly accurate results ($R^2 = 0.999$). The study reveals that under optimal conditions, characterized by a specific dolochar quantity and near-neutral pH, dolochar can effectively eliminate a substantial portion (92.8%) of lead from water, even in scenarios mimicking highly contaminated water sources such as mining sites. These results highlight the considerable promise of dolochar as an economical and effective means to address lead pollution in water sources.

KEYWORDS: *Sorption, Box-behnken design, Dolochar, Lead remediation, Response surface modeling.*

INTRODUCTION

Rapid industrialization and urban expansion are contributing to an increase in heavy metal pollution, with substances such as lead, chromium, and mercury becoming more prevalent in the environment. These toxic metals persist for extended periods, posing grave risks to human health, wildlife, and ecosystems. Lead, for instance, is associated with severe organ damage, particularly when present in elevated concentrations. Various industrial activities, spanning mining to electronics manufacturing, discharge wastewater laden with hazardous heavy metals like lead, which can infiltrate drinking water sources, leading to detrimental effects on brain function and the nervous system, particularly in young individuals.

Numerous techniques are available for lead removal from water, including solvent-based methods and specialized filtration systems. However, adsorption stands out due to its cost-effectiveness, environmental friendliness, efficiency, ease of implementation, and the wide array of available materials (adsorbents). Scientists have explored the application of diverse waste materials., such as steel production slag or sawdust, for lead capture. Nonetheless, some of these methods may be cumbersome or intricate to establish. Consequently, the quest continues for novel and economical approaches to eliminate lead from water, leading to the exploration of dolochar, a byproduct of iron factories.

Dolochar, a residual material generated by iron factories, shows promise as a water pollutant remover.

Its widespread availability in various regions makes it an appealing subject for researchers. Although some investigations have delved into dolochar's applications, its specific efficacy in lead (Pb) removal from water remains relatively unexplored.

Conventional approaches to studying adsorption are typically time-consuming and constrained. They tend to maintain specific parameters constant while altering only one variable at a time. However, this simplistic approach fails to capture the complexity of real-world conditions, where multiple factors can interact simultaneously.

To tackle this issue, a more sophisticated technique known as Response Surface Methodology (RSM) was utilized. This method enables the researchers to explore the combined effects of factors such as lead concentration, dolochar dosage, and water pH on the process of lead removal from water.

MATERIALS

Adsorbent

The dolochar, sourced from iron factories in Odisha, India, underwent several preparation steps before being used in the study. Initially, it was pulverized and sifted to achieve consistent particle dimensions. Subsequently, the dolochar underwent thorough washing with purified water to eliminate any impurities, loose materials, or soluble components adhering to its surface.

The dolochar underwent drying in a hot air oven at 105°C overnight following its cleaning.. Stored in airtight containers to prevent contamination, the prepared dolochar was then ready for use in lead removal experiments. The entire preparation process is illustrated in Figure 1.

How Dolochar Removes Lead from Water (Experiments)

A sequence of experiments was carried out to determine the optimal conditions (process variables) for extracting lead from water with dolochar.. We used a specific method (Box-Behnken design) to optimize these factors. Here's a breakdown of what we did: (i) The lead solutions were prepared at different concentrations (0 to 50 milligrams per liter) and adjusted the water acidity (pH) between 3 and 9. (ii) Those measured out 100 milliliters of each lead solution and added it to flasks. (iii) Then those added different amounts of dolochar (10 to 30 grams per liter) to each flask. (iv) Each flask was shaken for different lengths of time (0 to 120 minutes) at a constant speed (150 rpm) at room temperature. (v) After shaking, separated the dolochar from the water using filter paper and measured the remaining lead concentration in the clean water using a special instrument (Atomic Absorption Spectrophotometer). (vi) It was also measured the water acidity (pH) in each flask. (vii) To ensure accuracy, we repeated each test three times, and the measurements varied by less than 5%.

Based on these measurements, we calculated how much lead the dolochar removed from the water using a specific formula (Equation 1, not shown here).

$$\eta = \frac{C_0 - C_t}{C_0}.100 \tag{1}$$

Where, (i) The percentage of lead removed (removal efficiency) is represented by the symbol η (eta), (ii) Co represents the starting concentration of lead in the water (milligrams per liter, mg/L). (iii) Ct represents the amount of lead remaining in the water at any specific time (t) during the experiment (also in milligrams per liter, mg/L).

Utilizing Response Surface Methodology (RSM) for Experimental Design, Modeling, and Statistical Analysis

The Running experiments one factor at a time can be slow and expensive. It requires a lot of materials and time. The use of a special method called Response Surface Methodology (RSM) to optimize experiments. RSM helps them find the best settings (process variables) for a process by analyzing data from multiple experiments. This method allows them to quickly gather the information they need compared to traditional methods that test one factor at a time.

What design was used in this study?

The use of a specific design called Box-Behnken Design (BBD) for their experiments. This design is popular because it allows them to optimize the process with a relatively small number of experiments. It also helps them analyze how different factors interact with each other.

How many experiments were conducted?

In this study, the scientists conducted a total of 15 experiments using the BBD design. The number of experiments is based on the number of factors being studied and the need for repeat measurements for accuracy.

For more details

Table 1 provides the specific range of values used for each factor in the lead removal experiments.

Table 1 Experimental Parameter Limits

Factors	Ranges of Factors
Adsorbent dosage (g/l) (X_1)	10-30 g/L
pH (X_2)	3-9
Starting concentration (mg/l) (X_3)	10-50 mg/L

Making the Experiments Accurate

To account for any errors or unexpected variations in the results, we included three experiments with the same settings (center points) in their design. Table 2 shows the overall plan for the 15 experiments created using the Box-Behnken Design (BBD). We used special software (Design Expert) to analyze the results, which involved both calculations and visual representations (graphs).

The Math Behind the Model

The mathematical formula (quadratic response model) to predict how well lead would be removed based on the different factors were studied (independent variables) and how those factors might influence each other (interactive effects).

$$Y=b_0+\sum_{i=1}^{n} b_i X_i+\sum_{i=1}^{n} b_{ii} X_{ii}^2+\sum_{i=1}^{n}\sum_{j=i+1}^{n} b_{ij} X_i X_j \quad (2)$$

Equation (2) is a general example of this type of formula, where Y represents the forecasted effectiveness of removal., Xi are the individual factors, and various b terms represent different effects (offset, linear, square, interaction).

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_{11}X_{21} + b_{22}X_{22} + b_{33}X_{23} + b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3 \quad (3)$$

Based on the experiments, the specific formula for this study looks like Equation (3). This equation considers the individual factors (X1, X2, X3), their own squares (X1^2, X2^2, X3^2), and how they interact with each other (X1X2, X1X3, X2X3).

In simpler terms:

The formula to predict lead removal efficiency based on the factors they studied and how those factors might influence each other. The model coefficients were unveiled through multiple regression analysis, while ANOVA illuminated the effectiveness of Pb(II) adsorption.

Table 2 BBD Experimental Design and Results

Runs	Adsorbent dosage (g/L)	pH	Initial Concent-ration (mg/L)	Removal Efficiency (%)	
				Experi-mental	Predicted
1	20	3	10	68	67.9
2	10	3	30	63.9	64.13
3	20	9	10	92	91.8
4	20	6	30	95	95
5	10	9	30	88.9	89.23
6	30	9	30	92	91.78
7	10	6	10	94.6	94.48
8	20	6	30	95	95
9	20	6	30	95	95
10	30	3	30	69.4	69.08
11	30	6	50	95.7	95.83
12	10	6	50	92.6	92.18
13	20	9	50	89.3	89.4
14	20	3	50	65.3	65.5
15	30	6	10	97.9	98.33

Equilibrium Kinetics and Rate-Limiting Investigations

Understanding How Quickly Lead Sticks to Dolochar. The different mathematical models were used (like pseudo-first order, pseudo-second order, and Elovich) to see which one best described how fast lead particles attached to the dolochar over time. It was compared the experimental results to the predictions of these models to find the best fit. We also applied additional models (kinetic, Boyd, and Weber-Morris) to the data. These models helped us understand: (i) How lead molecules moved within the dolochar particles, (ii) The slowest step in the overall lead removal technique (the rate-limiting step).

In simpler terms, it was investigated how quickly lead gets captured by the dolochar and what factors might be slowing down this process.

RESULTS & ANALYSIS

Analysis of the Adsorbent Properties

Dolochar Properties: The dolochar used in this study is black colored, likely due to the presence of carbon. The dolochar particles are fairly large, about half a millimeter in size. Dolochar is a relatively dense material, with a density of around 3.25 grams per cubic centimeter. Tests showed that dolochar has a good surface area for adsorption, which is important for capturing lead. The Langmuir surface area is 97.56 m²/g and the Brunauer-Emmett-Teller surface area is 62.42 m²/g (surface area is like having many nooks and crannies for lead to stick to).

Dolochar and Lead Analysis (XRD): (i) Figure 2 shows a comparison of two scans (XRD spectra) of the dolochar: one before and one after it captured lead particles. These scans reveal the material's composition like a fingerprint. (ii) Both scans show peaks that indicate the presence of quartz, a common mineral. (iii) While not entirely certain, there might be a slight increase in the intensity of some quartz peaks in the scan of the lead-adsorbed dolochar. This could suggest that lead ions are interacting with the dolochar.

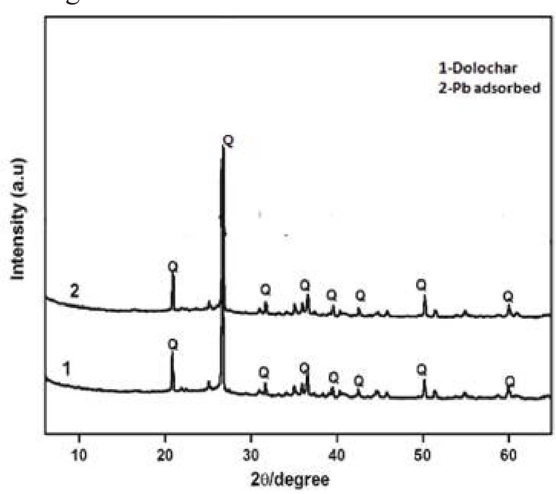


Fig. 2 displays the X-ray Diffraction patterns for dolochar before and after Pb adsorption

Dolochar Analysis After Lead Removal (FTIR) : (i) The scientists used a tool called FTIR to analyze the dolochar before and after it captured lead particles (like looking at its tiny building blocks). Figure 3 shows the results. (ii) Interestingly, the overall analysis of both dolochar samples looked quite similar. (iii) However, there were some minor shifts in the location and intensity of certain peaks in the scans. This suggests that lead attaching to the dolochar slightly altered the arrangement of these building blocks on the dolochar's surface.(iv) In simpler terms, the way lead interacted with the dolochar caused slight changes in the "fingerprint" of the dolochar material.

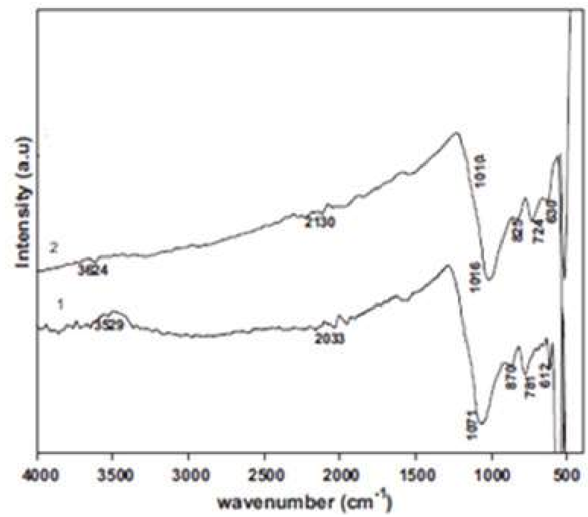
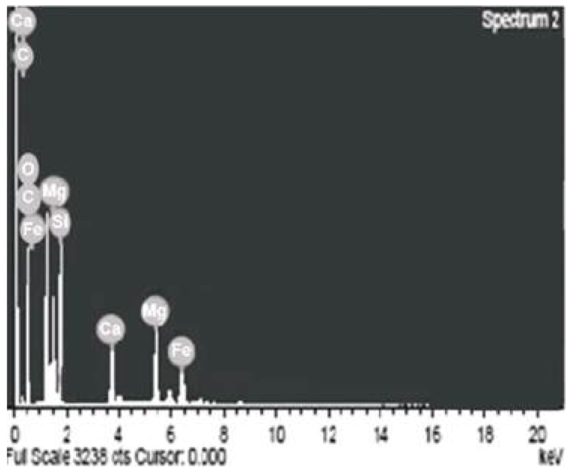


Fig. 3 shows the Fourier Transform Infrared spectra for both untreated dolochar and dolochar post-Pb adsorption.

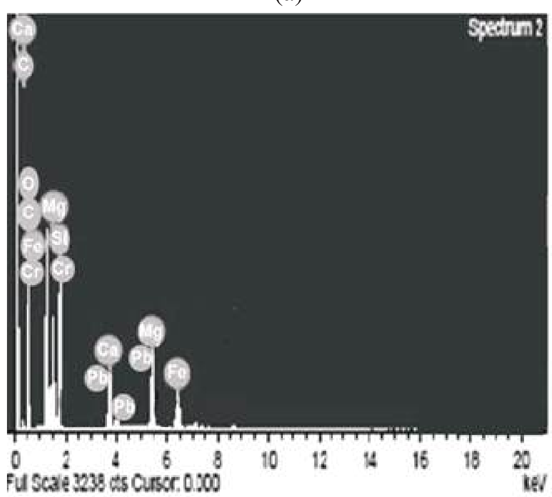
A powerful tool is used called Energy Dispersive X-ray Spectrum (EDS) to get a super close look at the elements present on the surface of the dolochar (like a magnified fingerprint). Figure 4a shows the results before lead capture: The analysis revealed elements like carbon, silicon (which is the main component of glass and sand), oxygen, calcium, magnesium, and iron. This suggests that carbon and silica might be good at attracting and holding lead. Figure 4b shows the results after lead capture: The analysis confirmed the presence of metal ions, which most likely refers to the lead that was removed from the water.

Presents the results of the batch study

In this section, the discussion covers the RSM model along with statistical analysis.



(a)



(b)

Fig 4. EDX spectra of dolochar: (a) before adsorption, (b) post-adsorption.

Finding the Best Settings for Lead Removal:- (i) A special method (Box-Behnken Design) used to run experiments and explore how different factors (adsorbent amount, water acidity (pH), and starting lead concentration) affect the amount of lead extracted from the water.. (ii) We considered the range of values for each factor as described earlier (Section 2.5, not shown here). (iii) Based on this design, we conducted a total of 15 experiments. Results are shown in Table 2 . (iv) The lead removal percentage achieved in these experiments varied widely, ranging from 65.9% to 98.1%. This large variation suggests that the amount of lead removed is extremely dependent on the factors they investigated. (v) The analysis using the Box-Behnken Design method suggested that a specific mathematical formula (quadratic model) would best describe the relationship between lead removal efficiency and the three factors they studied.

A specific mathematical equation with regression coefficients

$$\text{Pb(II) removal (\%)} = Y = 1.14 + 0.295X_1 + 26.383X_2 - 0.0775X_3 + 0.0005X^2_1 - 1.833X^2_2 + 0.0004X^2_3 - 0.02X_1X_2 - 0.0003X_1X_3 + 0.0X_2X_3 \quad (10)$$

This equation represents the relationship between lead removal efficiency and the three factors (adsorbent amount, water acidity, and starting lead concentration).

Equation (10) describes how well lead is removed from water using dolochar. According to the equation, the amount of lead removed increases proportionally with the amount of dolochar used (adsorbent dose), the water acidity (pH), and the starting lead concentration in the water (adsorbent concentration). However, the equation also suggests that these factors can influence lead removal in more complex ways. For instance, the amount of lead removed might not increase at the same rate as the amount of dolochar is increased. Similarly, the combined effects of two factors, like the amount of dolochar and the water acidity (or any other two factors), can also influence lead removal.

To see how reliable the formula (mathematical model) was for predicting lead removal, we used a statistical analysis method (ANOVA) presented in Table 3. This analysis considers two factors: (i) F-values: A larger F-value indicates that the formula well explains the changes in lead removal observed in the experiments. (ii) p-values: A value below 0.05 suggests a statistically important factor. In simpler terms, this means the factor has a real impact on lead removal, not just a random effect.

What do these factors mean?

If a factor in the formula has a low p-value (less than 0.05), it has a significant impact on lead removal according to the model, per the model, in line with the model. On the other hand, a factor with a p-value greater than 0.05 likely has little to no impact on how much lead is removed, regardless of how much that factor changes.

Table 3 ANOVA for the percentage removal of Pb (II) is conducted to assess the significance of different factors in the experimental setup

Source	Total of Squares	df	Mean Square	F Value	p-value Prob > F	Significance
Model	2201.76	9.00	244.64	1519.51	< 0.0001	significant
X_1	29.56	1.00	29.56	183.62	< 0.0001	
X_2	1963.36	1.00	1963.36	12194.78	< 0.0001	
X_3	10.91	1.00	10.91	67.79	0.0004	
X_1X_2	1.44	1.00	1.44	8.94	0.0304	
X_1X_3	0.01	1.00	0.01	0.06	0.8131	
X_2X_3	0.00	1.00	0.00	0.00	1.0000	
X_1^2	0.01	1.00	0.01	0.06	0.8203	
X_2^2	1005.23	1.00	1005.23	6243.67	< 0.0001	
X_3^2	0.08	1.00	0.08	0.52	0.5047	
Residual	0.80	5.00	0.16			
Lack of Fit	0.80	3.00	0.27			
Pure Error	0.00	2.00	0.00			
Cor Total	2202.57	14.00				

S= 0.40; R^2= 0.9996 ; $R^2_{(adj)}$= 0.999; $R^2_{(pred)}$= 0.9994 ; CV=0.46%; PRESS= 12.88

The Mathematical Model is Reliable as we performed several tests to see how well their formula (regression model) predicted lead removal based on the experiments. Here's a breakdown of what they found: (i) Overall significance:-The F-value (1519.91) and p-value (0.000) indicate that the model is statistically significant. This means it's highly unlikely that the good results were just due to chance.

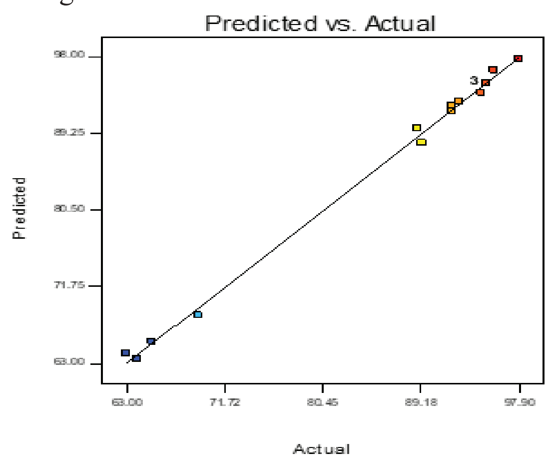
How well the model explains the data (i) R-squared (R^2) values closer to 1 show a better fit.

In this instance, an R^2 value of 0.999 indicates that the model accounts for 99.9% of the variability in lead removal seen during the experiments. Adjusted R^2 (0.999) and Predicted R^2 (0.9994) are very high, further indicating a good fit. The small difference between adjusted R^2 and predicted R^2 suggests they agree well.

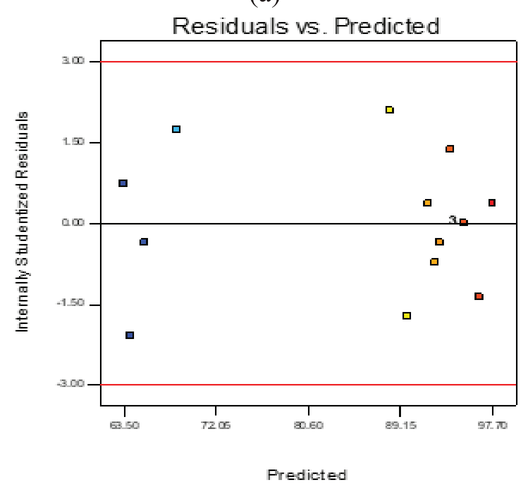
(ii)Model precision: A low standard deviation (not shown here) indicates a precise and reliable model. The coefficient of variation (CV) of 0.46% is well below 10%, which is a good sign for reliability.(iii) Signal-to-Noise Ratio (SNR). A high value for "Sufficient accuracy" (104.39 in this case) indicates a good signal-to-noise ratio. This means the model captures the important effects and minimizes random noise.

Double-Checking the Model

We looked at two additional graphs (Figures 5a and 5b) to confirm the reliability of their formula (model) for predicting lead removal.



(a)



(b)

Fig. 5. Plots between (a) Actual versus predicted (b) Predicted versus Residuals

- Figure 5a: This graph compares the actual lead removal percentages measured in the experiments (experimental removal efficiencies) to the values predicted by the formula (predicted removal values). Ideally, the data points should fall close to a diagonal line. In this case, the text says the points are very near the line, which supports the model's accuracy.
- Figure 5b: This graph shows the difference between the experimental values and the predicted values (residuals) plotted against the predicted values. Ideally, these residuals should be scattered randomly around zero and fall within a certain range (often shown as ±3). The text says the residuals in this graph are spread randomly around zero and within the expected range, again indicating a good fit for the model.

This section discusses how response surface and contour plots were created to illustrate the connections between process variables and the efficiency of lead removal. These plots provide insights into how changes in the variables impact the response.

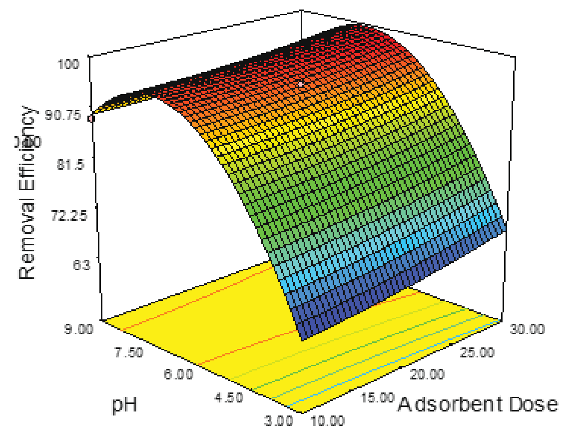
How Do Different Factors Work Together to Affect Lead Removal?

The use of 3D surface plots to examine how the factors (amount of dolochar, water acidity, and starting lead concentration) interact with each other to influence lead removal efficiency. This approach is based on previous work by Aktas (2005).To create these plots, we investigated the effect of changing two factors at a time while keeping the third-factor constant. Here's a breakdown of what the plots reveal: (i) Surface plots: These plots show how the predicted lead removal efficiency changes as two factors are varied. (ii) Contour plots: These plots are like a "top-down" view of the surface plots, but on a flat surface. They are useful for analyzing how the two factors interact with each other. Circular contour lines indicate that the factors have little to no interaction on lead removal. Elliptical contour lines suggest that the factors interact significantly. In other words, the impact of one variable on lead removal is contingent upon the setting of another variable. Visualizing How Factors Affect Lead Removal.

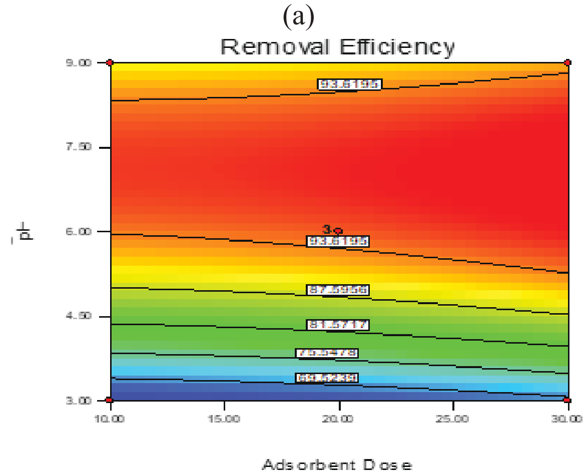
We used 3D surface plots, like Figure 6, to understand how two factors interact and influence lead removal efficiency.

Impact of Adsorbent Dose and pH

Figure 6 focuses on how the amount of dolochar used (adsorbent dose) and water acidity (pH) influence lead removal efficiency together. Here, the starting lead concentration was fixed at 30 mg/L.Key takeaways from this figure: (i) pH is crucial: Lead removal efficiency increases as the water becomes more neutral (pH rises from 3 to 7.1). This implies that pH significantly affects lead adsorption. (ii) Optimal pH for removal: The highest lead removal (almost 99.5%) occurs at a near-neutral pH (around 7.1). This pH likely creates a favorable surface charge on the dolochar, attracting lead ions. (iii) Influence of pH on removal: Lead removal increases from 61.5% to 94.5% as pH goes from 3 to 7.1, but then decreases slightly at even higher pH values. (iv) More dolochar, better removal: Increasing the amount of dolochar used (from 10 to 30 g/L) also improves lead removal from the water.



(a)



(b)

Figure 6 demonstrates how pH and adsorbent dosage (g/L) interactively influence the efficiency of lead removal at an initial lead concentration of 30 mg/L. Panel (a) shows the response surface plot, while panel (b) displays the contour plot. These plots provide visual insights into how changes in pH and adsorbent dose impact the efficiency of lead removal.

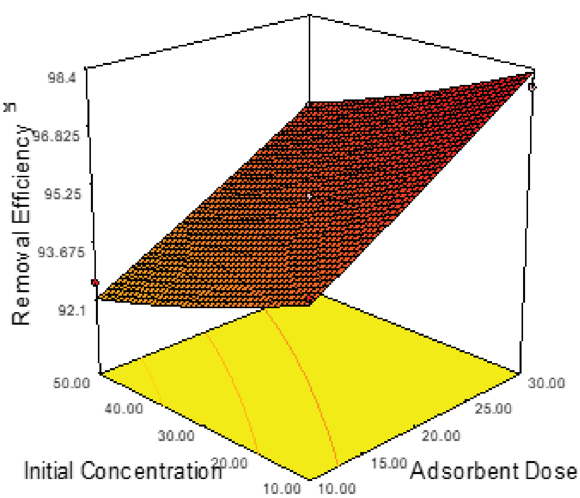
The impact of adsorbent dose and lead concentration on the removal process is analyzed in this section.

Understanding How Different Factors Affect Lead Removal ,Figure 7 examines how two factors interact to influence lead removal efficiency: (i) The amount of dolochar used (adsorbent dose) (ii) The starting lead concentration in the water

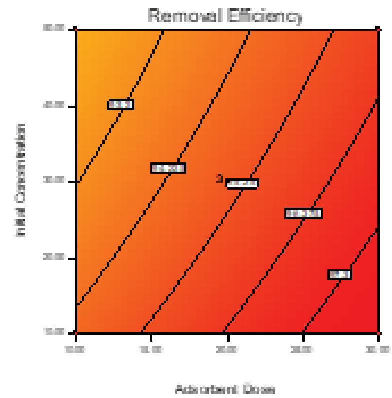
Effect of Lead Concentration on Removal

The Figure 7 shows how these two factors affect lead removal at a constant water acidity (pH) of 6.0.A key observation is that increasing the starting lead concentration reduces the percentage of lead removed.

Here's why this might happen: (i) At lower lead concentrations, there's plenty of surface area on the dolochar particles to capture lead ions. So, the amount of lead initially present in the water doesn't significantly affect how much lead is removed. (ii) At higher lead concentrations, there are more lead ions than available space on the dolochar particles. This reduces the efficiency of lead removal



(a)



(b)

Figure 7 illustrates how the interaction between adsorbent amount (g/L) and starting lead concentration (mg/L) influences removal efficiency (%) with pH fixed at 6.0. The response surface diagram (a) and the contour map (b) offer a view on how variations in adsorbent quantity and initial lead levels impact the effectiveness of lead extraction.

The impact of pH and adsorbate concentration on the system was investigated.

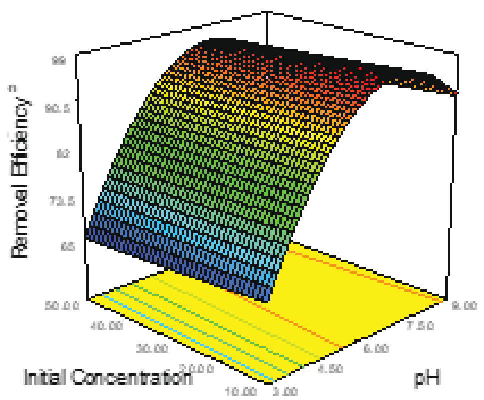
Understanding How Different Factors Affect Lead Removal, Figure 8 explores how two factors influence lead removal efficiency: (i) The water acidity (initial pH). (ii) The starting lead concentration in the water.

Effect of pH on Removal

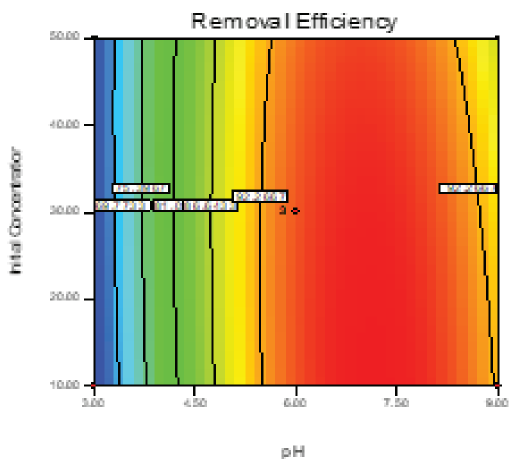
This figure considers a constant amount of dolochar (20.0g/L). The text says that lead removal is very sensitive to changes in water acidity.

Key observations about pH: (i) Lead removal is highest at a neutral pH (around 7). (ii) Lead removal is significantly lower at very acidic or very basic pH levels. (iii) A neutral pH provides a favorable surface charge on the dolochar for attracting lead ions. (iv) At very acidic pH, the dolochar surface becomes positively charged, repelling lead ions (which are also positively charged). (v) At very basic pH, lead ions might precipitate out of the water as Pb(OH)2, reducing the amount available for adsorption.

Effect of Lead Concentration on Removal, The text also mentions that the starting lead concentration has a minor effect on lead removal within the range investigated (10 to 50 mg/L).



(a)



(b)

Figure 8 shows how pH and initial lead concentration (mg/L) interactively affect removal efficiency (%) with an adsorbent dosage fixed at 20.0 g/L.The response surface plot (a) and contour plot (b) provide visual representations of how changes in pH and initial lead concentration affect the removal efficiency.

Adsorption kinetics

This set of experiments was organized to investigate the removal of lead from water with a particular adsorbent, dolochar. Here are the main highlights:

Experiment Setup

(i) Type of operation: Batch (all the lead-bearing water and dolochar are added at once)

(ii) Synthetic water: Lead was artificially added to clean water to a starting concentration of 10 mg/L.

(iii) Dolochar dosage: The optimal amount of dolochar used was 20 g/L.

(iv) Water acidity (pH): The pH of the solution was maintained at 6.0 (slightly acidic).

(v) Temperature: Room temperature

Purpose of Kinetic Study

(i) Kinetic studies help understand the rate of a reaction over time. In this case, the reaction is the lead being adsorbed by the dolochar.

(ii) Kinetic information is essential for designing efficient lead removal processes. It helps determine factors like:

How much lead is removed over time (solute uptake)

The optimal amount of dolochar to use (adsorbent dose)

The rate constants that govern the adsorption process (reaction coefficients)

Data Analysis:

(i) The study employed different kinetic models (mathematical equations describing the rate of lead removal).

The model with the best fit was selected based on its R-squared (R^2) value. R^2 indicates how well the model explains the experimental data (higher R^2 means a better fit).

Kinetics Type : Pseudo 1st Order

$$\ln\left(1-\frac{q}{q_e}\right) = -k_1 t$$

q(t): This represents the amount of lead adsorbed on the dolochar (in mg/g) at a specific time 't' (minutes). It's essentially the concentration of lead on the dolochar at that time. qe: This represents the amount of lead adsorbed on the dolochar at equilibrium (in mg/g). In other words, it's the maximum amount of lead the dolochar can hold under the specific conditions used in the experiment.t: This represents the contact time (in minutes). It refers to the time elapsed since the lead-bearing water and dolochar were first mixed.k1:

This signifies the rate coefficient for the pseudo-first-order kinetic model. (units are typically min^-1). It characterizes the speed at which the adsorption reaction occurs. A higher k1 value indicates faster adsorption.

Kinetics Type : Pseudo 2nd Order

$$\left(\frac{t}{q_t}\right)=\frac{1}{k_2 q_e^2}+\frac{t}{q_e}$$

q(t): This represents the amount of lead adsorbed on the dolochar (in mg/g) at a specific time 't' (minutes). It's essentially the concentration of lead on the dolochar at that time. qe: This represents the amount of lead adsorbed on the dolochar at equilibrium (in mg/g). In other words, it's the maximum amount of lead the dolochar can hold under the specific conditions used in the experiment. t: This represents the contact time (in minutes). It refers to the time elapsed since the lead-bearing water and dolochar were first mixed. k2:

This denotes the rate coefficient for the pseudo-second-order kinetic model (units are typically g/mg·min). It characterizes the interaction between the lead and the available adsorption sites on the dolochar. A higher k2 value indicates a stronger interaction or faster adsorption.

Kinetics Type : Elovich

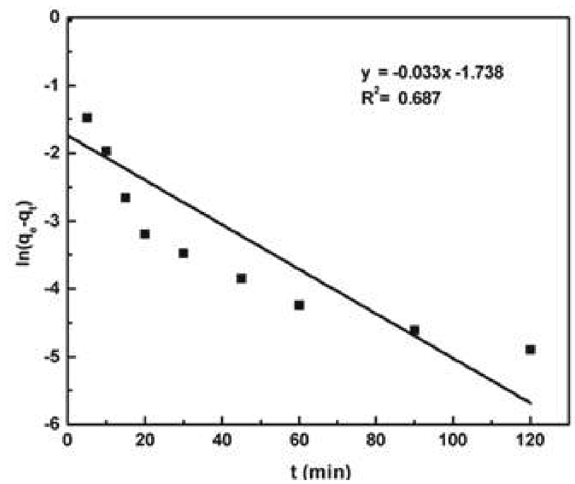
$$q_t=\frac{1}{b}\ln ab+\frac{1}{b}\ln t$$

q(t): This represents the amount of lead adsorbed on the dolochar (in mg/g) at a specific time 't' (minutes). It's essentially the concentration of lead on the dolochar at that time.t: This represents the contact time (in minutes). It refers to the time elapsed since the lead-bearing water and dolochar were first mixed. a: This represents the initial sorption rate (in mg/g·min). It reflects how quickly lead is adsorbed onto the dolochar at the beginning of the process.b: This represents a parameter related to the activation energy for chemisorption and surface coverage (units are g/mg).

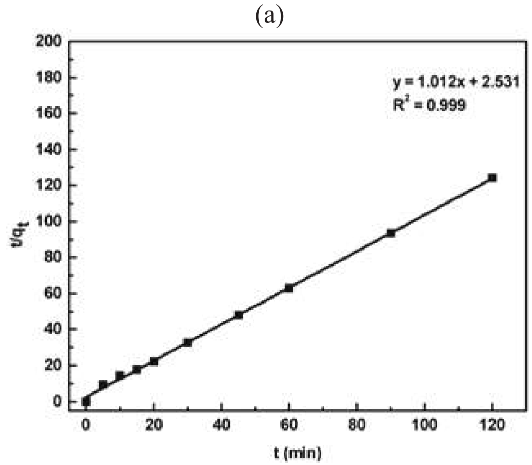
Kinetic Model Fitting: Figure 9 likely shows plots used to compare how well each kinetic model (pseudo-first-order, pseudo-second-order, and Elovich) fits the experimental data on lead adsorption.

