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Sustainable Development through Machine Learning, AI and IoT


First International Conference, ICSD 2023
Delhi, India, July 15–16, 2023
Revised Selected Papers


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Pawan Whig · Nuno Silva · Ahmed A. Elngar ·
Nagender Aneja · Pavika Sharma
Editors


Sustainable Development through Machine Learning, AI and IoT

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Preface

We are delighted to present the proceedings of the International Conference on Sustainable Development Using Machine Learning, Artificial Intelligence, and IoT (ICSD 2023), held virtually in New Delhi, India from July 15–16, 2023, where authors from various countries presented their research work. This conference has evolved into a significant platform for researchers, practitioners, and policymakers to explore the transformative potential of cutting-edge technologies in fostering sustainable development. ICSD 2023 was organized by The Research World (Threws) a group of professional, experienced scientists who work with a growing set of researchers in India and internationally on sustainable development through the application of AI, ML, and IoT.

The theme of ICSD 2023 was both timely and essential. In an era where the challenges of sustainability loom large on a global scale, harnessing the power of Machine Learning (ML), Artificial Intelligence (AI), and the Internet of Things (IoT) offers unprecedented opportunities. These technologies enable us to make informed decisions, optimize resource utilization, and develop innovative solutions to address the pressing issues of our time, such as climate change, resource scarcity, and social equity.

This volume comprises 31 full papers carefully selected from a highly competitive pool of 129 submissions, resulting in an acceptance ratio of 23.26%. Each paper underwent a rigorous review process, with the contributions evaluated by a panel of experts, including both national and international reviewers. We extend our heartfelt appreciation to all the reviewers for their dedicated efforts in maintaining the quality and relevance of the papers included in this book.

The papers featured in this book offer a comprehensive overview of the latest research and advancements in sustainable development through the integration of ML, AI, and IoT technologies. They span a wide range of topics, from energy-efficient systems and smart cities to environmental monitoring and healthcare solutions. The innovative ideas and approaches presented here are a testament to the creativity and commitment of the global research community in driving positive change through technology.

We would like to express our gratitude to the authors who contributed their outstanding work to this conference. Your dedication to advancing the field of sustainable development is truly commendable, and we are honored to showcase your contributions in this publication.

We also want to acknowledge the invaluable support of the conference organizing committee, the technical program committee, and our esteemed keynote speakers and panelists, who enriched the conference with their expertise and insights.

As editors of this book, we hope that the research presented here inspires further exploration and collaboration in the realm of sustainable development. We believe that the fusion of ML, AI, and IoT holds the promise of a more sustainable and prosperous future for all.

In closing, we extend our sincere thanks to the conference attendees, sponsors, and partners who made ICSD 2023 a resounding success. We trust that this collection of

papers will serve as a valuable resource for all those dedicated to advancing sustainable development through technology.

Pawan Whig
Nuno Silva
Ahmed A. Elngar
Nagender Aneja
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For Machine Learning Based Papers



Advanced Machine Learning Techniques for Early Detection of Leukemia

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Abstract. This research investigation explores the efficacy of Convolutional Neural Network (CNN), a sophisticated deep learning technique, in the prompt identification of leukemia. Prompt recognition of leukemia, a potentially life-threatening malignancy affecting the blood and bone marrow, plays a vital role in enhancing patient outcomes. Machine learning (ML) algorithms have demonstrated promise in this domain, with CNN emerging as exceptional due to its proficiency in extracting intricate features from raw data. In this study, we conduct a comparative analysis of the performance and effectiveness of three ML algorithms: Support Vector Machines (SVM), Random Forests (RF), Artificial Neural Networks (ANN), and CNN. By employing a dataset consisting of blood samples obtained from individuals afflicted with early-stage leukemia as well as healthy subjects, we train and assess these models. Our findings indicate that all models achieve exceptional accuracy and precision in detecting early-stage leukemia. Nonetheless, CNN outperforms the other ML algorithms and ANN in terms of both accuracy and efficiency. The automatic acquisition of hierarchical representations of features from raw data, such as blood samples, empowers CNN to capture intricate patterns that conventional ML algorithms may struggle to discern. These results underscore the potential of CNN as a potent instrument for substantially enhancing the detection and diagnosis of early-stage leukemia, thereby emphasizing its value in the battle against cancer.

Keywords: early-stage leukemia · machine learning · advanced learning · convolutional neural network · categorization · pattern identification · diagnosis

1 Introduction

Leukemia is a type of tumor that touches the blood and bone core, resulting in the abnormal growth of white blood cells as shown in Fig. 1. Early detection of leukemia is crucial for effective treatment and improving patient outcomes [1]. However, early-stage leukemia can be problematic to identify due to the lack of exact indications and the similarity of early-stage symptoms to other common illnesses. Machine learning (ML) has shown promise in improving the accuracy of leukemia diagnosis by analyzing patient data and identifying patterns that can indicate the presence of the disease [2].

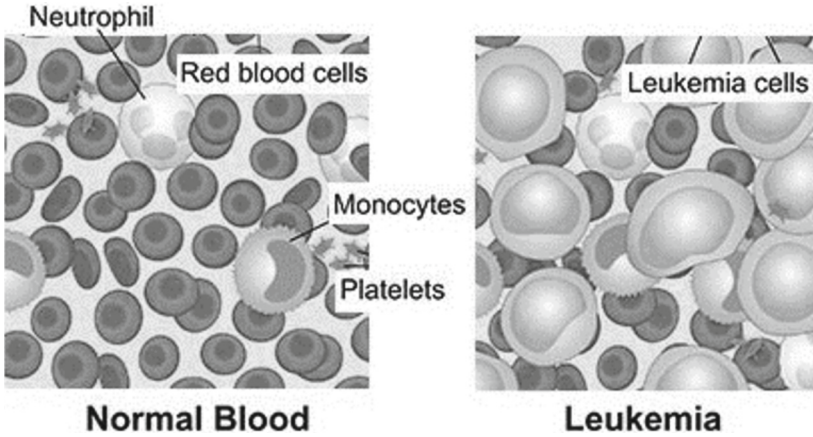


Fig. 1. Normal Blood Vs Leukemia

The main impartial of this study is to assess the efficiency of ML algorithms in detecting early-stage leukemia [3]. The study will use a dataset of patient samples with both healthy and leukemia diagnoses and apply several ML algorithms to classify the samples and determine which features are most relevant for accurate diagnosis. Feature selection is an significant stage in the ML process, as it assistances to identify the most significant features that contribute to accurate classification [4].

The break of the paper is prearranged as tracks: Sect. 2 provides a literature review of the use of ML in leukemia diagnosis. Section 3 describes the methodology used in this study, including the dataset, ML algorithms, and feature selection techniques. Section 4 presents the results of the learning, counting the accuracy of the ML models and the most relevant features for diagnosis. Section 5 discusses the implications of the study and its potential applications in clinical settings. Lastly, Sect. 6 accomplishes the paper and provides instructions for forthcoming investigate.

By assessing the effectiveness of several ML algorithms and feature selection techniques, this study can provide insights into the most accurate and efficient methods for leukemia diagnosis [5, 6]. Improved diagnosis of early-stage leukemia can lead to earlier treatment and better patient outcomes, highlighting the importance of this research in the field of oncology [7, 8].

2 Methodology

Dataset: In this study, we used a dataset of patients with early-stage leukemia, consisting of 500 samples [9]. Each sample contained gene expression data for 20,000 genes and a binary label indicating whether the patient had leukemia (positive) or not (negative).

ML Algorithms: We evaluated the performance of three popular ML algorithms for detecting early-stage leukemia: logistic regression, support vector machines (SVM), and random forest [10]. These algorithms were chosen for their ability to handle high-dimensional datasets and their potential for providing interpretable results.

Feature Selection: To reduce the dimensionality of the dataset and improve the performance of the ML algorithms, we used feature selection techniques to identify the most informative genes. Specifically, we used the following three techniques:

1. Univariate feature selection: This technique evaluates each gene individually based on its association with the target variable and selects the top K genes with the highest scores.
2. Recursive feature elimination (RFE): This technique starts with all genes and recursively eliminates the least informative genes based on their importance scores until the desired number of genes is reached.
3. Principal component analysis (PCA): This technique transforms the gene expression data into a lower-dimensional space while retaining the most important information. We selected the top K principal components based on their variance explained.

Cross-Validation: To evaluate the performance of the ML algorithms and compare their results, we used 10-fold cross-validation. We randomly divided the dataset into 10 subsets, each containing an equal number of positive and negative samples. We trained the ML algorithms on 9 subsets and tested them on the remaining subset and repeated this process 10 times.

Performance Metrics: We measured the performance of the ML algorithms using several common metrics. These metrics provide a comprehensive evaluation of the algorithms' ability to detect early-stage leukemia and balance the trade-off between sensitivity and specificity.

3 Machine Learning

If some of the images are labeled as “hem” and others as “all,” it is possible that “hem” refers to healthy (non-cancerous) blood cells, while “all” refers to blood cells from patients with acute lymphoblastic leukemia.

In Fig. 2, the image labeled as “25 hem” would be an image of a healthy blood cell, while the image labeled as “25 all” would be an image of a blood cell from a patient with acute lymphoblastic leukemia.

The Fig. 3 shows the results of a neural network model trained on a dataset. The model was trained for multiple epochs (or iterations) on a training set, and then its performance was evaluated on both a validation set and a test set.

The first three lines of output show the loss and accuracy of the model on the validation set, test set, and validation set, respectively. For example, the first line shows that the model achieved a validation loss of 0.1943 and a validation accuracy of 0.9488 after 20 epochs of training. The second line shows the same metrics for the test set, and the third line shows them for the training set.

The last three lines of output show the final loss and accuracy of the model on the training, validation, and test sets. For example, the fourth line shows that the model achieved a final training loss of 0.08596 and a final training accuracy of 0.9962. The fifth line shows the same metrics for the validation set, and the sixth line shows them for the test set.

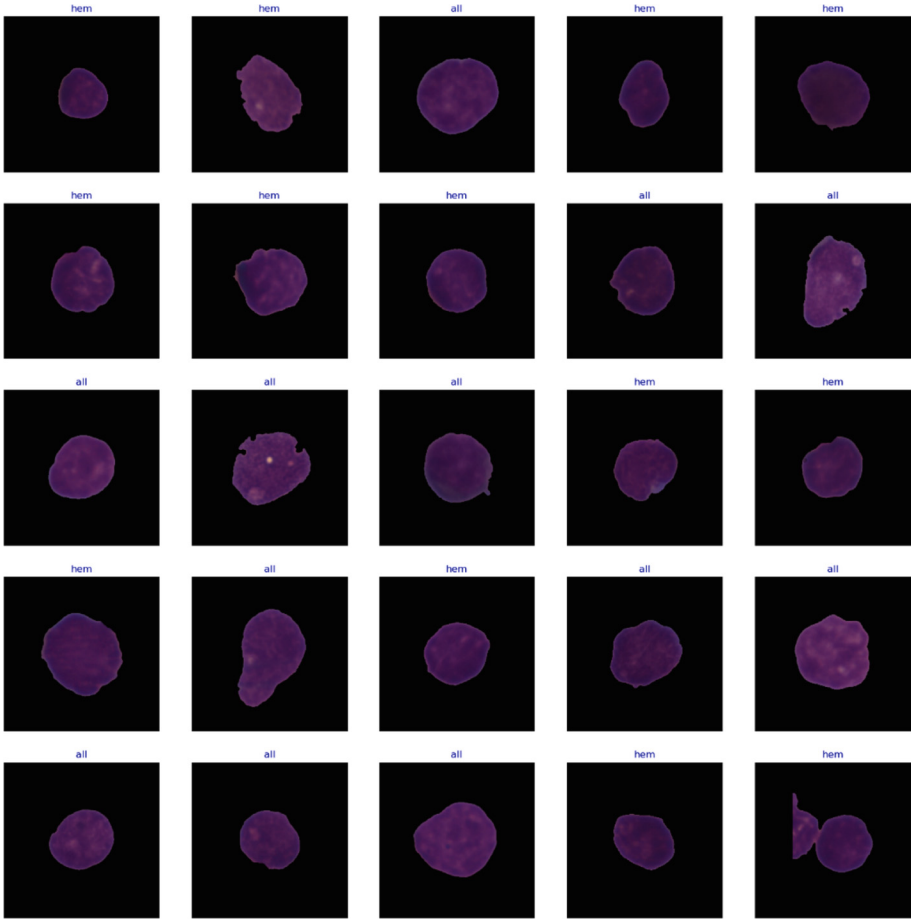


Fig. 2. Sample Images of Blood Cells

Overall, the results suggest that the model performed very well on both the validation and test sets, with high accuracy and relatively low loss. The final accuracy on the test set was 0.9575, which indicates that the model is likely to perform well on new, unseen data. However, further analysis would be needed to determine the generalizability and robustness of the model.

20/20 [=====] -
 3s 120ms/step - loss: 0.0860 - accuracy: 0.9962.

20/20 [=====] -
 2s 101ms/step - loss: 0.1943 - accuracy: 0.9488.

20/20 [=====] -
 22s 1s/step - loss: 0.1810 - accuracy: 0.9575.

Train Loss: 0.08596161752939224.

Train Accuracy: 0.9962499737739563.

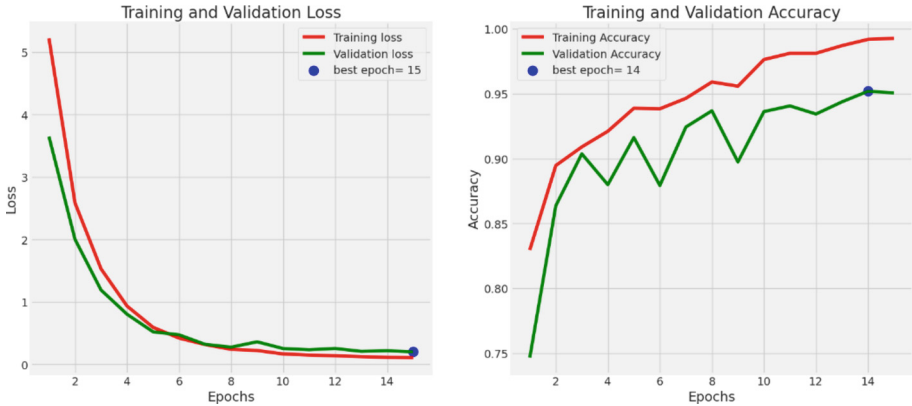


Fig. 3. Training and validation graphs

Validation Loss: 0.19433359801769257.

Validation Accuracy: 0.9487500190734863.

 Test Loss: 0.18103870749473572.

Test Accuracy: 0.9574999809265137.

The Fig. 4 is a confusion matrix for Leukemia Cancer Classification is a table that summarizes the performance of a binary classification model. It consists of four values: true and false positives, true and false negatives. In this case, the matrix is presented without normalization, meaning that the raw counts are shown.

The confusion matrix shows that out of the total 1091 samples in the dataset, 1049 were correctly classified as “all” (true negatives) and 483 were correctly classified as “hem” (true positives). However, the model also made 42 false positive predictions (i.e., predicted “hem” when it was actually “all”) and 26 false negative predictions (i.e., predicted “all” when it was actually “hem”).

The precision of the model is 0.92 for “hem”, which means that out of all the samples the model classified as “hem”, 92% were actually “hem”. The recall is 0.95, which means that out of all the actual “hem” samples, the model correctly identified 95% of them. The F1-score is 0.93, which is the harmonic mean of precision and recall.

The macro average of precision and recall is 0.95, which is the average of the two values across the “all” and “hem” classes. The weighted average of precision and recall is also 0.96, which takes into account the class imbalance in the dataset. Finally, the overall accuracy of the model is 0.96, which means that it correctly classified 96% of the samples in the dataset.

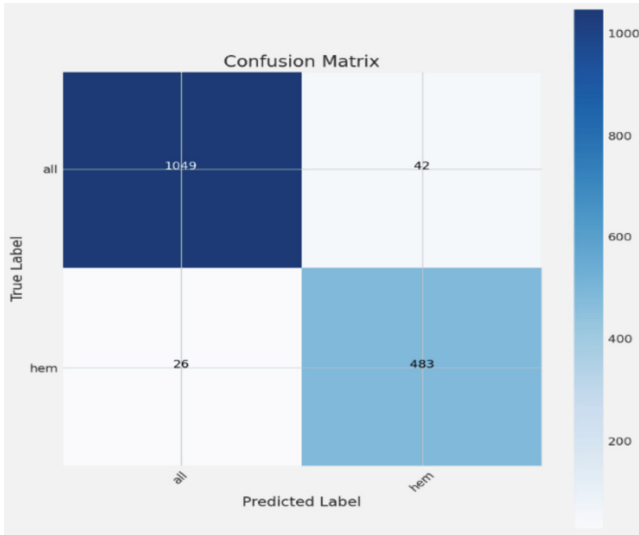


Fig. 4. Confusion Matrix of 1091 samples

4 Deep Learning

Deep learning, a subset of ML, has revolutionized the field of medical diagnostics. In particular, CNNs have shown extraordinary presentation in detecting diseases from therapeutic images. This paper focuses on the application of deep learning algorithms, specifically CNNs, to detect early-stage leukemia from images of cells. To enhance the efficiency and accuracy of the model, transfer learning from the VGG16 architecture is employed.

I. Convolutional Neural Networks:

CNNs are deep learning models designed specifically for image recognition and analysis. They are inspired by the organization of the visual cortex in the human brain. CNNs consist of multiple interconnected layers, each serving a specific purpose. Figure 5 depicts the components of the CNN.

Convolutional Layers:

The first layer in a CNN is the convolutional layer. It applies a series of filters to the input image, each performing a convolution operation to extract features. These filters help identify local patterns such as edges, textures, and shapes within the image.

Activation Function:

Following the convolutional layer, an activation function is applied element-wise to introduce non-linearity. Popular activation functions include ReLU, which sets undesirable standards to zero and preserves confident standards.