R-squared Values: The text uses R-squared (R^2) to assess the fit of each model. A higher R^2 value indicates a better fit. Here's what the text reports:(i) Pseudo-second-order model: R^2 = 0.999 (very good fit).(ii) Pseudo-first-order model: R^2 = 0.835 (worse fit than pseudo-second-order). (iii) Elovich model: R^2 = 0.847 (slightly better fit than pseudo-first-order, but worse than pseudo-second-order).

Based on the R^2 values, the pseudo-second-order kinetic model best describes the lead adsorption process on dolochar in this study.(i) Kinetic Model Parameters: Table 5 (not shown here) likely summarizes the specific values of the parameters (like k1, k2, a, and b) obtained from each kinetic model.(ii) Comparison with Other Adsorbents: Table 6 (not shown here) likely compares the lead adsorption capacity of the dolochar used in this study with the capacities of other reported waste materials. The text suggests that the dolochar performs competitively in treating wastewater containing lead (Pb(II)) ions.



(a)



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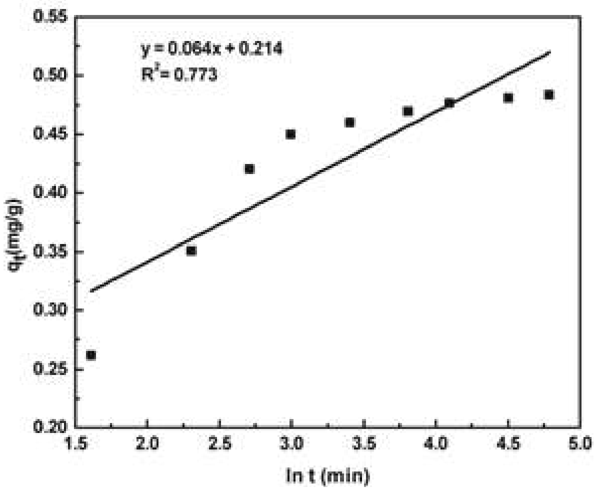

(c)

Fig 9. Linear fits for: (a) pseudo-first-order kinetics, (b) pseudo-second-order kinetics, and (c) Elovich kinetics.

Table 5 Kinetic model parameters at different concentration levels

Models	Pseudo first order		Pseudo second order		Elovich		
Starting Concentration (mg/L.)	K_1 (1/min)	R^2	K_2 (g/mg. min)	R^2	1/b	(1/b) ln ab	R^2
10	0.033	0.687	0.405	0.999	0.064	0.214	0.773

Table 6 Evaluating the lead adsorption capabilities of different adsorbents

Adsorbents	Adsorption capacity (mg/g)	Reference
Coal Fly ash	18.8	[23]
Bio slurry	28.0	[24]
Olive stone residue	9.26	[25]
Processed rice husk	12.61	[9]
Wood polymer	8.2-9.0	[26]
Iron making slag	40.0	[27]
Dolochar		Present study

CONCLUSION

In this study, we explored the potential of using dolochar, an industrial waste product, to remove lead from water. Our goal was to determine the optimal process conditions for maximizing lead removal efficiency., employing statistical methods such as Response Surface Methodology (RSM).

(i) We investigated three key factors: water acidity (pH), initial lead concentration, and dolochar dosage while maintaining other parameters constant. (ii) Throughout the experiments, factors like mixing time, speed, and temperature remained unchanged to isolate the effects of the variables under study.

Our analysis revealed a significant relationship between lead removal efficiency and the investigated factors, indicating the accuracy of our mathematical model in representing real-world scenarios. Notably, water acidity demonstrated minimal influence on removal efficiency, except under extremely acidic or basic conditions.

In conclusion, dolochar emerged as a cost-effective and efficient solution for lead removal from water. The optimal conditions identified were: (i) Slightly acidic water with a pH of 5.5, (ii) Initial lead concentration of 50 milligrams per liter, and (iii) Dolochar dosage of 10 grams per liter.

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Integration of PLC Based System to Automate the Bottle-Filling Operations

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ABSTRACT

In recent years, the global market has witnessed a rise in the demand for liquid products packaged in bottles. However, manual involvement in the production process poses challenges that lower productivity. To address this issue, we proposed the integration of a PLC (Programmable Logic Controller) based system to automate bottle-filling operations. Our design utilizes the Mitsubishi FX5U PLC, programmed using ladder logic in the GX Works3 software. The system operates by moving bottles along a conveyor to the filling station. The main objectives include controlling the start and stop of the conveyor at specific intervals and ensuring that bottles are filled with equal volumes by timing the filling process accurately.

The PLC handles all these tasks, leveraging its real-time application capabilities and its suitability for industrial automation. It manages various devices via input/output ports using ladder logic. The project also includes hardware components such as a sensing element to detect bottle position on the conveyor, an electromagnet and pump assembly for filling, a stepper motor for moving the conveyor, relays, and connectors. GX Works3 serves as the programming and simulation tool. This automated system optimizes the filling process, reduces manual errors, and increases overall efficiency in production.

KEYWORDS: *Programmable logic controller (PLC), Automation, GX Works3.*

INTRODUCTION

Since the early 20th century, the business landscape has undergone significant changes. Companies have shifted from regional producers catering to local markets to global corporations serving international consumers. This transformation began with the introduction of mass production techniques, enabling efficient and widespread manufacturing. In developing nations, industries such as beverage production, milk, mineral water, and cooking oil have become crucial to national economies. Recently, the bottled water industry and smallholder milk production have seen substantial growth, along with Small to Medium Enterprises (SMEs) involved in post-harvest fruit processing and liquid soap production. India, in particular, remains a key market for soft drinks like Coca-Cola, Pepsi, and Sprite.

To meet the increasing demand in these sectors, businesses rely heavily on automated bottle-filling systems, which provide precision and efficiency in liquid filling. This shift is part of a larger trend driven by globalization and technological advancements, showcasing how industries adapt to an interconnected global market.

Filling machines today use various technologies, including level sensing, volumetric flow meters, and weight-based filling systems. Some also control liquid flow by regulating filling duration. This project focuses on developing an automated bottle-filling station equipped with a conveyor belt, controlled by a Programmable Logic Controller (PLC). The system's primary objectives are to optimize time and speed, which are critical in industries such as food processing and packaging.

Automation plays a vital role in modern economies, and this project highlights its significance. Various systems on the market use controller algorithms like PID (Proportional-Integral-Derivative), AI (Artificial Intelligence), and PLC-based systems. PLCs, known for their accuracy and durability, have largely replaced older technologies like electromagnetic relays due to their simplicity and faster response times.

In this project, components such as IR sensors, a submersible pump, and motors work together to ensure precise and efficient bottle filling. This system aims to enhance productivity and consistency in liquid filling operations.

PROBLEM DEFINITION

Manual bottle filling techniques, while simple, encounter several challenges that impact efficiency and accuracy. Key issues include:

i. Irregularity: Variations in fill levels often arise from human error, compromising product quality and customer satisfaction.

ii. Ineffectiveness: Manual processes are generally slower than automated systems, resulting in lower throughput and increased labor costs.

iii. Labor-Intensive: Manual filling requires significant physical effort and constant attention, leading to operator fatigue and potential errors.

iv. Contamination Risks: Human handling raises the risk of contamination, as operators may inadvertently introduce impurities or neglect hygiene standards.

v. Erroneous Measurements: Achieving precise fill volumes without advanced measurement systems can lead to overfilling or underfilling.

vi. Increased Waste: Variability in fill levels can result in product waste due to spillage or the need to discard improperly filled bottles.

vii. Scalability Concerns: Scaling production using manual techniques is cumbersome and often requires additional labor, making it less adaptable to growing demand.

The proposed integrated PLC-based system to automate bottle-filling operations, offering advantages like low power consumption, reduced costs, minimal maintenance, and high accuracy. The system applies industrial automation principles across sectors such as dairy, chemicals, food processing, and mineral water production. A functional prototype has been developed, with the PLC serving as the central controller for efficient filling operations. A DC stepper motor drives the conveyor, while an infrared (IR) sensor ensures precise bottle positioning. The MITSUBISHI FX5U series PLC, programmed using ladder logic, enhances functionality and simplifies operations, providing a reliable and cost-effective industrial solution.

LITERATURE REVIEW

In today's technological landscape, industries enhance production by creating similar models with minor variations, making sorting crucial. This project introduces a Low-Cost Automation (LCA) system using DC geared motors and a PLC-controlled conveyor to accurately sort lightweight items by height, ensuring efficiency and reducing human error.[1]Automation utilizes control systems to manage equipment and processes while minimizing human involvement. Programmable Logic Controllers (PLCs) are compact and cost-effective, simplifying operations. Our paper, "PLC-Based Automated Flow-Controlled Mixing, Bottle Filling, and Capping in Cold Drink Manufacturing," discusses automating liquid mixing, filling, and capping. Using the Bosch Rexroth Indra Logic L10 PLC, we ensure precise mixing, filling, and capping, enhancing efficiency and flexibility.[2] Automation utilizes control systems to manage equipment with minimal human input, especially in liquid filling processes. This paper presents a water filling machine system for various bottle sizes, utilizing a Programmable Logic Controller (PLC) with solenoid valves and sensors. Our results show reduced costs, energy consumption, and enhanced efficiency.[3]The goal of this project is to create a miniature bottling plant using PLC and SCADA systems. The Programmable Logic Controller (PLC) automates electromechanical processes, while SCADA (Supervisory Control and Data Acquisition) oversees industrial operations. A Variable-Frequency Drive (VFD) adjusts electric motor speed by modifying power supply frequency. This integration results in a highly efficient, energy-saving, and precisely controlled bottling plant.[4]This project offers a cost-effective method for programming and controlling a unipolar stepper motor using a Programmable Logic Controller (PLC). While specialized drivers are available, PLCs provide a practical alternative for managing industrial equipment due to their flexibility and robustness. The approach highlights the simplicity and efficiency of PLC-based stepper motor control, showcasing its ease of programming and configuration.[5]The "PLC-Based Liquid Filling and Mixing" system is designed to reduce operational costs, lower power consumption, and improve accuracy and flexibility. It ensures precise liquid filling into bottles while minimizing operational time. A prototype has been built, with its operational sequence efficiently controlled and programmed using a ladder diagram for effective process management.[6]

PROBLEM IDENTIFICATION

Industries generate vast quantities of products daily, often relying on repetitive processes for mass production. Manual tasks pose several challenges:

1. Fatigue and Labor Intensity: Manual work can lead to exhaustion, while automated systems handle repetitive tasks effortlessly.
2. Inconsistent Quality: Human errors can damage materials or products, whereas automation ensures precision and consistent quality.
3. Efficiency: Automated systems outperform manual labor in speed and accuracy, making processes more efficient.
4. Data Tracking: Manual data collection is prone to errors, while automated systems accurately track and log production data.
5. Data Accuracy: Automated systems provide reliable data, enabling better decision-making and continuous improvement strategies.
6. Cost-Effectiveness: While manual labor may suit small-scale production, automation significantly reduces costs and increases efficiency in large-scale manufacturing.

DESIGN AND IMPLEMENTATION

We have integrated a Programmable Logic Controller (PLC) system to automate bottle-filling operations, simplifying the process and providing advantages like reduced power consumption and minimized human error. This system will benefit various industries that fill liquid products in bottles. The design concept is illustrated in a block diagram, showcasing key components.

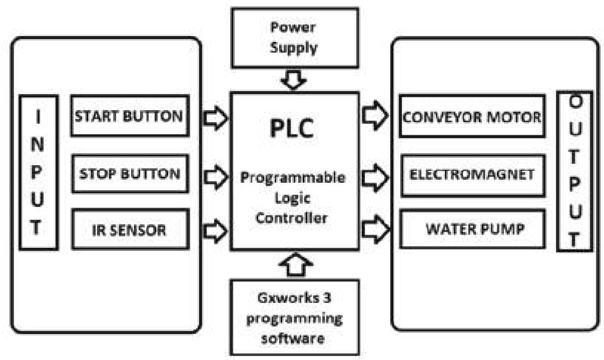

Fig. 1. Block diagram of the prototype with PLC

Inputs Used In The Prototype

i. Start Button: This push button initiates the conveyor and the entire filling process at the station. It is connected to the PLC module.

ii. Stop Button: This button halts the PLC program and is used to stop the filling process when complete. It also serves as an emergency stop in case of any issues during filling.

iii. Sensing Element: A proximity sensor that emits infrared light and detects objects by receiving reflected light. In this project, it identifies the presence of bottles on the conveyor belt.

Central Module

i. PLC: The most crucial component of the project, serving as its "brain." All process instructions are programmed and controlled by the Programmable Logic Controller.

ii. Power Supply: This provides power to the project's electronic and electrical components. It includes three types: a 24-volt supply for the stepper motor and PLC, a 5-volt supply for the IR sensor, and a 220-volt AC supply for the electromagnet and pump.

iii. Programming Software: GX Works3 is used to program the PLC, utilizing ladder logic for its simplicity and ease of understanding.

iv. HMI Designer Software: GTDesigner3 is employed to design and develop the Human-Machine Interface (HMI) for the project, with function modules created according to operational procedures.

v. SolidWorks: This design software is used to create the 3D model of the proposed prototype.

Outputs Used In The Project

i. Conveyor motor – A 24-volt stepper motor is used in the project to run the conveyor belt. Stepper motor is used to move the conveyor precisely as well as to nullify the effect of momentum.

ii. Electromagnet – It is a device that when given an AC or DC power supply generates the properties of a magnet. It is used in the project to put the filling nozzle inside the mouth of the bottle.

iii. Pump – An AC pump is used to fill the bottles. When the electromagnet's work is complete the pump starts to fill the bottle for a specific period to fill a defined volume of water or liquid into the bottle.

Software Requirements

The first and foremost requirement for the system design process is the programming part of PLC and specifically, we worked in GXWORKS software. The working environment is illustrated below-

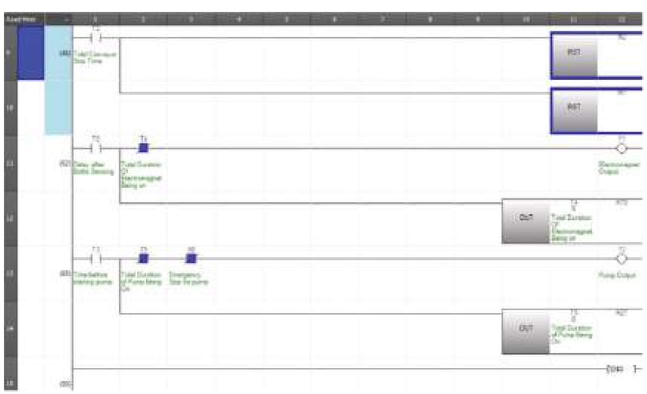

Fig. 2. GX Works3 Simulation

Technically we have used Mitsubishi FX5U series PLC to perform the hardware integration with the assembled components for the automation of bottle filling operations and accordingly, a prototype model is developed. Typically ladder logic programming is carried out for PLC programming and the input-output variables are configured as depicted in Table 2 below-

Table 2

Variable	Specifications
X1	Start Button
X2	Stop Button
X0	IR sensor Input
X5	Emergency Stop for pump
T0	Delay after Bottle sensing
T2	Total conveyor Stop time
T3	Time before Starting the pump
T4	Total time of Electromagnet being ON
T5	Total duration of pump being ON
Y1	Electromagnet Output
Y2	Pump Output

To design a graphic user interface the GTDesigner3 software tool is utilized, and a specific screen is created wherein push buttons and lamps are configured as objects however proper variables are configured as per the ladder logic programming. The designed graphic user interface is depicted below-

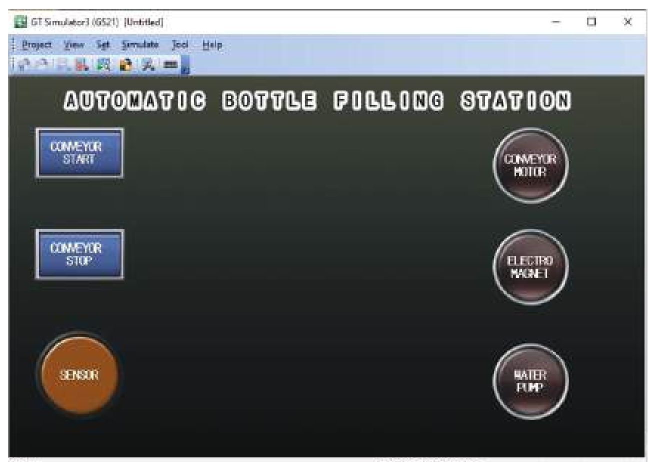

Fig. 3 GT designer3 simulation

Significantly illustrate the 3D modeling of the proposed system the AUTOCAD software is used and a respective 3D model is prepared that is shown in figure 4.

Further using a circuit development environment initially, a circuit layout was designed wherein significant components are connected to the PLC, however, proper assumptions are considered to achieve the desired circuit operations. The designed circuit diagram is illustrated in figure 5.

Fig. 4. 3D modelling diagrams

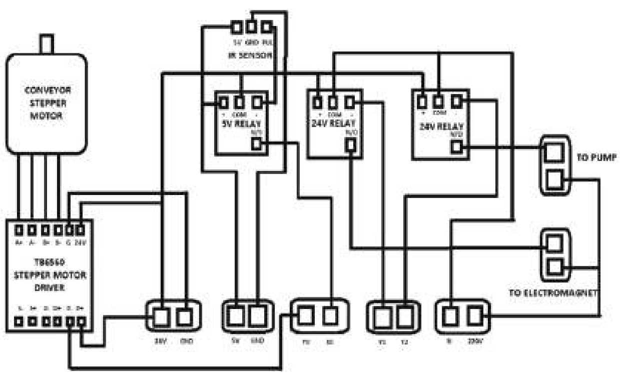

Fig. 5. Circuit diagram of the prototype

The circuit diagram can be explained in four parts as stated below-

i. IR Sensor Interfacing – The IR sensor needs a 5-volt supply to operate which is interconnected with a 5-volt relay. When the sensor detects an object the signal from the sensor triggers the 5-volt relay coil which transmits a 24-volt signal from the N/O pin of the relay. This 24-volt signal is fed to the input ports of the PLC (X0) to register an input pulse in the ladder program.

ii. Stepper Motor Interfacing – The stepper motor used in the project is a nema-17 hybrid stepper motor, it is capable of working in unipolar as well as bipolar configurations. In this project, we used the bipolar method to configure the motor. The four coil wires are connected to the A+, A-, B+, and B- ports of the motor driver respectively. The motor as well as the motor driver are capable of operating on 24-volt which is also the operating Voltage of PLC. The motor driver receives the voltage supply from the PLC as well as the pulses from the Y0 output of the PLC. Next, the driver modulates the step pulses and sequentially transmits them to the coils of the stepper motor. The motor takes 200 step pulses to rotate one revolution of the motor. In this way,the motor's speed can be regulated by adjusting the pulse count from the PLC.

iii. Interfacing of Electromagnet – Electromagnet is used in the project to provide linear actuation to the filling pipe. The pump pipe needs to be put inside the mouth of the bottle to avoid spillage of liquid on the conveyor and adjoining circuits which could cause failure of the circuit or could even cause life-threatening shock to the operator. When the Y1 signal is received from the PLC the 24-volt relay gets triggered and the neutral wire of the AC supply completes the circuit through the wire attached on the N/O pin of the relay to turn on the electromagnet.

iv. Interfacing of Pump – The AC pump is used in the project to fill the bottles. AC pump is used for faster filling of the bottles. The pump is operated by (Y2) output from the PLC which triggers the second 24-volt relay and the neutral wire of the AC supply completes the circuit through the wire attached to the N/O pin of the relay to turns on the pump the pump remains on until the trigger signal (Y2) is active from the PLC.

Flow Chart and Implementation with Procedure

The working procedure of the project can be easily understood from the above flow chart and in the following steps the implementation of the project is further explained-

i. In the initial state the bottle filling project will be in a stop state, the start push button attached to the PLC needs to be pushed to start the working of the filling station. When the start button is activated, the conveyor belt begins to move. The operational procedure of the designed system illustrated in the flow chart (figure 6).

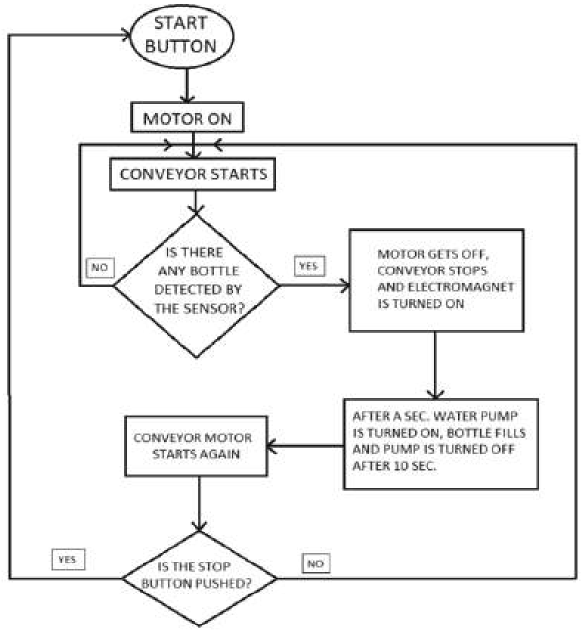

Fig.6 Flow chart

ii. The IR sensor is now activated to detect bottles on the conveyor belt. If the bottle is not detected the conveyor will keep on rotating. Else if the bottle is detected by the IR sensor the conveyor motor gets turned off and the electromagnet is turned on.

iii. After a small delay the pump is turned on to fill the water bottle. The bottle gets filled in a few seconds. Both the timers are set into the PLC by the hit and trial method to get the perfect timings. After the bottle is filled the electromagnet gets turned off and the bottle is now disengaged from the filling pipe. The conveyor motor starts again to push the water ahead of the filling area.

iv. If the stop button is pressed, the entire process will halt, and the start button must be pressed again to restart the conveyor and filling process. If the stop button is not pressed by the operator, then the IR sensor will remain active to detect another bottle to fill with the same procedure as written above.

RESULT AND DISCUSSION

Hardware Requirements

For the development of hardware prototype, we have prepared a list of required components that are mentioned in table 1.

S. No.	Component	Specification	Qty
1.	Stepper Motor	17PM-K841-P1US Nema 17 stepper motor Torque 4 Kg-cm Step Angle 1.8 Deg	1
2.	Stepper motor Driver	TB6560 Stepper motor Driver Operating voltage – 10 to 35V Rated Output - ±3A peak 3.5A	1
3.	IR Sensor (Photoelectric Sensor Module)	HW-201 IR Sensor Module 5VDC Operating Voltage 20mA Supply Current Adjustable Range Detection	1
4.	Electromagnet	SA-3602 Electromagnet Voltage – 220Volt AC Stroke – 20mm Force – 4kg	1
5.	Pump	18W magnetic water pump, 1-phase Power Rating – 0.018kW Power Supply – 220Volt AC Motor Power – 1hp	1
6.	5 Volt Relay	SRD-0V5DC-SL-C Pins - 5 Coil Voltage – 5V Output Voltage – 220V up to 10A	1
7.	24 Volt Relay	SRD-24VDC-SL-C Pins – 5 Coil Voltage – 24V Output Voltage – 220V up to 10A	2
8.	Conveyor Belt	Rexine Material Conveyor Belt Length – 50 inches Width – 4.5 inches	1
9.	Transistor	BC548 Transistor Max Collector Current – 500mA Max. (VCE): 30 V Max (VCB): 30 V Max (VEBO): 5 V Max Transition Frequency (fT): 150 MHz	1

10.	Ball Bearing	6200ZZ Bearing Inner Diameter (ID) – 10mm Outer Diameter (OD) – 30mm Thickness – 9mm Weight – 28gms	4

For hardware interfacing the most important part is to understand the wiring of the PLC. The wiring of MITSUBISHI FX5U PLC is explained as in the first step, we configured the input values for PLC that further interconnect the processor of the PLC to all the input modules. Technically the FX5U PLC is connected in sinking mode wherein its input module allows the flow of current through its control points. Similarly, output values are defined and configured with PLC pin values.

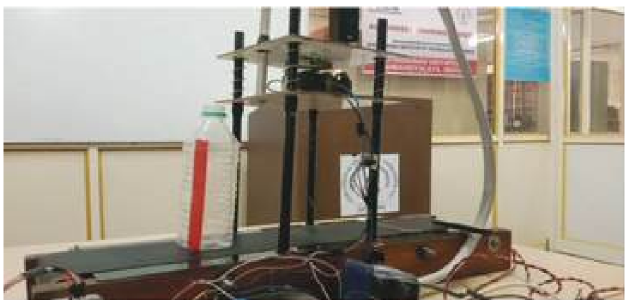

Fig. 7. Developed hardware model

CONCLUSION

In this work, we developed a prototype model to automate bottle-filling operations using a Mitsubishi FX5U series PLC as the core component. Other components were integrated following standard procedures. This PLC-based system improves productivity by ensuring high-quality output with minimal manual intervention, reducing errors and costs. As a result, it is suitable for small-scale industries. By utilizing PLC technology, the system effectively meets basic automation needs, offering a reliable, flexible, and efficient solution that minimizes operational time and boosts overall productivity.

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Harmonic Suppression Methods in Electric Vehicle Charging Networks: A Comprehensive Review

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ABSTRACT

This study uses both 13A and 32A refuelling modes to examine harmonic distortion total (THD) rates at various initial states in charge when charging several production electric automobiles. The results show that while THD levels generally remain within legal bounds, they differ amongst electric cars with comparably rated on-board chargers. The estimated current THD for one kind of on- board charger was between 2 and 4%, whereas it might go as high as 12% for another type. Chargers intended for 32A working in 13A modes exceeded the harmonic limitations established for 13A chargers, even when individual current harmonics met with standards. Using a sample network form India, the study also included simulations to assess the effect of harmonic distortion absent from low voltage networks. The findings suggested that there was little chance of noticeable voltage harmonic distortion occurring at the substation level. It is possible that some car models could be charged in every home without resulting in an excessive amount of voltage harmonic distortion. Up to 87% of families could charge their vehicles simultaneously, even with the worst-performing car type, without experiencing serious problems. Nonetheless, the investigation revealed deficiencies in the UK's 32A car charger rules. In order to solve potential issues brought on by distorted harmonics in electric vehicle requesting systems, regulatory requirements need to be reviewed and updated. Chargers that emit the highest allowed current harmonics may result in extremely high levels of distortion.

KEYWORDS: *Electric vehicle, Total harmonic distortion, Electric vehicle charging, Harmonic, Power quality.*

INTRODUCTION

The number inside electric motor vehicles (EVs) that are linked to the grid, especially low voltage networks, has significantly increased in recent years. The shift to greener energy in the future is greatly aided by the popularity of electric cars. The intersection of the energy industry automotive industries, in addition to the promise that electric mobility offers for the Smart Grid, has attracted a lot of interest. It is projected that in 2020, the electricity consumption of two million electric-powered cars in France will be between 4 and 5 TWh.

Concerns regarding possible technical problems and effects on power systems are raised by the anticipated increase in the total fleet of EVs, particularly with regard to distribution-level power quality disruptions. The increasing number of electric vehicles has the potential to cause instability and harmonic injection through charging currents, which need to comply with regulations like EN 50160, which cap the supply voltage's overall harmonic distortion at 8%.

Electric vehicles can be charged in a variety of ways. Generally, conventional charging runs at 3 kW (16 A) in up to 8 hours, whereas rapid charging runs at 43 kW (63 A) for 20 to 30 minutes. The Renault Zoe, for example, includes one charging connector, one charger, and one AC/DC converter. It can accept many current inputs, ranging from 230V 10A 1-stage to 400V 63A 3-period (43 kW) under auto-adaptive mode.

Because fast charging draws a lot of current, voltage quality is seriously impacted, especially at the connecting point. Studies have used statistical methods and load flow simulations to solve the harmonic difficulties of EV charging. Although there are practical issues, several methods involve lowering current harmonic distortion by coordinating among vehicles in the network.

Purchasing a PV solar power system is a long-term way to reduce costs, given the rising prices of electricity, natural gas, oil, petrol and fuel. Electric vehicle charging via photovoltaic (PV) systems is a feasible option, particularly as fast charging frequently takes place during hours of maximum sun production. Ancillary services can be provided by integrating solar power plants into rapid charging stations. Advanced control strategies can reduce harmonics created by EV fast charging by using solar power inverters as active filters.

OBJECTIVE

The following are the study's main goals as stated:

1. Creating a harmonic reduction model for charging stations for electric vehicles.
2. Accurately modelling the charging station by parameterizing analogous circuit parts using test data.
3. Creating the power circuits circuit layout that connects the control system and battery pack.
4. Creating closed-loop control methods for harmonic reduction and supervisory control.
5. Creating state observers for Resonance Reduction in PV-integrated charging stations for electric vehicles.

LITERATURE SURVEY

T. Busatto et. al. 2020, This paper examines the potential consequences of integrating two nonlinear loads into a low voltage system, focusing on voltage harmonic distortion. The analysis accounts for the combined impact on network impedance and current harmonic distortion. Initially, network impedance is determined for phase-to-neutral connections, incorporating uncertainty in customer impedance through Monte Carlo simulation and transfer impedance concept. Subsequently, real measurements of current harmonic distortion from the nonlinear loads are utilized to calculate resulting voltage distortion at any specified bus in the network. The study applies this analysis to an existing low-voltage network in Sweden. The results from the case study indicate that certain harmonics could increase by up to 83% with the penetration of electric vehicles and photovoltaic installations.

R. Carter1 et. al. 2012, The total harmonised distortion (THD) ratios seen during charging in a variety of production electric vehicles are presented in this study. Measurements were made at various initial stages of charge using the 13A and 32A recharge modes. Comparably rated on-board chargers were found to have different THD levels, however they all generally stayed inside legal bounds. THD, however, varied depending on the charger type, from 2–4% for one to 12% for another. The harmonic limitations for 13A chargers were exceeded by 32A chargers using 13A mode, even though the individual current harmonics complied with standards. Using a UK sample network, simulations were run to evaluate the effects of harmonic distortion for low voltage networks. The findings suggested that there was unlikely to be a major voltage harmonic excitation at the substation. Some car models were able to charge at each residence without producing too much voltage harmonic distortion; the least efficient type of car could charge as up to 87% of the households at once. However, it was discovered that UK laws governing 32A car chargers were insufficient because chargers outputting harmonics of the maximum allowed current might result in extremely high distortion levels.

Van-Linh Nguyen et. al. 2020, The research presents an enhanced control technique, validated by simulations, for PV inverters acting as active filters. The suggested control successfully lowers the total harmonic aberration (THD) of voltage and current to within acceptable bounds, as shown by the simulation results. The paper also provides an overview of the most recent methods for estimating the state of health (SOH) of batteries in a comparative table that makes it easier to choose the best estimation method based on models/algorithms, estimate errors, benefits, drawbacks, and system cost. Additionally, it looks at the global trend of electric cars and how it affects the environment, the economy, and energy efficiency, with a focus on Pakistan and Asia.

Mohd Zamri Che Wanik et. al. 2013, This study offers a thorough examination of harmonic measurement in the context of charging electric vehicles (EVs), looking at both individual and group EV charging situations. Two contemporary EV models and a golf cart were subjected to measurements, and the current and voltage waveforms were recorded in order to examine harmonic components within the electrical system. After calculations were made, it was discovered that, in comparison to golf carts, modern EVs had lower total current harmonics (THDi) and higher total voltage harmonics distortion (THDv). The study also looked into the total THD during team EV charging and discovered that there was a non-linear correlation between THD with the quantity of vehicles. Overall, the results imply that harmonic pollution on the electrical grid caused by EV charging might not be as bad as many power grid researchers had previously believed.

Abdollah Ahmadi et. al. 2019, Governments are switching from conventional vehicles powered by fossil fuels to electric automobiles (EVs), that emit fewer emissions, due to the urgent issues around global warming & environmental deterioration. Because of this change, there has been a notable increase in the number of EVs that are able to connect to the grid. Because of these vehicles' ability to communicate both ways—from the grid to the car and back—the electrical grid is facing a number of issues. Among these difficulties, power quality problems are the most important one for electrical systems impacted by the widespread use of EVs. Therefore, the purpose of this study is to investigate and evaluate the difficulties that the integration of EVs poses to electrical networks. The paper explores EVs' present and future position as well as ongoing research initiatives tackling EV-related problems. It also looks at the issues that come with EVs being connected to the power grid and suggests possible fixes to lessen these difficulties.

Angela C. Caliwag et. al. 2019, The ability of electric cars (EVs) to lower petrol emissions and oil consumption has attracted a lot of interest. Batteries are one of the main EV components and are regarded as a crucial bottleneck. Among the different battery kinds, lithium-ion batteries are commonly used to power electric vehicles. State estimate is used to accomplish monitoring and control, which are necessary to guarantee the safe use of batteries in EVs. State-of-charge (SoC), condition-of-health (SoH), condition- of-power (SoP), & state-of-life (SoL) are among the variables that make up a battery's condition. The SoC, which is impacted by changes in the EV's operating conditions, shows the usable portion of the battery's remaining capacity. The output voltage of the battery serves as an indicator, and when the resultant voltage drops below a designated cut-off value, the SoC is regarded as zero. This paper suggests a hybrid methodology that combines long short-term memory (LSTM) and vector autoregressive moving averages (VARMA) to forecast SoC and output voltage. The goal is to forecast and estimate a battery's SoC and output voltage as it is being driven through the CVS-40 drive cycle. When compared to standalone forecasting techniques that just use VARMA or LSTM, the combination of VARMA and LSTM forecast strategy shows a reduced root-mean-square error (RMSE).

EXISTING CONFIGURATION

Because of their effective generators, capacity to store excess energy to feed the grid, and the grid-to-capabilities, that promote peak periods and advance cleaner technology, plug-in electric cars, or PEVs, are growing in popularity. The public's desire, government laws, and technological developments have all helped to lower greenhouse gas emissions. Unfortunately, major voltage quality & harmonic distortion concerns have been brought about by the rapid rise of PEVs & the non-linearity of electricity transmission at charging stations. These issues have an impact on smart grid power transmission networks as well as alternative energy sources like wind and solar power.

Serious power quality issues, such as flicker, resonance, equipment disruption, transmission line losses, being heated, vibrations, sound, breakdowns, and defects in metering and delicate equipment, have been brought on by this proliferation in delivery feeders. Charging station currents, both sinusoidal and non-sinusoidal, greatly increase harmonic or fundamental losses. In order to address these problems, it is recommended to install an active filter in conjunction with charging stations. This will lessen the harmonics that the stations introduce and avoid temperature rise and additional damage.

PEVs are usually charged at power outlets, in customers' houses, or in parking lots, both public and private. The modernization of intelligent grids, which seek to modernise century-old transmission architectures to meet changing electrical needs, depends on this infrastructure for charging. Due to their high rating for rapid charging PEVs, charging stations, particularly those in suburban or light industrial regions, can stress the distribution systems by causing abrupt spikes in power consumption.