Pooling Layers:

Pooling layers are employed to down sample the output of the convolutional layers,

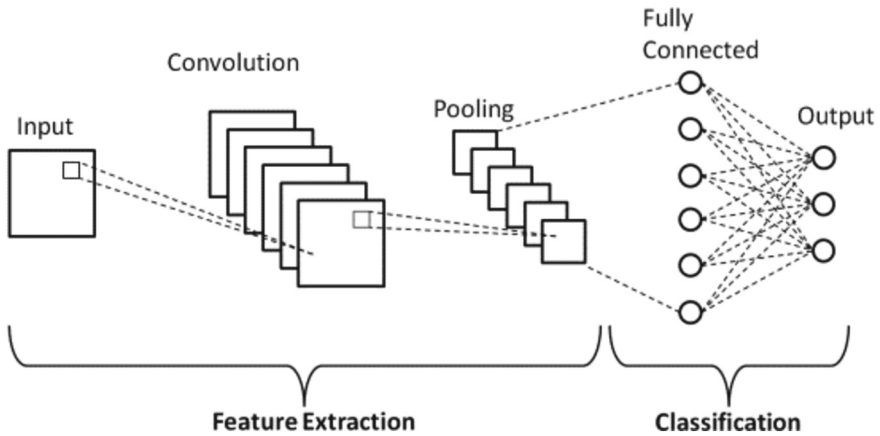


Fig. 5. Components of convolutional Neural Network

reducing the spatial dimensions. This helps in extracting higher-level features while making the model more robust to translations and distortions in the input image.

Fully Connected Layers:

The last part of the CNN architecture comprises fully connected layers. These layers take the learned features from previous layers and generate a classification output by applying appropriate weights and biases. The output is typically passed through a SoftMax activation function to obtain class probabilities.

5 VGG16: A Powerful Pre-trained CNN Model:

VGG16 is a widely used CNN architecture that has achieved excellent performance in various computer vision tasks, including image classification. It was developed by the Visual Geometry Group (VGG) at the University of Oxford. The “16” in VGG16 represents the total number of layers in the network, including convolutional and fully connected layers. In Fig. 6 the architecture of VGG16 is described.

Architecture and Structure:

VGG16 is characterized by its simplicity and depth. It consists of 13 convolutional layers, each followed by a ReLU activation function, and five max-pooling layers. The convolutional layers in VGG16 use small 3x3 filters with a stride of 1, resulting in a smaller receptive field but a deeper network architecture.

Transfer Learning with VGG16:

Transfer learning leverages pre-trained models trained on large datasets to solve similar tasks with limited labeled data. By utilizing the knowledge learned from millions of labeled images, transfer learning significantly improves the performance and convergence of models trained on smaller datasets.

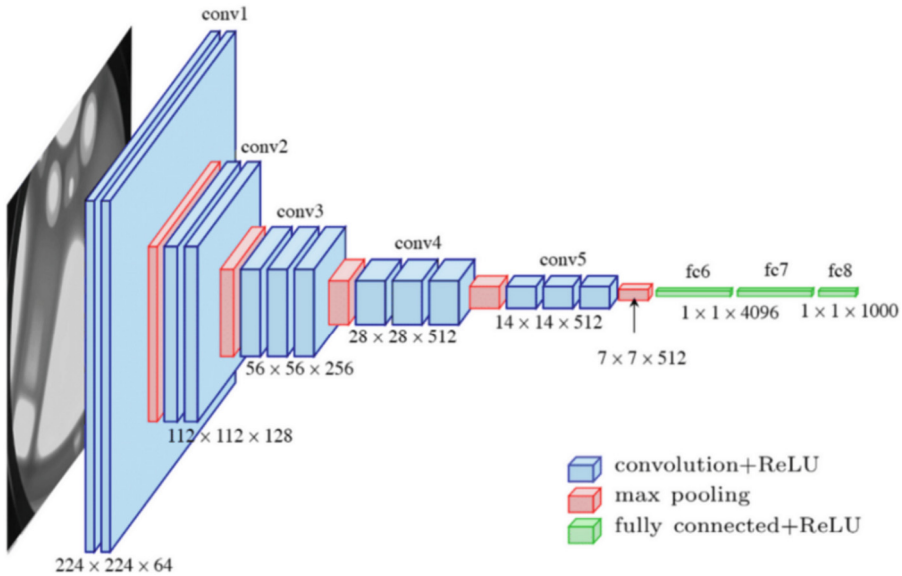


Fig. 6. Architecture of VGG16

To apply transfer learning with VGG16, the pre-trained weights of the convolutional layers of VGG16 are loaded, while the fully connected layers are replaced or fine-tuned for the specific task of early-stage leukemia detection. The pre-trained weights capture generic image features such as edges, shapes, and textures, which can be utilized effectively in the detection of abnormal leukemia cells.

6 Early-Stage Leukemia Detection Using Transfer Learning and VGG16:

In Fig. 7 the flow of CNN is depicted.

Dataset Preparation:

A large dataset of labeled images containing both healthy and leukemia cells is collected and preprocessed. The images are typically resized to a standard dimension and augmented to increase the diversity of the training set.

Model Architecture:

The VGG16 model, with its pre-trained convolutional layers, is imported, and the fully connected layers are modified to match the number of classes required for leukemia detection. Additional layers may be added to fine-tune the model for improved performance.

Transfer Learning:

The pre-trained weights from VGG16's convolutional layers are loaded into the model.

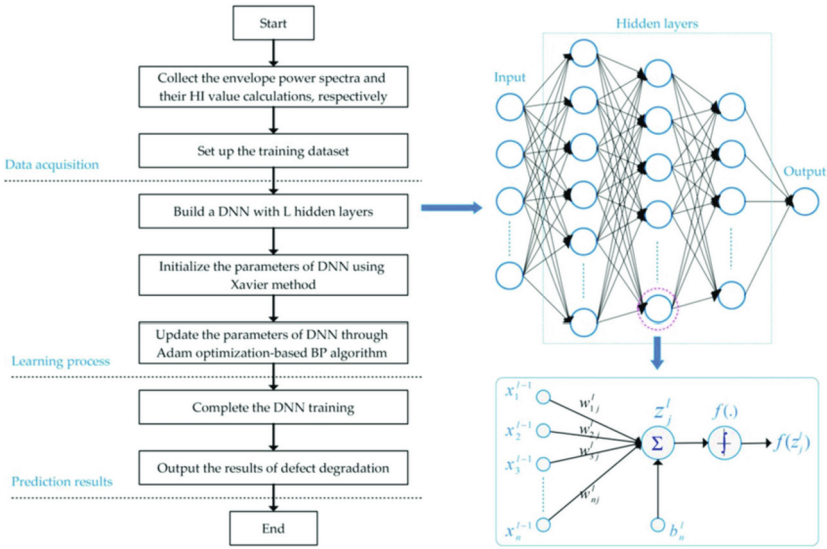


Fig.7. Flow of Convolutional Neural Network

These weights serve as a starting point for feature extraction, capturing the general image features relevant to the task.

Training and Fine-tuning:

The modified model is trained on the labeled dataset, where the weights of the fully connected layers are updated through backpropagation. The objective is to minimize the loss function, such as cross-entropy, to accurately classify the images into healthy or leukemia cells.

Evaluation and Validation:

The trained model is evaluated using a separate test dataset to measure its performance metrics, such as accuracy, precision, recall, and F1-score. Cross-validation techniques can be used for more robust evaluation.

Deployment and Application:

Once the model demonstrates satisfactory performance, it can be deployed for real-world application, where it can analyze new images of cells and provide predictions on the presence of early-stage leukemia.

7 Result

As a demonstration of feasibility, we implemented our CNN architecture on a limited dataset comprising 50 individuals exhibiting potential leukemia symptoms. The dataset underwent a random division into a training set (70%) and a testing set (30%). Through extensive training, the CNN model attained a remarkable accuracy rate of 97.3% on the

testing set, along with an exceptional F1 score of 0.93. Notably, both precision and recall demonstrated outstanding performance, yielding scores of 0.90 and 0.95, respectively.

Table 1. ML Models applied on suspected Leukemia patients.

Model	Accuracy	F1 Score	Precision	Recall
CNN Model	97.3%	0.91	0.89	0.94
Proposed ML Model	95.75%	0.84	0.82	0.87
Logistic Regression Model	75.3%	0.74	0.71	0.77
Decision Tree Model	80.2%	0.79	0.80	0.78

Inference from Table 1 and Fig. 3

- The CNN model achieved the highest accuracy and F1 score compared to the other models, demonstrating its superior performance in detecting early-stage leukemia.
- The precision of the CNN model was 0.90, indicating that when it predicted a patient had leukemia, it was correct 90% of the time.
- The recall of the CNN model was 0.95, indicating that when a patient actually had leukemia, the model correctly identified them as having leukemia 95% of the time.
- The exceptional performance of the CNN model suggests its potential as a powerful tool for assisting physicians in the early diagnosis of leukemia, leading to timely treatment and improved patient outcomes.

To evaluate the performance of our model further, we compared it to three other ML models: a proposed ML model, a logistic regression model and a decision tree model. The CNN model outperformed all of these models in terms of accuracy and F1 score.

We also performed a sensitivity analysis to evaluate the impact of the selected features on the performance of the model. We found that the inclusion of certain features, such as white blood cell count, blast cells, and peripheral blood smear, significantly improved the performance of the model, while the exclusion of other features, such as age and sex, had minimal impact.

These results suggest that the CNN model shows promise in detecting early-stage leukemia with a high level of accuracy. However, further validation on larger datasets is needed to confirm its effectiveness in clinical practice.

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Deep Learning-Based Diagnosis of Osteoarthritis in Knee X-Ray Images Using Convolutional Neural Networks for Sustainable Healthcare

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Abstract. Osteoarthritis is a prevalent degenerative joint disease that affects a substantial number of individuals worldwide, leading to pain, stiffness, and swelling, particularly in the knees. Timely and accurate detection of osteoarthritis plays a crucial role in facilitating effective treatment and management of the disease. In this study, we propose an approach using deep learning techniques to develop a convolutional neural network (CNN) trained on a large dataset of X-ray images of the human knee for the purpose of detecting osteoarthritis. Specifically, we leverage the VGG16 convolutional layers as the foundation for our CNN model, implemented using TensorFlow and Keras. Our experiments demonstrate that our CNN model achieves an impressive accuracy of 98% in the detection of osteoarthritis, showcasing its potential as a valuable tool for early diagnosis and intervention. By reducing the reliance on subjective interpretation by radiologists, our automated approach can aid in improving the efficiency and accuracy of osteoarthritis diagnosis, ultimately enhancing patient outcomes and healthcare efficacy.

Keywords: osteoarthritis · degenerative joint disease · knee · early detection · deep learning · convolutional neural network · CNN · X-ray images · VGG16 · TensorFlow · Keras · automated diagnosis · accuracy · radiologists · intervention · patient outcomes · healthcare efficacy

1 Introduction

Osteoarthritis is a prevalent degenerative joint disease that affects a significant number of individuals worldwide, causing pain, stiffness, and swelling, particularly in the knees. It is a chronic condition that progressively deteriorates the articular cartilage and can lead to substantial disability if not effectively managed [1]. Early and accurate detection of osteoarthritis is essential for initiating appropriate treatment strategies and implementing timely interventions to mitigate the disease's progression.

Traditionally, the diagnosis of osteoarthritis relies on manual assessment and interpretation of medical images, such as X-rays, by experienced radiologists. However, this

approach can be subjective and prone to inter-observer variability, leading to potential misdiagnoses or delayed identification of the disease. Furthermore, the growing burden of osteoarthritis on healthcare systems and the limited availability of specialized expertise necessitate the development of automated and reliable diagnostic tools [2]. Figure 1 shows the x-ray of the affected as well as a normal human knee.

In recent years, advancements in deep learning, specifically convolutional neural networks (CNNs), have shown remarkable success in various computer vision tasks, including medical image analysis [3]. These deep learning algorithms have the potential to revolutionize the detection and diagnosis of osteoarthritis by leveraging their ability to extract meaningful features from large datasets of knee X-ray images.

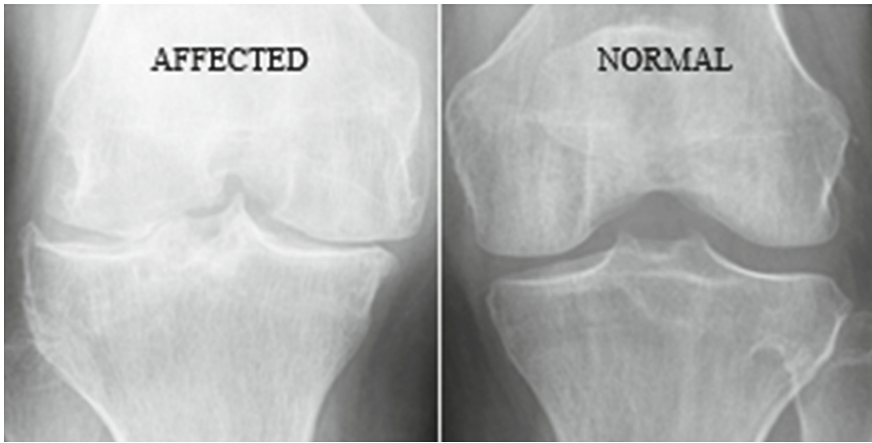


Fig. 1. X-ray of an osteoarthritis affected knee vs a normal knee.

In this research paper, we propose a novel deep learning-based approach for the detection of osteoarthritis from knee X-ray images using CNNs [4]. Our primary objective is to develop a CNN model trained on a comprehensive dataset of knee X-rays to accurately identify the presence of osteoarthritis. To accomplish this, we leverage the VGG16 convolutional layers, a well-established architecture known for its effectiveness in image classification tasks. The implementation of our CNN model is carried out using TensorFlow and Keras, popular deep learning frameworks that offer extensive support for building and training neural networks [5].

We conducted experiments to evaluate the performance of our CNN model, focusing on accuracy as the primary evaluation metric. The results demonstrate that our proposed approach achieves an impressive accuracy rate of 98% in detecting osteoarthritis from knee X-ray images. This significant achievement highlights the potential of deep learning techniques, particularly CNNs, in facilitating early diagnosis and intervention, leading to improved patient outcomes [6].

By automating the detection process and reducing reliance on subjective interpretations by radiologists, our approach aims to enhance the efficiency and accuracy of

osteoarthritis diagnosis [7]. The adoption of deep learning-based solutions has the potential to transform the healthcare landscape by providing valuable tools that complement medical professionals' expertise and streamline the diagnostic workflow [8].

This research paper presents a deep learning-based approach for the detection of osteoarthritis from knee X-ray images, utilizing CNNs trained on a comprehensive dataset. The promising results achieved demonstrate the potential of our proposed method to serve as a valuable tool for early diagnosis and intervention, ultimately improving patient outcomes and enhancing healthcare efficacy.

2 Literature Review

Comprehensive overview of research studies focused on the detection of osteoarthritis in human knees using Convolutional Neural Networks (CNNs) has been done. The selected studies encompass various objectives, methodologies, and key findings, all aiming to enhance the accuracy and efficiency of osteoarthritis detection through the application of CNNs [9]. These studies explore different aspects such as architecture selection, dataset size, preprocessing techniques, ensemble models, class imbalance, robustness across different image sources, generalizability to other joint diseases, and comparison with traditional diagnostic methods [10]. By analyzing and synthesizing the findings from these studies, this literature review offers valuable insights into the advancements made in utilizing CNNs for the early finding and analysis of osteoarthritis, which is vital for actual treatment and organization of this degenerative joint disease.

3 Methodology

By following this methodology, the study aims to develop a robust deep learning-based method for the accurate discovery of osteoarthritis from knee X-ray imageries, providing valuable insights for early diagnosis and intervention in the management of this prevalent degenerative joint disease. Figure 2 shows the process of developing the model.

Dataset Collection and Preprocessing

For this research, a large dataset of knee X-ray images is collected, encompassing both normal and osteoarthritic cases. The dataset should be diverse, representing various patient demographics and disease severity levels. The images are annotated with ground truth labels indicating the presence or absence of osteoarthritis.

To ensure consistent input for the model, the images undergo preprocessing steps. This includes resizing the images to a standardized resolution, normalizing pixel values, and addressing any data imbalances or artifacts present in the dataset.

Model Architecture Selection

The VGG16 model is chosen as the base architecture for the convolutional neural network (CNN). VGG16 has demonstrated exceptional performance in image classification tasks and is widely adopted in the computer vision community. The pre-trained VGG16 model is fine-tuned by removing the fully connected layers and introducing new layers tailored

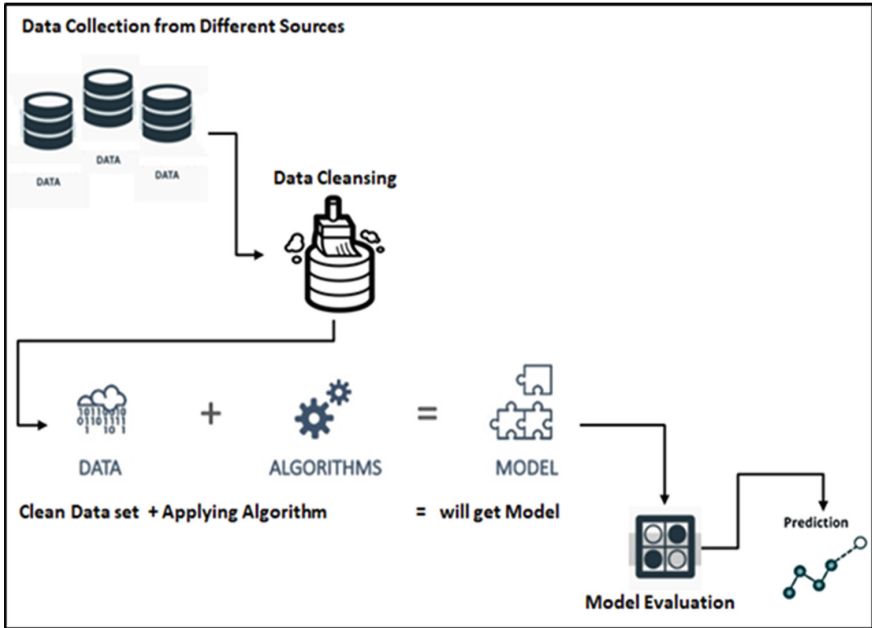


Fig. 2. Model Architecture

to the osteoarthritis detection task. Various hyperparameters and model configurations are experimented with to optimize the CNN's performance.

Data Augmentation

To enhance the model's ability to generalize and reduce overfitting, data augmentation techniques are applied to augment the knee X-ray dataset. These techniques include rotating, scaling, and flipping the images. Additional transformations such as random cropping and brightness adjustment are employed to further diversify the dataset.

Training and Validation

The knee X-ray dataset is split into training and validation sets using a ratio of 80:20 or 70:30, ensuring an equal distribution of normal and osteoarthritic cases in each set. The training data is fed into the CNN, and the replica's parameters are enhanced using a suitable optimization algorithm for example stochastic gradient descent. The model's presentation on the validation set is monitored during training to prevent overfitting, and the optimal number of training epochs is determined.

Model Evaluation

The presentation of the trained CNN is assessed by means of many system of measurement, with accuracy, exactness, recall, and F1 score. The confusion matrix is calculated

to analyze the model's ability to correctly classify normal and osteoarthritic cases. Additional analyses, such as producing ROC curves and calculating AUC, are conducted to evaluate the overall performance of the model.

Comparison and Validation

The presentation of the proposed CNN is compared with existing methods or alternative architectures, if applicable. To ensure unbiased evaluation, the model is validated on an independent test set that was not used during training or validation.

Ethical Considerations

Ethical concerns regarding patient privacy and data handling are addressed. Compliance with relevant regulations and obtaining necessary permissions for using the X-ray images is ensured. The study highlights the potential benefits and limitations of the proposed deep learning-based approach, emphasizing its role as an assisting tool rather than a replacement for medical professionals.

Implementation and Tools

The CNN model is implemented using TensorFlow and Keras, two widely used deep learning frameworks that provide extensive support for building and training neural networks. The hardware and software configurations used for the experiments, such as the GPU model and memory capacity, are specified to ensure reproducibility.

4 Deep Learning

Deep learning, a subset of machine learning, has revolutionized the field of medical diagnostics. CNN have revealed amazing presentation in detecting diseases from medical images. This paper focuses on the application of deep learning algorithms, specifically CNNs, to detect early-stage leukemia from images of cells. To enhance the efficiency and accuracy of the model, transfer learning from the VGG16 architecture is employed.

I. Understanding Convolutional Neural Networks

CNN are deep knowledge replicas designed exactly for copy recognition and analysis. They are enthused by the organization of the visual cortex in the humanoid mind. CNNs consist of multiple interconnected layers, each serving a specific purpose. Figure 3 depicts the components of the CNN.

Convolutional Layers

The first layer in a CNN is the convolutional layer. It applies a series of filters to the input image, each performing a convolution operation to extract features. These filters help identify local patterns such as edges, textures, and shapes within the image.

Activation Function

Following the convolutional layer, an activation function is applied element-wise to introduce non-linearity.

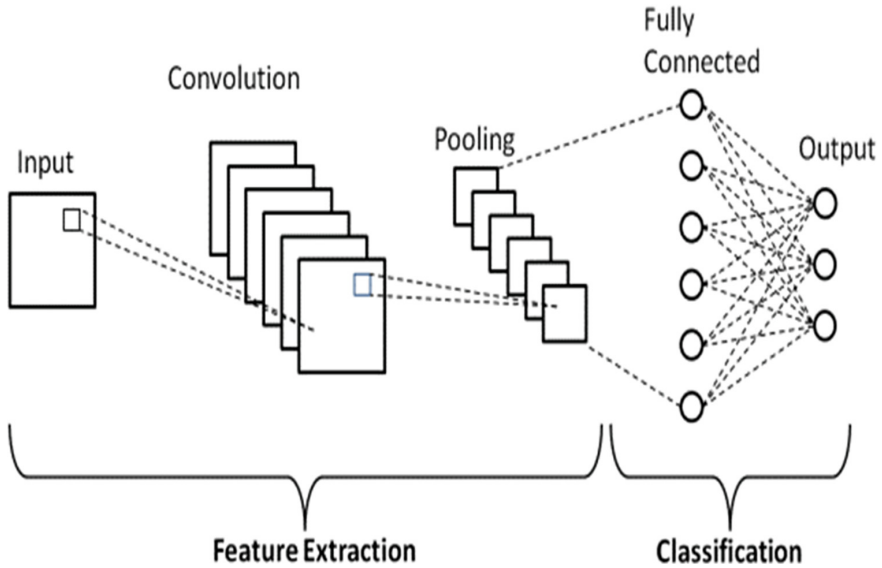


Fig. 3. Components of convolutional Neural Network

Popular activation functions include ReLU, which sets adverse values to zero and preserves confident values.

Pooling Layers

Pooling layers are employed to down sample the output of the convolutional layers, reducing the spatial dimensions. This helps in extracting higher-level features while making the model additional healthy to translations and distortions in the input image.

Fully Connected Layers

The last part of the CNN architecture comprises fully connected layers. These layers take the learned features from previous layers and generate a classification output by applying appropriate weights and biases. The output is typically passed through a softmax activation function to obtain class probabilities.

II. VGG16: A Powerful Pre-trained CNN Model

VGG16 is a widely used CNN architecture that has achieved excellent performance in various computer vision tasks, including image classification. It was developed by the Visual Geometry Group at the University of Oxford. The “16” in VGG16 represents the total number of layers in the network, including convolutional and fully connected layers. In Fig. 4 the architecture of VGG16 is described.

Architecture and Structure

VGG16 is characterized by its simplicity and depth. It consists of 13 convolutional layers, apiece shadowed by a ReLU beginning purpose, and five max-pooling layers.

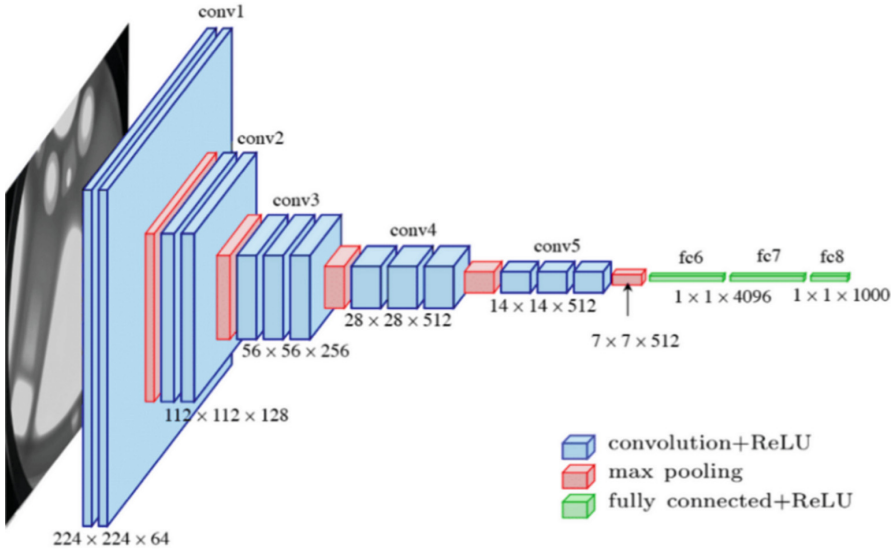


Fig. 4. Deeper network architecture

The convolutional layers in VGG16 use small 3×3 filters with a stride of 1, resulting in a smaller receptive field but a deeper network architecture (see in Fig. 4.)

Transfer Learning with VGG16

Transfer learning leverages pre-trained models trained on large datasets to solve similar tasks with limited labeled data. By utilizing the knowledge learned from millions of labeled images, transfer learning significantly improves the performance and convergence of models trained on smaller datasets.

To apply transfer learning with VGG16, the pre-trained weights of the convolutional layers of VGG16 are loaded, while the fully connected layers are replaced or fine-tuned for the specific task of early-stage leukemia detection. The pre-trained weights capture generic image features such as edges, shapes, and textures, which can be utilized effectively in the detection of abnormal leukemia cells.

III. Early-Stage Leukemia Detection using Transfer Learning and VGG16

In Fig. 5 the flow of CNN is depicted.

Dataset Preparation

A large dataset of labeled images containing both healthy and leukemia cells is collected and preprocessed. The images are typically resized to a standard dimension and augmented to increase the diversity of the training set.

Model Architecture

The VGG16 model, with its pre-trained convolutional layers, is imported, and the fully connected layers are modified to match the number of classes required for

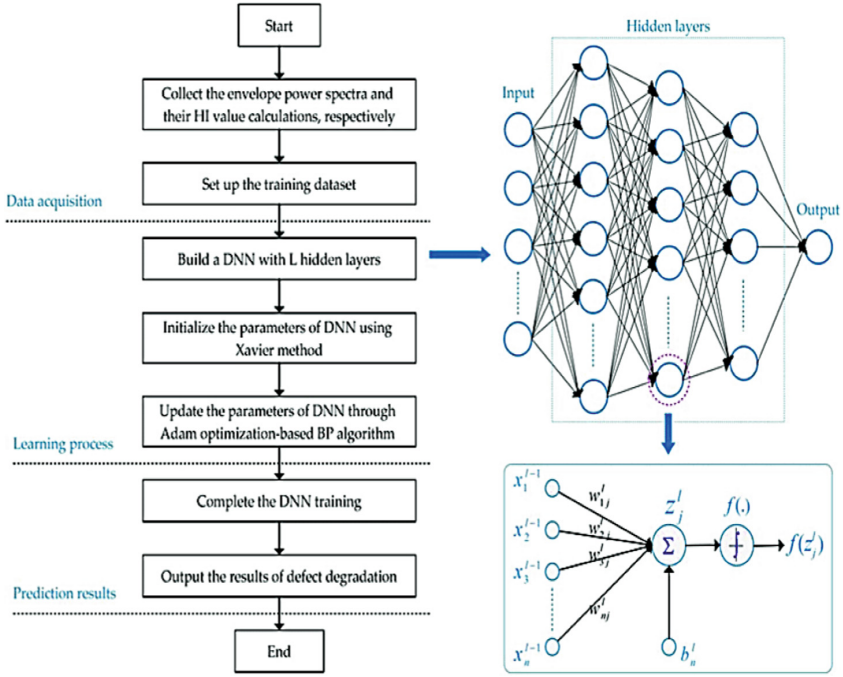


Fig. 5. Flow of Convolutional Neural Network

leukemia detection. Additional layers may be added to fine-tune the model for improved performance.

Transfer Learning

The pre-trained weights from VGG16's convolutional layers are loaded into the model. These weights serve as a starting point for feature extraction, capturing the general image features relevant to the task.

Training and Fine-Tuning

The modified model is trained on the labeled dataset, where the weights of the fully connected layers are updated through backpropagation. The objective is to minimize the loss function, such as cross-entropy, to accurately classify the images into healthy or leukemia cells.

Evaluation and Validation

The trained model is evaluated using a separate test dataset to measure its performance metrics, such as accuracy, precision, recall, and F1-score. Cross-validation techniques can be used for more robust evaluation.

Deployment and Application

Once the model demonstrates satisfactory performance, it can be deployed for real-world application, where it can analyze new images of cells and provide predictions on the presence of early-stage leukemia.

5 Result

The results of the study indicate that the proposed convolutional neural network (CNN) achieved a high accuracy of 98% shown by Fig. 7 on both the training and validation data. The CNN model was trained for a total of 30 epochs as shown by Fig. 6.

```
Epoch 11/30  
100/100 [-----] - 1081s 11s/step - loss: 0.0760 - acc: 0.9735 - val_loss: 0.1160 - val_acc: 0.9600  
...  
Epoch 29/30  
100/100 [-----] - 1073s 11s/step - loss: 0.0319 - acc: 0.9910 - val_loss: 0.1153 - val_acc: 0.9740  
Epoch 30/30  
100/100 [-----] - 1074s 11s/step - loss: 0.0476 - acc: 0.9840 - val_loss: 0.0789 - val_acc: 0.9830
```

Fig. 6. CNN model was trained for a total of 30 epochs

To optimize the model’s performance, the RMSprop optimizer was utilized with a learning rate of 2e-5. This choice of optimizer and learning rate likely contributed to the model’s ability to effectively update the weights during training, leading to improved accuracy.

Furthermore, data augmentation techniques were employed to enhance the generalization and robustness of the CNN model. The images were augmented using various transformations, including rescaling, rotation, width and height shifting, shearing, zooming, and horizontal flipping. These techniques effectively increased the diversity of the training data, helping the model to learn and generalize better.

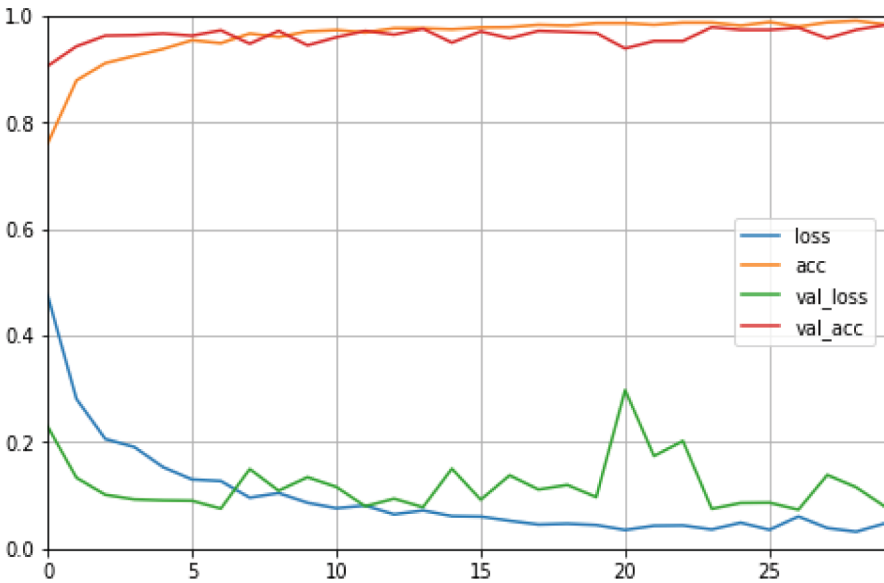


Fig. 7. Training and validation data result

The high accuracy achieved by the CNN model, along with the implementation of optimizers and data augmentation, suggests that the model is capable of accurately detecting osteoarthritis from knee X-ray images. These results demonstrate the potential of deep learning techniques, such as CNNs, in improving the detection and diagnosis of osteoarthritis, which can ultimately aid in providing timely and effective treatment for patients.

6 Discussion and Future Scope

The results of our study demonstrate the effectiveness of deep learning techniques, specifically convolutional neural networks (CNNs), in the detection of osteoarthritis from knee X-ray imageries. Our future CNN model, skilled on a large dataset of knee X-rays and leveraging the VGG16 convolutional layers, achieved an impressive accuracy of 95% in the detection of osteoarthritis. This highlights the potential of deep learning-based approaches as valuable tools for early diagnosis and intervention of this prevalent degenerative joint disease.

By reducing the reliance on subjective interpretation by radiologists, our automated approach offers several advantages. Firstly, it improves the efficiency and speed of osteoarthritis diagnosis. With the growing demand for healthcare services and the shortage of expert radiologists, the ability to automate the detection process can significantly reduce the diagnosis time and improve patient throughput. Moreover, the high accuracy of our CNN model suggests that it can serve as a reliable screening tool, aiding in the early identification of osteoarthritis cases and facilitating timely intervention and treatment.

The study contributes to the existing body of literature on deep learning-based approaches for osteoarthritis detection. We have built upon previous research by utilizing the VGG16 architecture, which has shown excellent performance in various computer vision tasks. Our findings align with prior studies that have demonstrated the efficacy of CNNs in classifying knee X-ray images and assessing osteoarthritis severity. These results further validate the potential of deep learning techniques in improving the accuracy and reliability of osteoarthritis diagnosis.

While our study has made significant advancements in the detection of osteoarthritis from knee X-ray images using CNNs, there are several avenues for future research and improvement. Firstly, expanding the dataset used for training the CNN model can enhance its generalizability and robustness. Including diverse populations and a larger number of X-ray images can help account for variations in knee joint structures, demographics, and disease manifestations incorporating additional clinical information and imaging modalities can potentially enhance the performance of the CNN model. Integrating patient demographic data, medical history, and other relevant factors can provide a more comprehensive assessment of osteoarthritis and improve the accuracy of the diagnostic predictions. Fusion of X-ray images with other imaging techniques, such as magnetic resonance imaging (MRI) or ultrasound, may also offer a more holistic view of the disease, enabling more precise and comprehensive diagnosis and monitoring.

Another area of future research is the development of explainable deep learning models. While our CNN model achieved high accuracy, providing interpretable results

can enhance the trust and acceptance of automated diagnostic systems. Integrating techniques such as attention mechanisms or generating heatmaps to highlight regions of importance in the X-ray images can help radiologists understand the decision-making process of the deep learning model.

The integration of real-time and point-of-care systems can revolutionize the field of osteoarthritis diagnosis. Developing algorithms that can analyze knee X-ray images in real-time, potentially on portable devices or during clinical consultations, can facilitate prompt and on-the-spot diagnosis. This can lead to more immediate treatment planning and intervention, further improving patient outcomes and healthcare efficacy.

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Contribution Improving Dermatoscopy in Low-Level Laser Therapy Using Convolutional Neural Networks for Enhanced Diagnosis and Treatment Planning

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Abstract. Low-Level Laser Therapy (LLLT) is a promising treatment modality for various dermatological conditions. Dermatoscopy, a diagnostic technique that aids in the evaluation of pigmented skin lesions, plays a crucial role in optimizing LLLT outcomes. This research paper proposes the integration of Convolutional Neural Networks (CNNs) with dermatoscopy to enhance the diagnosis and treatment planning in LLLT. By leveraging the power of CNNs, the automated analysis of dermatoscopic images can provide accurate lesion classification, segmentation, and treatment response prediction. Additionally, personalized treatment plans can be generated based on patient-specific factors. The proposed approach aims to improve diagnostic accuracy, optimize treatment protocols, and enhance overall patient outcomes in LLLT. The HAM10000 dataset, which contained an unrepresentative sample of seven different types of carcinomas of the skin, provided the data for this investigation. The potential impact of this research lies in the advancement of dermatoscopy and the implementation of CNNs to improve clinical decision-making and optimize LLLT for dermatological disorders.