In addition, the demand for EVs has been strengthened by the volatile price of crude oil, which has increased the allure of electric vehicles. The distribution system's installation of charging points has increased as a result of this trend. Nevertheless, there may be an increase in power losses if multiple charging stations are installed haphazardly. These issues are further made worse by harmonic distortion brought on by the electronics control mechanisms at charging stations that change alternating current (AC) into direct current (DC). Reduced efficiency, a lower energy factor, greater insulation heat voltage, shorter insulation existence, and higher heating losses are just a few of the negative consequences that might result from this distortion. Total distortion of harmonics, reactive energy distribution, and simultaneous voltage profile control are the subjects of one field of research. A lot of work has gone into integrating client-side needs into smart grids in order to lower peak demand and enhance the load profile of the system. The goal of this research is to ensure that intelligent grids can efficiently handle the changing demands of current electricity consumption by addressing the issues brought about by the rapid deployment of PEVs & the accompanying infrastructure.[11], [12].

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PROPOSED CONFIGURATION WORK

In order for Plug-in electric vehicle (PEVs) to compete with traditional gas stations as a long-distance transportation option, they must be widely deployed in a variety of places. These stations allow PEVs to be fast-charged in the same way as fuel-powered cars. Fig. 1 shows an example of a charging station intended for 10 fast electric car chargers. A 500 KVA step-down 20/0.4 kV the mains distribution transformer is used to link this station to the distribution network. Through the use of a sizable voltage diode rectifying device with the same rating, the transformer transforms AC power into the direct current (DC) energy required for battery charging.

Ten rapid charger sections, each with a standard DC bus, can fit in the suggested charging station. Ten PEVs can only be charged at a time at the station; this is comparable to the ability of ten traditional petrol stations. 50 kW is the maximum power that may be used to charge these 10 EVs. A 50 kW solar (PV) power plant is also included in the charging station. A high-frequency switch charger built into this PV system is intended to counteract high-order harmonics.

When these 10 EVs are linked for charging, the PV inverter is crucial in minimizing harmonics. In addition to supporting the electric grid, the combination of a PV system and a high-frequency switch charge at the charging station helps to reduce harmonic distortion that is commonly brought on by numerous EV chargers operating at the same time. With this configuration, PEVs are guaranteed to charge effectively and consistently, which makes them a more sensible choice for long-distance driving and a step towards a cleaner energy economy.

The accompanying figure shows the suggested arrangement for the PV-centered shunt powered filters. This configuration consists of a bi-directional, two-phase DC/DC converter and a DC/AC converter, which work together to charge the battery. in a reversible chopper fashion. A three- level Neutral Position Clamped (NPC) inverter linked to the main grid is another element of the system. Each leg of the inverter has two clamping diodes and four adjustable switches (S1–S4). At the AC terminal output from the inverter, there are three levels of voltage (VDC/2, -VDC/2, and 0) due to the equivalency of the two capacitance currents, VDC1 and VDC2, within the DC connection.

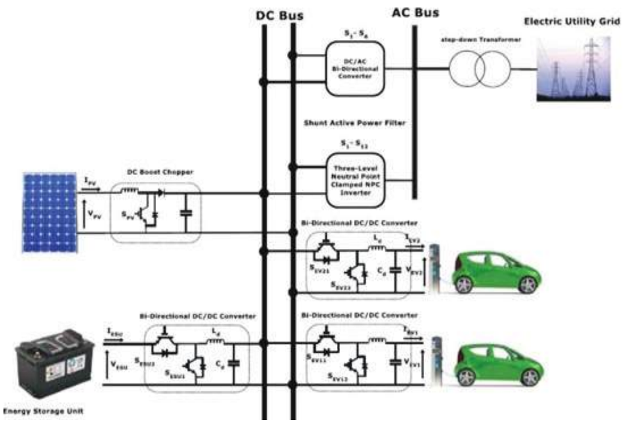

Fig. 1. The proposed Electric Motor Plug-In charging station with ten (10) fast electric vehicle chargers

In order to provide reactive and harmonic currents that balance out the nonlinear loads and reduce harmonic currents, the shunt active electricity filter works in tandem with a nonlinear load. The source current is effectively brought in phase with the input voltage, decreasing current harmonics, by introducing harmonic currents at the point of regular coupling that have identical but distinct phases to those of the nonlinear load.

As an inverter shunt supply for DC voltage, the suggested system combines a photovoltaic array with a DC-DC boost converter that offers Maximum Power Point Tracking (MPPT). The system has a converter from DC to DC that adapts to abrupt variations in weather that impact solar irradiation level and cell temperature settings since solar energy production is a variable process. The active power filter for PV shunts operates in three modes:

Inverter Mode: The system shares the regular load and adjusts for reactive or harmonic energy during the day or during periods of solar radiation. The PV array's extra capacity concurrently charges the battery.

In the compensator mode, the PV array does not receive active power as the unit makes up for variations in voltage, current, and reactive power. To guarantee constant compensation, the battery-connected DC-DC boost converter controls the DC-link.

UPS Mode: Using the solar panels and battery bank, the PV-Filter continuously supplies power to key loads day or night, even during voltage disturbances.

The major objectives of this system are to share the load, use renewable energy sources, keep the three-level neutral- point clamped inverters' DC link voltage constant for continuous compensation, and supply important loads with continuous power. The PV array contributes to voltage growth and stable DC link voltage by being coupled to a high-step-up DC-DC boosting converter. The PV array shares the electricity generated with the electrical grid during the day, and any extra power that isn't needed for compensation charges goes to the battery. During the night, the battery functions as the boost converter's DC source, guaranteeing constant compensation.

Furthermore, the approach reduces the requirement for UPSs and stabilisers for particular devices. To maximise the use of the PV setup, a low step-up converter from DC to DC featuring maximum voltage monitoring is installed between the photovoltaic system and battery. Results from experiments and simulations confirm that the suggested strategy works well.

CONCLUSION

An investigation into harmonic monitoring and analysis during charging of electric vehicles is presented in this work. Two contemporary EV models and golf carts were used for the measurement. As predicted, the data show that EVs today emit less THDi than golf carts. On the other hand, the percentage of distortions in THDv is larger in current EVs. The total harmonic distortion (THD) of voltage and current for a group of EVs charging simultaneously does not add up from one car. These results offer important new information about the harmonic distortion caused by EVs that are linked to the network for charging.

ACKNOWLEDGMENT

I would want to utilise this occasion to offer our genuine thanks and respect for the project guide at the Tulsiramji Gaikwad Patil College of Engineering and Technology in Nagpur, who gave us direction and space to complete this assignment.

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Slit & Stub Loaded Inset Fed Patch Antenna with better Return Loss and Tri-band Resonance

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ABSTRACT

The study of patch antennas with variously shaped stubs and slits of varied length and width is presented in this article. The patch is made on a FR4 substrate with a thickness of h = 1.6 mm and a dielectric permittivity of $\varepsilon_r = 4.3$. Three distinct frequencies that span wireless application bands with better return loss (RL) have been resonantly covered by the antenna. With bandwidths (BWs) of $BW_1 = 2.9\%$ (RL=-19 dB) at first resonance, $BW_2 = 2.9\%$ (RL=-21 dB) at second resonance, and at third resonance the $BW_3 = 3.5\%$ (RL=-17.5 dB) respectively. The proposed antenna (TBMSA) has tri-resonances at $fr_1 = 2.5$ GHz, $fr_2 = 4.5$ GHz, and $fr_3 = 5.1$ GHz that are appropriate for wireless communication applications.

KEYWORDS: *Antenna, Stub, Bandwidth, Wireless, Communication, VSWR.*

INTRODUCTION

In current world, communication in wireless mode is now unavoidable and antenna technology has greatly expanded in electronics realm. In addition, with advancements I n technologies considering all sectors, the antennas, communication systems are rapidly becoming more sophisticated and used case in all scenarios of wireless applications. When compared to conventional communication systems, the fifth generation (5G) communication system today offers the benefits of high speed, broad frequency bandwidth, low power consumption, and high dependability. As a result, antennas are important in communications. The antenna used for wireless communication systems is designed to ensure reliable, fast, and efficient two-way data transfer across transmitter and receiver. A careful antenna design is a critical concern for obtaining the better performance in such systems [1]. In this circumstance, patch antennas have been studied for several decades, due to its unique characteristics, such as cheap cost, low profile, lightweight, and low volume, microstrip patch antennas are widely and steadily used in a variety of microwave circuits, including telemetry, radars, portable, biomedical systems, and so forth. Mounting a low-profile radio antenna on a level surface is possible with only patch antenna [2 - 4]. This antenna is made out of a small size metal patch with substrate in between and ground plane placed back on flat rectangular metal, or "patch". Patch antennas are unique among microstrip antenna types because of their low cost, tiny profile, and flexibility in production [5]. These antennas are a great option for dual-band antenna device designs like smartphones and laptops considering they are lightweight, compact, and simple to incorporate. They can also be incorporated into a variety of electronic devices and are also reasonably simple to fabricate. Their mechanism involves the radiation from a metallic side, also called a "patch," positioned above a dielectric substrate. [6].To prevent damage to the antenna construction, the assembly is often housed inside a plastic or other flexible material. These antennas are superior to other antennas in a number of ways, including low profile, low weight, comparatively cheap production costs, an easy-to-use fabrication technique, polarization diversity, and ease of customization [2, 10-11, 13]. The limited gain and bandwidth of microstrip patch antennas are among its drawbacks. Many different methods have been explored to boost microstrip antenna bandwidth, which consists of use of impedance matching technique, utilizing a low dielectric substrate, having several resonators [8], thick substrate, and utilizing different feeding techniques. However, the antenna's bandwidth and size are mutually exclusive qualities, meaning that enhancing one would worsen the qualities of the other. Recent years have seen a great deal of research on microstrip printed slotted patch antennas5. The slot loading approach is utilised to improve the antenna's size and bandwidth miniaturization performance parameter [12]. On the other hand, we have a multiband with good radiation properties.

This work proposes a triple band multi-slit and stubs loaded antenna (TBMSA) with improved radiation characteristics and fractional bandwidths of 2.9%, 3.5%, and 2%. Multiple resonant over the operational frequency bands are produced by adding the different stub geometries on the patch. These resonances may be combined throughout the operational band by carefully selecting the different sizes and shapes of stubs, allowing the antenna to be utilized across a very large bandwidth. The proposed antenna's modeling studies are explained and given in the paper.

DESIGN ASPECTS OF CONVENTIONAL MICROSTRIP ANTENNA (CMA) AND TRIPLE BAND MULTI SLOT ANTENNA (TBMSA)

The designs have been simulated using CST 2018 software, a computer simulation tool. Firstly, a proper dielectric substrate must be chosen which can work for the 3 GHz operating design frequency suitable for wireless applications. The standard microstrip antenna (CMA), with a resonant frequency (fr) of 3 GHz, is constructed using the basic equations presented in the literature [3, 7]. Figure 1 shows this designed antenna's geometry. To build the antennas, equations 1 - 4 are utilised [3].

The patch is excited with inset feed which can make a better flow of current across the copper patch and also in the ground plane making it to have multiple resonances for desired frequencies.

The below formula gives the patch width W seen in Fig. 1.

$$W = \frac{c}{2fr}\sqrt{\left(\frac{\varepsilon r+1}{2}\right)} \tag{1}$$

The patch's length is determined by,

$$L = \frac{c}{2fr\sqrt{\varepsilon r}} - 2\Delta l \tag{2}$$

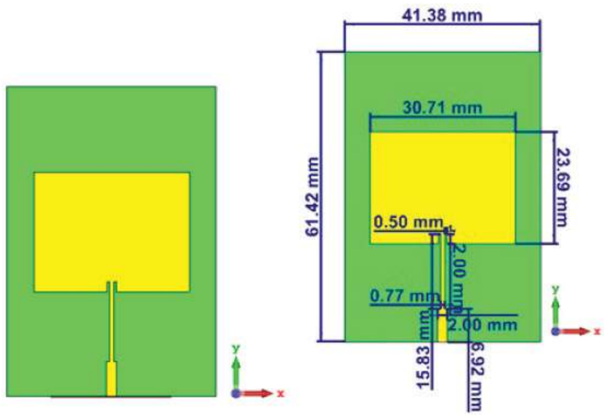
where, effective length

$$\Delta l = 0.412h\frac{(\varepsilon e+0.3)+\left(\frac{w}{h}+0.264\right)}{(\varepsilon e+0.258)\left(\frac{w}{h}+0.8\right)} \tag{3}$$

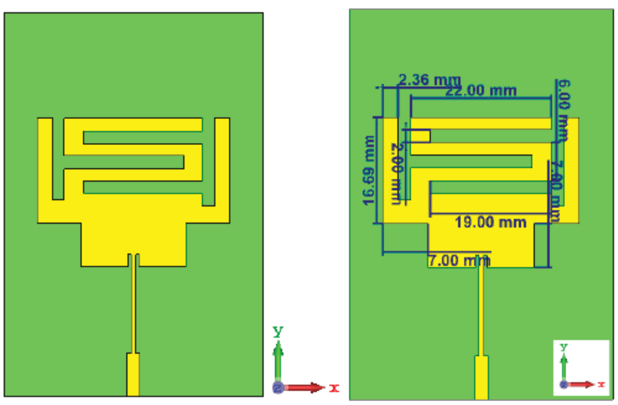
$$\varepsilon_e = \left(\frac{\varepsilon_r+1}{2}\right)+\left(\frac{\varepsilon_r-1}{2}\right)\sqrt{1+\frac{12h}{w}} \tag{4}$$

The substrate material thickness is denoted by the h.

The patch is fabricated on a low cost FR4 substrate material of thickness h = 1.66 mm and permittivity ε_r = 4.3 with full copper ground plane. The length and width of the patch is (L x W) (23.69 x 30.71 mm). The length and width of quarterwave transformer (L_t x W_t) is (15.83 x 0.77 mm). The length and width of microstrip feedline (L_f x W_f) is (6.92 x 2 mm) a 50 ohm microstrip feed line, a small and a finite ground plane L_g x W_g = 41.38mm X 61.42mm which is as shown in Fig.1 (a). The inset gap and its length are 2mm x 0.5mm. Later the same antenna is etched with various shape and sized slits on the patch plane i.e., along the patch width with full ground plane maintaining the feed dimensions intact as it was used while designing the conventional antenna which is as shown in Fig.1 (b). A microstrip-fed line on the bottom plane of the substrate is as a microstrip fed excitation of the slot antenna to excite the slot mode. Due to the higher impedance of the narrow slot, the width of the open circuited feedline is tuned and decreased more as before.



(a)

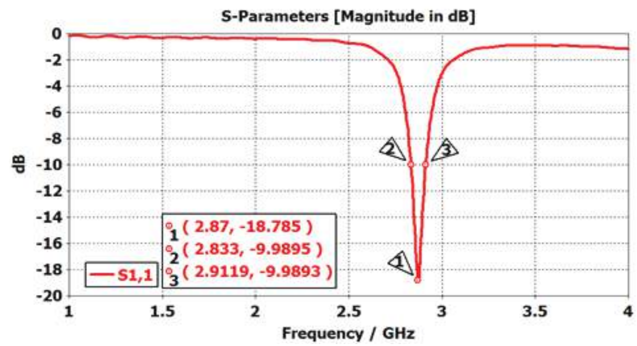


(b)

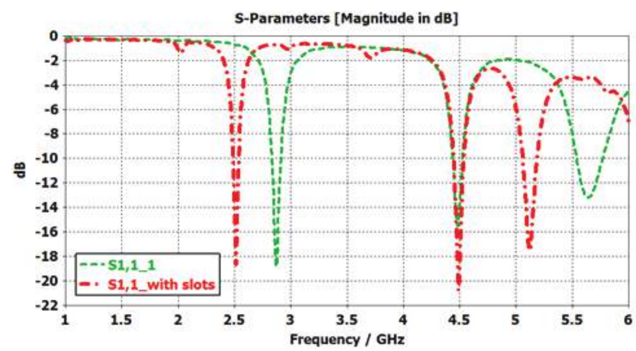
Figure 1. Proposed antenna designs with dimensions of a) conventional microstrip antenna (CMA) and b) Triple Band Multi Slot Antenna (TBMSA)_top view

RESULTS & DISCUSSIONS OF CONVENTIONAL MICROSTRIP ANTENNA (CMA) AND TRIPLE BAND MULTI SLOT ANTENNA (TBMSA)

Initially the conventional antenna is designed and later TBMSA is designed with optimized dimensions as to obtain better performance and both are simulated using EM CST simulation software. The simulated return loss against frequency for the designed conventional microstrip antenna (CMA) is displayed in Fig. 2(a). It makes evident that the simulated results have a single resonance frequency of 2.87 GHz with an improved return loss. It is also well-matched using 50 ohm SMA connector in between input and load. When contrasted with the center frequency at 2.87 GHz, the simulated lower resonant mode obtains an impedance bandwidth at –10 dB, which extends from 2.833 GHz to 2.911 GHz. The simulated impedance bandwidth at resonant frequencies is 2.7 % at 2.87 GHz. Fig. 2(b) shows the simulated results for TBMSA with triple band resonance due to addition of stubs along the width of patch which elongates the current path on the patch giving rise to three resonances suitable for S & C band wireless applications.



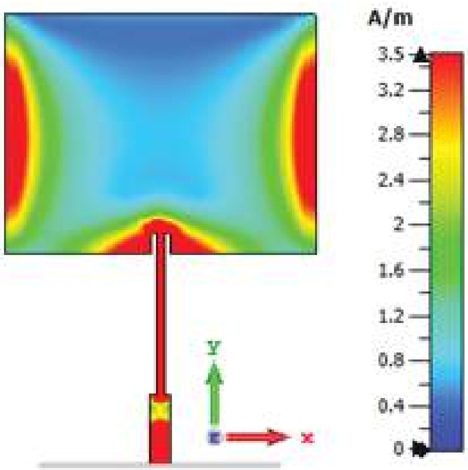
(a)



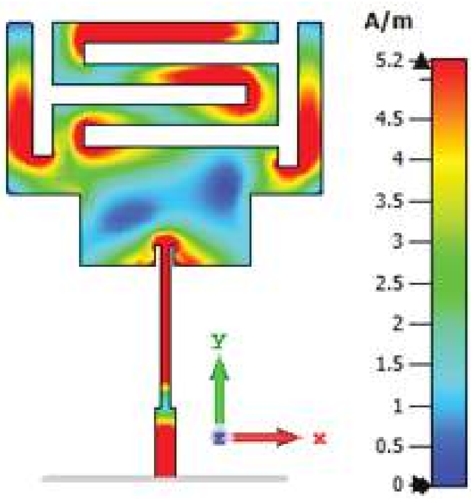
(b)

Fig. 2. Simulated return loss plot for a) conventional microstrip antenna (CMA) and b) Triple Band Multi Slot Antenna (TBMSA)_ top view

The three resonances are fr_1 = 2.5GHz, fr_2 = 4.5 GHz and fr3 = 5.1 GHz having bandwidths (BWs) BW_1 = 2 % (RL= -19 dB), BW_2 = 2.9 % (RL= -21 dB) and BW_3 = 3.5 % (RL= -17.5 dB). The return loss is reduced at large extent meaning the better matching of antenna and load. Fig.3(a) and (b)depicts the surface current distribution diagram of CMA and TBMSA. It is quite evident that the current is crowded along patch width and on the feed portion as indicted in red color of Fig.3(a) and when the patch is cut with three stubs placed in horizontal and two slits in vertical arrangement placing them adjacent to the length and width of patch as in Fig.3(b), there exist the portion of current getting divided along the edges of patch stubs and also in the feed portion of patch. Fig. 4 show the far field radiation characteristics in 2D, 3D format of the proposed antennas which is broadsided in nature.



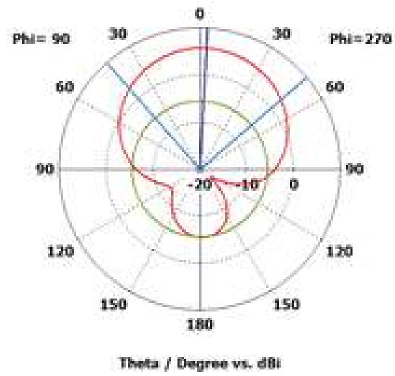
(a)



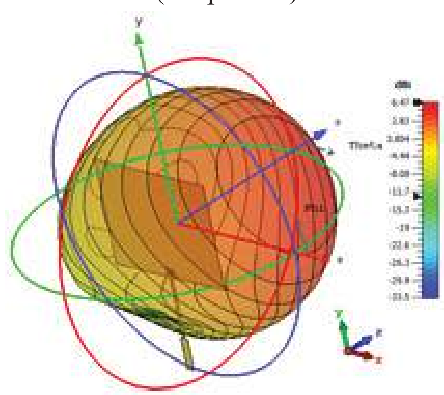
(b)

Fig. 3. Surface Current distribution diagram of CMA & TBMSA

As the simulated radiation pattern shows, there should be almost little radiation beneath the ground plane. This is so because the microstrip patch antenna's ground plane acts as a reflector for all frequencies. The plot of VSWR with frequency of proposed CMA & TBMSA is shown in Fig. 5 (a, b) and it clearly depicts that the antennas have its values less than 1.5 showing the better impedance matching. The Smith chart plot of proposed CMA & TBMSA is depicted in Fig. 6 (a, b) and it clearly represent that the antenna resonance points are located near the centre of the circle of the smith chart justifying the better input and output match.

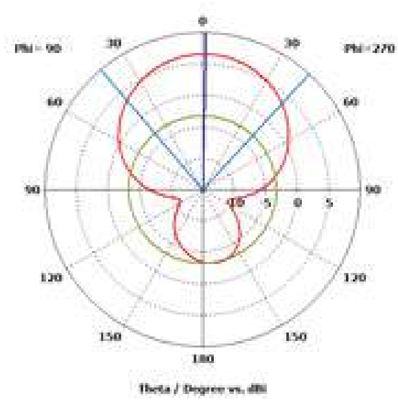


(2D pattern)

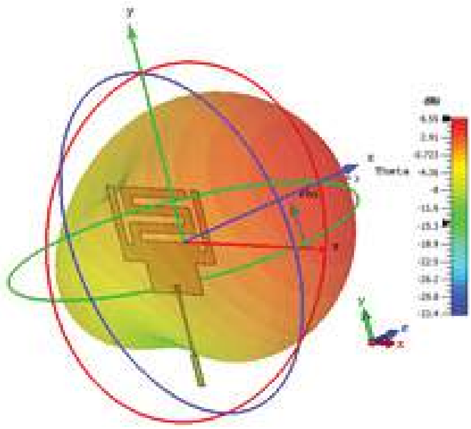


(3D pattern)

(a)



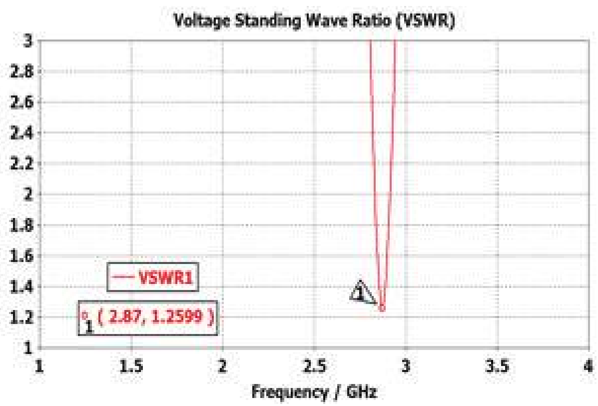
(2D pattern)



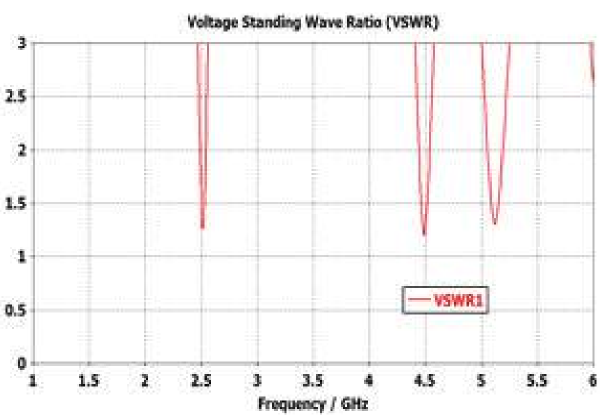
(3D pattern)

(b)

Fig. 4. Radiation Characteristics (2D & 3D) of a) CMA & b) TBMSA

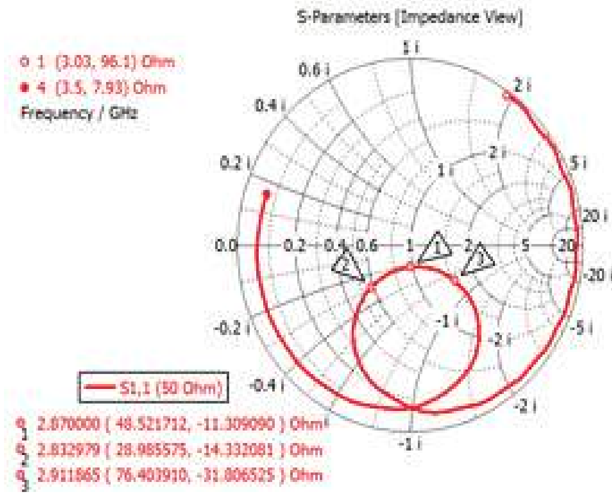


(a)

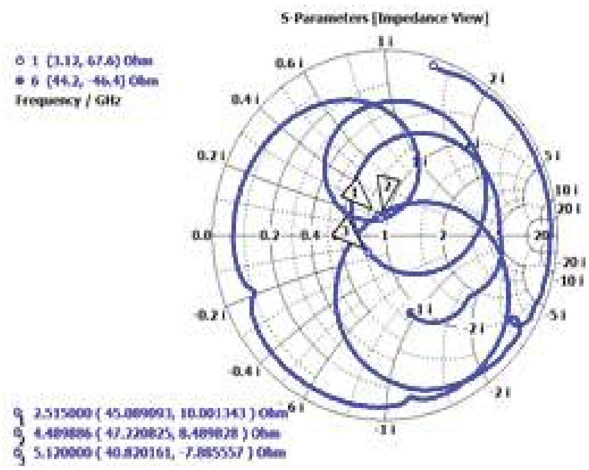


(b)

Fig 5. Plot of VSWR with frequency of a) CMA & b) TBMSA



(a)



(b)

Fig. 6. Smith chart Plot of a) CMA & b)TBMSA

CONCLUSION

A triple resonant microstrip antenna excited by inset feed approach is designed and simulated in this paper. By etching stubs and slits on the patch, the improvements in the antenna parameters have been observed and are suitable for wireless applications. The simulated findings for the proposed antennas have been listed and included in the paper such as the Smith chart plot, VSWR, radiation pattern, current distribution, and return loss. Due to its simple construction, makes its fabrication and design simplification easier. The proposed triple resonant antenna finds its application for S and C band wireless communication.

ACKNOWLEDGMENT

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Mitigation Issue of Carrier Frequency Offset for Generalized Frequency Division Multiplexing Using Least Mean Square Algorithm

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ABSTRACT

Generalized frequency division multiplexing is one of the candidates for the 5G wireless communication system. This modulation scheme is found versatile for the fifth generation (5G) through various simulations. However Generalized frequency division multiplexing (GFDM) affects carrier frequency offset (CFO) causing degradation in the performance. The proposed technique least mean square can suppress the problem of CFO and efficiently improve the problem of CFO and efficiently improve symbol error rate (SER) performance of wireless communication systems.

KEYWORDS: *Least mean square error, CFO, GFDM, cyclic prefix.*

INTRODUCTION

GFDM is a filter multi-carrier bank. It is a non -orthogonal multicarrier modulation. A multi-carrier modulation technique called GFDM offers adjustable pulse shaping and uses closed-spaced non-orthogonal carrier1. The carrier frequency at the transmitter in a communication system does not match the carrier frequency at the receiver2. Figure 1 shows a block diagram of generalized frequency division multiplexing with carrier frequency offset estimation. A binary source generates the binary data that encodes the signal and mapped into the signal. GFDM modulator modulates the signal and then passes through the cyclic prefix (CP) 3-5. GFDM transmitter is a binary source that performs various operations and generates data in binary forms 1 and 0. This binary data (b) vector is fed into the encoder. The encoder takes binary data as input and splits a larger stream of bits into a smaller stream of bits. Its result encoded is fed into the mapper.

The figure depicts a modulator of GFDM, performing different operations on the data vector (d). The mapped data is divided into sub-carriers (k) with sub-symbols (M) each using a serial-to-parallel converter. Its d = [d_0 d_1.................d_{k-1}] and dk,m = [$d_{k,0}$ $d_{k,1}$................. d_{kM-1}]^T. It a number of subcarriers N=KM is the total number of symbols found in a GFDM block and dk,m is the amount of data transmitted on the kth sub-carrier and in the mth sub-symbol of the block. The signal passes through the wireless channel and CFO estimation. The CP is inserted at the end of its block after the transmitted signal has been modulated. Carrier frequency offset problem in transmission due to mismatch frequency between transmitter and receiver and doppler shift. From the received signal, CP is eliminated first. Intercarrier interference distorts a signal carried across a channel. It uses the LMS to recover the required signal by removing channel distortion. The QAM de-mapper uses the demodulated output from the QAM demapper as an input to perform the opposite of what the QAM mapper does. It changes the data symbols that were received into data bits. If there are no errors during the process, the output from the decoder is then considered the final data received, it is similar to the input data.

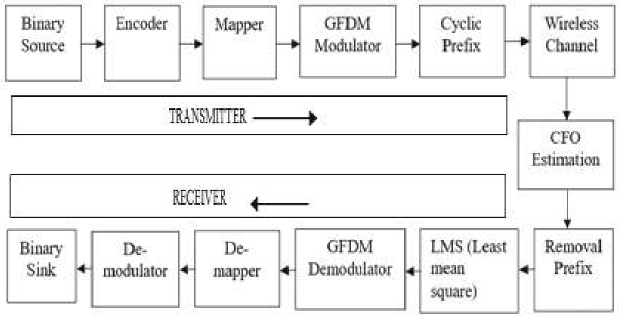


Fig. 1: Block Diagram of Generalized Frequency Division Multiplexing with carrier frequency offset

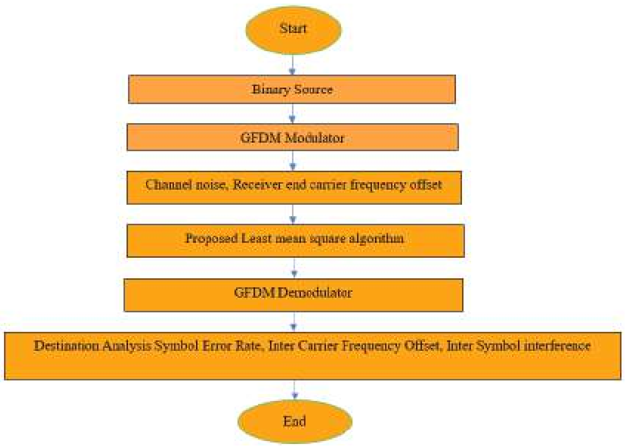


Fig. 2: Proposed Least Mean Square algorithm

In Figure 2 shown a binary source generates the binary data that maps into the signal and encodes to GFDM modulator and passes through the channel noise and carrier frequency offset, Intercarrier interference distorts a signal that is sent over a channel. Using the LMS, it eliminates channel distortion to recover the required signal.

Initially, this problem of symbol error rate, inter-carrier frequency offset, and inter-symbol interference is an optimization problem with multiple constraints. Specifically, the proposed least mean square algorithms are implemented for solving the optimization problem that helps determine the minimum symbol error rate as shown in Figure 2. The binary data that maps into the signal and encodes it is generated by a binary source. A binary source called GFDM transmitter generates data in binary forms. The encoder receives this binary data (b) vector as input. By splitting a larger stream of bits into smaller streams, the encoder divides binary data as input. The mapper receives its encoded result. The signal goes with the CFO estimation and wireless channel. A signal that is transmitted over a channel is distorted by intercarrier interference. It removes channel distortion using the LMS to recover the needed signal.

Carrier frequency offset and least mean square algorithm

The carrier frequency at the transmitter in a communication system does not match the carrier frequency at the receiver. This is referred to as carrier frequency offset. To detect the training sequence in the presence of a CFO, which is usually difficult to do using correlation with a known training sequence. After identifying the training sequence, the CFO will be estimated and corrected to get the proper symbols[6].

Carrier frequency offset (CFO) estimation considers a repetition of two training sequences7. Suppose there exists a carrier frequency offset (fe) for n=0 ....N_t, the first half of the received training sequence is

$$Y(n)= ej^{2\pi fenTs}t(n) \tag{1}$$

Where the symbol period is denoted by TS. Then, the second half of the received training sequence is

$$y(n+Nt)=e^{j2\pi fe(n+Nt)\ ts}t[n+Nt]$$

$$y(n+Nt)=e^{j2\pi f_e nt_s}\ y(n) \tag{2}$$

The least-square solution for α is

$$\alpha = \frac{\sum_{n=0}^{N_t-1} y^*[n]y[n+N_t]}{\sum_{n=0}^{N_t-1} y^*[n]y[n]} \tag{3}$$

Since we are only interested in its phase, the estimated CFO is

$$\hat{f}_e = \frac{Phase(\sum_{n=0}^{N_t-1} y^*[n]y[n+N_t])}{2\pi N_t T_S} \tag{4}$$

LEAST MEAN SQUARE (LMS)

The adaptive algorithm is also called LMS make advantage of the performance criterion value , as well as measurements of the input and desired signals, to modify the filter's parameters to improve its performance with respect to carrier frequency offset[7-10]. LMS algorithm has low complexity and a convergence environment[11-16]. The LMS is an adaptive filter that determines the LMS of the error signal difference between the desired and actual signals. The filter is only changed based on the current mistake in this stochastic gradient descent method[17-21]. Here R is denoted matrix by R^(k) and vector p denoted p^(k).

$$wo = R-1p \tag{5}$$

Wiener solution is denoted by

$$w(k+1)=w(k)-\mu\ \hat{}gw(k)$$

$$= w(k)+2\mu(p\hat{}(k) - R\hat{}(k)w(k)) \tag{6}$$

Where k=0,1,2……….. and ˆgw(k) an estimate of the gradient vector by employing instantaneous estimates for R and p indicate as

$$R\hat{}(k) = x(k)xT\ (k)\ p\hat{}(k) = d(k)x(k) \tag{7}$$

The resultant gradient estimate is represented by

$$\hat{}gw(k) = -2d(k)x(k)+2x(k)xT\ (k)w(k)$$

$$= 2x(k)(-d(k) + xT\ (k)w(k))$$

$$= -2e(k)x(k) \tag{8}$$

Here objective function is replaced by the instantaneous square error e2(k), instead of the minimum square error (MSE), the above gradient estimate represents the true gradient vector.

$$\frac{\partial e^2(k)}{\partial w} = \left[2e(k)\frac{\partial e(k)}{\partial w_0(k)}2e(k)\frac{\partial e(k)}{\partial w_1(k)}\ldots\ldots 2e(k)\frac{\partial e(k)}{\partial w_N(K)}\right]^T$$

$$= -2e(k)x(k)$$

$$= g\hat{w}(k) \tag{9}$$

The resulting gradient-based algorithm is known as least mean square algorithm

$$w(k+1)=w(k)+2\mu e(k)x(k) \tag{10}$$

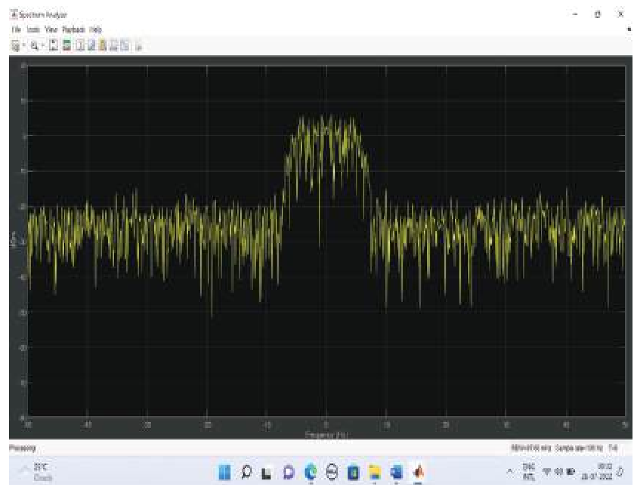
Here μ is denoted by the coverage factor and X(k) is denoted by delay line input.