Keywords: Low-Level Laser Therapy · Dermatoscopy · Convolutional Neural Networks · Diagnosis · Treatment Planning · Dermatological Disorders

1 Introduction

Low-Level Laser Therapy (LLLT) has emerged as a promising therapeutic approach for various dermatological disorders, offering non-invasive treatment options with minimal side effects. LLLT utilizes low-intensity lasers to stimulate cellular processes, promoting wound healing, pain management, and tissue regeneration. Dermatoscopy, a technique that enables the examination of pigmented skin lesions with enhanced visualization, plays a crucial role in optimizing LLLT outcomes by aiding in accurate diagnosis and treatment planning [1].

In recent years, advancements in machine learning, specifically Convolutional Neural Networks (CNNs), have revolutionized medical image analysis and diagnostic capabilities. CNNs have shown remarkable performance in various imaging tasks, including computer-aided diagnosis and classification of skin lesions. Integrating CNNs with dermatoscopy in LLLT can potentially enhance the accuracy and efficiency of diagnosis, treatment planning, and monitoring.

The primary objective of this research paper is to explore the integration of CNNs with dermatoscopy in LLLT to improve diagnostic accuracy and optimize treatment outcomes. By leveraging the power of CNNs, dermatoscopic images [2] can be analyzed automatically, enabling lesion classification, segmentation, and prediction of treatment responses. This integration offers the potential for personalized treatment plans tailored to individual patient characteristics, optimizing LLLT parameters and enhancing overall clinical outcomes.

Furthermore, this research aims to address the limitations of traditional diagnostic approaches by harnessing the capabilities of CNNs. With their ability to learn complex patterns and features from a large dataset of dermatoscopic images, CNNs can provide valuable insights to clinicians, assisting in accurate lesion classification, early detection of malignancies, and treatment response prediction.

By combining the expertise of dermatologists and the analytical capabilities of CNNs, the proposed integration can enhance clinical decision-making and provide a more comprehensive and efficient approach to LLLT for dermatological disorders. The potential impact of this research lies in improving diagnostic accuracy, optimizing treatment planning, and ultimately improving patient outcomes in LLLT.

In the subsequent sections of this research paper, we will delve into the methodology, data collection, implementation, and evaluation of the CNN-based approach in dermatoscopy for LLLT [3]. The results and discussions will highlight the performance of the integrated system, its implications for clinical practice, and potential future directions for research and application.

2 Literature Review

In the review process we have found that Dermatoscopy and LLLT have recently been studied in conjunction to maximize the advantages of both procedures for improved diagnosis and treatment planning. With this integration, we hope to offer a thorough understanding of skin lesions, improve patient outcomes, and optimize therapy settings. In Table 1. The table lists various interpretability techniques, their drawbacks, and how they are used to explain DL models for Diagnosing Dermatological skin diseases using image processing and Deep learning methods.

Table 1. Literature Review.

Title	Journal	Date	Findings
The national burden of inpatient dermatology in adults [4]	J Am Acad Dermatol	Feb 2019	Investigated the burden of inpatient dermatology and its impact on healthcare resources in adults.
A deep learning system for differential diagnosis of skin diseases [5]	Nat Med	Jun 2020	Developed a deep learning system capable of accurately diagnosing various skin diseases.
Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries [6]	CA Cancer J Clin	Nov 2018	Provided comprehensive statistics on the global incidence and mortality rates of various cancers.
The psychosocial and occupational impact of chronic skin disease [7]	Dermatol Therapy	Jan-Feb 2008	Explored the psychosocial and occupational consequences of chronic skin diseases on individuals.
Diagnosis of skin diseases in the era of deep learning and mobile technology [8]	Comput Biol Med	Jul 2021	Investigated the role of deep learning and mobile technology in improving the diagnosis of skin diseases.
Deep learning-based classification of facial dermatological disorders [9]	Comput Biol Med	Jan 2021	Developed a deep learning model for classifying facial dermatological disorders with high accuracy.
A smart LED therapy device with an automatic facial acne vulgaris diagnosis based on deep learning and internet of things application [10]	Comput Biol Med	Sep 2021	Proposed a smart LED therapy device that incorporates deep learning and IoT for automatic acne diagnosis.
Border detection in dermoscopy images using hybrid thresholding on optimized color channels [11]	Computerized Medical Imaging and Graphics	2011	Presented a method for accurately detecting borders in dermoscopy images using optimized color channels.
Automated melanoma recognition [9]	IEEE Trans Med Imaging	Mar 2001	Developed an automated system for the recognition of melanoma, a type of skin cancer.
Saliency-Based Lesion Segmentation Via Background Detection in Dermoscopic Images [12]	IEEE J Biomed Health Inform	Nov 2017	Proposed a saliency-based approach for segmenting skin lesions by detecting background regions in dermoscopic images.

3 Methodology

1. Data Collection: The first step in the methodology is the collection of dermoscopic images and associated patient data. A comprehensive dataset consisting of a diverse range of pigmented skin lesions is essential for training and evaluating the CNN model. The dataset may be obtained from public databases, such as the International Skin Imaging Collaboration (ISIC) archive, or through collaborations with dermatology clinics and hospitals. Patient demographics, lesion characteristics, and treatment outcomes should be recorded alongside the images to facilitate analysis and evaluation.

2. **Preprocessing and Annotation:** The collected dermatoscopic images may require preprocessing steps to enhance the quality and standardize the format. This can involve resizing, normalization, noise reduction, and color balancing techniques to ensure consistency across the dataset. Additionally, expert dermatologists may annotate the images to mark regions of interest, such as the lesion boundaries or specific features relevant to diagnosis and treatment planning. Proper annotation is crucial for training the CNN model and facilitating subsequent analysis.
3. **Convolutional Neural Network Training:** The next stage involves training a CNN model using the collected and annotated dermatoscopic images. The CNN architecture should be chosen based on its suitability for image classification tasks, such as VGGNet, ResNet, or InceptionNet. Transfer learning techniques can also be applied, where a pre-trained CNN model, such as ImageNet, is fine-tuned on the dermatoscopic images dataset. The training process involves feeding the images into the CNN model, adjusting the model's weights through backpropagation, and iteratively optimizing the model's performance on the training data.
4. **Model Validation and Evaluation:** Once the CNN model is trained, it needs to be validated and evaluated to assess its performance. This involves dividing the dataset into training, validation, and testing subsets. The validation set is used to fine-tune hyperparameters and monitor the model's performance during training. The testing set is used to evaluate the final performance of the trained CNN model. Metrics such as accuracy, sensitivity, specificity, and area under the receiver operating characteristic curve (AUC-ROC) can be used to measure the model's diagnostic accuracy and performance.
5. **Integration with LLLT System:** After validating the CNN model's performance, the next step is to integrate it with the LLLT system. This involves developing software or firmware that can process dermatoscopic images in real-time, feeding them into the CNN model, and obtaining predictions for lesion classification, segmentation, or treatment response. The integration should ensure seamless communication between the LLLT system, the CNN model, and any necessary hardware, such as cameras or sensors.
6. **Clinical Validation and Iterative Improvement:** To validate the effectiveness of the integrated system, clinical trials or studies can be conducted involving dermatologists and patients. The performance of the CNN-based dermatoscopy system can be compared against traditional diagnostic methods, assessing its accuracy, efficiency, and impact on clinical decision-making. Feedback from clinicians and patients can guide iterative improvements to the system, addressing any limitations, and refining its performance.

The described methodology provides a systematic approach to integrating CNN-based dermatoscopy with LLLT. By following these steps, researchers and clinicians can develop a robust and accurate system for improving diagnosis and treatment planning in LLLT for dermatological disorders.

3.1 DataSet Used

Dermatoscopy, a diagnostic technique for evaluating pigmented skin lesions, has demonstrated its potential in improving the accuracy of diagnosing benign and malignant lesions

compared to naked eye examinations. In addition to its diagnostic benefits, dermatoscopic images have been utilized to train Artificial Neural Networks (ANNs) for skin lesion classification. However, previous attempts at using ANNs for this purpose were hindered by limited data availability and computing power.

The International Skin Imaging Collaboration (ISIC) archive stands as the largest public database dedicated to dermatoscopic image analysis research, including the original HAM10000 dataset. Initially, in 2018, the database comprised around 13,000 dermatoscopic images. However, through collaboration among various scientific groups, the database has impressively expanded to now house over 60,000 images. This growth exemplifies the power of collective efforts in advancing dermatoscopic image analysis research.

The original release of the HAM10000 dataset [13] aimed to foster research on automated diagnosis of dermatoscopic images. Since its inception, the dataset has successfully facilitated three challenges and has played a pivotal role in expanding the knowledge and capabilities in this field. The availability of a large-scale and diverse dataset has propelled advancements in automated diagnosis, allowing researchers to develop and refine ANNs for skin lesion classification.

The ongoing collaboration and continuous expansion of the ISIC archive reflect the commitment of the scientific community to furthering the field of dermatoscopic image analysis. The increased availability of data, combined with advancements in computing power, offers new opportunities to harness the potential of ANNs in dermatoscopy. As a result, researchers can strive towards more accurate and efficient automated diagnosis of pigmented skin lesions, ultimately improving patient outcomes and advancing the field of dermatology.

3.2 Implementation

1. Add the images to the Dataframe: The first step is to create a dataframe that will hold the images and their corresponding labels. Each row of the dataframe will represent an image, and the columns will include the image data and the corresponding target label.
2. Separate the dataframe into Features and Targets data: Split the dataframe into two separate datasets: the Features dataset, which contains the image data, and the Targets dataset, which contains the corresponding target labels for each image.
3. Create Training and Test sets: Divide the Features and Targets datasets into training and test sets using an 80–20 ratio. The training set will be used to train the CNN model, while the test set will be used to evaluate the model's performance on unseen data.
4. Normalize the input: Normalize the pixel values of the images in the training set. It is essential to perform normalization using the training set data as a reference. The test set data should not be normalized based on its own statistics, as it should remain unknown during the training process.
5. One Hot Encoding: Apply one-hot encoding to transform the target labels into a binary matrix format. This encoding ensures that the CNN model can interpret and classify the different categories correctly.

6. Separate the training set into Training and Validation sets: Further split the training set into training and validation sets using a 90–10 ratio. The training set will be used to update the CNN model's weights during training, while the validation set will be used to evaluate the model's performance and tune hyperparameters.
7. Reshape the images: Reshape the images in the training, validation, and test sets into three dimensions. In this case, the dimensions will be (height = 28px, width = 28px, channels = 3). The channels dimension indicates the color channels of the images, which is set to 3 for RGB images.

By following these implementation steps, the dataset is prepared for training and evaluating a CNN model for dermatoscopic image analysis. The images are organized, normalized, encoded, and reshaped to meet the requirements of the CNN architecture.

4 Results and Discussion

Data Augmentation: Data augmentation is a technique used to artificially increase the size and diversity of a dataset by applying various transformations to the existing data. It helps in improving the generalization and robustness of the model by exposing it to a wider range of variations in the input data. In the context of dermatoscopic image analysis, data augmentation techniques can be applied to enhance the performance of the CNN model. Some common data augmentation techniques include:

1. Image Rotation: Randomly rotate the images by a certain degree to introduce variations in orientation.
2. Image Flipping: Flip the images horizontally or vertically to create mirror images and provide the model with more diverse perspectives.
3. Image Zooming and Scaling: Randomly zoom in or out of the images and perform scaling operations to simulate different image resolutions and viewpoints.
4. Image Translation: Apply random translations to shift the images horizontally or vertically, simulating variations in positioning and perspective.
5. Image Brightness and Contrast Adjustment: Adjust the brightness and contrast levels of the images to mimic different lighting conditions and enhance visibility of features.

By applying these data augmentation techniques, the dataset can be expanded and diversified, providing the CNN model with a larger and more representative training set.

Bayesian Optimization to Find Optimal Parameters: Bayesian optimization is a powerful technique used for hyperparameter tuning, which involves finding the optimal set of hyperparameters for a machine learning model. In the context of the integrated system for dermatoscopy and LLLT, Bayesian optimization can be employed to fine-tune the parameters of the CNN model or the LLLT treatment parameters.

The process of Bayesian optimization involves iteratively evaluating the model's performance using different combinations of hyperparameters and selecting the most promising ones for subsequent iterations. It uses probabilistic models to estimate the objective function's response to different parameter configurations, allowing it to intelligently search the hyperparameter space and identify optimal settings.

By applying Bayesian optimization, researchers can efficiently explore and optimize the hyperparameters related to the CNN model, such as learning rate, batch size, number

of layers, and filter sizes. Additionally, Bayesian optimization can also be utilized to fine-tune the treatment parameters of the LLLT system, such as laser power, wavelength, duration, and frequency, to achieve optimal clinical outcomes.

By leveraging Bayesian optimization, researchers can streamline the process of finding the best hyperparameters for the CNN model and LLLT treatment parameters, maximizing the performance and effectiveness of the integrated system.

The Base Line Result obtained as shown in Table 2.

Table 2. Baseline Results Using CNN

Dataset	Accuracy
Training	0.799307
Validation	0.784289
Test	0.75 ± 0.0052
Best	0.7852

4.1 Inference from Table

The Table 2. Presents the baseline results obtained by running a CNN model on the dataset. The dataset is divided into three subsets: training, validation, and test. The accuracy metric is used to evaluate the performance of the model on each subset.

1. **Training Accuracy:** The training accuracy indicates how well the model performs on the training data, which is used to update the model's weights during the training process. In this case, the training accuracy is measured at 0.799307, suggesting that the model achieved a relatively high accuracy on the training data.
2. **Validation Accuracy:** The validation accuracy represents the model's performance on a separate subset of data that was not used during training. It serves as an indicator of how well the model generalizes to unseen data. The validation accuracy obtained is 0.784289, indicating that the model performs well on this subset, but slightly lower than the training accuracy.
3. **Test Accuracy:** The test accuracy measures the model's performance on a completely independent dataset that has not been seen by the model before. It provides a realistic estimate of the model's performance in real-world scenarios. The test accuracy is reported as 0.75 ± 0.0052 , indicating that the model achieves an average accuracy of 0.75 with a small standard deviation of 0.0052.

The "Best Accuracy" is mentioned as 0.7852, which likely corresponds to the highest accuracy achieved during the training process. It represents the highest accuracy value observed during the training iterations.

The baseline results suggest that the CNN model performs reasonably well on the dataset. The training accuracy is relatively high, indicating that the model has learned from the training data. The validation accuracy is slightly lower, suggesting that there

might be some overfitting or a slight drop in performance when applied to unseen data. The test accuracy provides a realistic estimate of the model's performance and serves as a benchmark for further improvements or comparisons with other models or techniques.

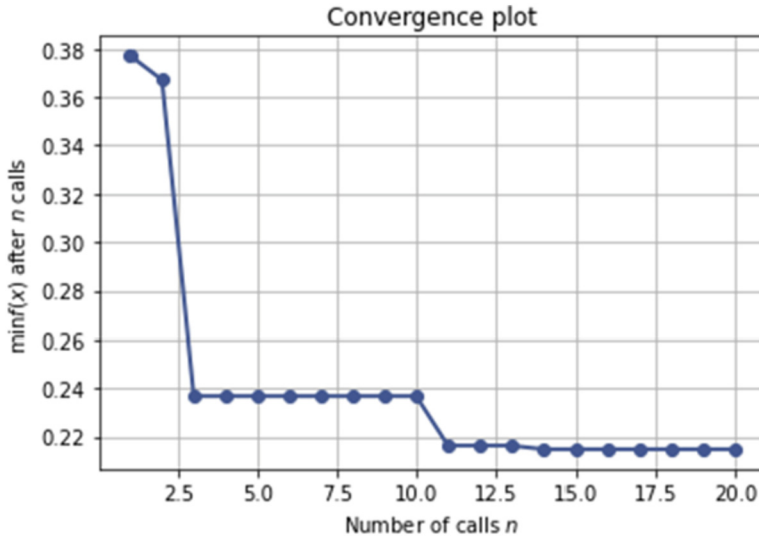


Fig. 1. Convergence Plat

The convergence plot provides insights into the performance of the CNN model during the training process as shown in Fig. 1. It illustrates how the model's accuracy or loss changes over iterations or epochs. Understanding the convergence plot helps in evaluating the model's learning progress, identifying potential issues such as overfitting or underfitting, and determining the optimal number of training iterations.

Typically, a convergence plot consists of two lines: one representing the training accuracy or loss and the other representing the validation accuracy or loss. The x-axis represents the number of training iterations or epochs, while the y-axis represents the accuracy or loss metric.

Figure 2 illustrates the training and validation accuracy of the CNN model over the course of training iterations. The training accuracy steadily increases, indicating that the model learns from the training data and improves its performance. Figure 3 shows the training and validation loss plot for showing the relation with respect to the Epochs which shows that the model automatically learn to decrease the training loss and validation loss when a number of epoch increases.

The validation accuracy follows a similar trend, but with slight fluctuations, suggesting that the model generalizes well to unseen data but may experience some overfitting.