RESULT AND DISCUSSION

The outcome and simulation results were obtained by using the software MATLAB 2019. LMS algorithms are used in the GFDM. The results of the SER are determined using the AWGN channel, Rayleigh fading, and different roll-off factor values. The signal passes through also carrier frequency offset. Using MATLAB 2019, the simulation result was achieved.

Table 1: Different Input parameters of the GFDM Model with carrier frequency offset

Parameter	Value
Sub-symbols	2
Sub-carriers	4
Mapping	BPSK
Roll off factor	0.2

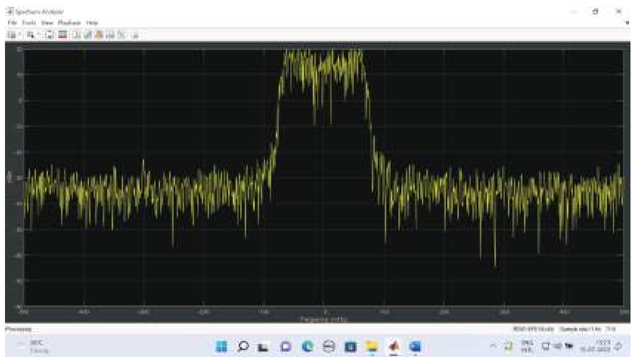


Graph 1: GFDM Spectrum transmit signal with carrier frequency offset with BPSK

The modulation technique is used a binary phase-shifting key. A raised cosine filter and least mean square are used to improve the performance. The following input parameter is shown in table 2. The signal is transmitted through AWGN channel, Rayleigh fading channel and carrier frequency offset. In this case, the achieved symbol error rate (SER) performance is an improved result as shown in graph number 1.

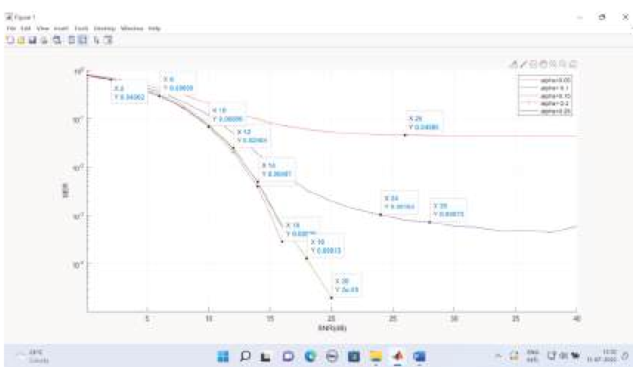
Table 2: Input Parameter spectrum analysis of GFDM on carrier frequency offset

Parameter	Value
Sub-symbols	64
Sub-carriers	4
Mapping	QAM
Channel	AWGN, Rayleigh fading channel
Roll-off factor	0.05:0.05:0.25



Graph 2: GFDM spectrum transmit signal on carrier frequency offset with QAM

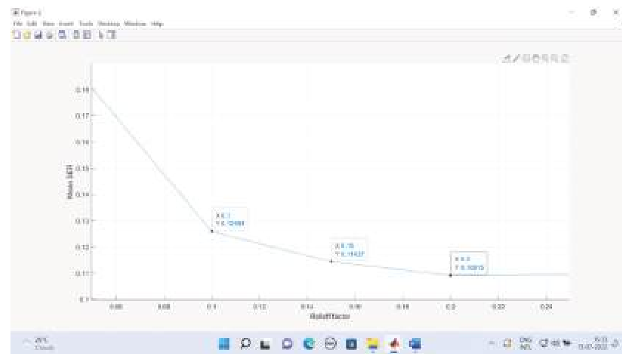
The graph 2 shows the Spectrum analysis of the GFDM system. A raised cosine filter and least mean square is used to improve the performance. 64 symbols were used, and 4 subcarriers were used. It employs quadrature amplitude modulation as shown in table 2. The signal is passed through the AWGN channel, Rayleigh channel and carrier frequency offset. It gets improved results.



Graph 3: Graph between symbol error rate and signal to noise

The SNR ratio on the x-axis and SER on the y-axis. Different roll-off factors of 0.05, 0.1, 0.15, 0.2, and 0.25 are employed in the transmitter when using the modulation technique known as QAM. The signal is then passes through an AWGN, Rayleigh channel and CFO. The cosine filter and least mean square are used at the receiver end to enhance result as shown in graph 3. The output shows an enhance result at the SNR ratio 20 and here obtained SER is 0.00002.

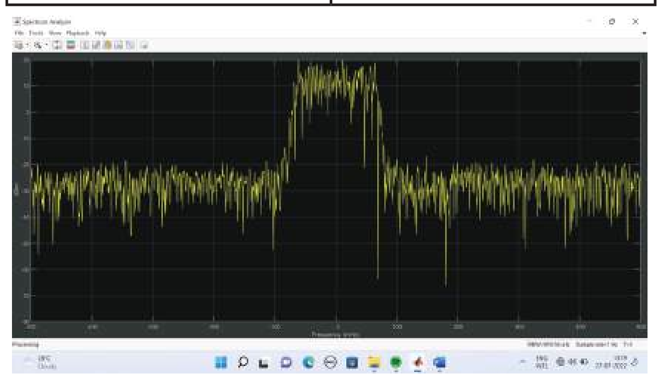
Graph 4 shows the roll-off factor at the x-axis and SER at the y-axis. Quadrature Amplitude modulation is used at the transmitter. Signal is then transmitted through AWGN, rayleigh channel and a carrier frequency offset. Raised Cosine Filter and Least Mean Square are employed at the receiver end to improve output results. The outcome shows an improvement at an SNR of 0.2, and the achieved SER is 0.109.



Graph 4: Output result Mean SER between roll-off factor with carrier frequency offset in GFDM

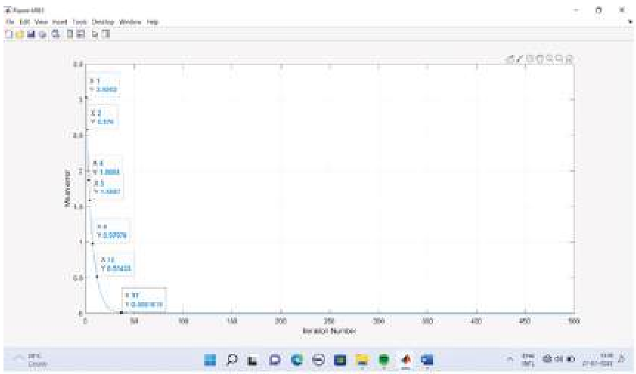
Table 3: Analysis of the GFDM simulation parameter spectrum model QAM With carrier frequency offset

Parameter	Value
Sub-symbols	16
Sub-carriers	4
Mapping	Quadrature amplitude modulation
Channel	AWGN, Rayleigh channel
Roll-off factor	0.05:0.05:0.25



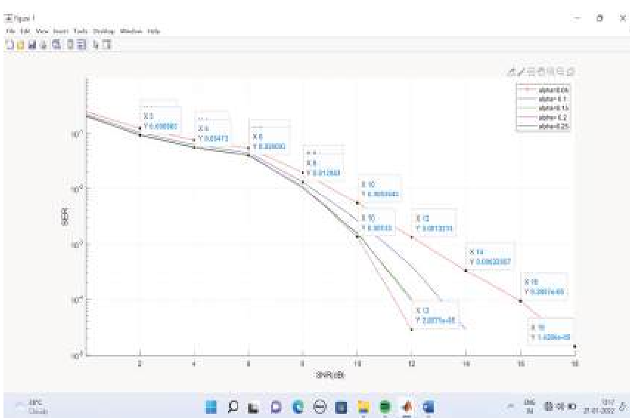
Graph 5: GFDM transmit signal spectrum analysis with carrier frequency offset

In Graph 5 indicate GFDM transmit signal spectrum analysis with carrier frequency offset. The modulation technique is used Quadrature amplitude modulation.16 symbols were used and 4 subcarriers were used, and the 0.25. roll of a factor was used as shown in table 3. The signal is transmitted through the AWGN channel and rayleigh channel and carrier frequency offset. Raised cosine filter and least mean square are used to enhance result. It achieved improvement result



Graph 6: Mean error Versus iteration number with carrier frequency offset in GFDM

Graph 6 shows the iteration number represented at the x-axis and the mean error represented at the y-axis. At the transmitter, QAM is employed with various roll-off factors of 0.05, 0.1, 0.15, 0.2, and 0.25. The signal is then transmitted through AWGN and a carrier frequency offset. Raised Cosine Filter and Least Mean Square are employed at the receiver end to enhance performance. The result shows an improvement at a SNR of 37, and the symbol error rate here is achieved is 0.00916.



Graph 7: SER between SNR ratio with carrier frequency offset in GFDM

Graph 7 shows SNR at x -axis and y axis represents SER. QAM is used at the transmitter. Then the signal is passes through an AWGN channel, Rayleigh channel and carrier frequency offset. At the output end raised cosine filter and least mean square is used to improve the performance. The result indicates improvement result at the SNR is 18 and here obtained SER is 0.00001.

Table 4: Result comparison table between the earlier method and the present method

Result by earlier method (SER)	Reference	SNR	Result by present
Method			
(SER)			
0.3	[22]	6	0.2
0.08	[23]	12	0.02
0.06	[24]	10	0.05

Table 4 represents result comparison table between the earlier method and the present method. the x-axis shows the signal-to-noise ratio and the y-axis represents the symbol error rate. When the signal-to-noise ratio is 6 get an error rate of 0.3 in the earlier method and an error rate of 0.2 in the present method. When signal to noise ratio is 12 and get an error rate of 0.08 in the earlier method and 0.02 in the present method. when signal to noise ratio is 10 and the error rate is 0.06 in the earlier method and signal to noise ratio is 10, the error rate is 0.05 in the present method. It concludes that spectrum analysis gets improved result.

CONCLUSION

The LMS algorithm is used in this paper to perform a thorough analysis of the spectrum analysis, roll-off factor, carrier frequency offset, SER, and SNR analysis. In addition to the number of sub-symbols, subcarrier, roll-off factor, and mapping of the modulation technique, channel types such as AWGN,rayleigh channel and carrier frequency offset. Results of simulations for spectrum analysis and various rolls of a factor with carrier frequency offset are reported. Carrier frequency offsets are used to improve the performance of SER. The overall research effort made a significant contribution to the carrier frequency offset and least mean square algorithm. This study's findings will aid in the quality enhancement and error reduction of spectrum analysis and the various roll-off factor test results with SER.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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Optimizing Process Parameters in Sand Casting for Enhanced Microhardness of Al-6063 Alloy: A Taguchi Method Approach

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ABSTRACT

This article discusses the importance of specific process parameters in determining the microhardness of Al-6063 alloy during sand casting. Sand casting is a versatile manufacturing process that allows for the creation of components of different shapes, sizes, and quantities. The process involves complex elements such as patterns, risers, runners, gating, design considerations, and casting allowances. This study focuses on how pouring temperature, green sand condition, and vent hole system affect the casting process. Using the Taguchi method and an L9 orthogonal array, the study optimizes melting temperature, pouring time, and cavity fill time process parameters. The results show that melting temperature and pouring time significantly impact microhardness, while cavity hold time has a minor effect. With these parameters, a regression equation can predict microhardness. This research highlights the importance of optimizing process parameters to achieve optimal mechanical properties and enhance material performance in sand casting.

KEYWORDS: *Casting, Microhardness, Taguchi method, S/N ratio, Regression equation.*

INTRODUCTION

Casting Process

Casting is outstanding amongst other assembling cycles, and it gives the furthermost freedom of plan as far as size, shape and the item amount where fluid metal is apportioned into a form hole.

The sand casting measure incorporates, for example, riser and sprinter, gating, plan thought and casting remittance. schematic outline of the casting mold is demonstrated in Figure 1.

The pattern is a copy of the genuine piece of form cavity. It is made of wood and, at some point, different metals. The cavity is encased in a joined shape box, particularly Cope and Drag. The lower half of the case is known as Drag which is loaded up with sand to make the shape cavity and gating framework. The upper portion of the container is known as adapt and is loaded with sand to make the sprue bowl, sprue pin, and riser. The splitting line with dry sand isolates the adapt and drag. The adept is eliminated from the drag, and the example is taken out without the harm of shape depression.

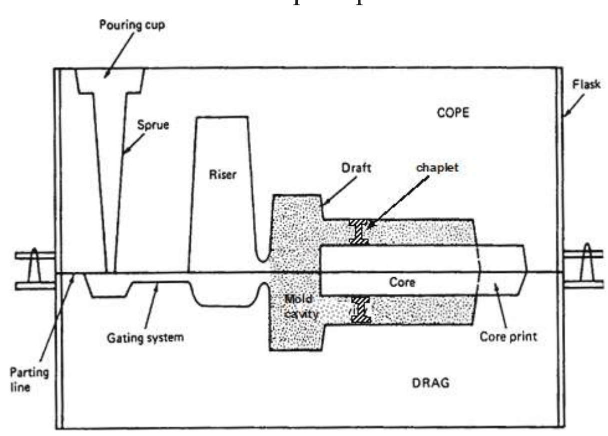

Fig. 1. Line diagram of working of sand casting [1]

The vent opening is made on the top surface of the adept. It ought not to upset the shape pit and gating framework. The motivation behind vent opening is to get away from the air/gases to the air. It likewise assists with moving the warmth from the shape depression.

The number of vent openings and the width of vent openings are significant boundaries in casting measure. The following parameters govern the casting process. They are

- Pouring temperature
- Green sand condition
- Vent hole system [2,3,4].

Yadav et al. [5] conducted a study to explore the influence of various process parameters on the surface roughness of aluminum alloy A713. They manipulated factors such as wax composition, binders, firing and pouring temperatures, and assessed their effects on surface roughness. The study aimed to optimize these parameters to achieve minimal surface roughness. Through surface roughness measurements and the Taguchi method with ANOVA analysis, the researchers determined the significance of wax composition while finding the binders' impact negligible. The study provided optimized values for the process parameters to attain optimal surface finish. Bhardwaj et al. [6] focused on elucidating the impact of distinct process parameters on the mechanical properties of sand castings made from aluminum alloy A713. They investigated grain fineness number, moisture content, green strength, and clay content as input variables. Using the Taguchi optimization technique, the researchers fine-tuned these parameters to optimize the castings' tensile strength, hardness, and impact strength. Their findings revealed trends in hardness and impact strength concerning grain fineness number and moisture content. Moreover, they observed how clay content and green strength had limited effects on impact strength, while tensile strength exhibited sensitivity to grain fineness number, green strength, and moisture content. Huang et al. [7] delved into the effects of heat treatment conditions on cast Cr-Ni-Mo-V alloys to enhance mechanical properties and structural consistency. Liang et al. [8] explored the impact of copper and magnesium on microstructure and wear resistance in Al-Si alloys. They found that the clustering of Si and Mg2Si particles improved wear resistance. Lu et al. [9] introduced electromagnetic twin-roll casting (ETRC) to refine the microstructure and properties of Al-Li alloy. Wan et al. [10] investigated optimal heat treatment conditions for aluminum alloy casting molds. Oza and Patel [11] utilized vortex-free fast mix casting for Al-Si-Al2O3 composites to enhance mechanical properties and reduce porosity. Rashad et al. [12] analyzed building materials for AA6061 composites, focusing on tribological and mechanical performance. Roussel et al. [13] compared the properties of Al 7075 alloys produced through different casting methods, highlighting improved fatigue resistance in twin-roll strip casting. Saikaew and Wiengwiset [14] studied the microstructure and crack behavior in Al-10 wt%Si composite castings, revealing the influence of convection and rapid solidification on material properties. Together, these studies contribute valuable insights into alloy composition, casting techniques, heat treatment, and their effects on various metallic materials' mechanical and wear properties, thereby offering guidance for optimizing manufacturing processes and enhancing material performance.

The present study aims to ascertain the role of distinct process parameters in influencing the microhardness of Al-6063 alloy. The parameters of interest encompass melting temperature, pouring time, and cavity fill time, with the Taguchi method employed to determine their optimized values for the desired outcomes.

MATERIALS AND METHODS

Material

For the current research, the chosen material was used for the investigation on casting. This decision was made after conducting a local market survey and reviewing relevant literature.

Aluminum-Alloy- Al-6063

The material presented here has been cast using the sand casting process, a common method for engineering applications. Al-based products are often casted using this process. The melting point temperature of aluminum (Al) ranges from 650 to 700 degrees Celsius, depending on the type of alloy used. Aluminum alloys have a lower melting temperature, making them suitable for sand-casting. Tables1,2 and 3 shows the respective chemical, thermal and mechanical properties of Al6063.

Table 1. Chemical properties of Al-6063

Element	Mg	Fe	Cu	Cr	Mn	Al
%	0.55	0.27	0.11	0.13	0.11	Balance

Table 2. Thermal properties of Al-6063

Material	Melting Point	Thermal Conductivity	Sp Heat Capacity
Al-6063	650-720	97.12	0.91

Table 3. Mechanical properties of Al-6063

Material	Density (g/cm3)	Tensile Strength (MPA)	Hardness (BHN)
Al-6063	2.77	236	67-76

Selection of Process Parameters

The selection of process parameters and levels as shown in table 4 for sand casting of Al6063 alloy involves optimizing variables such as Molten temperature, pouring time, and cavity hold time. These parameters affect solidification, microstructure, and mechanical properties. By carefully adjusting these factors, the casting process aims to achieve desirable grain structure, minimize defects, and enhance mechanical integrity, ensuring high-quality Al6063 castings with optimal properties. In the current study, the "Taguchi method," a design of experiment technique, has been employed. Nine experiments have been systematically designed and generated using the L9 orthogonal array (OA) to facilitate investigation [15].

TABLE 4. FACTOR AND LEVELS

Factor	I	II	III
Molten Temperature (MT)(^{0}C)	700	750	800
Pouring Time (PT)(Sec.)	15	20	25
Cavity Holding Time (CHT) (Sec.)	20	30	40

The orthogonal array table 5 is designed to explore the effects of different parameter settings on a process with three factors and three levels each. It presents various experimental combinations systematically in a matrix-based approach, which minimizes the number of experiments needed. Each table row represents a unique experimental condition, allowing for comprehensive analysis to determine the optimal process parameter combinations and their influence on the desired outcomes.

Table 5. Experimental Orthogonal Array

Run	MT(oC)	PT(Sec.)	CHT(Sec.)
1	700	15	20
2	700	20	30
3	700	25	40
4	750	15	30
5	750	20	40
6	750	25	20
7	800	15	40
8	800	20	20
9	800	25	30

Fabrication of Al6063 According to L9 OA

The process of creating Al-6063 using sand casting started with preparing the material. Aluminum was locally sourced and cut to size. The pieces were placed in the furnace, and the temperature was adjusted to fit the experiment's needs. The melting phase, lasting 2-3 hours, played a crucial role. Subsequently, attention shifted to the sand casting process, which is integral to the study. All necessary casting procedures were carefully arranged as per figure 2, and the green sand mix was optimized for quality. Ensuring pure molten metal posed a challenge due to raw material impurities, demanding thorough purification for a clean molten state. In the final step, cooling rates and boundary conditions were meticulously recorded in alignment with experiment specifications (process parameters). This methodology offers an insightful exploration of Al-6063 fabrication using the sand-casting technique [16].

Fig. 2. The casting of Al6063 According to L9 OA

RESULTS AND DISCUSSIONS

Table 6 displays the specific outcomes of all 9 experiments concerning the response variable microhardness, denoting the surface hardness of casted Al6063. The analysis in this experimental configuration has adopted the "larger is Better" signal-to-noise (S/N) ratio criterion for assessment [17,18]. In Figure 3, the result is shown for the response setting. This indicates that the S/N ratio can assist in determining the best solution for the specific response variable.

Table 6. Signal-to-noise ratio analysis for MH

Run	MT (^{0}C)	PT (Sec.)	CHT (Sec.)	MH (BHN)	S/N ratio
1	700	15	20	68	36.6502
2	700	20	30	69	36.7770
3	700	25	40	71	37.0252
4	750	15	30	72	37.1466
5	750	20	40	70	36.9020
6	750	25	20	74	37.3846
7	800	15	40	73	37.2665
8	800	20	20	72	37.1466
9	800	25	30	74	37.3846

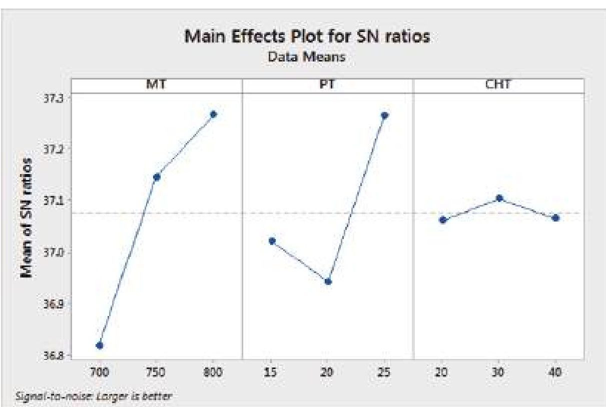

Fig. 3. Signal-to-Noise Ratio analysis for MH

Table 7. Response table for MH

Level	MT(^{0}C)	PT(Sec.)	CHT(Sec.)
1	36.82	37.02	37.06
2	37.14	36.94	37.10
3	37.27	37.26	37.06
Delta	0.45	0.32	0.04
Rank	1	2	3

The data in Table 7 shows the varying responses of the different variables, with higher ranks given to those with greater variability. The delta value determined the ranking, with higher values resulting in higher ranks. When it came to peak microhardness, MT was found to be the best, followed by PT and CHT. This is because sand casting benefits from higher melting temperatures and longer pouring times, improving the workpiece's surface quality.

Regression Modeling for Micro Hardness(MH)

ANOVA is a statistical method used to determine the significance of primary components and their interactions. This is achieved by comparing the mean squares with the estimated experimental errors at specific confidence levels. ANOVA also helps quantify parameter contributions and identify their percentage [19]. Analysis of variance for microhardness has been carried out at 95% confidence level. The ANOVA table 8 elucidates the influence of distinct factors on microhardness in cast Al6063 alloy. The "Regression" segment exhibits collective moderate statistical significance ($F = 4.34$, $p = 0.074$). "MT" (melting temperature) significantly affects microhardness, with a higher F-value (10.03) and lower p-value (0.025). "PT" (pouring time) moderately influences microhardness ($F = 2.98$, $p = 0.145$). In contrast, "CHT" (cavity hold time) lacks significance ($F = 0.00$, $p = 1.000$). The "Error" term accounts for unexplained microhardness variability. Overall, "MT" and "PT" significantly impact microhardness, while "CHT" has a minor influence.

Residual plots for microhardness provide insight into model validity.

The figure 4 shows that predicted values closely align with the observed data, signifying a strong correlation between the chosen factors and microhardness response.

Table 8. Analysis of variance analysis for MH

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	26.1667	8.7222	4.34	0.074
MT	1	20.1667	20.1667	10.03	0.025
PT	1	6.0000	6.0000	2.98	0.145
CHT	1	0.0000	0.0000	0.00	1.000
Error	5	10.0556	2.0111		
Total	8	36.2222			

Regression Equation

MH= 39.94+0.0367 MT + 0.200 PT + 0.0000 CHT

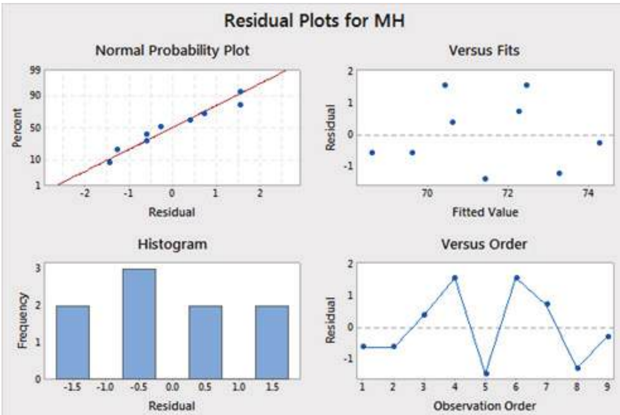

Fig. 4. Residual plot for MH

Table 9. Model Summary for MH

S	R-sq	R-sq(adj)	R-sq(pred)
1.41814	72.24%	55.58%	18.13%

The summary of the model (table 9) contains important metrics that assess its explanatory and predictive capabilities. The R-squared value of 72.24% shows the extent to which the microhardness variability is explained. The adjusted R-squared value of 55.58% considers the number of predictors for model fitting. Additionally, the predictive R-squared value of 18.13% measures the accuracy of future microhardness forecasting. Overall, these metrics provide a comprehensive evaluation of the model's performance.

CONCLUSION

In conclusion, this study has explored the influence of distinct process parameters in shaping the microhardness of Al-6063 alloy through the sand casting process. The Taguchi method, supported by ANOVA analysis, was employed to systematically optimize melting temperature, pouring time, and cavity hold time. The results revealed that melting temperature (MT) and pouring time (PT) significantly influence microhardness, while cavity hold time (CHT) exhibited minimal impact. The regression equation, MH = 39.94 + 0.0367 MT + 0.200 PT + 0.0000 CHT, provides a predictive tool for microhardness based on these factors. The model's R-squared (72.24%) indicates strong microhardness predictability, while adjusted (55.58%) and predictive (18.13%) values offer nuanced insights. The high R-squared values indicate the model's ability to explain and predict microhardness variations. This research contributes to the optimization of casting processes, enabling the production of Al-6063 castings with enhanced mechanical properties and performance.

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CONFLICT OF INTEREST

The authors state that financial conflicts or personal relationships have not affected their work in this paper.

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A Review on Investigation of Layered Composite Sandwich Structure under Static and Dynamic Loading Conditions

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ABSTRACT

The laminated sandwich structure has high-performance structural composite, promising excellent specific energy absorption capabilities, lightweight and high strength-to-weight ratio. Multilayer composite sandwich constructions exhibit two external face sheets and an intermediate core material. Different shaped cutouts made of laminated composite materials are provided in plate-like structural components for construction are supplied as a fundamental element for building purposes. The various categories, such as static, dynamic, transient vibration, buckling, post buckling has been incorporated for evaluating Composite materials with layers and sandwiched structures. The benefits of employing composite sandwich constructions in engineering applications are also highlighted here. Here we present an overview of the material properties, various analytical techniques, including finite element analysis, analytical models, and experimental tests, adopted for the performance of structures in both static and dynamic conditions is examined, encompassing advantages and disadvantages.

This review paper offers researchers with broader recommendations for developing and fabricating next-generation multilayer core sandwich structures.

KEYWORDS: *Analytical models, Finite elements, Multilayer composite sandwich constructions, Static and dynamic behaviour.*

INTRODUCTION

The layered composite sandwich constructions have gained popularity for a variety of applications, due to distinctive mix of strength, rigidity, and weight characteristics. The stiffness, strength, and damping of the layers must be taken into account while designing a multilayer composite sandwich structure. Ensuring the structural stability and performance demands a thorough examination of how the multilayer composite sandwich like structure behaves when subjected to both static and dynamic loads. In poly material moisture and thermal characteristics are different for various geometry, laminated plates are frequently regarded as complicated constructions when structures experience consistent temperature variations and uneven moisture distribution, conventional laminated plate theory can be employed to accurately calculate the stress components linked to temperature fluctuations.

Composite sandwich constructions are valued for their exceptional mechanical properties, making them a common choice across a range of engineering applications because of its lightweight nature and impressive ratio of stiffness to weight. The face sheets are often made of metal or fiber - reinforced polymer, whereas the core material is frequently formed of foam or honeycomb (FRP). The three pieces are adhered together to form a single laminate structure.

The review focuses on experimental techniques and finite element analysis (FEA) used to assess the structural behaviour of composite. These constructions consist of a pair of face sheets and a core material which can encompass foam, honeycomb, balsa wood, metal, and fiber-reinforced composite materials. The analysis of these structures behaviour under both static and dynamic loading situations is a difficult process, due to its complicated nature. This research provides a comprehensive review of numerous analytical methods employed to study the behaviour of multilayer composite sandwich like structures under both static and dynamic loading conditions.

The review focuses on the employment of advanced computational techniques including topology optimization as well as optimization considering multiple objectives classical and finite element approaches. Each technique's benefits and drawbacks are examined, and a research outlook is also provided. This study conducts a thorough examination of the impacts of various factors on the structural performance of sandwich constructions, encompassing material properties, loading conditions, and geometric parameters.

This study encompasses various theories and models for analyzing the behavior of composite structures.

LITERATURE REVIEW

This literature review focuses on the assessment of laminated composites and sandwich like structures under both static and dynamic loading conditions. It further delves into subcategories that explore their behaviour under both static and dynamic circumstances.

Noteworthy Contribution

In the field of composite layer structure analysis Jian-Ping Lin et. al 2022 has brief out the core engineering composite structure analysis based on static and dynamic behaviour. He presents analytical as well as practical analysis of static and dynamic stiffness for composite structure incorporation with finite-element (FE) expressions (locking phenomenon, global behaviour with distinct material properties), Timoshenko's beam theory, Variational method. He summarised finite-element (FE) framework is boon for three-layered composite beams investigation in various perspective.

In a study conducted by Aman Garg et. al (2019), an investigation into the material properties and behaviors of laminated composites and sandwich like structures were carried out. The study particularly emphasizes the impact of varying conditions, especially thermal and moisture effects. The analysis encompasses a range of aspects, including static, dynamic, buckling, post-buckling, vibration analysis and transient studies. The research emphasizes the impact of temperature and humidity variations on the structural integrity of composites.

Table 1 Impact of temperature and humidity variation on laminated composites.

Temperature & Humidity	Increase	Unequal expansion/ contraction of layers due to Residual stresses. Decrease in strength of composites due to a weak connection between matrix and fibres. Restriction in free movement in laminates.
strength and stiffness	Reduce	

A study conducted by A. K. Noor et al. focuses on multi-layered composite materials, examining how changes in lamination, geometric parameters, and boundary conditions affect the system. The study identifies and presents five distinct modelling approaches. The research culminates in a comprehensive comparison involving 2-D and 3-D models, boundary conditions, and stress analysis techniques.

Displacement-based theories are frequently employed to analyze layered composite sandwich structures when exposed to hygrothermal conditions. This approach can be categorized as ESL, LW, ZZ etc.

These theories exhibit variations in their consideration of transverse shear stresses, which significantly contribute to predicting laminate behavior. The theory of Classical Lamination (CLT) is grounded in plate theory of Kirchhoff-Love's. In the context of analyzing sandwich structures under hygrothermal conditions, several literature sources explore methods like Navier's approach, Finite Element Method (FEM) and Rayleigh-Ritz method.

Researchers such as Wang et al. employ a complex boundary integral method to assess stress fields in infinite plates featuring multiple circular holes. E.

Muskhelishvili addresses elasticity theory challenges through the utilization of a complex variable method. Multiple techniques have been introduced by various researchers to estimate stresses around cutouts in plates. Notably, Chen et al. employ a specialized finite element method to analyze stress concentration around holes in infinite plates.

This review focuses on the evaluation of multilayer composite sandwich constructions when applied with both static and dynamic loading scenarios. The core of this assessment lies in the exploration of layered composite sandwich structures which exhibits adhesive layers, face sheets, and core materials. The foundation for this review draws from the collective insights gleaned from various research studies. The static behaviour of multilayer composite sandwich structures, including their static strength, stiffness, buckling, and failure analysis, is examined by Li et al. (2016). The dynamical approach of multilayer composite sandwich structures is covered in the second section along with topics like dynamic buckling and fatigue analysis (Garg et al.2019). The paper also discusses potential future research areas and compares several numerical methods for analysing multilayer composite sandwich constructions.

Table 2: Summary of static loading analysis

Static Loading	Materials	Sandwich Structure	Method used	Result
Tension	Composite	Symmetric	Finite element analysis (FEA)	Stress distribution in the layers of the sandwich structure
Compression				
Bending				

The literature has a strong foundation for the static behaviour of multilayer composite sandwich constructions. According to studies, the rigidity of the sandwich's face sheets, adhesive layers, and core material all affect the sandwich's static strength (Khoshgoftar et al.2020). A layered composite sandwich structure's stiffness is also influenced by the materials used for the face sheets and core. Studies have shown that the core material, face sheets, and adhesive properties play a significant role in buckling of layered composite sandwich structures (Md Shah et al.2021). The critical failure mode is typically a combination of buckling and delamination, according to failure analysis of multilayer composite sandwich structures.

Many investigations have concentrated on the dynamic performance of multilayer composite sandwich structures. Research has indicated that the core material, face sheets, and adhesive layers play a crucial role in the static and dynamic behavior of a multilayer composite sandwich structure (Redmann et al. 2021). The core material, face sheets, and adhesive material properties of layered composite sandwich constructions play a significant role in dynamic buckling as well. The fatigue life of a layered composite sandwich structure is closely correlated with the fatigue strength of its core material, face sheets, and adhesive layers, according to fatigue analysis of layered composite sandwich structures.

The purpose is to give a summary of the current methods and to talk about the difficulties and possibilities for further study. The review focuses on numerical and experimental methods for analysing sandwich constructions made of layered composite materials (Chowdhary et al. 2021). The benefits and drawbacks of various methods are also covered, along with several potential areas for further study. Layered composite sandwich structures have become a popular choice for many engineering applications because of its superior mechanical, thermal, and acoustic properties. In recent times, there has been a notable surge of interest in the scientific literature regarding the examination of layered composite sandwich structures.

This review article discusses the study of sandwich constructions made of layered composite materials subjected to static and dynamic loads. In order to assess the structural behaviour of these constructions, the paper focuses on experimental techniques and finite element analysis (FEA) (Li et al. 2021). The article also conducts a literature assessment on the impact of several factors, including material characteristics, loading scenarios, and geometrical parameters, on the structural behaviour of sandwich constructions. The report also covers the advantages and limits of the current sandwich structure analysis approaches.

Kumar et al. (2019) Studies on static and dynamic performance of sandwich structures made of layered composite like materials should concentrate on creating more precise numerical methods and models for their analysis. Studies should also take into account how external factors, such as temperature and humidity, affect the multilayer composite sandwich structures' static and dynamic behaviour (Palomba et al. 2019). In future research, It is crucial to investigate how various manufacturing techniques affect the static and dynamic characteristics of layered composite sandwich structures.

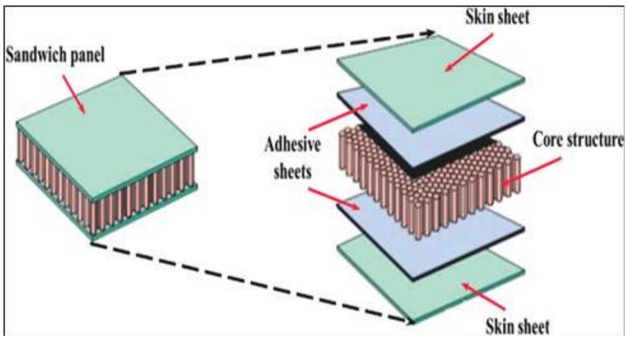

Fig. 1: Sandwich Panel dissection view of layers
Source: (Novak et al.2019, P.56)

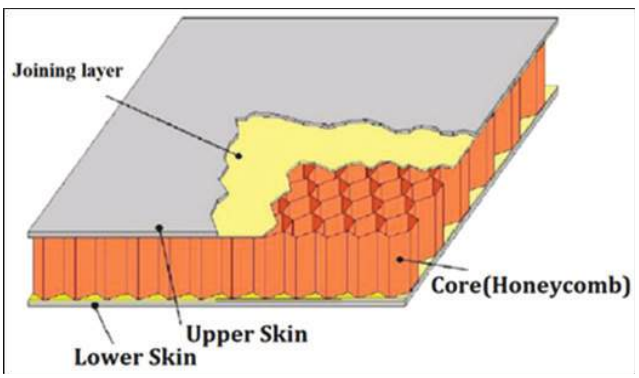

Fig. 2: Joining layer of Lower and upper skin of multilayer composite sandwich constructions (Zhang et al.2020, p.90)

These structures find widespread application in numerous industries because of its remarkable attributes such as high strength-to-weight ratio, low density, stiffness, and energy absorption capabilities. Two thin face sheets plus a core material—typically constructed of foam or honeycomb—make up this kind of structure. In this paper we discuss about the multilayer composite sandwich structures under both static and dynamic loading scenarios. Typical uses of static loading conditions include civil engineering and aircraft (Mazaev et al.2021). To assess the strength and stiffness of these kinds of structures, measurement of the static response is crucial. The static behaviour of layered composite sandwich constructions has been investigated using a variety of numerical and experimental techniques. According to Tewari et al. (2022) Finite element analysis, energy methods, experimental testing, and analytical approaches are some of these techniques. The static behaviour of multilayer composite sandwich constructions is reliant on the material characteristics of the face sheets and central core, according to numerical and experimental data.

Due to their distinctive mix of strength, rigidity, and weight efficiency, layered composite sandwich constructions have gained popularity with variety of applications, including aerospace, automotive, medical and maritime (Onyibo et al.2022). To assure structural integrity and performance, a comprehensive analysis on behaviour of the multilayer composite sandwich like structure under both static and dynamic loading conditions is required.

This review paper aims to offer a succinct summary of present methodologies while delving into the challenges and potential directions for future research. The review focuses on numerical and experimental methods for analysing sandwich constructions made of layered composite materials (Sabah et al. 2019).

Conversely, dynamic loading scenarios are frequently harnessed in applications within the automotive and aerospace sectors. In evaluating the dynamic stability and fatigue longevity of multilayer composite sandwich structures, dynamic analysis emerges as pivotal. The exploration of dynamic responses in these structures has been pursued through a spectrum of numerical and experimental methods, encompassing analytical approaches, dynamic testing, and finite element analysis as evidenced by Han et al. (2022).

The dynamic performance of multilayer composite sandwich constructions is intricately tied to the substance characteristics of the face sheets and central core, in addition to the dynamic loading conditions, as supported by both numerical simulations and empirical investigations. This review encompasses an analysis of loading conditions affecting multilayer composite sandwich like structures subjected to both static and dynamic stresses, as explored in the study by Bergmayr et al. (2020). Notably, the behaviour of multilayer composite sandwich constructions is underpinned by the interplay of material attributes in the face sheets and central core, along with the prevailing loading conditions, substantiated by data from numerical simulations and practical experiments.

Sandwich structures have seen increased use in a vast range of applications in recent years because of their good strength-to-weight ratio, high stiffness, and low price. Two rigid, thin facial skins are joined by a light core to form this kind of construction. Applications for sandwich structures include the medical, aerospace, automotive, and naval fields. However, due to the complexity of layered composite sandwich structure, it might be difficult to analyse these structures. In-depth research has been done in the journals on both the static and dynamic investigation of multilayer composite sandwich like constructions (Xiong et al.2019). To forecast the static and dynamic characteristics of sandwich like structures under varied loading circumstances, a number of analytical models have been created.

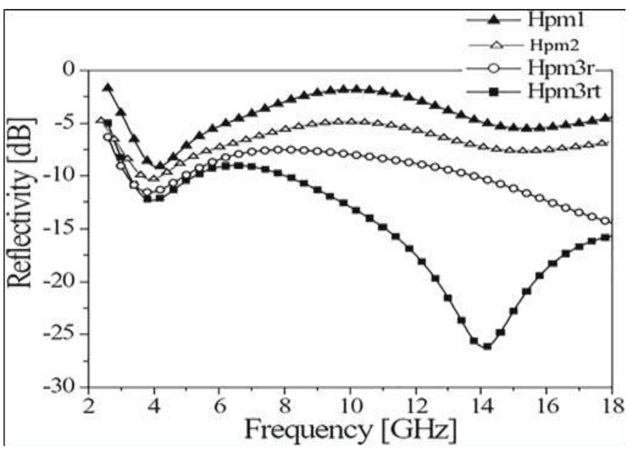

Fig. 3: Frequency and reflectivity of multilayer
Source: (Onyibo et al. 2022, p.102)

Exact and approximate techniques are two categories into which these models can be divided. The Boundary Element Method and the Finite Element Method (FEM) are examples of precise approaches (BEM). On the contrary, approximation techniques rely on analytical or semi-analytical procedures. The sandwich construction is modelled as a compilation of separate pieces using the FEM technique. By adding the proper boundary conditions, the equilibrium equations are solved (Wang et al.2021).

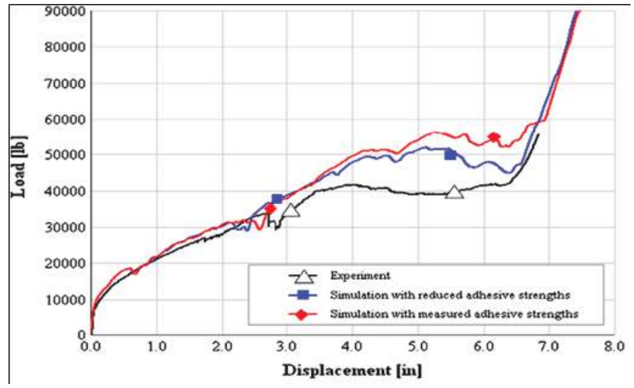

Fig. 4: Displacement in various loads composite sandwich constructions in the sandwich construction
Source: (Wu et al. 2021, p. 89)

The behaviour of sandwich constructions under varied loading conditions can be correctly predicted by FEM models. The basis of the BEM method lies in solving a set of integral equations derived from the virtual work principle.

Exact and approximate techniques are two categories into which these models can be divided. However, the size of the mesh and the quantity of elements employed affect how accurate the FEM is.

Table 3: Summarised result of static loading conditions for layered composite sandwich structures

Static Loading Condition	Result
Compressive Loading	Core crushing
Shear Loading	Core shear failure
Tensile Loading	Core tensile failure
Bending Loading	Core shear and tensile failure

Over the past years, the utilization of composite sandwich constructions has surged across various domains like civil engineering, automotive, and aerospace. These sandwich structures, composed of composite materials, offer a plethora of advantages such as reduced weight, remarkable stiffness-to-weight ratio, enhanced strength-to-weight ratio, and heightened structural dependability. Nonetheless, attaining an optimal design necessitates a comprehensive exploration of the intricate structural responses exhibited by these systems when subjected to static and dynamic stress conditions, as emphasized in the study by Amir et al. (2021). The literature review discusses the many analytical approaches, including as analytical beam theory, finite element analysis, and others, that are used to analyse composite sandwich structures (Ren et al.2020). He discussed how different boundary conditions, including contact theory, boundary element method, and other approaches, were used in his analysis. Additionally included in the review are the various loading situations used in the analysis, including static, dynamic, and crash loading (Chen et al. 2019).

This literature review centers on the examination of multilayer composite sandwich constructions, particularly under the influence of both static and dynamic loading scenarios, as highlighted in the work by Sofiyev et al. (2019). Applications for composite sandwich constructions span from automotive to aerospace. In contrast to conventional materials, they offer greater rigidity and strength while having the unusual capacity to absorb tremendous energy. Therefore, it's crucial to comprehend how these structures behave under static and dynamic loads (Arumugam et al.2019).

The aim of this paper is to provide an extensive overview of studies focused on layered composite sandwich structures under both static and dynamic loading conditions. Specifically, this review zeroes in on the utilization of finite element analysis (FEA) for evaluating these structures and aligns the findings with corresponding experimental outcomes, as elucidated by Sánchez et al. (2020). The review covers the major topics, including the material properties, the theoretical models, the FEA techniques, and the experimental results. Finally, the review discusses the current challenges and future research possibilities in the field.

The principles of the analysis process, numerical techniques for analysis, and the outcomes of static and dynamic loading studies are just a few of the subjects covered in this review, which gives an overview of the body of research that has been done in this field (Zhang and Tan 2020). It takes a lot of work to analyse layered composite sandwich constructions under static and dynamic loading conditions. Determining the material qualities is the most crucial step in the analysis. These characteristics are influenced by the material employed and the structure's geometry (Shi et al.2022). For the purpose of investigating the material properties of layered composite sandwich constructions, numerous analytical techniques have been developed. These include of analytical solutions, alternative numerical techniques, including finite element analysis (FEA).

Applications for composite sandwich constructions span from automotive to aerospace (Njim et al.2021). In contrast to conventional materials, they offer greater rigidity and strength while having the unusual capacity to absorb tremendous energy. Therefore, it's crucial to comprehend how these structures behave under static and dynamic loads (Sun et al.2020). The principles of the analysis process, numerical methods for analysis, and the outcomes of static and dynamic loading studies are just a few of the subjects covered in this paper, which provides an idea of the body of research that has been done in this field.

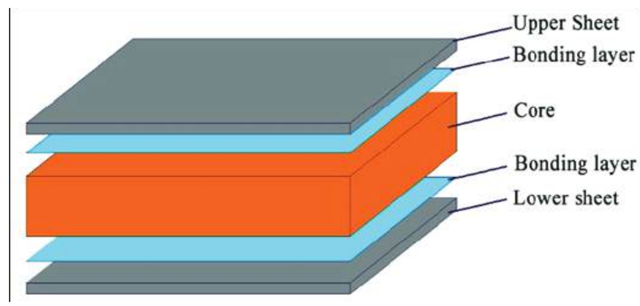

Fig. 5: Sheet bonding of multilayer composite sandwich constructions

Source: (Garg et al.2021)

It takes a lot of work to analyse layered composite sandwich constructions under static and dynamic loading conditions. Determining the material qualities is the most crucial step in the analysis. These characteristics are influenced by the material employed and the structure's geometry (Li et al.2022). Wu et al. (2021) stated that, it is a difficult task to analyse layered composite sandwich constructions under static and dynamic loading circumstances. To determine the material properties and validate the numerical models utilised in the research, several investigative and numerical techniques have been done by (Palomba et al.2021). Additionally, tests with static and dynamic loading are utilised to examine the behaviour of the structure and create design recommendations.

CONCLUSIONS

By reviewing the research papers with different layers laminated materials and their behavioural characteristic in significant with composite sandwich geometry under static and dynamic loading circumstances, it has been summaries that, the many analytical and numerical methods described in this review article shed light on how multi layer composite sandwich structures behave under static as well as dynamic loading situations. Enhancements in the precision of the outlined analytical and numerical techniques are necessary, alongside the exploration and development of innovative methodologies tailored for investigation of layered composite sandwich like structures. By reviewing literature it is also found that in many practical cases these solutions are inappropriate when the plate size is finite.

The analysis of multi layer composite sandwich constructions under static and dynamic loading conditions has been covered in this review. It paper has given an overview of the various methods that have been applied to investigate the structures, along with the benefits and drawbacks that came out with them. The review has also covered how these structures behave in relation to boundary conditions, boundary layer effects, and material attributes. The evaluation has also made clear the necessity for greater study in order to enhance the reliability of the findings and completely comprehend how these constructions behave under heavy loads.

Due to the layered nature of the structure, it is difficult to analyse layered composite sandwich constructions under static and dynamic stress situations. The behaviour of these structures has been studied using a number of analytical and numerical techniques. The most widely utilised techniques are plate theory, analytical beam theory, and finite element analysis. The choice of methodology depends on various factors, including the complexity of the applied forces, the specific boundary conditions, and other relevant considerations. Each method has advantages and disadvantages of its own. Despite the difficulties, the analysis of multilayer composite sandwich constructions has offered insightful knowledge about how these materials operate and behave under diverse loading circumstances.

Some key concluding remarks are as follows.

The effective approach for analyzing the challenge of finite plates with various cutouts lies in utilizing the complex variable method in concurrence with the boundary collocation method. A generalized solution can be obtained which will be capable of solving the plate with different discontinuities and are made up of different materials. The impact of diverse factors, including plate dimensions, hole geometry, hole orientations, material properties, and loading angles, can be assessed to analyze and subsequently mitigate stresses and stress concentration factors (SCF). Highly stressed areas near the discontinuity will be fabricated by providing reinforcement through composite material. Proper selection of thickness of the composite material layers will reduce the stress concentration factor to some extent. Structural health, monitoring will also be investigated by various techniques, such as radiographic testing, electromagnetic testing, and ultrasonic testing. Among these the damage identification can be done by guided ultrasonic waves.

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Design and Development and Analysis of Fixture for Cylindrical Cap with an Approach to Improve Productivity

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INTRODUCTION

Fixture is device which is used to hold the job , for different jobs different fixture are used or may be different jobs can be machined on single fixture . Mainly fixture is designed on the basis of shapes of fixture .While designing the fixture we consider different factors they are shape and size of fixture , weight of fixture , faces on which the operations are performed ,different operations which are going to perform on that particular job.

Fixture designing is very important part of mechanical industry as a fixture can affect your overall production of company or indirectly the profit of company basically from manufacturing point of view .We consider different factors while designing the fixture so that ha fixture we design must not affect the accuracy or productivity of job .

Objectives

- To increase the Productivity.
- To enables heavy and complex shaped parts to be machined by holding rigidly to a machine.
- To provide interchangeability.

FIXTURE DESIGN

Basic Factors to Be Considered for Fixture Design

Fixture designing is a complex process while designing the fixture we have to consider different parameters from basics to advance such as the size and shape of the object for which we are designing the fixture, different machining processes to be carried out on or going to perform on that particular job.

While designing the fixture we must follow following design criteria for fixture design:

- Specifications required in design
- Check for different factory standards
- Fixture must be easy to use
- Use of fixture is safe
- It must be economic

While designing the fixture it is important to consider all the other component which we mount on its base plate will not damage the work piece at the time of machining such a the clamping clamps should not damage the work piece while we clamping the work piece. All the locators we use must restrict the require degrees of freedom which we need to restrict.

Calculations for base plate

Material :- M.S. Sut= 485-650 N/mm². i.e. 485-650 MPa.

Fe415 D grade of steel is used

Sut= 500N/mm²

F.S. = 2

R= 90%. (90%. Reliability)

Kc = 0.897 (Reliability factor).

kb = size factor.

kb = 0.7979 as d= 70 mm

if d > 51mm and d < 254mm kb: 0.859-0.000873d

0.859 - 0.000 873 x 70 = 0.7979

Kb=0.7979

Ka =Surface finish Factor

ka = 1

Consider F.S. = 2.

kt= theoretical stress Concentration factor

Kt= 2.48

Kf = 1 + q (kt - 1)

q= notch sensitivity factor.

q= 0.8

Kf = 1 + 0-8 (2·48-1)

Kf = 2.184

Kd Modified factor to account for stress concentration

kd= 1/KF

Kd=1/ 2.184

kd=0.4579

Se= endurance limit Stress for Plate.

s'e = 0·5 x sut

s'e = 0·5 x 500

S'e = 250 N/mm²

Se = Ka kb kc kd s'e.

se = 81.9316 N/mm².

For axial load,

(se)a= 0.8xse

(Se)a = 65 54 N/mm²

Permissible stress amplitude =6a

6a= (Se)a/ fs.

= 65.54/2

6a = 32.77 N/mm²

Plate thickness (t)

6a = P/ (w-d)t.

=P/ (w-d) x6a

t = 32 mm

ANALYSIS

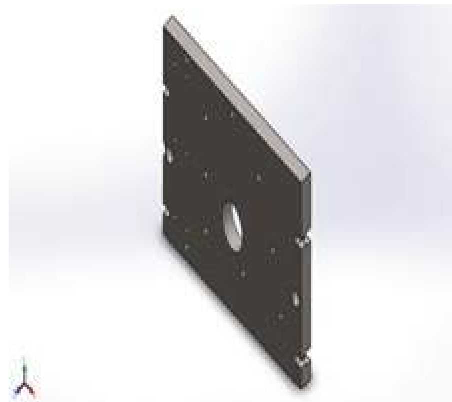
Analysis Of Base Plate

Simulation of Base Plate :

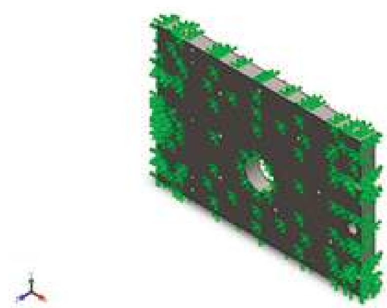
Designer: Solidworks

Study name:Static 1

Analysis type:Static



Model Information



Model name: Base Plate

Current Configuration: Default

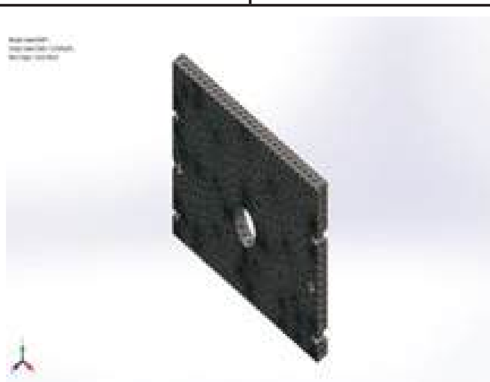
Study Properties

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFEPlus

Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	SOLIDWORKS document (D:\AA-LEARN P\ SOlIDWORKS\4 C E)

Mesh type	**Solid Mesh**
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	16.3725 mm
Tolerance	0.818627 mm
Mesh Quality Plot	High

Total Nodes	45757
Total Elements	27983
Maximum Aspect Ratio	23.832
% of elements with Aspect Ratio < 3	84.1
% of elements with Aspect Ratio > 10	0.65
% of distorted elements (Jacobian)	0
Time to complete mesh(hh; mm; ss):	00:00:04
Computer name:	ADMIN-PC



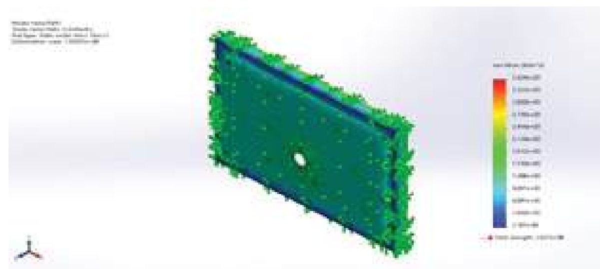
Resultant Forces

Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	-6.40345e-05	-6.86059e-05	-233	233

Study results :- stress analysis

Name	Type	Min	Max
Stress1	VON: von Mises Stress	2.101e-06 N/m^2 Node: 37010	3.624e+03 N/m^2 Node: 35695



Part1-Static 1-Stress-Stress1

Analysis Of Locator

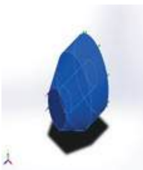
Simulation of Loicator :

Designer: Solid works

Study name: Static 1

Analysis type : Static

Material Properties

Model Reference	Properties		Components
	Name:	AISI 316 Annealed Stainless Steel Bar (SS)	SolidBody 1(Stock-hfg-1)(Part1)
	Model type:	Linear Elastic Isotropic	
	Default failure criterion:	Max von Mises Stress	
	Yield strength:	1.37895e+08 N/m^2	
	Tensile strength:	5.5e+08 N/m^2	
	Elastic modulus:	1.93e+11 N/m^2	
	Poisson's ratio:	0.3	

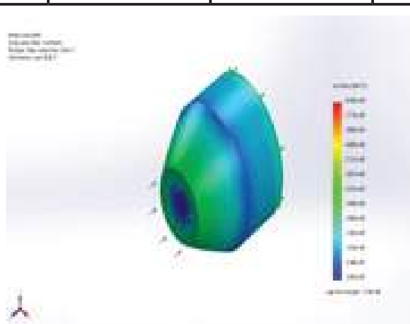
Reaction forces :

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	-0.00103426	0.000823557	570.001	570.001

Study results

Stress analysis

Name	Type	Min	Max
Stress1	VON: von Mises Stress	2.501e+05 N/m^2 Node: 6374	8.456e+06 N/m^2 Node: 7843



Locator -Static 1-Stress-Stress1

DEVELOPMENT AND TESTING RESULT OF FIXTURE

Testing of fixture Testing for increase in production rate

Calculations (For one machine)

Testing Parameters	Result For Vmc	Result For Hmc
Machining time for 1 job in min	37.40 MIN	30.20 MIN
Machining time for 1 job in hr	0.623 hr	0.5033 hr
No. of job produced in 1 hr	1.6051	1.9868
No. of job produced in 1 shift	11.7172	14.5036

Actual Increase in production per day =

= Actual increase in production per shift x 3

= 8.3592 Components More Produced Per Day

Actual Image of Fixture With Component

CONCLUSION

In this paper, the design requirements of the fixture were studied and according to that the study is carried out in which the design and development of fixture with analysis in approach to increase productivity is achieved. Here we conclude that the main aim of our project to increase productivity successfully achieved we can produce 8.3592 approximately 8 more components in a single day.

ACKNOWLEDGEMENT

The satisfaction and exhilaration that accompany the successful completion of any task would be incomplete without the mention of the people whose constant guidance and encouragement aided in its completion. The authors would like to express the voice of gratitude and respect to all who had directly or indirectly supported for carrying out this study and special thanks to my guide Prof.- P. S. Ladgaokar, M.Tech Co-coordinator mechanical design department & Prof. M. A. Sutar HOD, Mechanical department, Ashokrao Mane group of Institute Vathar traf wadgaon . I am thankful to them for their support and encouragement.

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Design and Analysis of Yelgaon Dam Water Pumping Station

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ABSTRACT

The main objective of this work is to design and analyze. The water pumping station for Yelgaon Dam water pumping station, Yelgaon, Buldana. The existing pumping station is nearly out of service. This is installed in 1930, this is having many problems such as reduced water head due to leakages, rusted pipe surfaces, and also the design is outdated. The current work mainly aims at design/Analysis of pumping station. The cad model of pumping station is developed using Triflex software. Also, structural analysis is performed in the same software. For optimization CFD (computational fluid dynamics) software are used. On the basis of result obtained in software design modification are suggested.

INTRODUCTION

The Yelgaon Dam water treatment plant collect water from Yelgaon Lake & sewer filter water. Water treatment plants filter water & supply to the Buldana City or distribution network. The components of the pumping stations as follows,

A. Centrifugal pump: - A centrifugal pump is high head, high efficiency, smooth flow rate, easy in operation & maintenance. The pump existing specification are Total head: - 85 m, Discharge: - 455 m^3/s, Pump input: - 135.570 m/s, Pump efficiency: - 77.69 %, Motor: - 180 kW, Speed: - 1488 rpm, NPSH (Net positive suction head):- 2.18 m, Specific gravity: 1000 kg/cm2 , Material constant code: - 40,Impellerdia.:- BR/497 mm, Suction size: - 200 mm, Delivery size: - 150 mm, Freq: - 50 5 %

B. Butter fly valve: - A Butterfly Valve is used to control the flow of material through a circular pipe or tube. Its specification shown in table no.1

C. Non return valve: - Non return valve prevent reverse flow & protect pump from excessive back pressure. Its specification shown in table no.1

D. Gate valve: - Gate valve either used fully closed or fully open never used to control flow of water. Its specification shown in table no.1

Table 1

Components	DN (mm)	theoretical weight (kg)	Mae-rial	Pressure
Butter fly valve	300	83	DI	PN-10
Non return valve	300	230	DI	PN-10
Gate valve	300	160	DI	PN-10

E. Flanges: - Flanges are use to connect valves & pipes by nut & bolt. Packing is provided to prevent leakages. Its specification shown in table no.2

Table 2

Table	Flange dia.	PCD	Bolts	Bolt size	Hole size	Thikns	Material
BS4505-16	840 mm	770 mm	20	M33	36 mm	48 mm	Grey CI

F. Reducer & Expander: - An eccentric reducer & concentric expander are used in piping systems between two pipes of different diameters. Eccentric reducers are used at the suction side of pumps to ensure air does not accumulate in the pipe. Its specification shown in table no.3

Table 3

component	Input dia.	Output dia.	Length	Thickness
Reducer	300 mm	200 mm	175 mm	15mm
Expander	150 mm	300 mm	175 mm	15mm

The working of pumping station is usually the transport of water from storage facilities to distribution networks takes place through pressurized pipelines. The pressure is created either through gravity or through associated pumping stations. The water is moved from source (such as dams) to water treatment plants and then (usually) pumped into service reservoirs and distribution networks to homes and businesses. As shown in fig.no.2 typically water transmission pipelines are constructed using concrete pressure pipes, ductile iron pipes, steel pipes or GRP/GRE pipes. At the lower end of the dimensional range plastic pipes (such as HDPE) may be used.

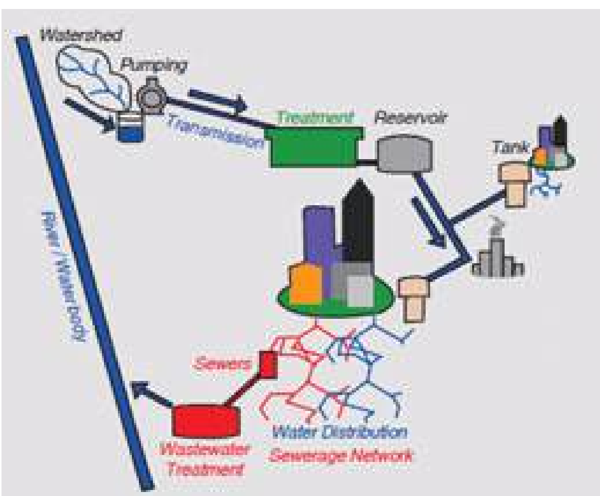

Fig. 1 Water transmission pipe lines

The reason of choosing this project is its pump, valves and pipelines are old, due to which required discharged pressure doesn’t obtained as well as maintenance is required. Therefore we design new water pumping station pipe lines.

LITERATURE REVIEW

According to Laszlo E. Kollár, Rakesh Mishra, and Taimoor Asim. The repair cost of pipe and cost of pumping power increase as the pipe becomes older due to more frequent pipe breaks and due to the pipe wear that makes wall roughness, and thereby pressure drop, greater. According to Salah El-Din Sayed Mohamed Increasing the corrosion rate leads to the failure of the pipeline, low values of soil resistivity increase the corrosion rate rapidly. Technical data including the material of pipelines and operating conditions were collected. According to N. Ursinoa*, P. Salandina Pump failure is defined as the inability of the pump to pump at design capacity. However, the system failure may be due to an unexpected rainfall event exceeding the overall design capacity of the pumps, or to the failure of one or more pumps being the inflow to the pumping station less than the design capacity. According to Peter J. Baker These will use true maximum loads to select the appropriate components, rather than a notional factor of the mean operating pressure. This will lead to safer designs with less over-design, guaranteeing better system control and allowing unconventional solutions such as the omission of expensive protection devices. It will also reveal potential problems in the operation of the system at the design stage, at a much lower cost than during commissioning.

METHODOLOGY

- 2D layout of pumping station using Auto-cad.
- Selection of components.
- 3D model of pumping station using Triflex software.
- Structural analysis of pumping station.
- 2D model of pumping station using ICEM(Ansys) software.
- Fluid flow analysis using CFD software.
- Validation of result by Bernoulli’s equation.
- Result interpretation.

DESIGN & ANALYSIS OF PIPELINES

Proper design of suction piping is important to minimize pressure losses and allow sufficient flow into the pump. Suction piping should be as short as possible as but never smaller than pump suction opening. Suction elbows to avoid high unequal zed thrust loads that will overheat bearings and cause undue wear as well as affecting hydraulic performance, Suction pipe will slope upward to the pump connection when operating on suction lift. If the discharge pipe is short, the diameter of the pipe will be same as pump discharge nozzle. If the discharge pipe is long, the diameter will be increased by one or two sizes depending on length. Consider above design criteria, the pumping station layout is design. Details of diagram with dimensions as shown in fig no.2

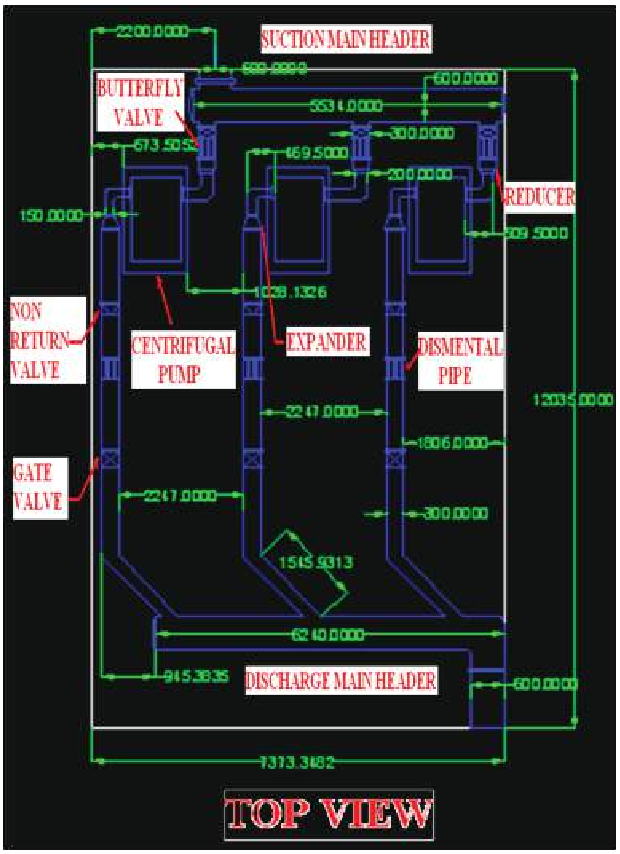

Fig. 2 top view of pumping station layout

Triflex Software for Structural Analysis

The triflex is pipe stress analysis software. Valves icon is available & graphics is good as compare to other stress analysis software. Is used for 3D layout & analysis purpose. 3D model of suction pipes as shown in fig.no.4. The water fetches from tank to suction main header & then flow to pump, through butter fly valve & reducer. The dia. Of Suction main header is 600 mm & pipe dia. is 300 mm.

3D model of Discharge pipes as shown in fig.no.5. The water fetches from suction main header to discharge pipe by centrifugal pump & centrifugal pump to discharge main header. The dia. of discharge pipe is 300 mm & main header dia. is 600mm.

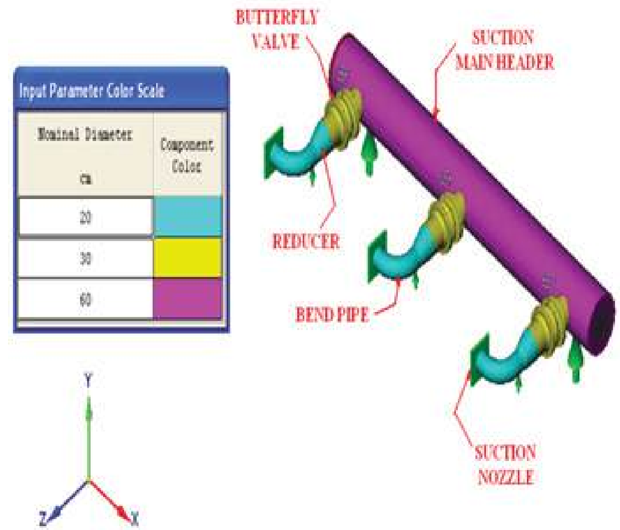

Fig. 3 Geometric Plot of Suction Pipes

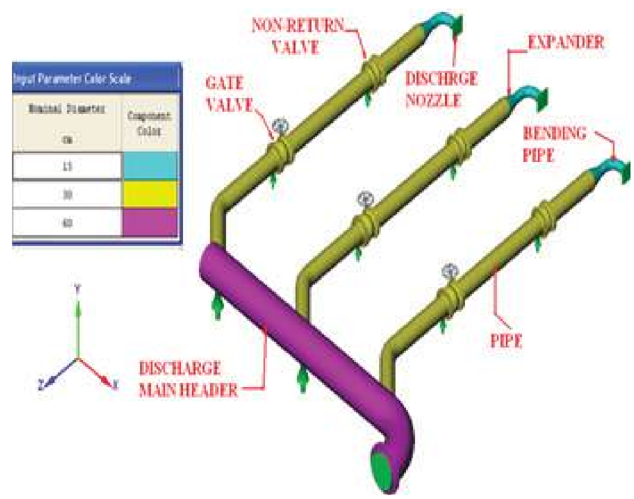

Fig. 4 Geometric plot of discharge pipe

Plant specification of structural analysis of 3D model is proposed for analysis purpose selected. So as to check the viability of proposed design for static self loading condition in real time. The pipe will be selected to self weight & weight of fluid flowing inside.

Initially no support is provided along overall length of pumping station. Hence, boundary condition selected for initial analysis purpose as are follows. Shown in table no. 4.

Table 4

Parameter	unit	pump discharge
Fluid	-	Water
Piping code	ANSI/ASME	B31.3
Fluid temperature, tf	ºC	28
Ambient temperature, ta	oC	21
Discharge pressure, pd	KG/CM2G	7.8
Suction pressure, ps	KG/CM2G	0.49
Material specification	ASTM	ASTM A 36

On the basis of result obtained for discharge pipes as shown in fig.no.6 & table no.5

Table 5

stresses	allowed stress	without support	with support
Actual sustained stress (kg/cm2)	1251	5208.5	124.9
Sustained stress (%)	1876	416	10

Observing above table, for discharge pipes we get actual sustained stress are 5208.5 and allowed stress are 1251, it means there are more number of chances of failure. Therefore we provide support to the pipes and getting safe design stress which is lower than upper critical point. The result obtained for suction pipe.

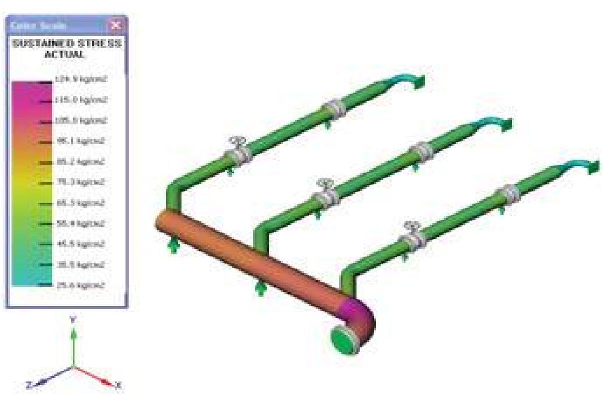

Fig.5 with support actual sustained stress for discharge pipes

Table 6

stresses	allowed stress	without support	with support
Actual sustained stress (kg/cm2)	1251	314.8	19.1
Sustained stress (%)	1876	25	2

Observing above table, for suction pipes we get actual sustained stress are 314.5 and allowed stress are 1251, it means there are no chances of failure. But for future safety we provide support to the pipes and getting safe design stress which is lower than upper critical point.