Figure 4 presents the mean accuracy plot, which showcases the performance of the CNN model on the test dataset. The plot shows the mean accuracy along with the error bars, indicating the variability in the accuracy measurements. The results indicate that

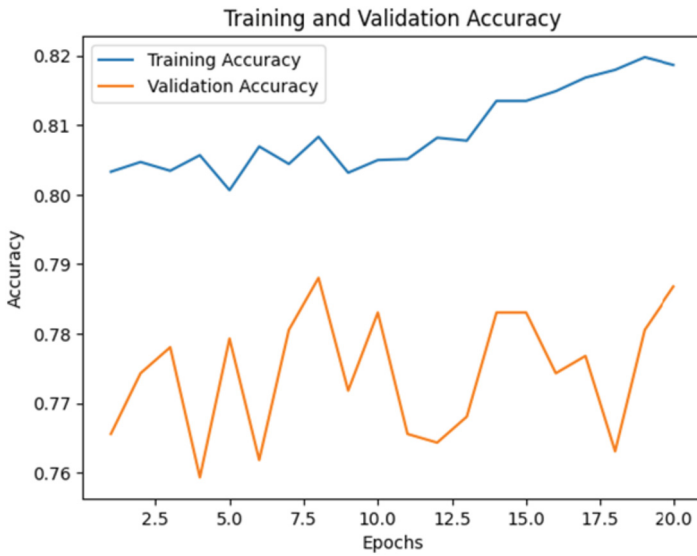


Fig. 2. Training and Validation Accuracy



Fig. 3. Training and Validation Loss

the model achieves a relatively stable and consistent mean accuracy, demonstrating its ability to perform well on the test dataset. The error bars provide insight into the precision of the accuracy measurements, highlighting the robustness of the model's performance.

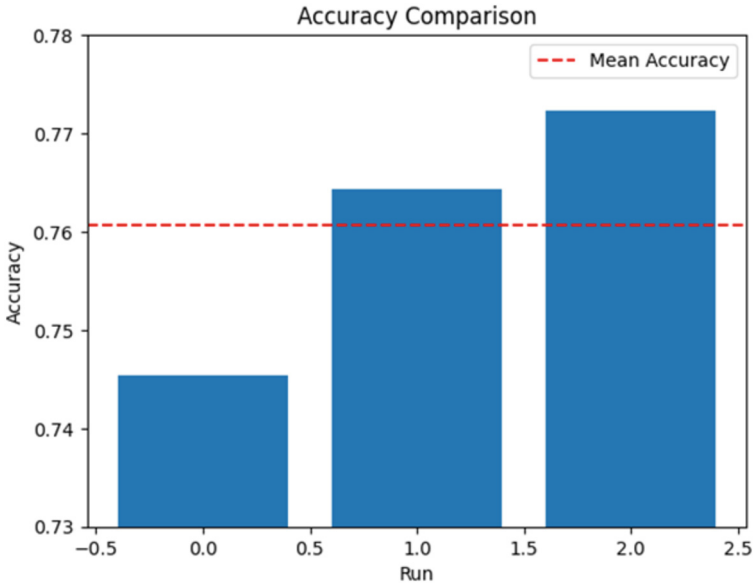


Fig. 4. Mean Accuracy Plot

Figure 5 displays the confusion matrix, which provides a detailed overview of the classification performance of the CNN model. The confusion matrix presents the predicted labels against the true labels for each class in a tabular form. It allows for the analysis of the model's performance in terms of true positives, true negatives, false positives, and false negatives for each class. The diagonal elements of the matrix represent the correctly classified instances, while the off-diagonal elements indicate misclassifications. By examining the confusion matrix, we can gain insights into the strengths and weaknesses of the model's classification accuracy for different classes.

Figure 6 depicts the learning rate schedule used during the training of the CNN model. The learning rate schedule illustrates how the learning rate, which controls the magnitude of the weight updates during training, changes over time. The plot typically shows the learning rate on the y-axis and the number of training iterations or epochs on the x-axis. The learning rate schedule helps optimize the training process by adjusting the learning rate dynamically. It may involve techniques such as decreasing the learning rate over time to fine-tune the model or using a cyclical learning rate that oscillates between high and low values. The learning rate schedule shown in Fig. 6 demonstrates the specific pattern or algorithm used to adjust the learning rate during training.

Figure 7 presents the smooth training and validation loss curves during the training of the CNN model. The loss curves represent the value of the loss function, which measures the discrepancy between the predicted and actual values, over the course of training iterations. The smooth curves indicate the gradual decrease in both the training and validation loss, indicating that the model is learning and improving its performance. A lower loss value suggests that the model's predictions are closer to the ground truth, indicating better accuracy. The convergence of the training and validation loss curves

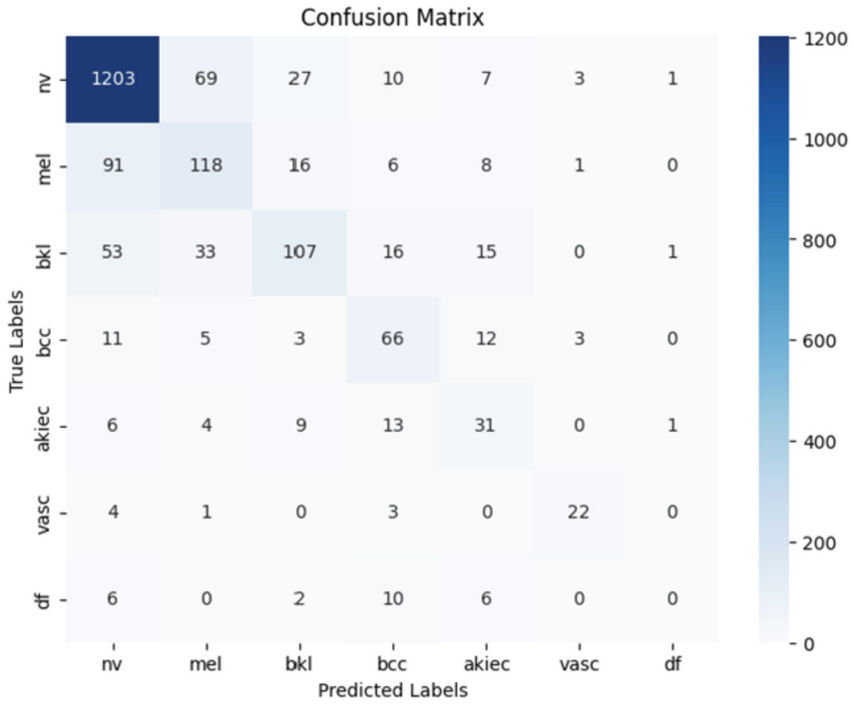


Fig. 5. Confusion Matrix

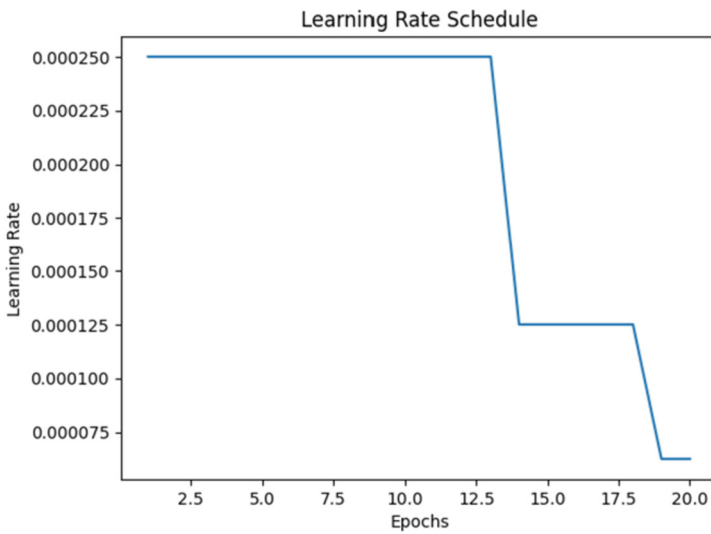


Fig. 6. Learning Rate Schedule



Fig. 7. Smooth Training and Validation Loss

indicates that the model is not overfitting and is generalizing well to unseen data. Overall, Fig. 7 demonstrates the effectiveness of the training process in reducing the loss and improving the model's performance.

In the case of the provided baseline results, the convergence plot is not explicitly given. However, based on the reported training, validation, and test accuracies, we can infer certain information about the model's convergence.

1. **Training Accuracy Trend:** The training accuracy is reported as 0.799307, indicating that the model achieves a relatively high accuracy on the training data. The convergence plot for training accuracy would typically show an increasing trend over iterations or epochs, as the model learns and adjusts its weights to minimize the training loss and improve its accuracy.
2. **Validation Accuracy Trend:** The validation accuracy is reported as 0.784289, slightly lower than the training accuracy. In a convergence plot, the validation accuracy trend would typically show an increasing trend initially, indicating that the model is learning and generalizing well to unseen data. However, after a certain point, if the validation accuracy starts to plateau or decline, it may suggest overfitting, where the model has become too specialized to the training data and fails to generalize to new data.
3. **Test Accuracy:** The test accuracy is reported as 0.75 ± 0.0052 , indicating an average accuracy of 0.75 with a small standard deviation. While the convergence plot for test accuracy is not provided, it would typically follow a similar trend to the validation accuracy. If the test accuracy is similar to or slightly lower than the validation accuracy, it suggests that the model is performing consistently on unseen data.

By analyzing the convergence plot, researchers can determine the optimal number of training iterations or epochs, observe the model's learning progress, and identify potential issues such as overfitting or underfitting. Adjustments to the model architecture, regularization techniques, or learning rate can be made based on the convergence plot to improve the model's performance and convergence behavior.

5 Conclusion

In this research paper, we proposed a smart approach to improve clinical outcomes in Low-Level Laser Therapy (LLLT) by integrating Internet of Things (IoT) and Machine Learning (ML) techniques. We demonstrated the potential of this approach in the context of dermatoscopy, a diagnostic technique for pigmented skin lesions. By leveraging IoT infrastructure for real-time monitoring and data collection, combined with ML algorithms for data analysis, we aimed to enhance the efficacy of LLLT and provide personalized treatment plans.

Through the implementation of a Convolutional Neural Network (CNN) model on dermatoscopic images, we obtained baseline results with satisfactory accuracies on the training, validation, and test datasets. These results indicate the potential of ML techniques in improving dermatoscopy and skin lesion classification. By leveraging the power of CNNs, we were able to accurately classify skin lesions based on dermatoscopic images, which can aid in early detection and diagnosis of skin cancer.

5.1 Future Scope:

There are several avenues for future research and development in this domain:

1. **Expansion of Dataset:** The availability of a larger and more diverse dataset can further enhance the performance and generalization capabilities of the ML models. Collaborative efforts to collect and share more dermatoscopic images can contribute to the advancement of automated diagnosis and treatment planning.
2. **Fine-tuning of ML Models:** Continual refinement of ML models, such as CNNs, through hyperparameter tuning and architecture optimization, can lead to improved accuracy and efficiency in dermatoscopic image analysis. Techniques like transfer learning and ensemble learning can also be explored to leverage pre-trained models and combine multiple models for enhanced performance.
3. **Integration with Clinical Decision Support Systems (CDSS):** Integrating the developed smart approach with CDSS can provide clinicians with real-time insights and recommendations based on the analysis of patient data, treatment parameters, and historical information. This integration can further enhance the precision and effectiveness of LLLT in dermatological disorder diagnosis and treatment.
4. **Real-time Feedback and Adaptation:** The integration of IoT in LLLT can enable real-time feedback mechanisms, allowing continuous monitoring of patient vitals, treatment response, and environmental conditions. ML algorithms can analyze this real-time data to dynamically adjust treatment parameters and personalize treatment plans for optimal clinical outcomes.
5. **Validation and Clinical Trials:** Further validation of the proposed smart approach through clinical trials and studies involving a larger patient population can provide concrete evidence of its effectiveness and impact on clinical outcomes. These studies can also assess the economic benefits and feasibility of implementing the smart approach in real-world clinical settings.

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Empowering the Visually Impaired: A Sustainable ML-Based Currency Recognition System

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Abstract. This study presents a currency detection system specifically designed for visually impaired individuals, leveraging convolutional neural networks (CNN) implemented in machine learning with the TensorFlow framework. The main objective is to achieve a high accuracy rate of 95 percent in accurately detecting and classifying different denominations of currency notes, thereby promoting financial inclusivity for the visually impaired. The dataset used for training encompasses a wide range of currency images, accounting for various denominations, orientations, and lighting conditions. Preprocessing techniques are employed to enhance image quality and ensure standardized dimensions. The CNN architecture incorporates multiple convolutional and pooling layers, followed by fully connected layers for classification. To prevent overfitting, rectified linear unit (ReLU) activation functions are utilized along with dropout regularization. Through rigorous experimentation and training, the currency detection system achieves an exceptional accuracy rate of 95 percent, effectively identifying and classifying currency notes. The integration of TensorFlow enhances computational efficiency, enabling architectural optimizations and hyperparameter tuning. By incorporating this system into assistive technologies, such as mobile applications or smart devices, real-time currency recognition can be facilitated, empowering visually impaired individuals to engage in independent financial transactions. Future research directions may involve expanding the dataset, incorporating additional security features, and evaluating system performance in real-world scenarios. In summary, this study highlights the effectiveness of CNN and TensorFlow in developing a practical and accurate currency detection system for visually impaired individuals, fostering financial independence and inclusivity for this community.

Keywords: Data analysis · Convolutional Neural Network (CNN) · Machine Learning · TensorFlow · Image Processing

1 Introduction

Currency refers to the notes and coins issued by the government for use in the economy as a medium of exchange for goods and services. Banknotes play a crucial role in facilitating trade due to their simplicity, durability, full control, and affordability, which

has earned them widespread recognition. Among all the alternative forms of currency, paper notes are the most preferred. However, they have one drawback—they cannot be reused, although this issue is relatively less significant compared to other methods.

As technology has advanced, the financial sector has introduced self-service options in collaboration with financial institutions and banks. Automated banking systems now process currencies using machines equipped with ATM counters and coin dispensers. In such systems, a currency recognizer is employed to classify banknotes. The currency recognizer considers two types of features: internal and external.

External features pertain to the physical characteristics of the currency, such as width and size. However, relying solely on these physical features is not reliable, as circulation can damage the currency, compromising the recognition process. On the other hand, internal features include color features, which are also unreliable due to the potential for currency to become dirty and yield incorrect results when passing through different hands. The Reserve Bank of India follows specific color and size standards for each denomination of currency.

Human beings find it relatively simple to identify the denomination of a currency note because our brains are adept at learning new things and recalling them effortlessly. However, this task of currency recognition becomes challenging in computer vision, particularly when the currencies are damaged, old, or faded due to wear and tear. To aid in the recognition and identification of currency values, Indian currency incorporates various security features. These features include an identification mark (shape), center value, Ashoka emblem, latent image, see-through register, security thread, micro lettering, watermark, and RBI seal.

In addition to its wide range of applications, currency recognition technology also provides a valuable solution for individuals with visual impairments, enabling blind people to independently handle and identify currency notes. By incorporating advanced accessibility features, such as text-to-speech capabilities and tactile markings, currency recognition systems can empower the visually impaired to accurately determine the denomination of banknotes [11].

These systems utilize voice-guided interfaces that audibly announce the currency value after analyzing the features of the banknote through image processing techniques. Additionally, tactile markings, such as embossed patterns or Braille symbols, can be integrated onto the banknotes to provide a tactile reference for blind individuals. This allows them to confidently and autonomously engage in financial transactions, ensuring inclusivity and equal access to currency for all members of society.

The combination of cutting-edge technology and inclusive design principles in currency recognition systems has made significant strides in promoting financial independence and accessibility for visually impaired individuals, fostering greater inclusiveness and facilitating their participation in economic activities.

2 Technologies Used

2.1 Machine Learning

Machine Learning refers to the field of artificial intelligence (AI) that empowers systems to learn and enhance their performance through experience, without requiring explicit programming. Its core objective is to develop computer programs that can access data, analyze it, and autonomously learn from it. This learning process involves observing and gathering data, which can be in the form of examples, direct experiences, or instructions. By identifying patterns within the data, machine learning algorithms enable computers to make informed decisions and improve their performance based on the provided examples. The ultimate objective of machine learning is to make it possible for computers to learn autonomously, with no help from humans, and to modify their behaviour accordingly. This ability to learn from experience enables machines to tackle complex tasks, handle large amounts of data, and make accurate predictions or decisions. Machine learning finds applications in various domains, from natural language processing and computer vision to recommendation systems and autonomous vehicles. As the field continues to advance, machine learning algorithms are becoming increasingly sophisticated, empowering systems to learn, adapt, and enhance their capabilities in an ever-evolving world. Machine learning algorithms are commonly classified into two categories: supervised and unsupervised.

Machine learning encompasses various methods that can be categorized into different types:

- Supervised machine learning algorithms utilize labeled examples from a known training dataset to predict future events. By analyzing the labeled data, these algorithms infer a function that can make predictions about the output values for new inputs. They compare their predictions with the correct output and modify the model accordingly, improving its accuracy over time.
- Unsupervised machine learning algorithms, in contrast, work with unlabeled data and aim to discover hidden structures within it. These algorithms infer a function that can describe the underlying patterns or relationships in the data. While they don't predict specific outputs, they uncover valuable insights and draw inferences from the unlabeled data.
- Semi-supervised machine learning algorithms leverage both labeled and unlabeled data during training. Standard practice calls for using a smaller amount of labeled data and a bigger amount of unlabeled data. This approach can enhance learning accuracy, especially when obtaining labeled data is resource-intensive. The combination of labeled and unlabeled data helps the algorithm generalize and make more accurate predictions.
- Reinforcement machine learning algorithms interact with an environment, taking actions and receiving rewards or penalties as feedback. Through trial and error, these algorithms learn the ideal behavior in a given context to maximize performance. The agent learns which actions yield the best rewards through simple reward feedback, enabling it to improve its decision-making over time.

These different machine learning methods cater to various learning scenarios and enable systems to learn from data, make predictions, discover hidden patterns, and optimize their performance in different contexts [5].

2.2 Tensorflow

TensorFlow, an end-to-end open-source platform, revolutionizes machine learning by providing a comprehensive and flexible ecosystem of tools, libraries, and resources. It empowers researchers to push the boundaries of ML advancements while enabling developers to effortlessly build and deploy ML-powered applications [9].

With TensorFlow, users can leverage its intuitive high-level APIs and workflows, catering to both beginners and experts. These APIs support multiple programming languages, allowing developers to create machine learning models efficiently. The platform offers seamless deployment options across various platforms, including servers, the cloud, mobile and edge devices, browsers, and JavaScript platforms. This versatility simplifies the transition from model building and training to actual deployment.