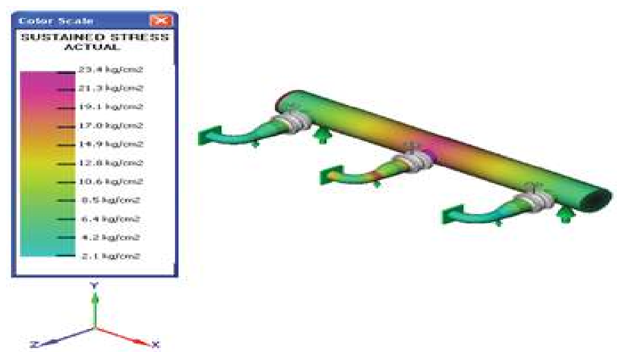

Fig. 6 with support actual sustained stress for Suction pipes

CFD Fluid Flow Analysis & Result

For Design modification CFD (computational fluid dynamics) software is been used. The purpose of modification is to increase mass flow rate by reducing friction of pipe and flow and which will therefore reduce actual head. Resultantly reduce the consumption of electricity for pump. In the system three centrifugal pumps are used. Each pump head is 85m and discharge is 455 m3/hr respectively. We need 16 MLD (million letters per day) therefore when one pump is in operation than the time required is 35 hrs. In the same way when two pumps are in operation18 hrs. Is the time required and for three pump its 12 hrs. For design modification number of parameters are considered which are changing diameter of pipes, varying bends and inclined portion of pipes. The 3D model meshing is not proper meshing and taking more time to solve these meshing therefore taking 2D models.

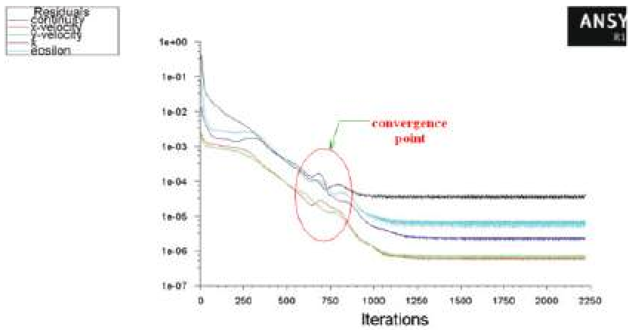

Fig. 7 Conversion graph

The discredited conservation eqn. are solved iteratively until convergence is shown in fig no.5.2.17. The conservation graph shows the iteration of x & y velocity because geometry in 2D, continuity eqn, k and epsilon. The iteration done upto 2250 & its convergence point are below 1e-04.

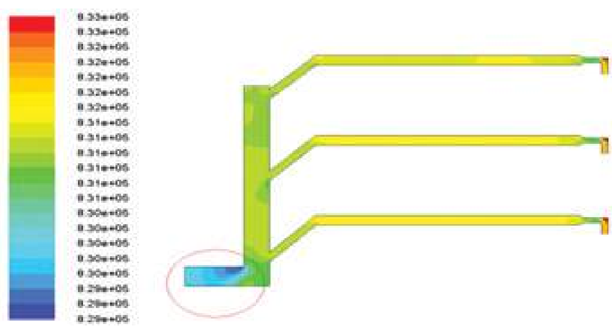

Fig. 8 Static pressure

In the static pressure geometry the inlet pressure is 833000 Pascal and outlet pressure is 829000 Pascal but by default software shows in bar. The pressure

drop in 0.04 bar means 0.48%.due to low length of

pipe it shows small pressure drop is shown in fig.8

In the velocity magnitude geometry shows the red color shows high velocity magnitude and blue color shows the low velocity of magnitude.

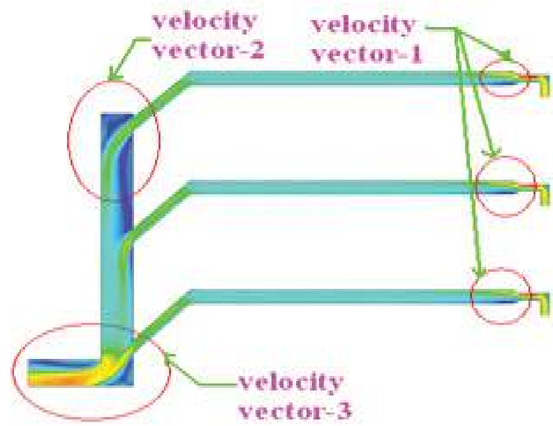

Fig. 9 Velocity vector

In Velocity vector red color arrow shows high velocity, green color shows medium velocity and blue color shows back flow of water as shown in fig.no.9

RESULT ANALYSIS OF CFD FLUID FLOW

Case	Total dynamic head (m)	Length (mm)	Inlet pipe dia. (mm)	Middle pipe dia. (mm)	Last pipe dia. (mm)	Inlet pressure (bar)	Outlet Pressure (bar) BY CFD	Pressure drop (bar) By CFD	Analytical pressure drop (bar) by Bernoulli's equation	Percentage of deviation Up to ± 5%
1	85	10000	150	300	600	8.33	8.29	0.04	7.99	3.73
2	85	10000	150	300	600	8.33	8.30	0.03	8.023	3.22
3	85	10000	150	200	600	8.33	8.30	0.03	8.08881	2.43
4	85	10000	150	400	600	8.33	8.30	0.03	8.0127	3.34

1. In case-1 inlet pressure is 833000 Pascal and outlet pressure is 829000 Pascal. But by default software shows value in bar. It means pressure drop is 0.04 bar or 0.48%. Due to low length of pipes software shows small pressure drop.
2. In case-1 pressure drop is more at the end of pipe hence, to change the geometry at end of pipe in case-2.
3. In case-2 pressure drop is 0.03bar or 0.34%. Means pressure drop is reduced upto 0.01 bar.
4. In case-3 middle dia. is reduced upto 200mm. Pressure is reduced as compare to other but pressure

drop is same means 0.34%.

5. In case-4 middle dia. is increase upto 400mm. Pressure is increase as compare to other but pressure drop is same means 0.34%.
6. The CFD result and Bernoulli's equation result are near about same & its percentage deviation upto ± 5%.

CONCLUSION

It is observed that the stress at bend of discharge pipe is exceeding the safe value. Structural design modifications are suggested, as per the new design stress level falls well below the safe limit. From the CFD analysis it is observed that the Pressure loss in old design of pumping station is 0.04 bar means 0.48%. Applying basic principal of Fluid Mechanics, some design changes are proposed in the old design pipelines, from CFD analysis of this proposed layout, it is observed that pressure loss in the new design pipe has reduced upto o.34%. Hence it is concluded that proposed design of pumping station pipeline can be implemented at Yelgaon Dam pumping station.

SCOPE OF THE WORK

To create the 3D geometry from pumping station to main distribution center and analyze in CFD. It's more beneficial for design the complete pipelines.

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A Microcontroller Based Automation System for Biodiesel Production by Enzymatic Transesterification of Waste Cooking Oil and its Characterization as Bio-lubricant

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ABSTRACT

An increased awareness of the environment is a driving force behind upcoming technological advances. Eco-friendly products like fuels and lubricants are exhibiting outstanding potential and are extremely captivating to renew the conventional products as they are structurally comparable. The aim of work in this study was to make use of waste cooking oil (WCO) for the synthesis of bio lubricants, through Transesterification process. This method uses microwave irradiation technique, commercially available enzymatic catalyst and thus effectively converts waste cooking oil into biodiesel. A microcontroller based automation system aids in continuous collection of biodiesel produced. An indicator panel indicates various stages involved in the biodiesel production. In the post transesterification reaction phase, the catalyst and excess alcohol can be retrieved by the process of distillation which can be reused later. The methyl esters synthesized by waste palm cooking oil exhibiting outstanding potential as base material for bio-lubricant formation. In spite of its high pour point, other properties of lubricants like viscosity, viscosity index and flash point are comparable to ISOVG46 commercially available lubricants.

KEYWORDS: *Biolubricant, Automation system, Transesterification process, Biodegradable, Viscosity index, Lubrication properties.*

INTRODUCTION

A lubricant helps to reduce friction .wear, corrosion between surfaces in mutual contact, it also reduces the heat generated between the moving surfaces .Synthetic lubricants are toxic and also they are not environment friendly. A very large amount and types of synthetic lubricants are spilled into environment every year. Bio lubricants are produced from natural oil or renewable resources possess superior characteristics despite high pour point ,like high viscosity index, superior lubricity ,high thermal stability, and moreover they are found to be nontoxic [1]. In recent years, Bio-diesel has become a promising a cleaner and cheaper alternative to Petro-Diesel. The Biodiesel is produced from waste cooking palm oil using a Biocatalyst in the Transesterification Reaction [2]. The cost of Bio-Diesel produced is cheaper than the Petro-Diesel facilitating its Economization and Commercialization. The bio lubricant formulated using biodiesel had some properties that were better than mineral lubricants [3,4]. The process by which biodiesel is produced is known as transesterification In this process organically derived oils (triglycerides, fatty acids) are mixed with alcohol (ethanol or methanol) to form ethyl or methyl ester in the presence of a catalyst along with a byproduct which has glycerol. A gravity separator is used for separating biodiesel and byproducts (Fig.1). With advancement of technology and to make things simple and easier for us an it is becoming more popular to use automatic systems instead of manual ones [5].

Control systems and information technologies are used in automation to lessening the manpower required to produce goods and services. Within industrialization, automation is advancement over mechanization [5].

While mechanization has rendered human workers using equipment to help workers cope with muscular demands of their works. Additionally, automation greatly reduces the mental and sensory demands placed on humans (Figure 2). Automation is playing an increasingly important role in the global economy and in our daily lives.

The chemical reaction between bio-diesel and trimethylolpropane using bio-catalyst for production of palm waste cooking oil base trimethylolpropane esters (Figure 1) (bio lubricants). A 97.4% yield of trimethylolpropane esters derived from palm oil was recorded later 4 hours of reaction at 60°C by microwave irradiation. The synthesized compounds were inveterate by Fourier transform infrared spectra and estimated by ASTM analysis under the same reaction environment.

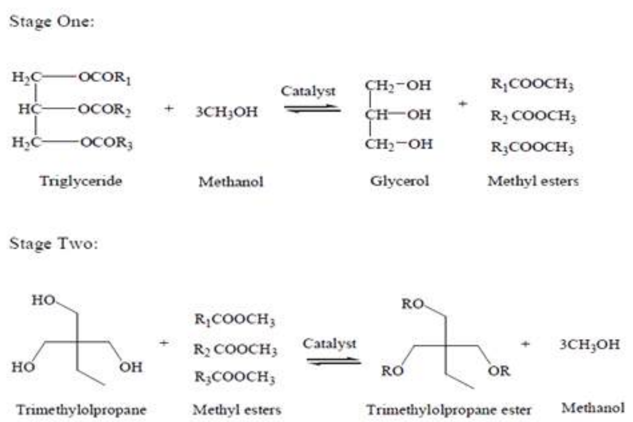

Fig. 1. Production of Palm based WCO TMP Esters

MATERIALS AND METHODS

Raw Materials

Palm oil based WCO samples were collected by local fast food centres. Methanol 99.8% (Sigma–Aldrich),panlipase a bio-catalyst was purchased from local medical stores, TMP (Trimethylolpropane) 98% (Sigma–Aldrich), ethyl acetate 99.5% (Aldrich) and Anhydrous Magnesium Sulfate 97% were utilized in this production process.

A microcontroller based automation system for bio-diesel production

Now-a-days the use of alternate fuel is enhanced for the purpose of energy security and environmental concerns [6]. Escalating oil prices and depletion of oil reserves necessitate identifying a better alternative for existing fossil fuels.

In the post transesterification reaction phase, the catalyst and excess alcohol can be retrieved by the process of distillation which can be reused later. In the present method automation is introduced to control the bio-diesel production process. This technology replaces human working force. Automated devices work with determination, adaptability and with almost without errors. Microcontroller base systems provide constant output voltage with varying input voltage [5].

In the present process maximum of 1 watt power is required, to generate the required power 12V/230mA transformer is used (Figure 2). Temperature indicator sensors were installed; output indicator is shown by using LED to detect the functioning of system. Every step of the process is indicated by glow in LED.

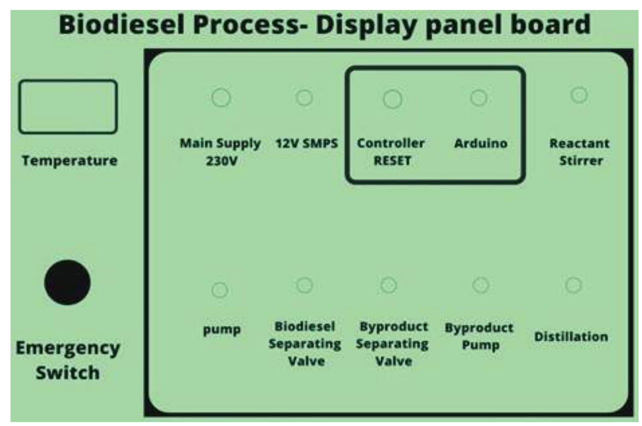

Fig. 2. Microcontroller based automation system – Display panel board

This method uses microwave irradiation technique and thus effectively converts waste cooking oil into bio-diesel (Figure 3). This project introduces a commercially available enzymatic catalyst that is panlipase which is responsible for getting desired yield of bio-diesel i.e. up to 95 %. A gravity separator is used for separating bio-diesel and by-products. A microcontroller based automation system aids in continuous collection of bio-diesel produced. An indicator panel indicates various stages involved in the bio-diesel production.

Production of TMP Based Esters

Palm based waste cooking oil was converted to monoalkyl ester of fatty acid using methanol by transesterification process then the process is carried out by different purification steps as represented elsewhere [7]. The synthesized methyl palm bio-diesel is processed with silica gel about half an hour for the removal of soap. After that the sample was filtered. After filtration sample placed in oven at 110°C and dried overnight.

Fig. 3. A microcontroller based automation system for bio-diesel production

Palm oil based TMP esters were synthesized by transesterification process (Figure 1) by using a rotary vacuum evaporator model N-1110S (Tokyo Rikakikai CO., LTD) with 500 ml round bottom flask. TMP ester was first dissolved in a small quantity of synthesized bio-diesel by heating at 70-90°C and stir well until crystalline solid was dissolved.

After known quantity of TMP ester was added, the mixture was heated with stirring at required temperature 120–130°C by adding known quantity of TMP and stir well before the addition of enzymatic catalyst panlipase (0.9–1 weight %) based on the type of methyl esters.[8]

In order to prevent spillover reactions (10–50 mmHg), while adding catalyst vacuum is applied slowly at the reaction time about 4 hours. At room temperature this reaction mixture cooled after the completion of reaction. The catalyst and solid materials were removed using ethyl acetate and vacuum filtration, followed by distillation.The bio-lubricant obtained was analysed using ASTM standard method for its lubrication properties [9].

RESULTS AND DISCUSSIONS

Synthesis of bio lubricant from palm oil based WCO

Fatty acids and glycerol ester s are the primary components of Palm oil. Presently, this is primarily exploited as cooking oil for eatable purposes. Other applications include manufacture of oleochemicals, animal feed raw material, margarine and soap. It is because of most affordability of palm oil in internationally as vegetable oil. The use of crude palm oil to produce environmentally friendly products is a promising alternative. Several methods for producing bio-diesel from crude palm oil have been published in the last decade [10].

Transesterification is the process of converting three moles of triglyceride into glycerol and mixtures of methyl esters containing fatty acid by reacting with three moles of methanol [11].

Table 1. Effect of vacuum on trans esterification at temperature 130°C for 4 hrs

SPECIFICATIONS	VACUUM PRESSURE AT 10 mmHg		
	PALM OIL BASED TMP ESTERS	ISO VG32	ISO VG46
Yield, wt. %	95.8	--	--
Kinematic viscosity cSt 40^0 C	50.33	>28.8	>41.4
Kinematic viscosity cSt 100^0 C	10.87	>4.1	>4.1
Viscosity Index	214	>90	>90
Pour Point	5	-6	-6
Flash point	253	204	220

Kinematic viscosity measurements were conducted on palm TMP esters using viscometers at 40°C and 100°C according to ASTM method. In accordance with ASTM method D445, measurement of kinematic viscosities at 40 °C and 100 °C was performed using viscometers. The VI was calculated using ASTM method D2270 [9]. How the temperature changes influence its viscosity is indicated by Viscosity Index (VI) of an oil.A low Viscosity Index indicates a comparatively high change in viscosity value with the change of temperature [12].

In other words, at high temperatures, oil transformed to highly thin, while at low temperatures, it becomes highly thick. A excessive Viscosity Index shows that viscosity modifications notably little over a huge temperature range. The high-quality oil for maximum applications is maintaining steady viscosity even though in changes of temperature. As mentioned in Table 1, lowering vacuum pressure from 50 to 10 mmHg improved the VI from 171 to 214, flash point from 240 to 253°C while maintaining the pour point without changing the yield from 97.4 weight percent to 97.8 weight percent at 5°C .

The most effective conditions of the reaction for synthesizing TMP esters of palm oil had been observed, and the influence of pressure, temperature, catalyst quantity of sodium methoxide and molar-ratio of palm methyl esters-to-TMP have been analysed [13]. Trimethylolpropane was chosen because it has low melting point than other polyols [14]. Low pour point is a critical characteristic of low temperature properties in the lubricant industry. By the usage method represented in ASTM D97, palm TMP esters pour point was determined [9].

The effect of chemical structure on polyol and other esters' pour points has been studied [15]. Lowering of pour point in vegetable oils is due to the existence of cis-unsaturated fatty acids in the oleic fraction. [16], while palm oil methyl ester contain high palmitic content (39.24 percent), (saturation of fatty acids and long chain length), seems to revoke the influence of Cis-unsaturation, as shown in Table 1 which results in high pour point of bio lubricant. Because of high level of saturation, the natural synthetic esters prepared by the mixing of trimethylolpropane and palm oil based methyl esters having low-temperature properties are significantly modest to certain different lubricants which are based on vegetable oil. Despite higher pour point value, other lubricating properties like flash point, viscosity and viscosity Index are similar to commercially available industrialized oils like VG46 and ISO VG32.

The FTIR spectra of both bio-diesel and diesel (Figure 4) precisely showing the related absorption bands between 2850–3000 cm-1 & 1350–1480 cm-1 due to C-H stretching vibration, indicating same functional group like alkane in its molecular structure. Moreover, FTIR spectra of bio-diesel shown the new bands between 1670-1820 cm-1, where in petroleum diesel there are no absorption peaks were shown. This result provided additional evidence for the presence of an oxygen molecule in the product of bio-diesel. FTIR tests were performed for (a) trimethylolpropane (TMP), (b) bio-lubricant & (c) bio-diesel to investigate chemical composites and results are showing in (Figure 5).

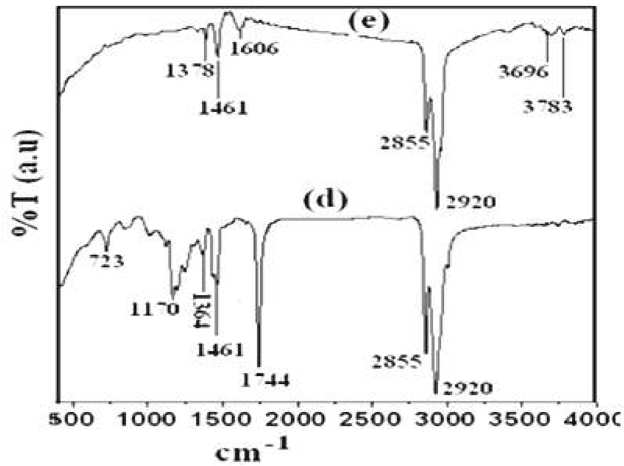

Fig. 4. FTIR Spectrum of (d) Palm oil methyl ester (e) Diesel oil

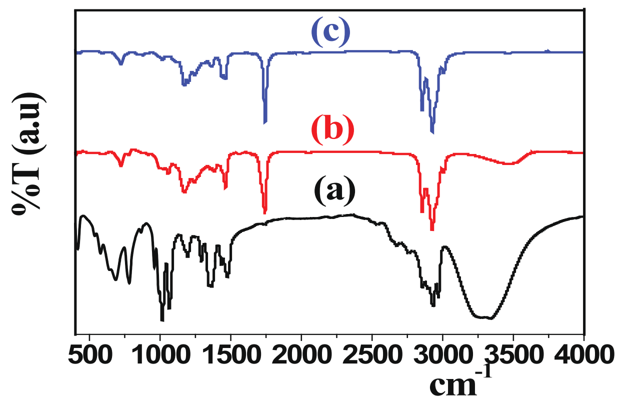

Fig. 5. FTIR spectrum of (a) TMP; (b) Bio-lubricant; (c) Bio-diesel

The absorption bands in FTIR spectra of bio-lubricant and bio-diesel are 1742 cm-1 and 1744 cm-1, respectively. The above absorption peaks caused by C-O stretching vibrations & C=O in the ester, that allowed the existence of oxygen to also be demonstrated in bio-lubricant and bio-diesel. The peak at 3326 cm-1 has been identified in TMP, which indicates the presence of -OH group, whereas a very small peak at same value is appeared for bio-lubricant which was almost ignored, suggesting that perhaps the reaction of bio-lubricant esterification was nearer to finish.

CONCLUSION

TMP esters synthesized by using waste cooking oil derived from palm oil demonstrated promising potential as a base stock in biodegradable lubricant formulation. Some other lubrication properties, such as flash point, Viscosity Index and viscosity are comparable with conventional industrial oil ISO VG46 despite their high pour point. Flash point and Fire point of present product are high compared to mineral oils. lubricants volatility and fire resistance properties are identified by its flash point and fire point they also play important role in transportation and storage requirements, it can considerably reduce the risk of fire accidents if there is a leakage providing extra safety [17]. Bio-lubricant derived from natural oil, particularly non-edible oils, holds promise for highly specialized and environmentally sensitive uses. The use of this method can significantly increase palm oil's oxidative stability and still retain its beneficial VI and lubricating properties. The FTIR spectra of WCO TMP esters (palm oil based) shows that the esterification reaction of bio lubricant was substantially close to completion. Chemical modifications in palm based bio-diesel lead to the development of better lubricants with improved physic-chemical properties.

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DECLARATIONS

Conflict of interest

The authors state that there is no conflict of interest.

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Conversion of Kitchen Waste into Biogas

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ABSTRACT

Biogas technology offers significant potential for sustainable energy production while providing numerous environmental and socioeconomic benefits. Here are some key points regarding its advantages and the need for advancement, especially in the context of India. Biogas technology holds great promise for sustainable energy production, waste management, and environmental protection. Advancing this technology and expanding its use in both urban and rural areas in India can significantly contribute to reducing fuel imports, managing solid waste, and providing a reliable source of renewable energy. With continued support and innovation, biogas can play a pivotal role in achieving energy and environmental goals. The aim of this paper is to highlight importance of this technology to bring social and economic changes to India. In this work, biogas digester was fabricated and analyzed to investigate bio gas generation using kitchen waste.

KEYWORDS: *Biogas, Methane, Carbon dioxide, Hydrogen (H2), Oxygen (O), Nitrogen (N2), Sulphur (S).*

INTRODUCTION

Biogas production from kitchen waste offers a sustainable and efficient method for managing organic waste while reducing greenhouse gas emissions. Biogas technology offers a multifaceted solution to waste management, renewable energy production, and environmental protection. By utilizing kitchen waste for biogas production, we can achieve significant reductions in greenhouse gas emissions, enhance public health, and promote sustainable development. With the right infrastructure, community involvement, and government support, biogas technology can play a vital role in addressing climate change and fostering a sustainable future.

Aim of the project

The aim of converting kitchen waste into biogas is to utilize organic matter to produce a renewable and clean energy source. This process helps in waste management by reducing landfill disposal, while also generating biogas, a mixture of methane and carbon dioxide which can be used for cooking or as a source of electricity and heat. It promotes sustainability, resource efficiency, and contributes to a greener environment.

Statement of the Problem

The purpose of this project is to find out how the food waste could be converted into biogas and to design an anaerobic digester which uses food waste to generate the biogas. Using kitchen waste for biogas production in urban areas presents a viable and efficient solution to waste management and energy needs. With the implementation of above-ground biogas plants, urban communities can effectively manage their organic waste, produce renewable energy, and reduce their reliance on fossil fuels. This approach not only addresses the challenges of waste disposal and energy scarcity but also contributes to environmental protection and public health improvement.

Site selection for biogas plant

- Land surface should be flat, where we1want to

install the biogas plant.

- Soil of land should not be loose, its bearing strength should be 2kg/cm2.
- Biogas plant should near to home or farm.
- Sufficient water should be available where we want to install the biogas plant.

Principle for production of biogas

Organic substances are diverse and are found in both living organisms and their remains. These substances are primarily composed of carbon (C) and other elements such as hydrogen (H), oxygen (O), nitrogen (N), and sulfur (S). These elements form a variety of organic compounds, including carbohydrates, proteins, and lipids. The breakdown of these complex organic compounds is facilitated by microorganisms (MOs) through the process of digestion. Organic substances, composed of carbon and other essential elements, form the basis of life and various organic compounds. Microorganisms play a crucial role in breaking down these complex compounds through the digestion process. This microbial activity is fundamental for nutrient cycling, biogas production, and efficient waste management, contributing to ecological balance and sustainability.

There are 2 types of digestion process:

- Aerobic digestion.
- Anaerobic digestion.

Both aerobic and anaerobic digestion play important roles in waste management and environmental sustainability. However, anaerobic digestion offers significant advantages in terms of renewable energy production and greenhouse gas mitigation. By converting organic waste into biogas, anaerobic digestion provides a viable and environmentally friendly energy source that can help reduce our reliance on fossil fuels and mitigate the impacts of climate change.

Biogas

Biogas production through the anaerobic digestion of organic material is an integral part of the bio-geochemical carbon cycle and offers numerous benefits for both rural and urban areas. It provides a renewable energy source, effective waste management, environmental protection, economic advantages, and health improvements. By promoting and advancing biogas technology, we can contribute to sustainable development and a cleaner, healthier environment.

Table 1 Biogas Composition

Component	Concentration (by volume)
Methane (CH_4)	55-60 %
Carbon Dioxide (CO_2)	35-40 %
Water (H_2O)	2-7 %
Hydrogen Sulphide (H_2S)	20-20,000 ppm (2%)
Ammonia (NH_3)	0-0.05 %
Nitrogen (N)	0-2 %
Oxygen (O_2)	0-2 %
Hydrogen (H)	0-1 %

Flow chart for biodegradation

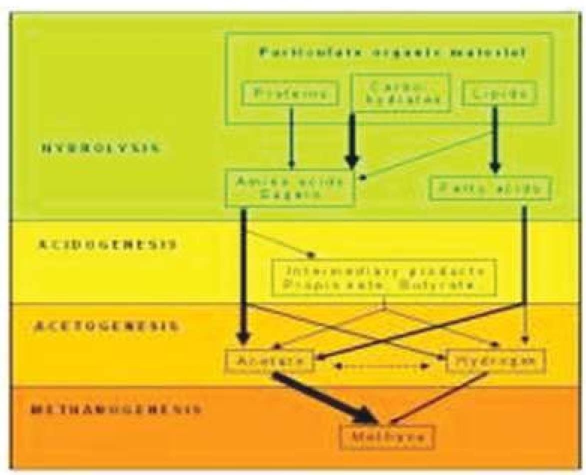

Fig. 1. Flow chart for biodegradation

Biogas Production Process

The biogas production process includes several stages, from the collection and preparation of organic waste to the production of biogas. .

- Collection of Raw Materials: The first step is to collect organic waste, required as raw material for biogas production. This may include waste from kitchen, unwanted food, agricultural surplus, manure, and sewage sludge.

- Waste Pretreatment: Collected waste is sorted and ready for the biogas digester. This may involve crushing or grinding the waste to increase its surface area and improve the digestion process. Large or bulky materials often break down into smaller particles.
- Anaerobic digester: The waste generated is fed to an anaerobic digester, which is a closed tank or tank where the fermentation process takes place. The oven has an oxygen-free environment, which is necessary for the life of anaerobic bacteria.
- Anaerobic Digestion: In a digester, organic waste is decomposed anaerobically. Anaerobic bacteria break down organic matter and transform it into biogas through complex biochemical reactions. The main components of biogas are methane (CH_4) and carbon dioxide (CO_2), as well as a small number of other gases.
- Retention time: The waste remains in the digester for a certain time, called retention time. This gives the bacteria enough time to break down the organic matter and produce biogas. The storage time can vary according to the characteristics of the raw material and the design of the oven.
- Biogas Collection: The generated biogas rises to the top of the boiler and is collected in a separate gas storage or container. A system is necessary for efficient collection and storage of biogas. Use of biogas: Collected biogas can be used in various applications. Alternatively, biogas can be processed to remove pollutants, particularly carbon dioxide, and produce bio methane, a higher- quality gas that can be injected into natural gas pipelines or used as vehicle fuel.
- Digestion Management: The material left behind in the digester after the fermentation process, known as digestate, is rich in nutrients and can be used as fertilizer. It is usually separated from the liquid phase and further treated or composted before being applied to agricultural land.
- Monitoring and Maintenance: Continuous monitoring of the biogas production process is important to ensure optimal conditions and to solve potential problems. Regular maintenance of the digester and related equipment is also necessary to maximize the efficiency of biogas production. It is important to note that the details of the biogas production process can vary depending on factors such as the type of digester used (e.g., continuously stirred tank reactor, plug flow or fixed dome digester) and feedstock characteristics. That is why it is important to plan and use the biogas system according to the specific requirements and conditions of each project.

Benefits of biogas technology

Biogas technology offers comprehensive benefits that contribute to environmental sustainability, economic development, social well-being, and public health. By harnessing organic waste to produce renewable energy and valuable by- products, biogas systems support a circular economy, reduce greenhouse gas emissions, and promote sustainable development in both rural and urban settings.

Disadvantages

While biogas technology has numerous benefits, there are also several disadvantages and challenges associated with its implementation and operation. These include technical complexities, high initial and operational costs, environmental and health concerns, social and cultural barriers, logistical issues, and regulatory hurdles. By addressing these challenges through proper planning, community engagement, technical support, and policy frameworks, the potential of biogas technology can be fully realized to contribute to sustainable development and environmental protection.

PROBLEM DEFINITION AND EXPERIMENTATION

Objectives of the Project

The objectives of the present work are:

- To design a biogas digester utilizing waste from kitchen.
- To evaluate biogas in “above ground level floating dome biogas plant”.

- To find the potential of biogas generation. from major kitchen wastes.

Construction and Fabrication

The most common type of design studied are:

- Floating dome Type
- Fixed dome type

Floating Dome Type

The floating gas holder biogas plant, developed by Jasu Bhai J. Patel and popularized by KVIC, represents a significant advancement in biogas technology. Its design effectively manages biogas production and pressure, making it a valuable tool for renewable energy generation and waste management. This technology has had a lasting impact, especially in rural areas, providing a sustainable solution for energy and organic waste utilization. The floating gas holder in a biogas plant is crucial for maintaining consistent pressure within the system. As the digester produces biogas, the floating gas holder rises, which helps to manage the pressure and allows excess gas to be released through the gas supply pipe. Conversely, when the gas production decreases, the floating gas holder lowers, reducing the release of biogas.

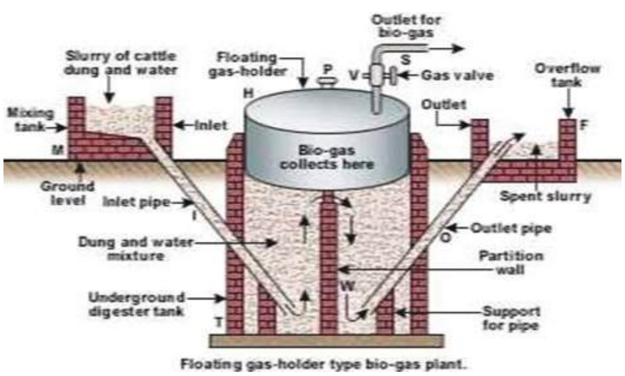

Fig. 2. Floating Dome type Biogas

Fixed Dome Type

Fixed dome biogas digesters combine the digester and gas storage into a single structure. The digester's upper part serves as the gas holder, and the level of the slurry inside the digester dictates the pressure for gas release. These digesters are typically built below ground and rely on the displacement of slurry to provide the necessary pressure for biogas collection and use. Fixed dome biogas digesters offer an integrated solution for biogas production and storage.

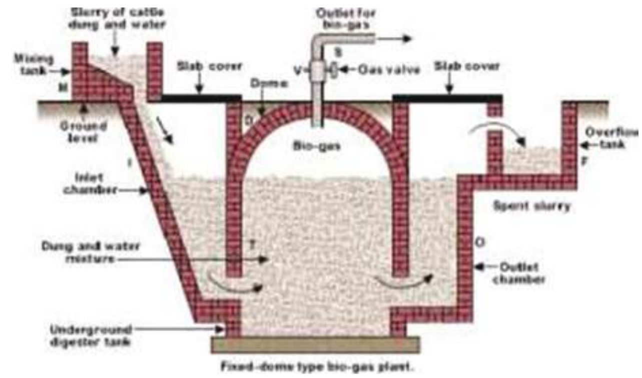

Fig. 3. Fixed dome type Biogas

The development of modified designs, such as the GGC and Deenbandhu models, has made these systems more adaptable and cost-effective for different regions. Each model provides a unique set of advantages, tailored to meet local needs and economic conditions. By understanding the strengths and limitations of these designs, stakeholders can select the most appropriate model for their specific requirements.

Description of Fabrication

250L fixed digester drum: First the 250L fixed polyethylene drum was taken and cut for the required size and after that cleaned from inside by water. 3.5-inch diameter hole cut at one side of the drum for the kitchen waste inlet, and 3.5-inch diameter hole cut at another side for outlet of the slurry and fix the tank connectors lastly connected the pipes.

Fig. 4. Fixed Digester

2.3.2 150L floating polyethylene drum: The 150L fixed digester drum is cleaned from inside with water. 0.5-inch dia hole cut at the top side of the drum for the gas outlet and fixed the 0.5-inch PVC pipe and ball valve to that hole, and drilled another hole for the pressure gauge fixing purpose and fixed the pressure gauge.

Fig. 5. Floating drum

PVC Tank connectors: Tank connectors are fittings used to connect PVC pipes to liquid storage tanks, allowing for the efficient transfer of liquids into or out of the tank. These connectors ensure a secure and leak- proof connection between the tank and the piping system.

Fig. 6. Tank Connector

PVC el-bow: A pipe elbow is a type of pipe fitting designed to connect two pipes at an angle, allowing for a change in direction within a plumbing or piping system. This fitting is essential for directing flow and accommodating layout changes in the system.

Fig. 7. El-bow

Pressure gauge: It is used to measure the pressure of biogases. It is used for the inspection of pressure in tank.

Fig. 8. Pressure gauge

Gas outlet pipe: Here the gas outlet pipe is used to get the gas out from the floating drum when the gas is required for using.

Fig. 9. Gas Outlet pipe

Kitchen waste inlet pipe: To feed the kitchen waste to the digester the kitchen waste inlet pipe has been provided and the funnel is also provided to avoid the scattering of the waste on the ground.

Fig. 10. Kitchen waste inlet pipe

Slurry outlet pipe: To get out the wastage slurry which has deposited and to avoid the overflow of the slurry from the digester.

Fig. 11. Slurry Outlet pipe

M-seal and PVC seal: M-Seal and PVC Seal are versatile, multi-purpose sealants ideal for a range of applications, including sealing, joining, fixing, and building. Their ease of application, durability, and flexibility make them valuable tools for both industrial and household use, providing effective solutions for repairs, maintenance, and construction tasks.

Fig. 12 M-seal and PVC seal

Experiment

The procedure involves inoculating a 20-liter digester with a cow dung slurry to initiate anaerobic digestion. After a period of initial digestion, kitchen waste is added to evaluate its effect on biogas production. Monitoring and analyzing the results helps in understanding how kitchen waste influences the efficiency of biogas generation and can provide insights for optimizing biogas production.