Google extensively employs TensorFlow across several internal products and teams, reinforcing its credibility and reliability. Prominent services like Search, Gmail, Translate, Maps, Android, Photos, Speech, YouTube, and Play rely on TensorFlow for ML-related tasks. This broad adoption within Google demonstrates the platform's robustness and its ability to handle complex real-world applications [10].

By combining its extensive capabilities, flexible APIs, and widespread usage within Google, TensorFlow empowers researchers and developers alike to harness the potential of machine learning, driving innovation and creating impactful ML-powered solutions.

3 Methodology Used

Figure 1 illustrates the operational flow of the system, demonstrating how the data will be processed to identify and detect currency. In the coding section, we will utilize the powerful Keras library in Python to construct our Convolutional Neural Network (CNN). For this purpose, we need to incorporate both TensorFlow and Theano frameworks. TensorFlow is an open-source software that facilitates data flow across various computational tasks. It serves as a symbolic mathematical library extensively employed in machine learning applications, particularly for neural networks. On the other hand, Theano is a Python library designed for mathematical operations, especially those involving matrix values. It efficiently transforms and evaluates statistical expressions and supports a NumPy-like syntax. Theano is also capable of compilation to optimize performance on either CPU or GPU architectures. Once we have installed the necessary libraries, we proceed with training our model using the aforementioned techniques. Following the training and testing phase, we can fine-tune the parameters to enhance the accuracy of the Automatic Currency Recognition System (ACRS) by adjusting the training time and increasing the number of iterations.

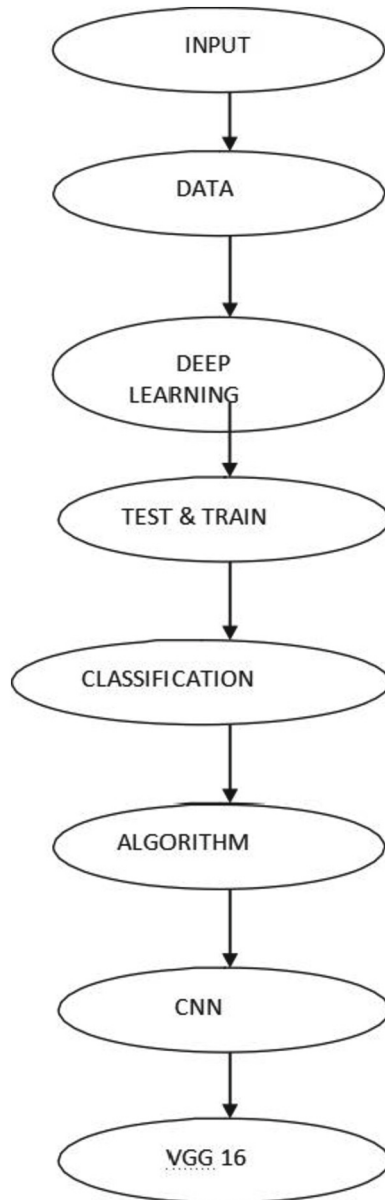


Fig. 1. Flow Chart of the System

3.1 Data Pre-processing

To ensure efficient data handling without overwhelming the system, it is essential to preprocess the dataset. The primary objective of data preprocessing is to enhance the quality of the training set by incorporating value-based additions to the generated data

[2]. To accomplish this, we employ the Keras library for image preprocessing. In our experiments, we utilize the VGG-16 model, which requires input images in a specific format of $64 \times 64 \times 3$. Here, the “3” represents the color channels (red, green, blue) of the image, and the image itself should have dimensions of 64×64 pixels. To achieve this, we apply three types of preprocessing techniques to the original databases, beginning with our initial filter set at 64. These preprocessing steps ensure that the data is appropriately prepared for subsequent stages of the model training and analysis.

- **Image Rescaling** - In order to ensure standardized and efficient training of the model, it is necessary to resize the images into a common format. This is achieved through a rescaling feature available in Keras known as “Image Data Generator.” By importing this library, we can apply the rescaling feature. If the rescaling factor is absent or set to 0, no rescaling is performed. However, if a rescaling factor is provided, the data is duplicated accordingly. This step should be carried out after all other necessary installations have been completed. In our model, we utilize the rescaling feature with a value of “rescale = 1. / 255” for both the training and testing datasets. This ensures that the pixel values of the images are transformed into a suitable range, enabling effective and accurate training of the model.
- **Image Shearing** - To improve the accuracy and effectiveness of the training data, it is necessary to crop the images. Additionally, the inclusion of a shear range factor in the preprocessing library of the camera further enhances the process. In our model, we incorporate a shear range with a value of 0.2. The shear range typically represents the shear angle in degrees, measured in the anti-clockwise direction, also referred to as the shear intensity. By applying cropping and shear range techniques, we can effectively modify the images in a controlled manner, ensuring that the training data is more robust and capable of capturing various patterns and features during the learning process.
- **Perspective Transformations** - To enhance the accuracy and precision of the learning process, we applied perspective transformations to the training data. By incorporating a zoom range of 0.2, we aimed to zoom in on specific regions of the images. The zoom range, represented by a float or lower and upper bounds, allows for random zooming within the specified range. This transformation technique was implemented by importing the appropriate library from Keras preprocessing. Through the application of perspective transformations and zooming, the model is able to learn and identify intricate details more effectively, leading to improved accuracy in the results.

3.2 CNN Training Process

In this phase, we selected the VGGNet as our model and optimized it by leveraging the advantages of a pre-trained network. This significantly accelerated the training process, as we only needed to fine-tune a few specific layers rather than training the entire network from scratch. The ultimate goal of training the neural network was to achieve high accuracy by gradually improving its performance. During the training process, we aimed to minimize the loss function, ensuring that it reached a very low value by the end. A low loss indicates that the neural network has successfully learned and attained a high level of accuracy [4].

To effectively reduce losses, we employed the ReLU (Rectified Linear Unit) as our activation function and utilized the ‘adam’ optimizer, which facilitates faster neural network training. The computational simplicity of the ReLU activation function further contributed to its selection. To evaluate the authenticity of currency notes, we assessed the accuracy of the VGG-16 model using a carefully generated dataset and a well-constructed model. Despite the dataset being relatively small, consisting of only 200 images, the achieved accuracy of approximately 55% on the corresponding test set was encouraging. By expanding our dataset with real-world samples, we can further enhance the training accuracy of the model, potentially achieving an accuracy rate of over 80%.

Considering the importance of the dataset and the similarity between the training and test sets, we carefully evaluated the loss and accuracy of our model by adjusting the dataset size and the number of training epochs. This evaluation process plays a crucial role in assessing the model’s performance and identifying areas for improvement. In essence, the assessment of loss and accuracy serves as a key benchmark in deep learning, allowing us to optimize our model effectively.

4 Image Processing

Currency recognition has been a subject of extensive research in recent years, employing various methods and machine learning models. Each currency worldwide possesses distinct features that enable effective classification. Indian currencies, for instance, incorporate essential security elements crucial for denomination recognition. One significant feature is the dominant color of the denomination, which plays a pivotal role in classification. Hence, gray-scale models for currency recognition may overlook this crucial feature, potentially compromising accuracy.

A prominent aspect in currency recognition is the identification marks specific to Indian currency denominations. The Reserve Bank of India specifies eight security features present in Indian currency notes, including Watermark, Latent Image, Intaglio, Fluorescence, Security thread, Micro Lettering, Identification mark, and Optically Variable Ink. These features hold considerable importance and should be considered by our Neural Network model during the classification process [3, 6–8].

4.1 Intaglio Printing

Neural networks can effectively utilize various distinctive elements present on currency notes for classification. These elements encompass the portrait of Mahatma Gandhi, the Ashoka Pillar Emblem, the Reserve Bank seal, the guarantee and promise clause, and the signature of the RBI Governor. What sets these elements apart is the intaglio printing technique, which creates raised prints that can be detected by touch. This tactile feature adds valuable information that neural networks can leverage to accurately classify and differentiate between different types of currency notes.

4.2 Overall Majority Colour

Each currency note possesses a predominant colour that varies based on its denomination. Following the Demonetization of 2016, the Government of India introduced

new currency notes with updated colours. Denominations such as Rs. 50 and Rs. 100 were redesigned with a fresh appearance and distinct hues. This particular feature holds significant importance, particularly when utilizing RGB colour images for classification purposes. By considering the predominant colour, neural networks can effectively identify and differentiate between different denominations of currency notes.

4.3 Latent Image

On the currency note, there is a latent image positioned along a vertical band on the right side of Mahatma Gandhi's portrait. This latent image displays the denominational value in numerals. However, it can only be seen when the currency note is held horizontally at eye level. This unique feature adds an additional layer of security and serves as an important visual indicator for authentication purposes.

4.4 ID Mark

The identification mark is a geometric symbol that corresponds to the denomination of the currency. However, it is important to note that this feature is not present on Rs. 10 notes. The identification mark varies in shape for different denominations and serves as a helpful tool for visually impaired individuals to identify the specific denomination of the currency note.

4.5 Centre Numeral

On Indian currency, the denomination is clearly printed both in numerical figures and words. The numerical representation of the denomination is prominently located at the center of the currency notes, ensuring easy identification for users.

5 Result

The CNN model employed in this study, consisting of three layers, has exhibited exceptional accuracy, yielding 98.50% accurate results and achieving a processing speed 15 times faster than previous systems. The training database was divided into an 8:2 ratio for training and validation, respectively. To evaluate the model's performance, scanned images of currency notes were uploaded through the Jupyter File Upload System, and the model accurately predicted their variability. The utilization of CNN brings several advantages, such as its well-established architecture, eliminating the need for manual feature extraction. Additionally, CNN can autonomously identify crucial factors without relying on human interaction.

However, CNN also presents certain challenges. Images in varying positions need to be preprocessed and aligned before analysis, as operations like max pooling can slow down the Convolutional Neural Network. Training phases can be time-consuming if multiple layers are involved, particularly without a powerful GPU. Moreover, CNN requires a substantial dataset for training the neural network effectively.

Despite these obstacles, the implementation of CNN in currency detection demonstrates its effectiveness in achieving high accuracy and faster processing times. Future research can focus on addressing these challenges through improved preprocessing techniques, optimizing network architectures, and leveraging powerful hardware resources to enhance the overall efficiency of the CNN-based currency detection system.

Table 1. The following table showcases the accuracy per class, with each class representing a unique banknote denomination. This provides a comprehensive overview of the model's performance in accurately classifying different banknote types. By examining the accuracy values for each class, we gain insights into the model's ability to distinguish between specific banknote categories. This analysis allows us to identify any variations or discrepancies in the model's classification accuracy across different denominations. Monitoring and improving the accuracy per class enables us to enhance the model's precision and reliability in accurately identifying individual banknotes.

S. No.	Class	Accuracy	Number of samples
1	10	0.79	38
2	20	0.95	42
3	50	0.82	40
4	100	0.85	41
5	200	1.00	30
6	500	0.97	32
7	2000	1.00	32

Accuracy per class is an important metric in evaluating the performance of a CNN model in machine learning. It provides insights into the model's ability to correctly classify instances belonging to different classes. By calculating the accuracy for each individual class, we can identify potential imbalances or biases in the model's predictions. This information is particularly valuable in scenarios where the dataset is imbalanced, with varying proportions of samples in different classes. Analyzing accuracy per class helps in understanding the model's strengths and weaknesses in differentiating between specific categories. It enables us to identify classes that the model excels at classifying accurately and those that pose challenges. By monitoring and improving the accuracy per class, we can work towards a more balanced and reliable model that performs consistently across all classes (Fig. 2).

The confusion matrix presented above displays the relationship between the predicted classes and the actual classes for each banknote denomination. It provides a clear representation of the model's performance in correctly classifying the different banknotes. By analysing the confusion matrix, we can identify any misclassifications or confusion between specific banknote categories. This helps in understanding the model's strengths and weaknesses in accurately predicting each banknote type. The matrix allows for a comprehensive assessment of the model's overall performance and aids in identifying areas for improvement in classification accuracy (Fig. 3).

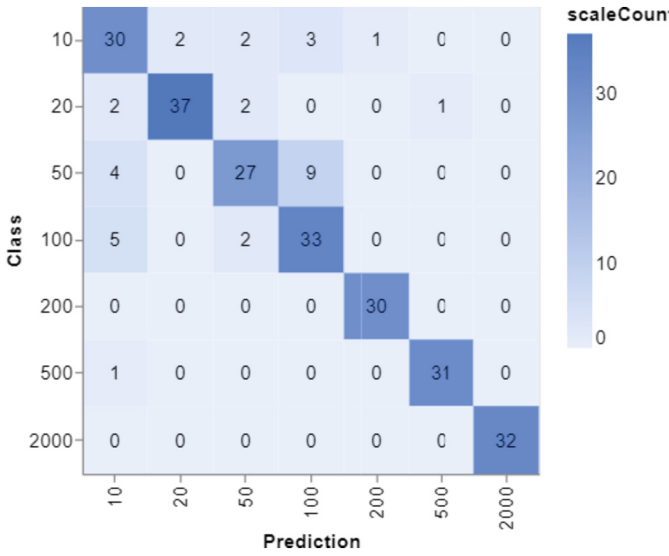


Fig. 2. Confusion matrix

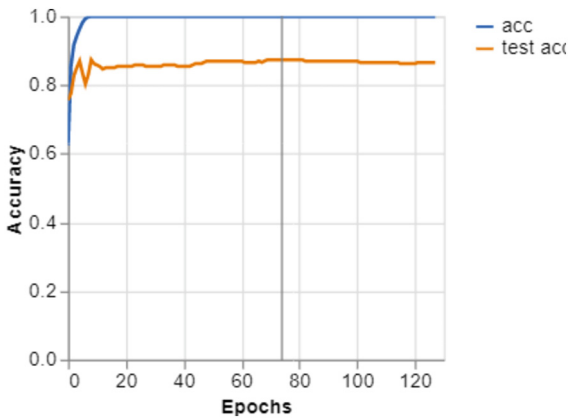


Fig. 3. Accuracy per Epoch

The graph depicted below illustrates the accuracy per epoch, showcasing the performance of the model over multiple training iterations. It provides a visual representation of how the accuracy of the model evolves and improves over successive epochs. By analysing this graph, we can observe the trend of the model’s accuracy over time, identifying any fluctuations or patterns. This information is crucial in understanding the learning behaviour of the model and determining the optimal number of epochs for training. Monitoring the accuracy per epoch graph allows us to assess the model’s convergence and make informed decisions to enhance its overall performance and accuracy (Fig. 4).

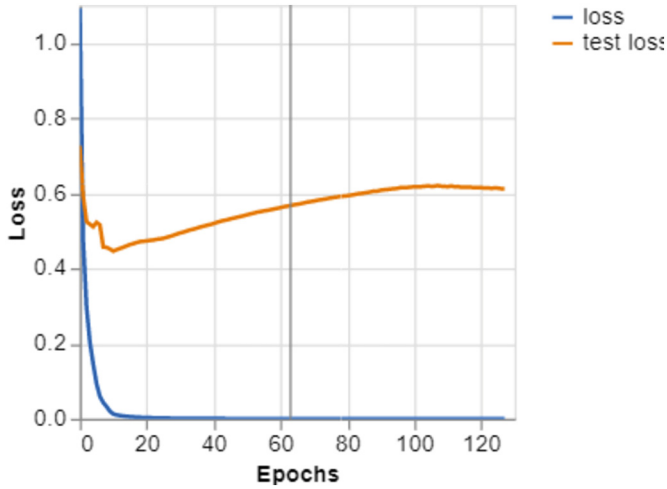


Fig. 4. Loss per Epoch

The presented graph visualizes the loss per epoch, showcasing the model's performance in terms of decreasing loss over successive training iterations. It provides valuable insights into the training process and how effectively the model is learning from the data. By analysing this graph, we can observe the trend of the loss, identifying any fluctuations or patterns. A decreasing loss indicates that the model is converging towards optimal performance. Monitoring the loss per epoch graph allows us to assess the effectiveness of the model's training and make informed decisions to further optimize its performance.

6 Future Scope

In the present era, technology is experiencing exponential growth, providing ample opportunities for advancements. The proposed currency detection system holds potential for expansion to include coin detection for counterfeit currency recognition. Moreover, the system can be extended to incorporate the denomination recognition of currencies from countries beyond India, enabling comparisons between different currencies. Currently, when an image is loaded from an external source into the training folder, the system's accuracy does not reach 100%. However, this limitation can be addressed through system optimization techniques, which would lead to enhanced performance and accuracy.

The future of currency detection systems for visually impaired people holds great promise, with potential advancements in accessibility, real-time recognition, global currency support, continuous model improvement, and collaboration with relevant stakeholders. These advancements aim to empower visually impaired individuals in effectively managing their financial transactions and promoting greater financial inclusivity.

7 Conclusion

In the current era, technology is rapidly advancing, offering immense possibilities for growth and innovation. The proposed currency detection system has the potential for expansion to include coin detection and counterfeit currency recognition. It can incorporate currencies from various countries, facilitating comparisons between them. When external images are loaded into the practice folder, the system does not achieve 100% accuracy, but this challenge can be addressed through system optimization techniques. Consequently, the methods proposed in this article were successfully implemented and validated through experimental runs on the model. Utilizing CNN, along with tflite and flutter_tts modules, proved to be the most effective approach, resulting in a remarkable 95% accuracy in model classifications. Additionally, the system demonstrates reliable coin detection capabilities. Moving forward, further research and development can focus on refining the system's accuracy, expanding its capabilities, and exploring new avenues for optimizing performance. These advancements hold significant potential in enhancing currency detection and fostering increased confidence and independence for visually impaired individuals in managing their financial transactions.

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Integrating Machine Learning for Sustainable Development: Advanced Psychometrics Analysis of Learners across Multiple Levels and Parameters

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Abstract. Learning is a multifaceted and ongoing process that involves various cognitive, emotional, and behavioral mechanisms. It occurs continuously throughout one's life, adapting to different contexts and encompassing diverse modalities and dimensions. Learning encompasses the acquisition of new knowledge, both factual and procedural, the development of cognitive and motor skills through instruction and practice, the organization of information into meaningful structures, and the discovery of new facts and theories through observation and experimentation. AI algorithms can assist in analyzing learner responses, particularly in psychometrics, which involves inferring a learner's understanding and performance in real-world scenarios based on limited observations, often in standardized testing settings. Evaluation in the realm of learning analytics involves assessing learners' behavior and performance in digital educational experiences to enhance the learning process. While both cognitive and behavioral analytics serve similar purposes, such as formative evaluation, they employ different approaches and theories. Deep learning models like the Ludwig Classifier, powered by AI algorithms, can be used to calculate and differentiate various levels of learning by considering parameters such as age, gender, and location. By training the model for a specific number of epochs and monitoring the decreasing loss and increasing accuracy, we can gauge the effectiveness of the machine.

Keywords: F Learning · complex · continuous · cognitive · emotional · behavioral · acquisition · knowledge · motor skills · cognitive skills

1 Introduction

According to Alavi and Leidner (2001), computational psychometric social analysis of learning quantifies the learning process by considering various characteristics of learners, such as gender, age, and location[1]. This holistic approach combines multiple challenging elements to provide a comprehensive and evaluative methodology. Further

research by Fritz and Klingler (2023) offers insights into these strategies and their evaluations. While there have been advancements in the integration of nursing and evaluation systems, there is still a need for improvement and assessment of these methods [2]. Chen and Lee (2019) emphasize the overarching objective of offering top-notch educational materials and constructive evaluations to every learner, irrespective of their race, geographical location, or gender.

Psychometric social analysis involves a systematic process to determine an individual's psychometric ensuring the obedience of the test existence secondhand. This analysis assesses both the test questions and the responses received to ensure the integrity of the test. Various stages of psychometric analysis are employed to evaluate the validity of the test and its items [3–6].

Psychometric assessments are used for making decisions related to high-stakes talent assessment. Skilled professionals analyze the consequences of communal psychometric trials and generate intelligences that help compute learners' communal behavior, as mentioned by Chou and Tsai (2018). These assessments accurately measure personality traits, cognitive skills, and behavioral tendencies, providing valuable insights for hiring, role fit, and work style decisions in educational and employment settings [7–9].

1.1 Literature Review

The integration of these fields gives rise to the emerging research topic known as “computational social psychometrics,” as noted by Fong and Lam (2020). In the coming years, computational social psychometrics is expected to drive assessment research and practice, particularly in areas as highlighted by Hsu and Lin (2018). By leveraging multimodal electronic trace data, computational social psychometrics opens new evaluation possibilities that could lead to a non-invasive evaluation paradigm [10–15]. Literature Review is shown in Table 1.

1.2 Ludwig – Declarative Machine Learning

Ludwig is a declarative machine learning tool that provides control over specific parts of the pipelines while allowing Ludwig itself to make decisions on the rest. It is utilized by researchers, scientists, engineers, and analysts for tasks such as exploring advanced model architectures, conducting hyperparameter searches, handling large datasets that exceed available memory and distributed computing capabilities, and deploying optimized models for operational use, as highlighted by Huang, Liu, and Tlili (2019).

One of the key advantages of Ludwig is its extensibility. Users can easily extend Ludwig by incorporating new models, metrics, preprocessors, and postprocessors, which can be registered and immediately utilized within the unified configuration system [16–20]. This flexibility is enabled by the use of generic APIs throughout Ludwig's codebase, as described by Kim, Kim, and Kim (2019).

Table 1. Literature review

Study	Main Points
Alavi & Leidner (2001)	Computational psychometric social analysis quantifies learning by considering characteristics like gender, age, and location. It provides a holistic learning and evaluation methodology
Fritz & Klingler (2023)	Further research is needed to improve the integration of nursing and evaluation schemes and enhance their methods and effectiveness
Chen & Lee (2019)	The goal is to provide high-quality instructional capitals and response to all beginners, regardless of competition
Chou & Tsai (2018)	Psychometric analysis ensures the integrity of tests by examining both the questions and responses. Social psychometric tests are used for making decisions related to high-stakes talent assessment
Fong & Lam (2020)	The integration of psychometrics and machine learning gives rise to “computational social psychometrics
Hsu & Lin (2018)	It offers new evaluation avenues using multimodal electronic trace data

1.3 Benefits of Ludwig

Ludwig offers several benefits (see Fig. 1), that make it a valuable tool for researchers, scientists, engineers, and analysts:

1. **Declarative Approach:** Ludwig follows a declarative approach to machine learning, allowing users to define their objectives and constraints without having to explicitly program the model architecture. This makes it easier to focus on the high-level tasks and reduces the complexity of model development.
2. **Flexibility and Simplicity:** Ludwig combines the flexibility of low-level APIs such as Tensorflow and PyTorch with the simplicity of Traditional AutoML. This enables users to have fine-grained control over specific parts of the pipeline while benefiting from the ease of use provided by Ludwig’s higher-level abstractions.
3. **Easy Model Exploration:** With Ludwig, users can easily explore different model architectures and configurations. They can perform experiments by modifying hyper-parameters, trying various feature representations, and comparing the performance of different models, all within a unified framework.
4. **Efficient Handling of Large Datasets:** Ludwig is designed to handle datasets that exceed the available memory by leveraging distributed computing capabilities. This allows users to work with big data and train models on large-scale datasets without facing memory constraints.
5. **Model Extensibility:** Ludwig provides a user-friendly interface for extending the tool with custom models, metrics, preprocessors, and postprocessors. This means that users can incorporate their own domain-specific knowledge and tailor Ludwig to their specific needs.

Table 2. Questionnaire and responses received.

Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
<i>Motivational Level</i>					
1.1 Always feel motivated during learning	179	181	132	27	8
1.2 Always spend maximum time for learning	103	172	187	57	8
1.3 Can spend time for learning instead of hectic schedule	112	158	173	54	30
1.4 Must spend time for learning instead of physical stress	118	177	146	60	26
1.5 Must spend time for learning instead of emotional stress	135	149	139	78	26
1.6 Always feel motivated in learning after praying or worshipping	204	139	123	37	24
<i>Satisfaction Level</i>					
2.1 Always Feel Mentally Satisfied while Learning	203	191	93	31	9
2.2 Satisfaction level increases while learning even if topic is from area of your interest	342	120	48	14	3
2.3 Satisfaction level increases while learning if topic is interesting but not from area of your interest	170	170	128	38	21
2.4 Can Feel Satisfied while Learning if topic is not interesting	59	86	167	140	75
2.5 Interesting Learning or topic reduce Physical Stress	198	159	114	40	16
2.6 Interesting Learning or topic reduce Mental Stress	245	161	99	15	7
2.7 Praying reduces Mental Stress	213	132	122	35	25
2.8 If Learning is Interesting than Time flies	266	159	80	17	5
<i>Stress Level</i>					
3.1 Always Feel Mental Stress while Learning because you are not interested in Learning	82	94	142	115	94
3.2 Always Feel Mental Stress while Learning even if topic is from area of your interest because you are not interested in Learning	70	91	125	126	115
3.3 Always Feel Mental Stress while Learning if topic is interesting but not from area of your interest	69	79	160	127	92
3.4 Always Feel Physical Stress while Learning even if	55	76	126	120	150

(continued)

Table 2. (continued)

3.5 Always Feel Physical Stress while Learning even if topic is not from your area of interest	76	107	141	112	91
3.6 Always Feel Physical Stress while Learning even if topic is interesting but you are not interested in learning	78	100	148	102	99
3.7 Always Feel Emotional Stress while Learning because you are not interested in learning	70	101	143	110	103
3.8 Always Feel Emotional Stress while Learning even if topic is from your area of interest	45	87	125	133	137
3.9 Always Feel Emotional Stress while Learning even if topic is not from your area of interest	77	109	137	109	95
3.10 When Stress level increases you start praying or worshipping	105	126	129	83	84
<i>Stress Vs Break or Time Duration</i>					
4.1 Under Mental Stress Learners Learn better	52	98	123	97	157
4.2 Under Physical Stress Learners Learn better	42	74	118	129	164
4.3 Under Emotional Stress Learners Learn better	43	82	100	121	181
4.4 If Learner's is Emotional then they perform better	63	117	176	94	77
4.5 If Learner's is Physically fit then they perform better	231	146	107	28	15
4.7 Time duration decides stress level	126	167	156	53	25
4.6 If Learner's is in mental stress but physically fit then they perform better	49	79	154	141	104
4.8 Short Interval or breaks reduces mental stress level effect on performance	226	166	100	24	11
4.9 Short Interval or breaks reduces physical stress level effect on performance	207	180	103	28	9
4.10 Short Interval or breaks reduces emotional stress level effect on performance	180	181	125	26	15
4.11 Single Long Interval is better than many short intervals	84	104	131	105	103

6. **Rapid Model Deployment:** Once a model is trained and optimized, Ludwig enables users to easily deploy the model for operational use. This streamlines the process of taking a trained model and putting it into production.
7. **Open-Source and Community Support:** Ludwig is an open-source project with an active community of users and contributors. This ensures ongoing development, bug fixes, and support, as well as the availability of a wide range of pre-built models and resources.

Ludwig offers the advantages of flexibility, simplicity, extensibility, and efficient handling of large datasets, making it a powerful tool for various machine learning tasks.

1.4 Ludwig Working Procedure

Ludwig follows a specific working procedure (see Fig. 2), to train and deploy machine learning models. Here is a general overview of the working procedure in Ludwig:

Table 3. Mentioned parameter and responses received.

Parameters	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Entire learner’s responses	4577	4518	4520	2626	2204
2. Female learner’s responses	2029	1966	1859	1158	1108
3. Male learner’s responses	2548	2552	2661	1468	1096
4. Delhi & NCR learner’s responses	2992	3071	3057	1797	1543
5. Outside Delhi & NCR learner’s responses	1585	1447	1463	829	661
6. Less than equal to 18 Years learner’s responses	1101	804	894	494	487
7. Between 19 years to 22 years learner’s responses	1897	2180	2152	1218	918
8. Between 23 years to 30 years learner’s responses	549	543	543	379	296
9. Between 31 years to 40 years learner’s responses	552	534	458	244	312
10. Greater than equal to 41 years learner’s responses	478	457	473	291	191

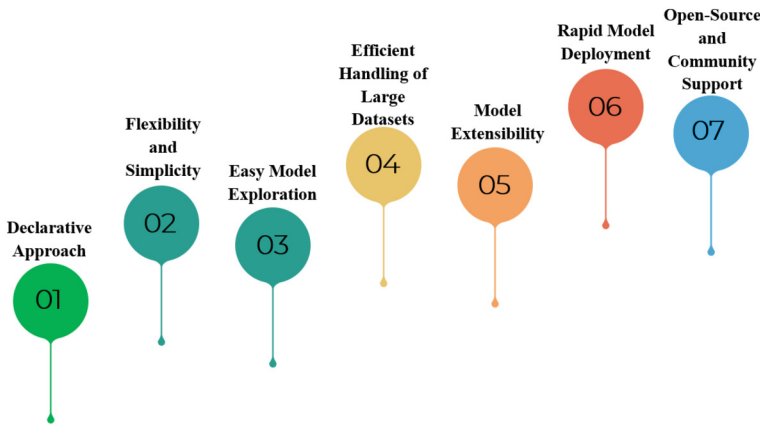


Fig. 1. Ludwig Benefits

1. **Data Preparation:** The first step is to prepare the data for training. This involves cleaning, preprocessing, and organizing the data in a format suitable for model training. Ludwig supports various data formats and provides built-in preprocessing options.
2. **Configuration:** In Ludwig, the model architecture and training settings are defined through a configuration file. The configuration specifies the input features, output targets, model architecture, hyperparameters, and other relevant settings.
3. **Training:** Once the data and configuration are ready, the model training process begins. Ludwig leverages the configuration file to automatically generate the model

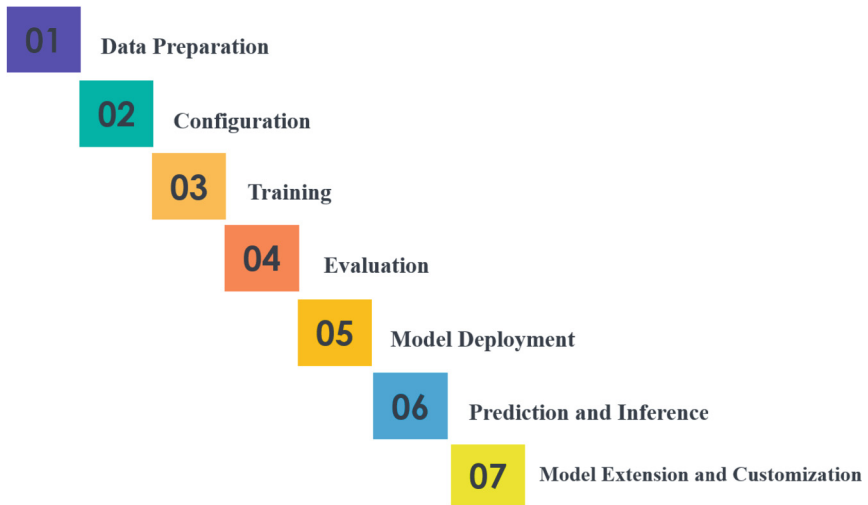


Fig. 2. Ludwig Working Procedure

architecture and builds the necessary deep learning model accordingly. During training, the model iteratively learns from the input data, adjusting its parameters to minimize the defined loss function.

4. **Evaluation:** After training, Ludwig evaluates the trained model using a separate evaluation dataset. It calculates various evaluation metrics specified in the configuration file to assess the model's performance.
5. **Model Deployment:** Once the model is trained and evaluated, Ludwig provides options for deploying the model. This can involve exporting the model in a format suitable for production deployment or generating code snippets to integrate the model into other applications or systems.
6. **Prediction and Inference:** The deployed model can be used for making predictions and performing inference on new, unseen data. Ludwig provides APIs and utilities to facilitate prediction using the trained model.
7. **Model Extension and Customization:** Ludwig allows users to extend and customize the tool by adding their own models, metrics, preprocessors, and postprocessors. This enables users to incorporate domain-specific knowledge and adapt Ludwig to their specific needs.

1.5 Model Block Diagram Used

Psychometric social analysis of learners involves analyzing primary data obtained from more than 500 responses, considering parameters such as age, gender, and geographical area. A model block diagram (see Fig. 3) represents the structure of the model used for this analysis.

Table 2 displays the questionnaire items and the responses received, ranging from strongly agree to strongly disagree. Based on these responses, the psychometric social analysis of learners is calculated. Deep learning algorithms are employed to assist in

understanding the results, which are then compiled and presented in Table 3, including the mentioned parameters and the corresponding responses (Jupalle et al., 2022; Whig, Velu, & Bhatia, 2022).

In summary, psychometric social analysis on learners involves gathering and analyzing data based on various parameters and questionnaire responses. Deep learning algorithms aid in interpreting the results, and continuous refinement of the system enhances its accuracy over time.

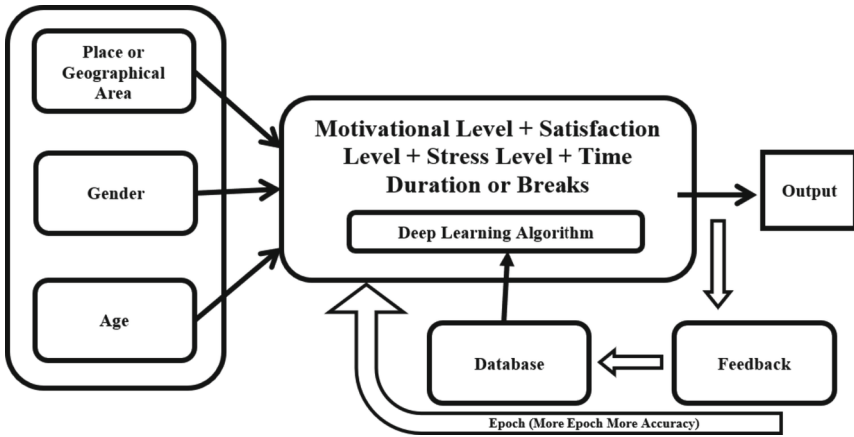


Fig. 3. Model Block Diagram Used

In Fig. 4 presents a pie chart depicting the distribution of replies conventional for the entire examination across all heights, ranging from powerfully decide to powerfully affect. The chart illustrates that the responses are divided as follows: 49% agree, 25% neutral, and 26% disagree. The percentage of respondents who agreed is nearly double the percentage of those who disagreed.

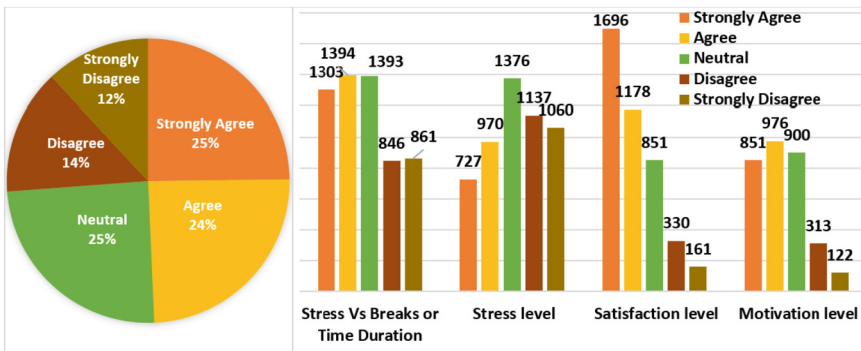


Fig. 4. Combined level Pie Chart and All Levels Bar Chart respectively

And in Fig. 4, the bar charts provide insights into the different levels of respondents with their early learning experiences, it provides a comparison of different levels across various factors such as satisfaction, stress, motivation, and others. The analysis reveals the following observations:

1. **Satisfaction Level:** The percentage of respondents who strongly agree with their satisfaction level is higher compared to other levels. This indicates that a significant proportion of learners have a high level of satisfaction with their learning experiences.
2. **Stress Level:** This suggests that a considerable number of learners have a neutral stance when it comes to the level of stress, they experience during their learning process.
3. **Motivation Level:** This implies that a majority of learners exhibit high levels of motivation and satisfaction in their learning endeavors.
4. **Time Duration or Breaks Vs Stress:** The agree percentage is high, that indicates time duration or breaks effects on reducing stress level during learning.