Fig. 13. Experimental setup

This digester contains the following composition.

- 150-liter Floating digester.
- Cow dung – 30kg
- Water – 40 liters

RESULTS AND DISCUSSION

Results

The total gas produced is contains methane constituent 55%-60% and carbon dioxide also forms 30%-35% of this value. And this the biogas production is dependent on the temperature and solar intensity of the atmosphere also the slurry temperature is always greater than the ambient temperature. Again, some studies also shows that the surrounding temperature has an effect on the inside temperature of the digester. So, when the ambient rise the inside will also rise.

Discussion

Small-scale biogas digesters offer a valuable solution to the energy, economic, and environmental challenges faced by developing countries. By enhancing energy availability and providing benefits such as improved soil fertility and reduced pollution, biogas technology can contribute significantly to sustainable development. However, overcoming challenges such as high initial costs, material availability, and technical issues is essential for maximizing the potential of biogas digesters.

CONCLUSIONS

Due to India's energy problems and increasing pressure on landfills, waste-to-energy technologies have become central to sustainable waste management. To solve this problem, we should focus on producing biogas from kitchen waste, especially from school and college campus waste. This initiative aims to mitigate the greenhouse effect caused by inappropriate waste management. By decomposing kitchen waste, we have found an effective solution for waste management.

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Proposed E-conductor Passenger Bus Service

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ABSTRACT

The bus/public transport ticketing system as well as cash transaction, prevailing in the developing countries, sometimes introduces severe breakdown in the system, hateful argument among public, corruption and most of all traffic jam. General problems in traditional ticketing method like transferring tickets from one person to another, sharing of tickets, without tickets etc. The presented paper proposed a much more public friendly service to avoid confrontation i.e. mesh between the supervisors/conductor and passengers regarding seat adjustment/allocation, reuse of seats, clashing for empty seats during the journey, suitable fare collection, safer cash handling, misuse of tickets as well as recognition of traveller and his/her travelling history for security purpose. In the proposed system, a Card Swipe Machine (CSM)/Electronic Data Capture (EDC) for payment transfer and control systems along with electromechanical seat folding/unfolding mechanism is suggested for proper allotment of seats to the passengers. The gate opening control, audio/visual alarms for arrival of the destination, emergency condition handling and many more mechanisms are in the possession of driver or his assistant.

KEYWORDS: *Card Swipe Machine (CSM), Electronic Data Capture (EDC), Conductor, fare, Traffic jam, Electromechanical, Driver, Audio/visual alarm.*

INTRODUCTION

Now days, it is become the prime concern for the government to provide a comfort, tension free and easy and secure way of travelling and also to reduce the man power and corruption. Recently most of the research work has been carried out for e-ticketing using Radio Frequency Identification (RFID) cards. An integrated approach using RFID and Zigbee for e-ticketing and its authentication has been discussed and automatic ticket vending machine is proposed in [1]. A user friendly system, which will automatically identify the passenger and deduct the passenger's fare according to the distance travelled with the help of RFID card and GPS are elaborated in [2]. In another application, a useful paperless ticketing system has been presented in [3]. The paper [4-5] aims for a proposal on bus and local train fare mechanisms tactics like "pay as you go method" and its management by using RFID tags. To overcome the disadvantages of paper ticket by service provider, the system will help make a user friendly bus-ticketing system where the entire bus ticketing process will be automated. It will be implemented using Near Field Communication (NFC) that allows data to be transferred between two NFC enabled electronic devices to generate E-ticket [6]. The project [7-8] involves the combined usage of smart cards and Global Positioning System (GPS) to make travelling smarter. In another work smart card which has become a common thing now, holds the particulars of the card holders and GPS which is an efficient tool in many fields like surveillance and tracking is used to find the distance travelled by the user. In another concept of a conductor less bus, as the passenger enters the bus, the camera will capture the image of his face and will verify whether the particular face is already exists in database. If it exists then automatically the fare of bus will be deducted from the passengers account and the respective update will be sent to the passenger. If the face captured is not available in database then the passenger will have to carry RFID card with him which he will use to pay the fare of the bus [9]. Unstructured Supplementary Service Data (USSD), a protocol used by GSM cellular telephones to communicate with the service provider's computers has been used for bus tracking and e-ticketing. In urban area conductor less bus services using RFID technology is becoming popular. An autonomous vehicle (AV) system is discussed in [10-11] for driver less bus. In our presented scheme of e-conductor bus service, a fool proof solution is proposed for varieties of problems being experienced during routine journey in India and other nearby south Asian countries. The system is more compatible to rural area where RFID concept is still not much popular. The paper is organised as follows: Section 2 contain the challenges and problems in public transport system, chiefly in Indian environment. Diagram of e-conductor bus system containing passenger's fare collection and seat fold/unfold mechanism along with different displays are shown in section 3. Flow chart of e-conductor bus system description is drawn and explains in section 4. Finally paper is concluded in section 5.

CHALLENGES AND COMMON PROBLEMS IN INDIAN PUBLIC TRANSPORT SYSTEM

(i) In some of the small cities, especially in rural areas, when the passengers are more and the available seats are less then there are chances of clashing regarding occupancy of seats as the passengers may enters simultaneously in the bus.

(ii) In rural areas many more persons are not acquainted fully with the applications of RFID or smart cards and these cards are to be prepared and training is required regarding its use for transport purpose.

(iii) During fare collection by conductor, there is probability of clashing and hot discussions regarding change and other related matter results in achieving suitable fare collection from particular passenger or their neighbour. The same can happen while collecting the fare of group of persons.

(iv) Occasionally RFID system may cause error especially in case of wireless connectivity.

(v) Some criminal minded person may loot the cash available with the conductor.

(vi) Entry of without ticket is possible even with the use of RFID/smart cards as all vacant seats are available simultaneously to the passengers and passenger use to enter in group so the conductor may be cheated.

(vii) Even with RFID cards, when the gate is opened for a passenger, another may enter during the period simultaneously.

(viii) A ticket can be shared by two or more persons. Two or more person can share the journey like relay race between two destinations. Although revenue loss may not be there but other related problem may exist.

(ix) A passenger can extend his/her journey without paying suitable money.

(x) A person can get down before the destination without informing the driver/bus supervisor.

(xi) Passengers willing to travel through the bus are not aware about the available seats in the bus at any of the station and unnecessary crowd may be collected near bus for searching the availability hence unnecessary chaos may occur in the bus.

(xii) The passengers not aware about the destination may miss it without any alarm.

(xiii) Sometimes driver need a record regarding the no of passengers to be step down at particular destination which is not possible without consultation with conductor.

(xiv) At times, security personnel may require face recognition of the passengers and their particulars regarding starting and end of journey which may be difficult to respond by ordinary conductor or some time RFID.

(xv) Although it may reduce the manpower but in India, instead of displacing conductor, the same may supervise or control the e-activity and related matter without much interaction with passengers.

RFID/smart cards or other methods for e-ticketing are not successful to solve some of the above problems efficiently as well as even an efficient conductor may be deceived or confused regarding fare collection in proper way as well as appropriate response to the passenger for his/her query. It may results in revenue loss or conflict, which may turn into quarrel. Our proposed system is compatible with the existing facilities available with the common passenger and also capable to solve almost all the mentioned problems and challenges. Overall block diagram of the e-conductor bus service system is shown in figure 1. The individual block is elaborated in the next few sections.

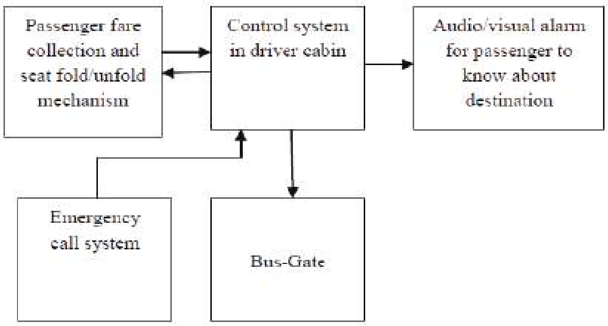

Fig. 1: Overall block diagram of the e-conductor bus service system

Diagram of e-conductor bus system

The diagram of the complete system in the bus is shown in fig. 2. The various systems, displays, control panels are suggested to be attached in the bus at suitable places. The different displays D1, D2, D3 and D4 along with associated control and features are shown in figure 3.

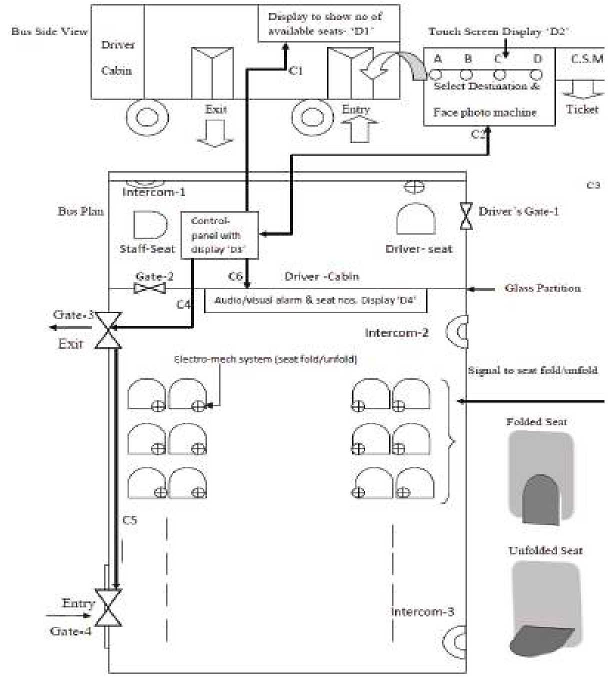

Fig. 2: Set-up of e-conductor bus

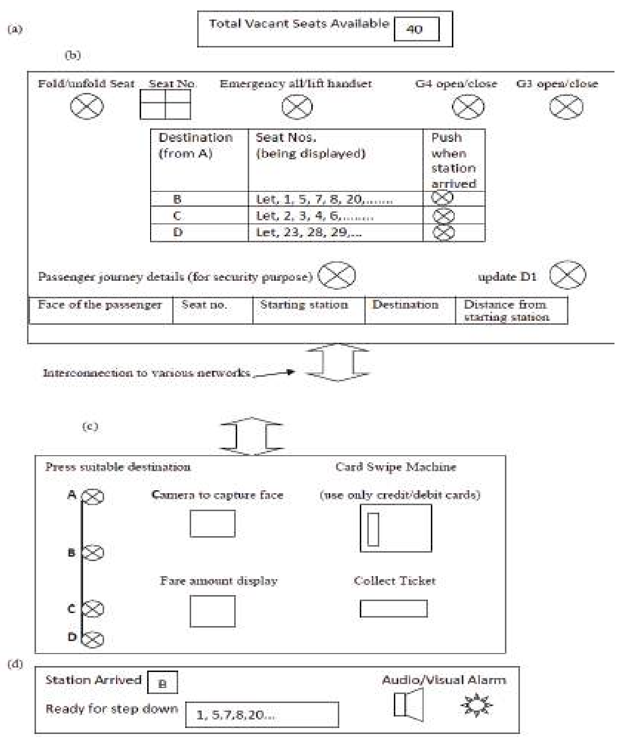

Fig. 3: (a) Display D1 at outer body of bus (above the G4), (b) Display D3 with control panel in Driver cabin (c) Display D2 with Touch sensitive panel and CSM machine (d) Display D4 in front of passengers in passenger section.

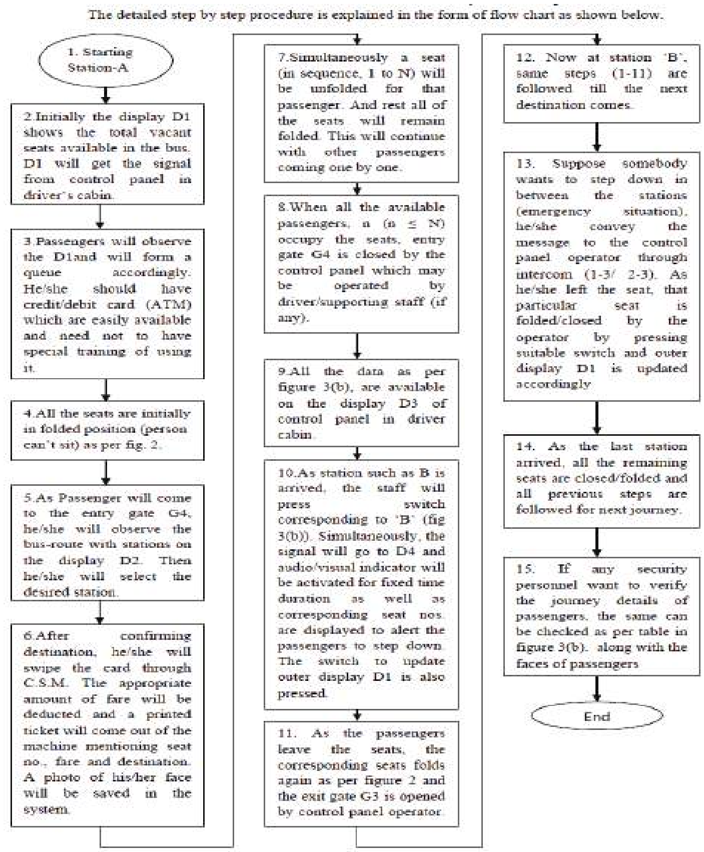

Fig. 4.Flow chart of e-conductor bus system description

CONCLUSION

If this proposal is implemented by suitable authority many disadvantages mentioned earlier can be rectified. Nowadays almost everyone has ATM card or credit card. This system can be upgraded by using GSM module to transmit bus location to the bus terminals. Further GSM can be used to tell information about the accident happened and bus break down. Face recognition system is useful to identify the passengers for security reasons. The main thing is that the seats are in folded position if unused which ensure the proper utilization of seats and no person can sit without ticket even if the gate is opened. This paper suggests a much more public friendly system as well as the credit transaction with the use of credit/ debit cards.

ACKNOWLEDGEMENTS

Some undergraduate (B.Tech.) engineering students have worked to develop model of such conductor less bus incorporating some of the proposed features and also presented in the Smart India Hackathon, 2022 (SIH, 2022) organised by AICTE and Ministry of Education, Govt of India and won the prize at national level under the mentor ship of the author. In this regard, I appreciate the successful efforts of SIH project (award winning team members) student team members Ms. H. Dadheech, (Late) H. Verma, S. Faizan, J. Nara, T. Ahamad and D. Dadhich. The venue of the event was at Arya College of Engineering and Tech. Jaipur. The desired components and facilities to assemble the project had been provided by the same.

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Photon Interaction Cross Sections, Effective Atomic Number and Electron Density of Some Crystalline Materials

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ABSTRACT

Effective atomic number (Z_{eff}) and electron density (N_{el}) of some crystalline materials viz., AlP, SiC, GaAs, ZnSe, AgI, AlAs, CdS, GaP, CuF, CuCl, ZnS and InSb have been calculated in the extended energy range 1 keV-100 GeV using mass attenuation coefficient from WinXCom program. The variation of Z_{eff} and N_{el} values for all photon interactions [coherent, incoherent, photoelectric, pair production, total photon interaction (with coherent and without coherent)], with energies are represented graphically and the variation of both parameters, Z_{eff} and N_{el} with energies is same. The considerable variation in Z_{eff} and N_{el} is due to the dominance of different interaction mechanisms in that energy region, such as photoelectric absorption, Compton scattering, and pair production. The maximum values of Z_{eff} and N_{el} are found in the low energy range, where photoelectric absorption is the main interaction process. The minimum values of Z_{eff} and N_{el} are found at higher energies, where Compton scattering is dominant. At intermediate energies Z_{eff} and N_{el} remains almost constant. This may be due to the dominance of pair production in the high energy region.

KEYWORDS: *Effective atomic number, Cross sections, Electron density, Crystal materials.*

INTRODUCTION

The effective atomic number, Z_{eff}, can be a useful metric when modelling X-ray and gamma ray interactions in complex media, such as when designing radiation shielding or calculating absorbed dose in radiotherapy. A material's effective atomic number cannot be represented by a single number because it is made up of different elements, as mentioned by Hine [1]. The various atomic numbers in the material must be weighted differently for each of the various ways that X-rays and gamma rays might interact with matter. Z_{eff}, thus, is not a true constant for a given material but rather a parameter that varies with photon energy based on the processes engaged in the interaction. The electron density, which is measured in terms of the number of electrons per unit mass, is closely connected to the effective atomic number [2]. From literature it has been found that no work has been carried out on calculation of effective atomic number and electron density. This prompted us to calculate effective atomic number and electron density of crystalline materials.

The serious study of solid state physics began with the discovery of x-ray diffraction by crystals and the publication of a series of simple calculations of the properties of crystals and of electrons in crystals. Why crystalline solids rather than noncrystalline solids? The important electronic properties of solids are best expressed in crystals. A crystal is formed by adding atoms in a constant environment, usually in a solution. The building blocks here are atoms or groups of atoms. The crystal thus formed is a three-dimensional periodic array of identical building blocks. Examples of the cubic zinc sulfide structure are, AlP, SiC, GaAs, ZnSe AgI, AlAs, CdS, GaP, CuF, CuCl, ZnS and InSb. The close equality of the lattice constants of several pairs, notably (Al, Ga)P and (Al, Ga)As, makes possible the construction of semiconductor heterojunctions. In this study interaction of X-ray/Gamma ray for crystalline materials have been calculated in the extended energy range [3]. The mass aattenuation coefficients of these crystal structures have been obtained from XCom software [4, 5], which has been brought to windows platform by L Gerward, known as WinXCom [6, 7] which exports mass attenuation coefficient values to MS excel template.

Aim of this present work is to calculate effective atomic number and electron density of the selected crystalline materisals in the energy range 1 keV-100 GeV using mass attenuation coefficient from WinXCom program in the energy range 1 keV - 100 GeV. The variations of effective atomic number and electron density with energy are shown graphically for all photon interactions for all photon interactions (coherent, incoherent, photoelectric, pair production, total photon interaction (with coherent and incoherent).

COMPUTATIONAL METHODS

Mass attenuation coefficients

The total photon mass attenuation coefficient $(\mu/\rho)_{comp}$ for a chemical compound or mixture was calculated using the WinXCom and the following 'mixing rule.'

$$\left(\frac{\mu}{\rho}\right)_{comp} = \sum_i \omega_i \left(\frac{\mu}{\rho}\right)_i \quad (1)$$

where $(\mu/\rho)_i$ and ω_i are the photon mass attenuation coefficient and the weight fraction of the i^{th} constituent element in the compound, respectively. The quantity ω_i of a material made up of multiple constituents is given by

$$\omega_i = \frac{n_i A_i}{\sum_i n_i A_i} \quad (2)$$

With condition that $\omega_1 + \omega_2 + \omega_3 + \omega_4 + ... = 1$

where A_i is the ith element's atomic weight and n_i is the number of formula units in i^{th} element.

Effective atomic number and electron density

The effective molecular cross section (σ_m) is estimated using the values of mass attenuation coefficients (μ/ρ) comp by the following relation

$$\sigma_m = \left(\frac{\mu}{\rho}\right)_{comp} \frac{\sum_i n_i A_i}{N} \quad (3)$$

where N is the Avogadro's number, n_i and A_i are the total number of atoms and atomic weight of the ith element in a molecule respectively. The total cross section (σ) and different partial cross-sections [17] are related by the relation

$$\sigma = \sigma_{coh} + \sigma_{incoh} + \tau + \kappa + \sigma_{ph,n} \quad (4)$$

Where σ_{coh} and σ_{incoh} are the scattering cross-sections of coherent and incoherent processes, respectively. τ is the atomic photoelectric cross-section, $\sigma_{ph,n}$ is the photonuclear cross-section, and κ is the positron electron pair production cross-section. The following equation connects the effective atomic cross-section (σ_a) and the effective molecular cross-section (σ_m) [8],

$$\sigma_a = \frac{\sigma_m}{\sum_i n_i} \quad (5)$$

Similarly, electronic cross-section (σ_e) is given by the following equation[9,10]:

$$\sigma_e = \frac{1}{N} \sum_i \left(\frac{f_i A_i}{Z_i}\right)\left(\frac{\mu}{\rho}\right)_i \quad (6)$$

where A_i and $f_i = n_i / \sum_i n_i$ are the atomic number and fractional abundance of the constituent element.

Effective atomic number

Effective atomic number (Z_{eff}) is the ratio of the atomic and electronic cross-sections and it is given by [11]

$$Z_{eff} = \frac{\sigma_a}{\sigma_e} \quad (7)$$

Using the above equations Manohara et al [12] have shown that Z_{eff} is given by

$$Z_{eff} = \frac{\sum_i n_i A_i \left(\frac{\mu}{\rho}\right)_i}{\sum_i n_i \frac{A_i}{Z_i} \left(\frac{\mu}{\rho}\right)_i} \quad (8)$$

here Z_i is the atomic number of the i^{th} element present in a molecule.

Electron density

The effective electron density (N_{el}) which is another parameter related to Z_{eff}, which represents the number of electrons per unit mass of interacting materials and may be computed using the following relationship [13, 14]

$$N_{el} = \frac{(\mu/\rho)_{comp} Z_{eff}}{\sigma_a} \quad (9)$$

RESULTS AND DISCUSSIONS

Mass attenuation coefficients

The variation of mass attenuation coefficient against optical energy of the compounds obtained by cross sectional data which were exported to MS Excel from WinXCom is shown in Fig. 1, for total photon interaction process (with coherent). The molecular formula of crystalline materials are presented in Table 1. Photoelectric absorption, Compton scattering and pair production are the three dominant mass attenuation mechanisms. Mass attenuation coefficient values are maximum for very small energy range 1 keV- 2 keV where photoelectric absorption is dominant, from 2 keV – 20 keV it is minimum where Compton scatting is dominant and above 20 keV pair production is dominant. In the energy region 2 keV- 20 keV there is significant variation in mass attenuation coefficient values for GaAs, ZnSe, ZnS, GaP and AlAs crystalline materials [15-18].

Table 1. Name of the crystalline material and its molecular formula

S. No	Crystalline material	Molecular formula	Crystalline material	Molecular formula
1	Aluminium Phosphide	AlP	Cadmium sulphide	CdS
2	Silicon carbide	SiC	Gallium phosphide	GaP
3	Gallium arsenide	GaAs	Copper fluoride	CuF
4	Zinc selenite	ZnSe	Copper chloride	CuCl
5	Silver Iodide	AgI	Zinc sulphide	ZnS
6	Aluminium Arsenide	AlAs	Indium titanate	InSb

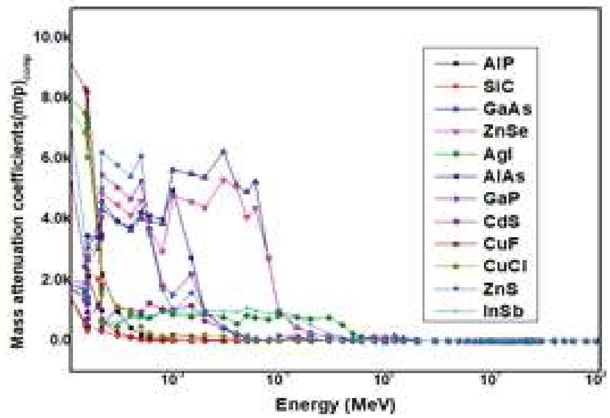

Fig 1.Variation of mass attenuation coefficient of crystalline materials in the energy region 1keV-100 GeV for photon interaction (with coherent).

Effective atomic number and electron density

The calculation of Z_{eff} and N_{el} of crystalline materials were carried out using above mass attenuation coefficients in the energy region 1 keV-100 GeV. These data shows that both the parameters depend upon chemical composition of the given molecule or compound.

Total photon interaction (with coherent and incoherent)

From Fig. 2 and 4 it can be easily seen that in the continuous energy range (1 keV– 100 GeV) the Z_{eff} and N_{el} are mainly dominated by different partial photon interaction processes. Energy below 0.02 MeV, Z_{eff} has maximum values, where photoelectric interaction is dominant. Z_{eff} drops to a lower value typically for Compton scattering from 0.02-0.3 MeV, in the energy region 0.3-30 MeV. Compton scattering or incoherent scattering is the main interaction process in this intermediate energy range and Z_{eff} is about constant and equal to mean (average) atomic number [19, 20]. In the transition region from 30 - 100 MeV, Z_{eff} increases with increasing energy as pair production gradually becomes dominant. At high energies above 100 MeV, Z_{eff} assumes an almost constant value determined by pair production.

The Z_{eff} varies from a higher value at lower energies to a lower value at higher energies, with a peak due to photoelectric effect near the K-edge of the high Z element present in the crystalline materials, then becoming constant with a minimum value at intermediate energies; further, there is an increasing trend in Z_{eff} values due to the relative dominance of photon interaction processes in various energy regions. The Z dependency of total atomic cross–sections explains all changes, leading to effective atomic numbers such as Z^{4-5} for photoelectric absorption, Z for Compton scattering, and Z^2 for pair creation. As a result of the above, the photoelectric absorption cross-section, which is proportional to Z^{4-5}, gives larger weight to the high Z elements than the other processes. The greatest values of Z_{eff} in the low energy zone are readily explained by this state. In contrast to photoelectric absorption and pair production processes, the Compton scattering cross-section is proportional to Z, giving high Z elements less weight [21].

Electron density is closely related to the effective atomic number, as shown by Equation (3). As a result, N_{el} qualitative energy dependence is similar to Z_{eff}. From Fig. 3 and 5, energy below 0.1 MeV, Z_{eff} has maximum values, where photoelectric interaction is dominant. Z_{eff} drops to a lower value typically for Compton scattering from 0.1-0.8 MeV, in the energy region 0.8-50 MeV. Compton scattering or incoherent scattering is the main interaction process in this intermediate energy range and Z_{eff} is about constant and equal to mean (average) atomic number. In the transition region from 50 - 100 MeV, Z_{eff} increases with increasing energy as pair production gradually becomes dominant. At high energies above 100 MeV, Z_{eff} assumes an almost constant value determined by pair production. Furthermore, within the dominance region of any of the three major photon interaction processes, the effective atomic number values remain constant, but the values of effective atomic number vary in the regions where the dominance region for one process shifts to the other. The presence of absorption edges of the constituent parts creates an exception in the lower energy zone [22]. The average effective atomic number and electron density values are given in Table 2. The average values are maximum for indium titanate, Z_{eff} depends upon elemental composition.

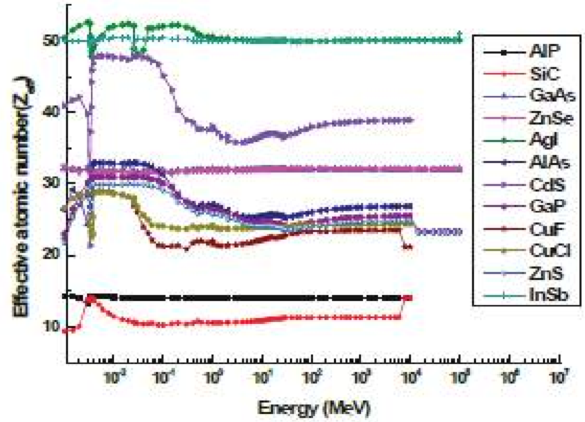

Fig. 2. Variation of the Z_{eff} as function of energy for total coherent process.

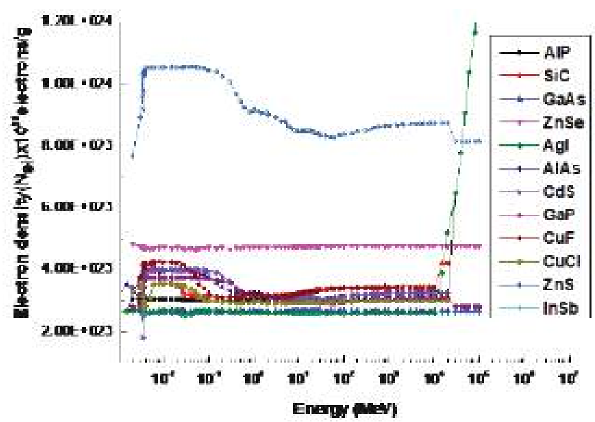

Fig. 3. Variation of the N_{el} as function of energy for total coherent process

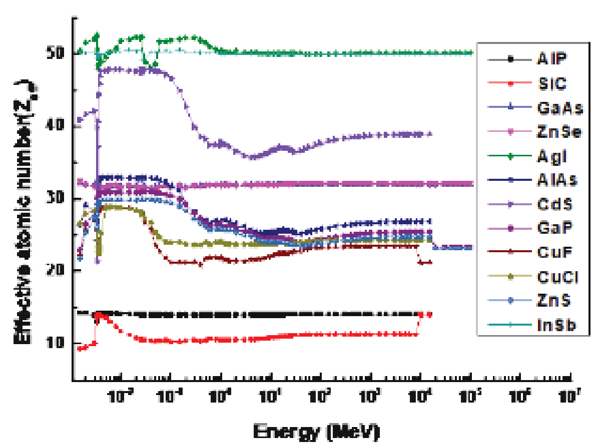

Fig 4. Variation of the Z_{eff} as function of energy for total incoherent process.

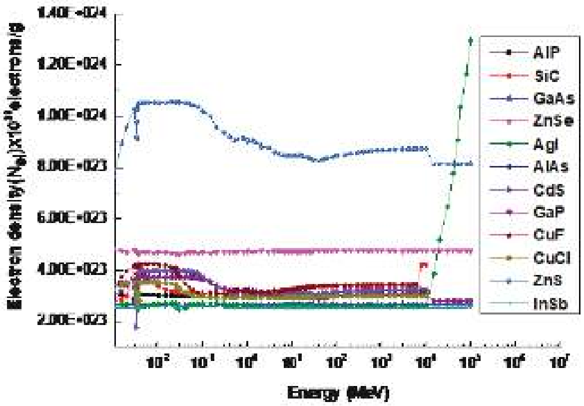

Fig. 5. Variation of the N_{el} as function of energy for total incoherent process

Coherent and incoherent scattering

The Fig. 6 and 7 shows the variation of Z_{eff} and N_{el} with photon energy for coherent scattering. It is apparent from the figures that Z_{eff} increases as energy increases from 1 keV to 3 keV. Average value of Z_{eff} and N_{el} of Crystalline materials are given in Table 2. Beyond that extent, Z_{eff} remains constant as energy is increased. Because of the inclusion of phosphorus, the behaviour differs from that of other organic molecules. It has demonstrated that in materials comprising periodic arrangement of atoms, which are crystalline structures, the effective atomic numbers tend to be constant as a function of energy. Similary, the variation of Z_{eff} with photon energy for incoherent scattering is shown in Fig 8 and 9 which indicates that Z_{eff} and N_{el} increases sharply in energy in the region 1 keV–100 GeV. From 3 keV- 40 MeV gradually increases and above 40 MeV it is almost independent of energy.

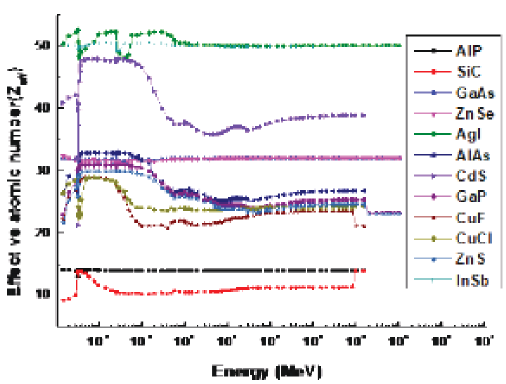

Fig. 6. Variation of the Z_{eff} as function of energy for coherent process

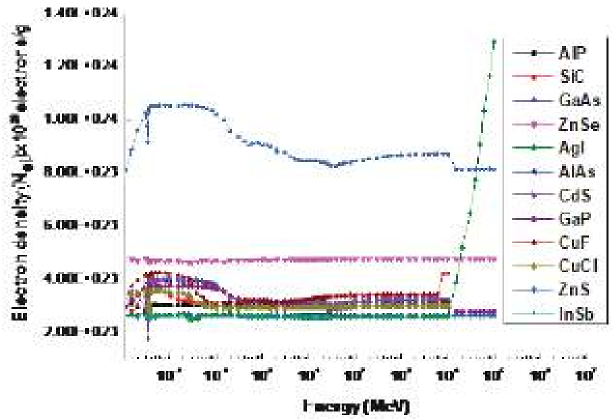

Fig. 7. Variation of the N_{el} as function of energy for coherent process.

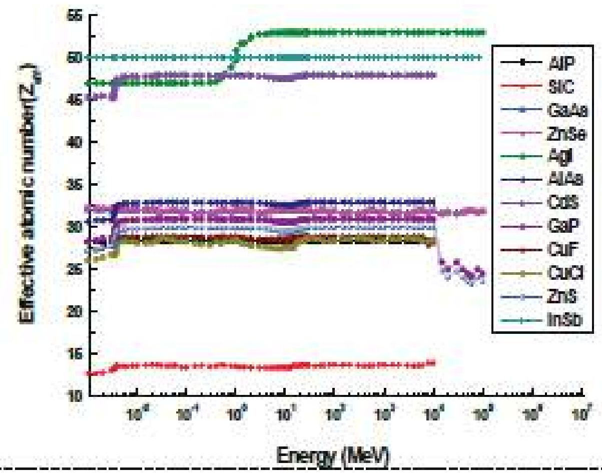

Fig. 8. Variation of the Z_{eff} as function of energy for incoherent process

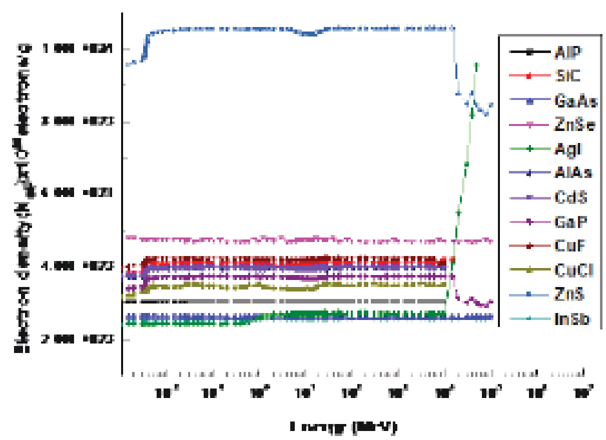

Fig. 9. Variation of the N_{el} as function of energy for incoherent process

Pair production in nuclear field and electric field

Pair production in the nuclear field, the change of Z_{eff} with photon energy is shown in Fig. 10 and 11, which demonstrates that Z_{eff} and N_{el} increases significantly with increasing photon energy from 0.2 MeV to 1.5 MeV before becoming almost energy independent [23]. The average values of both the parameters has been given in Table 2. It could be because pair production in the nuclear field is Z^2 dependent. Due to the inclusion of elements with a wide range of atomic numbers, the increase in Z_{eff} with energy is more significant for crystalline materials below 40 MeV as shown in the figure. Similarly, the variation of Z_{eff} and N_{el} with photon energy for electric field is shown in Fig. 12 and 13. The values increases with increase in energy from 1 keV- 6 MeV and above that it is independent of energy and becomes constant.

Table 2. Average values of Z_{eff} and N_{el} of Crystalline materials for all photon interaction process

	<Zeff>					<Nel>				
	Coh	Incoh	PE	PN	PA	Coh	InCoh	PE	PN	PA
AlP	14.18	14.07	14.30	14.14	14.07	3.05	3.02	3.07	3.04	3.02
SiC	13.62	11.91	13.83	12.22	11.10	4.10	3.58	4.16	3.68	3.34
GaAs	31.90	32.00	31.95	32.12	32.09	2.65	2.66	2.66	2.67	2.67
ZnSe	31.99	32.11	32.16	32.39	32.27	4.75	4.76	4.77	4.81	4.79
AgI	50.69	50.51	51.32	50.01	49.85	3.30	3.27	3.18	3.45	3.51
AlAs	32.69	28.74	32.78	26.26	23.14	3.94	3.46	3.95	3.16	2.79
CdS	47.59	42.71	47.43	39.20	34.16	3.98	3.57	3.97	3.28	2.86
GaP	30.17	26.75	30.14	24.34	23.47	3.64	3.23	3.65	2.94	2.83
CuF	28.73	25.17	28.89	24.37	21.17	4.22	3.70	4.24	3.58	3.11
CuCl	28.01	25.21	28.27	24.77	23.47	3.44	3.10	3.47	3.04	2.88
ZnS	29.14	26.11	29.08	23.69	22.06	10.3	9.20	10.2	8.35	7.77
InSb	50.01	50.01	50.21	49.59	49.98	2.55	2.55	2.56	2.54	2.54
*Coh(Coherent) *Incoh(Incoherent) *Pair electron (PE) *Pair Nuclear (PN) *Photoelectric absortion (PA)										

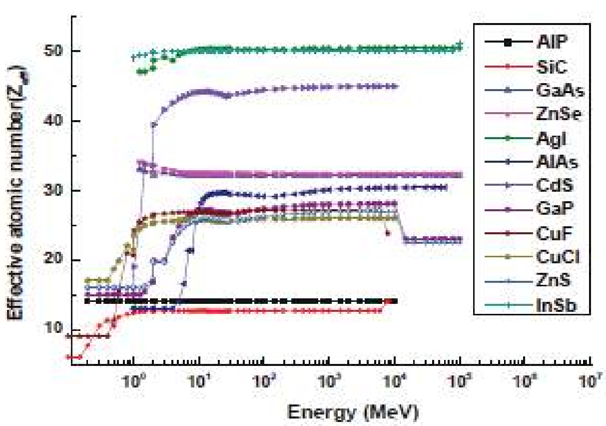

Fig. 10. Variation of the Z_{eff} as function of energy for pair nuclear process.

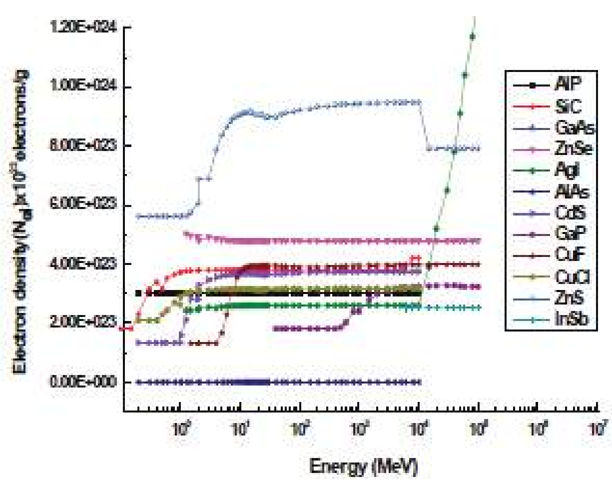

Fig. 11. Variation of the N_{el} as function of energy for pair nuclear process.

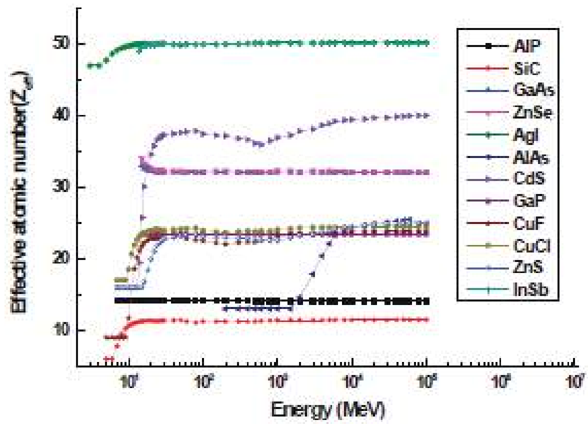

Fig. 12. Variation of the Z_{eff} as function of energy for pair electron process.

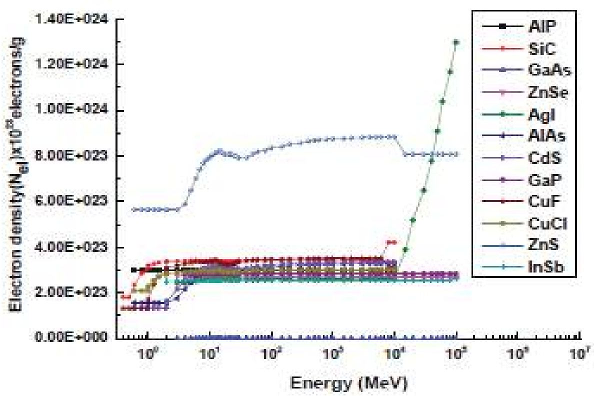

Fig. 13. Variation of the N_{el} as function of energy for pair electron process..

Photoelectric absorption

A plot of Z_{eff} vs photon energy, especially for medium and high-Z materials, shows the distinctive absorption edges as the binding energy of each electron subshell is reached and a new pathway for photoexcitation is energetically enabled. The average values of Z_{eff} and N_{el} has been given in Table 2. Fig 14 and 15 demonstrate the fluctuation of Z_{eff} and N_{el} with photon energy for photoelectric absorption, indicating that Z_{eff} is nearly independent of photon energy. This is due to the fact that these biological substances are made up of elements with the same or similar atomic numbers. Z_{eff} increases sharply from 1 keV to 3 keV and then it remains almost constant thereafter. This is because; photoelectric process is predominant at low energies and for materials of higher atomic numbers [24-28]. The variations of N_{el} with photon energy in all the biological compounds for partial and total interaction processes are similar to that of Z_{eff}.

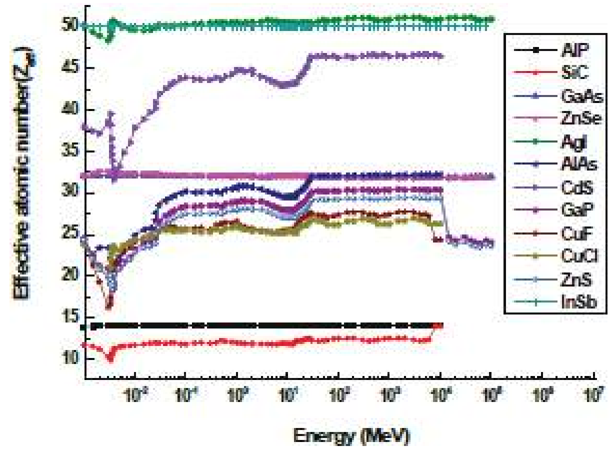

Fig. 14. Variation of the Z_{eff} as function of energy for photoelectric absorption process.

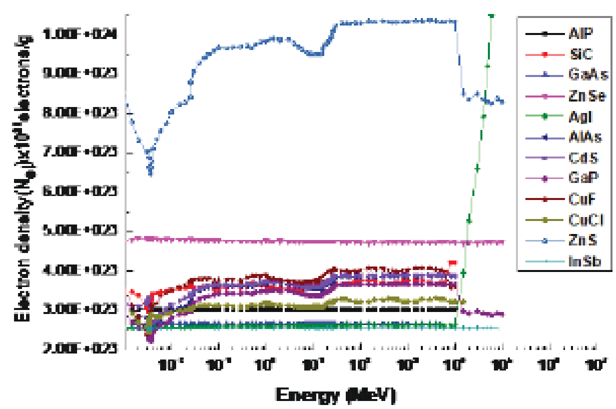

Fig. 15. Variation of the N_{el} as function of energy for photoelectric absorption process.

CONCLUSIONS

In this present work, the study has been undertaken to get information of the mass attenuation coefficients, effective atomic number Z_{eff}, electron density N_{el} and Kerma of crystalline materials using WinXCom. Mass attenuation coefficients, effective atomic number and corresponding electron density of selected crystals have been calculated in the photon energy region 1 keV-100 GeV. There are three main photon-interaction processes photoelectric absorption, Compton scattering and pair production respectively. Effective atomic number and electron density of the selected crystalline materials were obtained for total and partial photon interaction processes i.e total photon interaction with coherent and without coherent, photoelectric absorption, coherent scattering, incoherent scattering, pair production in the electric and nuclear field. The maximum value of effective atomic numbers where observed in the low energy region E >0.02 MeV where photoelectric absorption is the dominant process. At the K edges energies of the compounds more than a single values of Z_{eff} could be obtained due to non-uniform variation of mass attenuation coefficients. The minimum value of effective atomic numbers were observed in the intermediate energy region 0.3<E<30 MeV, where Compton scattering is the main interaction process. At high energy region the effective atomic number values have intermediate energies E<100 MeV where pair production is the dominating process. The N_{el} is closely related to the Z_{eff} and has the same qualitative energy dependence as Z_{eff}. The Z_{eff} and N_{el} variation of crystalline materials quite different from other materials because of periodicity of arrangement of atoms. These studies are useful in the field of material science and spectroscopic studies.

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Influence of Nano-TiO_2 and GGBS on the Water Absorption, Permeability and Sorptivity of Concrete Pavements

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ABSTRACT

This study investigates the effects of partial replacement of cement with Nano titanium dioxide (TiO_2) and ground granulated blast furnace slag (GGBS) on the durability properties such as water absorption, water permeability, and sorpitivity of concrete mixes with 1% TiO_2 and 30% GGBS, compared to conventional concrete. Results indicate that the modified concrete exhibits significantly lower water absorption (45-60% reduction), reduced water permeability (25-50% reduction), and improved Sorptivity resistance. These findings suggest that the incorporation of TiO_2 and GGBS enhances the long-term durability of concrete pavements, making them more suitable for aggressive environmental conditions.

KEYWORDS: *Concrete pavement, Nano titanium dioxide (TiO_2), Ground granulated blast furnace slag (GGBS), Water absorption, Water permeability, Sorpitivity, Durability.*

INTRODUCTION

Concrete pavements are a critical component of modern infrastructure, widely used in highways, airports, and urban roads due to their high strength, durability, and ability to withstand heavy traffic loads. However, despite their widespread use, concrete pavements are susceptible to degradation over time, particularly when exposed to water and aggressive environmental conditions. Water ingress, in the form of absorption, permeability, and capillary action, is one of the primary factors contributing to the deterioration of concrete pavements. This can lead to issues such as cracking, spalling, and corrosion of embedded reinforcement, ultimately reducing the service life of the pavement and increasing maintenance costs.

To address these challenges, researchers and engineers have explored various strategies to enhance the durability and water resistance of concrete. One promising approach is the partial replacement of cement with supplementary cementitious materials (SCMs) and nanomaterials. Ground granulated blast furnace slag (GGBS), a by-product of the iron and steel industry, has been widely used as an SCM due to its pozzolanic properties, which improve the long-term strength and durability of concrete. Similarly, Nano titanium dioxide (TiO_2) has gained attention for its ability to enhance the microstructure of concrete, leading to improved mechanical properties and resistance to environmental degradation.

The combination of GGBS and TiO_2 offers a synergistic effect, where GGBS contributes to the densification of the concrete matrix, reducing porosity and permeability, while TiO_2, as a nanomaterial, enhances the hydration process and refines the pore structure. This combination has the potential to significantly improve the water resistance and durability of concrete pavements, making them more suitable for use in harsh environments.

Despite the growing interest in the use of GGBS and TiO_2 in concrete, there is limited research on their combined effects, particularly in the context of concrete pavements. Most studies have focused on individual materials, and there is a need for comprehensive research to evaluate the performance of concrete with both GGBS and TiO_2. This study aims to fill this gap by investigating the effects of partial replacement of cement with 1% TiO_2 and 30% GGBS on the water absorption, permeability, and sorpitivity of concrete pavements.

OBJECTIVES

To assess the impact of TiO_2 and GGBS on the water absorption and water permeability of concrete

To analyse the sorpitivity of concrete containing TiO_2 and GGBS and compare it with conventional concrete

LITERATURE REVIEW

Garima Rawat et al. (2022)

This study evaluated the addition of Nano-TiO_2 to cement, highlighting its ability to enhance compressive strength and durability in M30 concrete while reducing workability. The optimal dosage ranged from 1–4%, significantly lowering water absorption and permeability when applied under controlled conditions.

Nikunj Patel & C.B. Mishra (2018)

The research explored Nano-TiO_2 effects on M40-grade concrete, showing enhanced compressive and flexural strengths at 1% dosage. Despite marginally reducing workability, nano-TiO_2 significantly decreased water absorption and permeability, proving its value for durable concrete pavements.

Arunabh Pandey & Brind Kumar (2019)

This research incorporated rice straw ash (10%) and micro-silica (7.5%) into concrete, improving water absorption and chloride penetration resistance. The sustainable mix showed superior durability, suggesting RSA as a viable substitute for micro-silica.

Jayeshkumar Pitroda et al. (2013)

Fly ash at 10% replacement of cement reduced sorpitivity and water absorption in M25 and M40 concretes, enhancing moisture resistance. However, performance declined beyond this threshold, indicating the need for precise optimization.

MATERIALS USED

All the materials used in the present study are detailed in the following table.

Table 1: materials used

Material	Description	source
Cement	OPC 53 grade	Ultratech
Course aggregate	ZONE II	Hyderabad
Fine aggregate		
TiO_2	Mineral admixtures	NCI Hyderabad
GGBS		JINDAL
SP430	Chemical admixture	FOSROC
Water	JNTUH bore well	Hyderabad

Nano Titanium Dioxide (Nano-TiO_2)

Nano-TiO_2 is a highly effective additive for enhancing the performance of concrete. It acts as a filler that refines the microstructure by reducing porosity and as a catalyst for pozzolanic reactions, accelerating early strength development. In the study, Rutile form of Nano-TiO_2 is used, with particle sizes of 19.6 nm. Optimal dosages ranged from 0.5% to 2.0% by weight of cement, with 1% identified as the most effective proportion for improving mechanical, durability, and resistance to environmental degradation. Nano-TiO_2 also contributed to reduced water absorption, permeability, and sorpitivity, making it ideal for applications requiring high durability and resistance to aggressive environments.

Ground Granulated Blast Furnace Slag (GGBS)

GGBS is a by-product of the iron and steel industry, widely recognized as a sustainable cementitious material for enhancing concrete properties. It improves workability, reduces heat of hydration, and enhances durability by mitigating chloride penetration and water permeability. In this study, GGBS was used at replacement levels of 30% and 40% by weight of cement, with 30% providing optimal results. The synergy between GGBS and Nano-TiO_2 proved effective in producing high-performance, environmentally sustainable concrete.

Experimental investigation

In the current experimental investigation, the mix proportion for M40 and M50 grades of concrete has been determined per IS10262: 2019. The tables below list the amounts of each component used in M40 and M50 concrete.

Table 2: Mix proportions of M40 grade concrete

Mix Designation	$NT_0 G_0$	$NT_{0.5} G_0$	$NT_1 G_0$	$NT_{1.5} G_0$	$NT_2 G_0$	$NT_1 G_{30}$	$NT_1 G_{40}$
W/C	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Cement Kg/m^3	390	388	386	384	382	270	232
TiO_2 Kg/m^3	0	1.95	3.9	5.85	7.8	2.7	2.34
TiO_2 %	0	0.5	1	1.5	2	1	1
GGBS Kg/m^3	0	0	0	0	0	117	156
GGBS %	0	0	0	0	0	30	40
Coarse Aggregate Kg/m^3	1316	1316	1316	1316	1316	1316	1316
Fine Aggregate Kg/m^3	596	596	596	596	596	596	596
Water (lit)	148	148	148	148	148	148	148
Admixture (lit)	2.73	2.73	2.73	2.73	2.73	2.73	2.73

Table 3: Mix proportions of M50 grade concrete

Mix Designation	$NT_0 G_0$	$NT_1 G_{30}$	$NT_1 G_{40}$
W/C	0.35	0.35	0.35
Cement Kg/m^3	423	292	251
TiO_2 Kg/m^3	0	2.96	2.58
TiO_2 %	0	1	1
GGBS Kg/m^3	0	126.9	169.2
GGBS %	0	30	40
Coarse Aggregate Kg/m^3	1236	1236	1236
Fine Aggregate Kg/m^3	628	628	628
Water (lit)	148	148	148
Admixture (lit)	2.96	2.96	2.96

RESULTS

Water absorbtion

Water absorbtion determines the amount of water the concrete sample absorbs at atmosperic conditions.

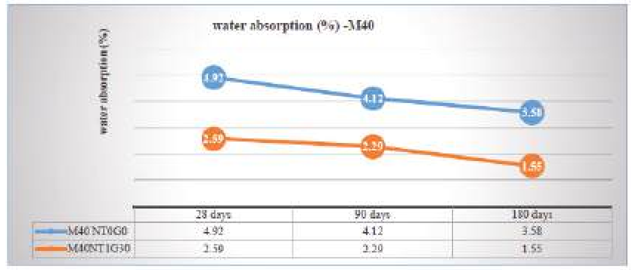
Here, specimen of 100mm cubes were used to conduct the experimant as per ASTM C642.

The specimens are oven dried at 105 C for at least 24 hours until their weight reaches stable value and taken as oven dried weight. The specimens are put in water for 48 hours and saturated weight is taken.

$$\text{Water absorbtion} = \frac{\textit{saturated weight of cubes} - \textit{ovendried weight}}{\textit{ovendried weight}} x100$$

All units are taken in grams

Graph 1: water absorption for M40 grade concrete



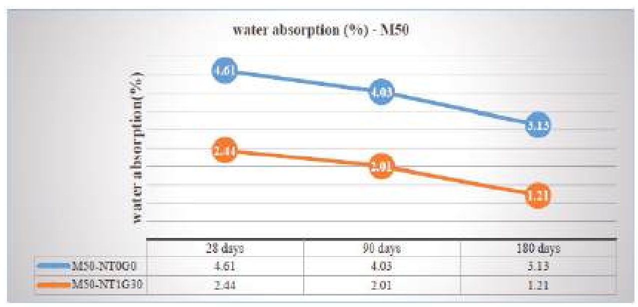
Note 1:

M40 NT0G0 represents conventional concrete.

M40NT1G30 represents special concrete with 1% TiO_2 and 30% GGBS.

Results from the above table show that special concrete has shown (45-55)% less water absorption compared to conventional concrete.

Graph 2: water absorption (%) for M50 grade concrete.



Note 2:

M50 NT0G0 represents conventional concrete.

M50NT1G30 represents special concrete with 1% TiO2 and 30% GGBS.

Results from the above table show that special concrete has shown (50-60)% less water absorption compared to conventional concrete.

Water Permeability

Water permeability of concrete refers to the ability of water to pass through the concrete under a pressure gradient It is a critical property that determines the durability and long term performance of concrete, particularly in structures exposed to water and aggressive environmental conditions.

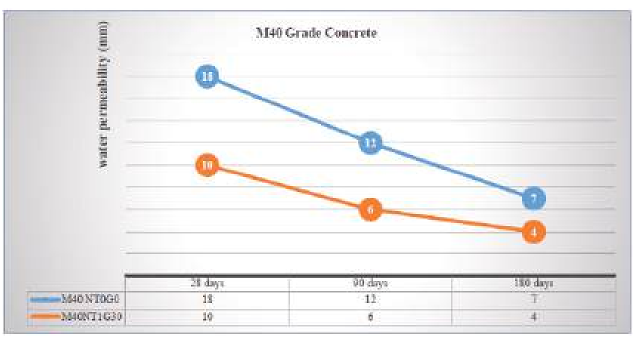
Codebook: IS 3085-2002

For our study, specimens of 150 mm cube is casted and water cured for 28 90 and 180 days

Water penetrometer is used to apply constant water pressure at 5 kg/cm2 over a period of 72 hours at room temperature

Fig. 1: Concrete Permeability Testing Machine

Graph 3: Water Permiability- M40



M40 grade concrete with 1%TiO 2 and 30% GGBS has shown (40-50)% less water permeability compared to conventional concrete.

Graph 4: Water Permiability- M50

M50 grade concrete with 1% TiO 2 and 30% GGBS has shown (25-35)% less water permeability compared to conventional concrete.

Sorpitivity

The rate at which water is absorbed by the concrete through capillary action, essentially measuring how quickly water can penetrate the concrete due to its porous nature.

A lower sorpitivity value indicates better resistance to water absorption

Codebook: ASTM C1585

Specimen: 100mmx 50mm cylinder.

$$\text{Sorpitivity} = \frac{change\ in\ mass\ of\ specimen(grms)}{exposed\ area\ of\ specimenXdensity\ of\ water}$$

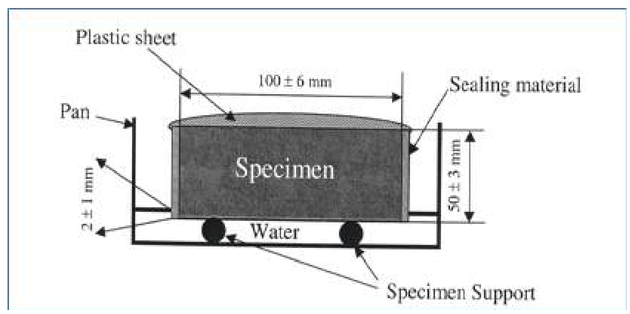
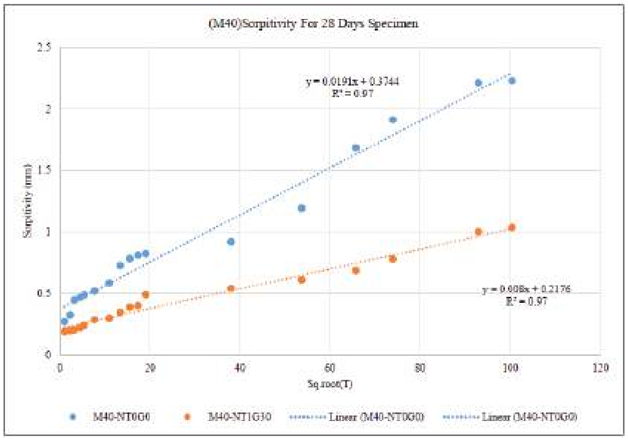


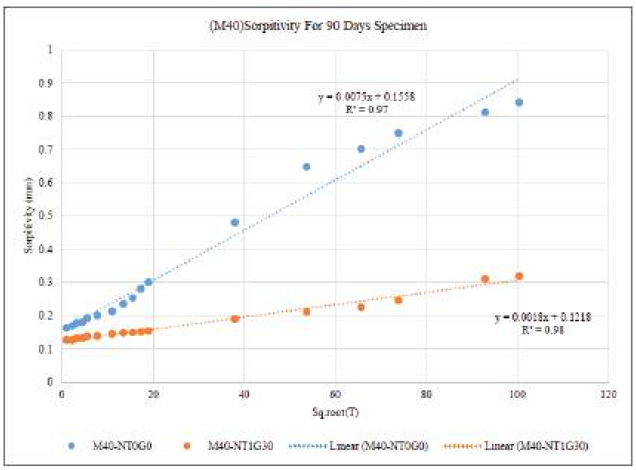
Table 4: Sorpitivity values (mm) – M40

Time (min)	Sorptivity Values (mm) for M40 grade concrete					
	28 days specimens		90 days specimens		180 days specimens	
	M40-NT_0G_0	M40-NT_1G_{30}	M40-NT_0G_0	M40-NT_1G_{30}	M40-NT_0G_0	M40-NT_1G_{30}
1	0.273	0.191	0.163	0.126	0.130	0.129
5	0.327	0.199	0.170	0.126	0.130	0.129
10	0.445	0.204	0.178	0.131	0.131	0.130
20	0.467	0.222	0.181	0.133	0.134	0.133
30	0.486	0.241	0.193	0.138	0.136	0.135
60 (1hr)	0.521	0.287	0.201	0.139	0.139	0.137
120 (2 hr)	0.587	0.298	0.213	0.145	0.141	0.139
180 (3 hr)	0.727	0.347	0.235	0.148	0.143	0.141
240 (4 hr)	0.782	0.389	0.271	0.149	0.155	0.145
300 (5 hr)	0.811	0.401	0.299	0.151	0.167	0.159
360 (6 hr)	0.824	0.489	0.327	0.154	0.189	0.168
1440 (1D)	0.921	0.541	0.481	0.190	0.344	0.200
2880 (2D)	1.194	0.613	0.649	0.211	0.400	0.207
4320 (3D)	1.684	0.687	0.701	0.225	0.446	0.228
5760 (4D)	1.912	0.779	0.750	0.246	0.513	0.265
8640 (6D)	2.211	1.001	0.900	0.311	0.554	0.270
10080 (7D)	2.228	1.035	0.915	0.319	0.561	0.278

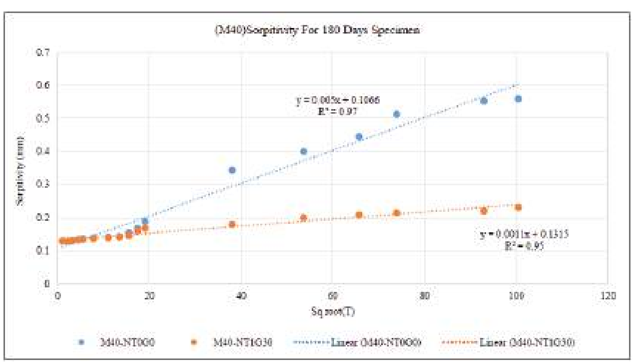
Graph 5: Sorpitivity for 28 days specimen (M40)



Graph 6: Sorpitivity for 90 days specimen (M40)



Graph 7: Sorpitivity for 180 days specimen (M40)

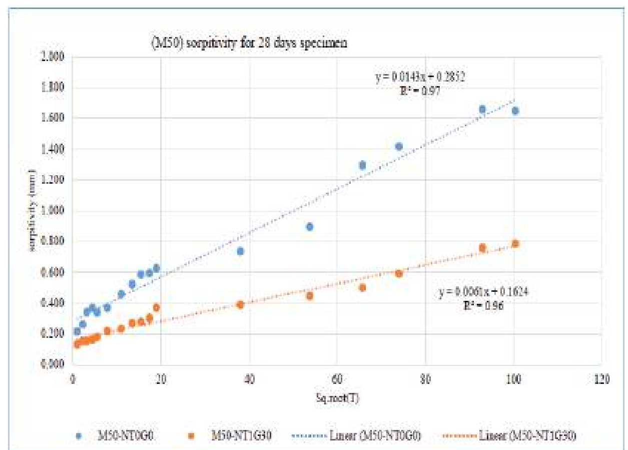


From all the above shown graphs, at any given time "T", Sorpitivity of M40 grade concrete specimens with TiO2 and GGBS has shown significantly less Sorptivity than conventional concrete due to being less porous in nature.

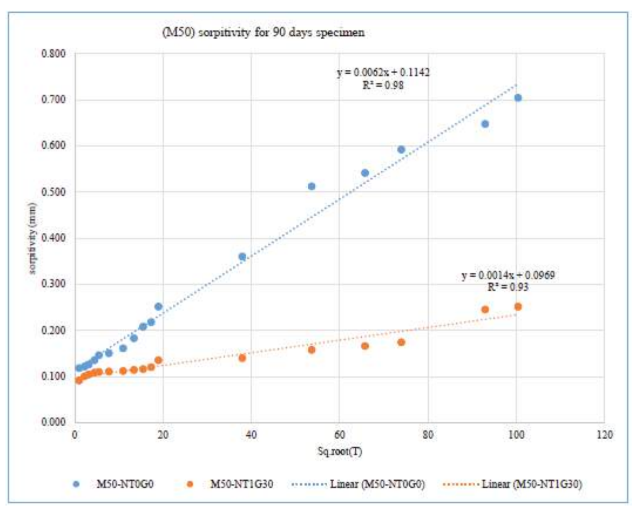
Table 5: Sorpitivity values (mm) – M50

Time (S)(min)	Sorptivity Values (mm) for M50 grade concrete					
	28 days		90 days		180 days	
	M50-NT_0G0	M50-NT_1G_{30}	M50-NT_0G0	M50-NT_1G_{30}	M50-NT_0G0	M50-NT_1G_{30}
1	0.216	0.134	0.119	0.092	0.101	0.082
5	0.262	0.153	0.122	0.101	0.101	0.082
10	0.343	0.153	0.126	0.105	0.113	0.085
20	0.369	0.164	0.136	0.109	0.134	0.93
30	0.340	0.181	0.147	0.110	0.136	0.109
60 (1hr)	0.370	0.218	0.151	0.111	0.139	0.122
120 (2 hr)	0.458	0.235	0.162	0.113	0.141	0.137
180 (3 hr)	0.523	0.273	0.183	0.115	0.143	0.141
240 (4 hr)	0.587	0.280	0.209	0.117	0.155	0.145
300 (5 hr)	0.596	0.305	0.218	0.121	0.167	0.159
360 (6 hr)	0.626	0.371	0.252	0.136	0.189	0.168
1440 (1D)	0.737	0.390	0.361	0.141	0.268	0.178
2880 (2D)	0.896	0.447	0.513	0.158	0.284	0.187
4320 (3D)	1.297	0.502	0.542	0.167	0.352	0.191
5760 (4D)	1.415	0.592	0.593	0.175	0.405	0.207
8640 (6D)	1.658	0.761	0.648	0.246	0.440	0.218
10080 (7D)	1.649	0.787	0.705	0.252	0.468	0.236

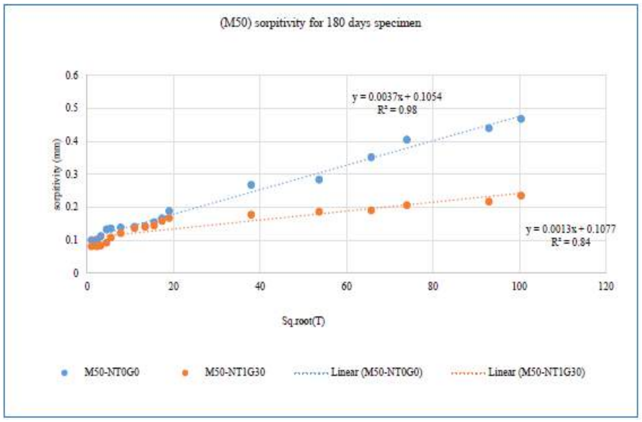
Graph 8: Sorpitivity for 28 days specimen (M50)



Graph 9: Sorpitivity for 90 days specimen (M50)



Graph 10: Sorpitivity for 180 days specimen (M50)



From all the above shown graphs, at any given time "T", Sorpitivity of M50 grade concrete specimens with TiO2 and GGBS has shown significantly less Sorptivity than conventional concrete due to being less porous and nature.

Note 3

The findings revealed that the concrete with 1% TiO2 and 30% GGBS has out performed the conventional concrete in all the experimental tests done in this study. The possible reasons are expressed below.

1. Microstructure Densification: Nano-TiO_2 acts as a nano-filler, reducing pore size and refining the microstructure of the cement matrix. This leads to lower capillary porosity, minimizing pathways for water ingress.
2. Pore Blockage Mechanism: The combination of Nano-TiO_2 and GGBS effectively blocks interconnected pores, restricting water movement within the concrete. This significantly decreases water absorption and permeability compared to conventional mixes.
3. Improved Particle Packing: The ultra-fine nature of Nano-TiO_2 enhances particle packing, reducing voids in the mix. Meanwhile, the spherical particles of GGBS contribute to a more compact and cohesive matrix, further limiting moisture penetration.
4. Reduced Microcracking: The optimized mix exhibits lower shrinkage and microcracking due to the controlled hydration process of GGBS, which mitigates internal stress development. This minimizes additional pathways for water absorption and transport.

Collectively, these mechanisms result in a concrete mix with significantly reduced water absorption, water permeability, and sorptivity, making it more durable and resistant to environmental deterioration.

CONCLUSION

The experimental investigation demonstrated that incorporating 1% Nano-TiO_2 and 30% GGBS as partial cement replacements significantly reduced the water absorption, water permeability, and sorptivity characteristics of concrete. The special concrete exhibited a denser microstructure due to the nano-filling effect of TiO_2 and the pozzolanic reaction of GGBS, which refined pore structure and minimized capillary porosity. This resulted in a substantial reduction in water absorption by (45–55)% for M40-grade concrete and (50–60)% for M50-grade concrete, highlighting improved resistance to moisture ingress.

Similarly, water permeability decreased by (40–50)% in M40 and (25–35)% in M50, attributed to the enhanced particle packing and reduced pore connectivity facilitated by the synergistic effect of TiO_2 and GGBS. The reduction in sorpitivity further confirmed the mix's ability to resist capillary water movement, ensuring lower permeability and improved long-term durability. These findings establish the special concrete mix as a superior alternative to conventional concrete, particularly for applications in aggressive environments where moisture-induced deterioration is a critical concern.

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GENERAL GUIDELINES FOR PREPARING AND SUBMITTING PAPERS

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Abstract

A single paragraph with a maximum of 200-250 words. Should comprise of important aims/objectives, results of the work and conclusions presented in the manuscript. Reader should easily understand and get a clear idea of what has been achieved and covered in the manuscript. Avoid the detailed information on the methodology followed.

Keywords

At the end of the abstract, in a separate line provide 4-6 familiar terms as keywords.

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Explain the background or past and present scenario of the problem under investigation. Start with general, then focus on to the research area. Make sure that all relevant materials or sources used as references must be cited in the text in sequential order and listed under references /bibliography in order as they appear.

Literature Review/Survey

Provide broad definitions and discussions of the topic and incorporate views of others (literature review) into the discussion to support, refute or demonstrate your position on the topic. Make sure that all relevant materials or sources used as references must be cited in the text and listed under references /bibliography in order as they appear within square brackets like [1, 2] at appropriate places.

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Provide the details of the materials or questionnaire used and the description of the standard experimental procedures and methods followed throughout the research work or survey. Make sure that all relevant materials or sources used as references are cited and listed. While doing the experiments/survey, adverse results if any obtained no need to present in the article. Make sure that all relevant materials or sources used as references must be cited in the text in sequential order within square brackets like [1, 2] and listed under references /bibliography.

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Acknowledgement

Authors can take the opportunity to acknowledge the persons who supported/encouraged in successfully completing the research work or survey and also the funding agencies.

References

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Journal Articles

Author 1 Name, Author 2 Name and Author 3 Name (Year), *Title of the* Article, Title of the *Journal Title in Italic*, Publisher Name, Publisher City Name, year. For example,

1. Bocky M Nat, Dolphin P Gem, Mcrath H. Sam (2021), "*Transforming Education Through Tech Age",* International Jour. of Sustainable Technologies, Vol. 47, No.03, Pp 56-65.
2. Bilroth N. Creen, Jingle M.S, Richy K. Mount (2023). *Embracing the Emerging Trends*, Int. Jour. of Engineering and Technologies 25(2): 35-42.

Conf. Proceedings

James F. Kennedy and Raj N. Cramp "*Studies on Recycling of Treated Waste from CETP for Green Belt Development"* at International Conference on "Special Conference on Water Quality" organized by the ABC College of Engineering & Technology, New Delhi, during 01-03 July2023.

Books

Author 1 Name, Author 2 Name and Author 3 Name, *Title of the Journal Title in Italic*, Publisher Name, Publisher City Name, year. For example,

Y. M. Bapu and S.M. Sastry, "*A Text Book on Machine Learning"*, Indian Society for Technical Education, New Delhi, 2023.

Theses

Ph.D Scholar Name, Title of the Ph.D thesis, Name of the University, year.

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