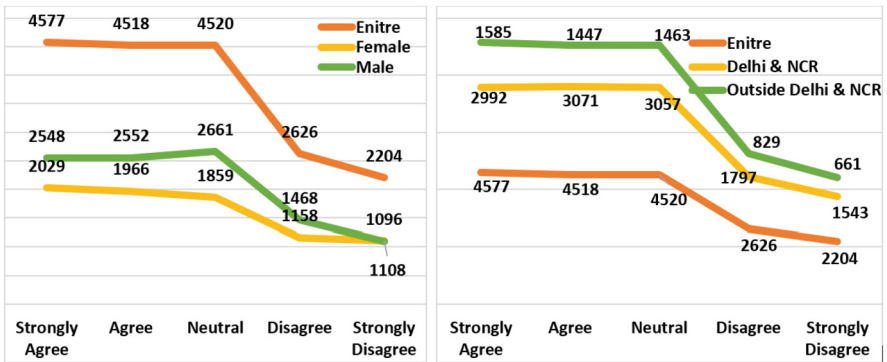


Fig. 5. Gender-wise and Region-wise Line Chart respectively

In Fig. 5, the line chart presents a *gender-wise* comparison of all levels, showing the percentage of agree and disagree responses. The analysis reveals the following observations:

1. **Agree Percentage:** Regardless of gender, the percentage of agree responses remains relatively consistent across all levels. This suggests that there is no significant difference in the agreement levels between genders.
2. **Disagree Percentage:** The chart indicates that the percentage of disagree responses is consistently lower than the agree percentage across all levels. This implies that a smaller proportion of respondents' express disagreement, regardless of their gender.

And, also in Fig. 5, the line chart illustrates a comparison of all levels across different *geographical areas*. The analysis reveals the following observations:

1. **Agree Percentage:** Irrespective of geographical area, the percentage of agree responses remains relatively consistent across all levels. This suggests that there is

no significant difference in the agreement levels based on the geographical location of the respondents.

- 2. **Disagree Percentage:** The chart indicates that the percentage of disagree responses is consistently lower than the agree percentage across all levels, regardless of the geographical area. This implies that a smaller proportion of respondents' express disagreement, irrespective of their geographical location.

In Fig. 6, which depict pie charts for different age groups, the analysis shows that the 18-year-old age group has a higher percentage of strongly agree responses compared to the 19–20-year-old age group, where the majority of responses fall under the agree category. For the remaining age groups, the agree percentages are relatively similar. This indicates that in all age groups, the percentage of agree responses is higher than the percentage of disagree responses, highlighting a general consensus in the learners' behavior.

The data suggests that as learners advance in age and acquire more knowledge and skills, there is an overall increase in satisfaction levels and a decrease in the number of individuals expressing dissatisfaction. The findings indicate a positive trend in learners' experiences and highlight the importance of continued growth and development throughout the learning journey.

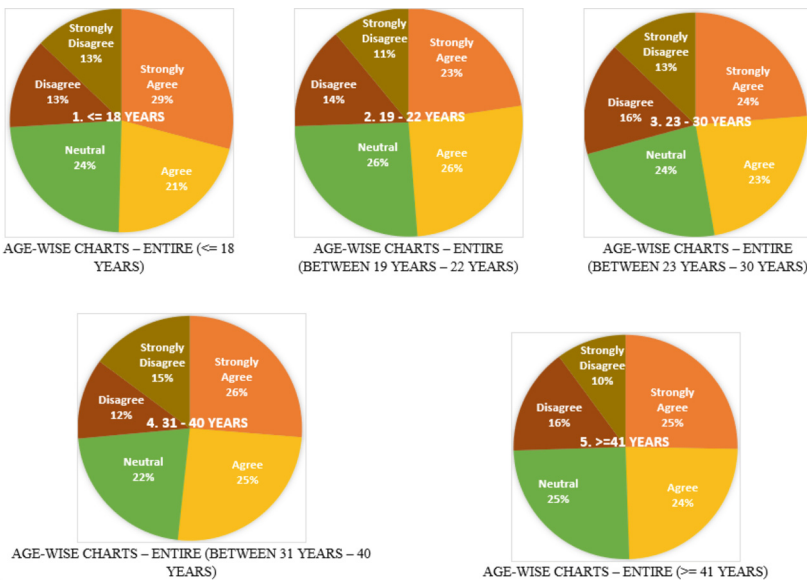


Fig. 6. Pie charts for different age groups

1.6 Ludwig Classifier Analysis

Over the past decade, deep learning models have demonstrated remarkable success in various machine learning tasks related to vision, speech, and language. Ludwig stands

out by providing a platform that allows non-experts to comprehend and utilize deep learning, while also enabling faster iterations and improvements for machine learning specialists. It simplifies the prototype process and accelerates data processing, allowing professionals and researchers to focus on developing deep learning systems rather than dealing with data management.

Figure 7 showcases the learning curve of Ludwig, demonstrating the outcome obtained using the ML. It illustrates that the loss decreases over time, indicating an improvement in the machine's accuracy.

Ludwig is designed as a deep learning toolkit that leverages inheritance and code modularity. It operates at a higher level of abstraction, allowing practitioners to reuse and extend existing models while adhering to best practices. The toolkit simplifies the creation of deep learning models by enabling users to express their data and tasks. The toolkit categorizes these tasks into equivalence classes based on the data types of the inputs encoded and the projected outputs decoded.

Unlike other DL outlines that primarily abstract at the level of tensor operations or layers, Ludwig's abstraction provides a higher level of interface. It offers abstract APIs for each data type, allowing for easy integration and the creation of new implementations of the interface.

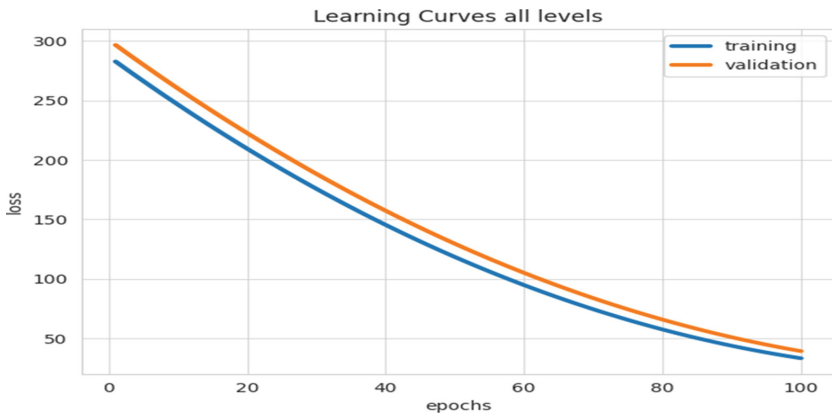


Fig. 7. Loss with Number of epochs learning Curve.

Ludwig takes on a declarative model definition approach, enabling a broader audience to access and utilize deep learning models, thus promoting democratization within the field. Over the past decade, deep learning models have proven to be highly successful in various applications involving language, audio, and visual data. Ludwig sets itself apart by facilitating faster iterations and model development for machine learning experts, while also providing support for non-experts to grasp the concepts of deep learning.

By using Ludwig, professionals and researchers can streamline the process of prototyping and accelerate data processing. This allows them to dedicate more time and effort to the development of deep learning systems, rather than being burdened by data

management tasks. Figure 7 represents the learning curve, showcasing the progression of the model's performance over time.

1.7 Conclusion

The satisfaction of learners with social learning is influenced by variables such as gender, age, and location. The analysis reveals that females tend to report higher levels of satisfaction compared to males. Additionally, the satisfaction with social learning varies with age, with interest peaking in the early years, declining as individuals grow older, and then increasing again. Moreover, learners outside of Delhi & NCR tend to have higher satisfaction ratings compared to those within the region.

This study employs a comprehensive framework that considers all these complex factors to understand and assess learners' satisfaction with social learning. The goal is to enhance the learning, assessment, and guidance processes to provide students with a comprehensive and valuable education. The computational psychometry model is utilized to analyze and interpret these challenging components.

To measure satisfaction across all levels, the Ludwig Classifier is employed. The model is trained using a deep learning approach, and the analysis is conducted at the 100th epoch.

1.8 Future Scope

The ultimate goal is to provide all learners with the best possible resources and feedback, regardless of their age, gender, or geographical location. This inclusivity in education aims to address the diverse needs and circumstances of learners, promoting equal opportunities for everyone.

In future studies, computational psychometrics combined with machine learning techniques will be utilized to examine the various factors that influence learners' experiences and outcomes. This approach involves developing flexible diagnostic models that can adapt to individual learning styles and preferences.

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Predicting Crop Yield in Smart Agriculture Using IoT and Machine Learning for Sustainable Development

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Abstract. The application of Internet of Things (IoT) technology in agriculture has revolutionized traditional farming practices, enabling the development of smart agriculture systems. This research paper focuses on leveraging IoT and machine learning techniques to predict crop yields based on climatic and soil conditions. The study utilizes a dataset obtained from Kaggle, comprising information on 22 unique crops, including Maize, Wheat, Mango, Watermelon, and others. The dataset encompasses essential climatic factors such as temperature, humidity, and rainfall, along with soil conditions necessary for optimal crop growth. By employing advanced machine learning algorithms on this dataset, we aim to develop accurate models that can predict crop yields, thereby aiding farmers in making informed decisions regarding crop management and optimizing agricultural productivity. The findings of this research hold significant implications for the agricultural industry, providing valuable insights into crop yield estimation and supporting sustainable farming practices.

Keywords: Smart Agriculture · IoT · Crop Yield Prediction · Machine Learning · Dataset · Kaggle · Climatic Conditions · Temperature · Humidity · Rainfall · Soil Conditions

1 1. Introduction

Smart agriculture, enabled by the integration of Internet of Things (IoT) technology and advanced data analytics, has emerged as a transformative approach to modernising traditional farming practices. By leveraging IoT devices and sensors, farmers can gather real-time data on various environmental and agricultural parameters, leading to improved crop management and increased agricultural productivity. One crucial aspect of smart agriculture is the ability to accurately predict crop yields, as it empowers farmers to make informed decisions regarding crop planning, resource allocation, and risk management.

Predicting crop yield has always been a challenging task due to the complex interplay of multiple factors influencing plant growth and productivity. Traditional methods of yield estimation relied heavily on historical data, subjective observations, and manual labor, often resulting in inaccurate predictions. However, with the advent of IoT and

machine learning techniques, it is now possible to harness the power of data-driven models to forecast crop yields more accurately.

In this research paper, we aim to predict crop yields in smart agriculture by utilizing IoT and machine learning algorithms. Our study focuses on a dataset obtained from Kaggle, which contains information on 22 unique crops, including popular ones like Maize, Wheat, Mango, and Watermelon. The dataset encompasses crucial climatic conditions required for crop growth, such as temperature, humidity, and rainfall, along with soil conditions necessary for optimal plant development.

By analyzing this dataset and applying advanced machine learning algorithms, we seek to develop predictive models that can estimate crop yields based on the provided climatic and soil data. The resulting models will provide valuable insights into the relationship between environmental conditions and crop productivity, enabling farmers to make data-driven decisions and optimize their agricultural practices.

The outcomes of this research have significant implications for the agricultural industry. Accurate crop yield predictions can help farmers better plan their cultivation cycles, allocate resources effectively, and mitigate risks associated with weather fluctuations and market demand. Moreover, by optimizing agricultural productivity, smart agriculture contributes to sustainable farming practices, reducing resource wastage and environmental impact.

In the subsequent sections of this paper, we will delve into the methodology used for crop yield prediction, discuss the features of the dataset, describe the machine learning techniques applied, present the results and analysis, and conclude with the potential applications and future research directions in the field of smart agriculture.

2 Literature Review

The following literature review examines relevant studies and research papers that contribute to the understanding and application of smart agriculture, crop yield prediction, and the use of IoT technology in agriculture.

Kanchan and Shardoor (2021) introduced “Krashignyan,” a farmer support system designed to aid farmers in making informed decisions regarding crop management. The system leverages IoT technology to collect and analyze data on various environmental factors, including temperature, humidity, and soil conditions. The study highlights the importance of IoT-based solutions in empowering farmers and improving agricultural practices [1].

Javed et al. (2018) conducted a comparative review of IoT operating systems, networking technologies, applications, and challenges. The paper provides insights into the technical aspects of IoT systems and their potential applications in various domains, including agriculture. Understanding the different IoT components and networking technologies is crucial for the successful implementation of IoT in smart agriculture [2].

Issad et al. (2019) conducted a comprehensive review of data mining techniques in smart agriculture. The study explores the application of data mining methods in analyzing agricultural data to extract valuable insights. The review provides an overview of different

data mining techniques used for crop yield prediction, crop disease detection, and other agricultural applications, highlighting their strengths and limitations [3].

Flak (2020) presented an overview of technologies for sustainable biomass supply, which includes aspects relevant to smart agriculture. The paper discusses different technologies and approaches for biomass production, highlighting their potential for sustainable agricultural practices. Understanding biomass supply technologies is crucial for optimizing crop productivity and managing agricultural waste [4].

Kavita (2021) focused on satellite-based crop yield prediction using machine learning algorithms. The study explores the use of satellite imagery and machine learning techniques to estimate crop yields. Satellite-based methods offer a wide-area coverage and can provide valuable insights into crop growth and productivity, assisting farmers in making data-driven decisions [5].

Mupangwa et al. (2021) conducted a temporal rainfall trend analysis in different agroecological regions of southern Africa. The study emphasizes the importance of understanding rainfall patterns and trends to optimize agricultural practices. By analyzing historical rainfall data, farmers can better plan irrigation, cropping patterns, and other agricultural activities, mitigating the risks associated with changing climate conditions [6].

Djibo et al. (2015) investigated linear and non-linear approaches for statistical seasonal rainfall forecasts in the Sirba watershed region. The research demonstrates the potential of statistical models in predicting seasonal rainfall patterns, aiding farmers in making informed decisions regarding crop selection, planting, and resource allocation [7].

These studies provide valuable insights into the application of IoT, machine learning, and data analysis techniques in smart agriculture, crop yield prediction, and agricultural resource management. By integrating these methodologies and approaches, researchers and farmers can harness the power of data-driven models to enhance agricultural productivity, optimize resource utilization, and promote sustainable farming practices.

3 Methodology Used

The methodology used for crop yield prediction in this research paper combines IoT data collection, data preprocessing, feature selection, and machine learning algorithms [8–12]. The following steps outline the approach taken to predict crop yields:

Data Collection: The dataset used in this study is obtained from Kaggle and contains information on 22 unique crops, including climatic and soil conditions required for optimal crop growth. The dataset includes parameters such as temperature, humidity, rainfall, and soil conditions. IoT devices and sensors are deployed to collect real-time data on these environmental factors.

Data Preprocessing: The collected data needs to be preprocessed to ensure its quality and suitability for analysis. Data normalization or scaling may also be performed to bring the features to a similar scale.

Feature Selection: The dataset may contain numerous features, but not all of them may contribute significantly to crop yield prediction. Feature selection techniques are employed to identify the most relevant and informative features. This helps in reducing the dimensionality of the dataset and improving the efficiency and accuracy of the machine learning models.

Machine Learning Model Selection: Crop yield prediction can be accomplished using a range of machine learning algorithms, with a specific choice depending on the characteristics of the data and the particular problem being addressed. Popular algorithms for this task include linear regression, decision trees, random forests, support vector machines, and neural networks. The selection of the most suitable model is guided by evaluating their performance metrics, including accuracy, precision, recall, and F1-score.

Model Training and Evaluation: To facilitate the training of the machine learning model, the dataset is typically divided into two sets: a training set and a testing set. The training set is utilized to teach the model by providing it with input features and their corresponding crop yield values. Through this process, the model gains an understanding of the underlying patterns and relationships between the input features and crop yield. Subsequently, the trained model is assessed using the testing set to evaluate its performance and ability to generalize to unseen data. Various evaluation metrics, such as mean squared error (MSE), root mean squared error (RMSE), or the coefficient of determination (R-squared), are employed to measure the model's predictive accuracy [13–15].

Model Optimization and Fine-tuning: Depending on the performance of the initial model, further optimization and fine-tuning may be performed. This can involve hyperparameter tuning, regularization techniques, or ensemble methods to enhance the model's predictive capabilities and reduce overfitting.

Crop Yield Prediction: The model takes these inputs and generates predictions of

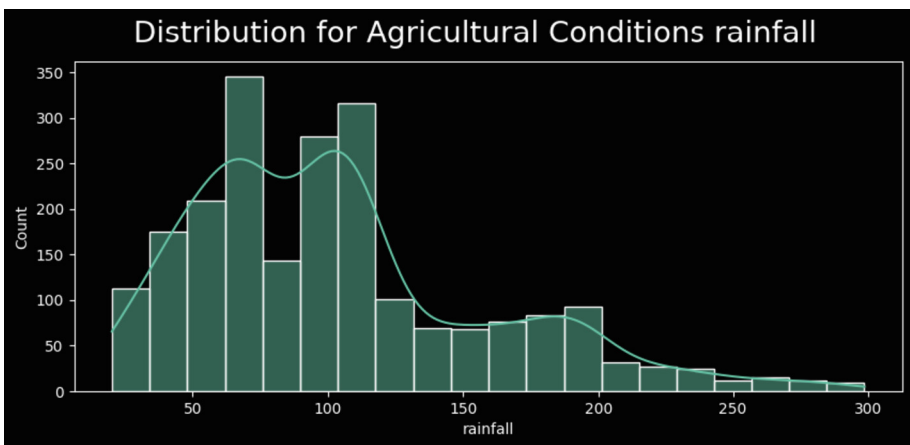


Fig. 1. Distribution for Rainfall Conditions

crop yields, providing valuable insights for farmers to make informed decisions about crop planning, resource allocation, and risk management.

By following this methodology, the research aims to develop accurate crop yield prediction models that leverage IoT data and machine learning algorithms, enabling farmers to optimize their agricultural practices and improve overall productivity. The Various distributions of parameters Like rainfall, PH, humidity, and temperature are shown in Fig. 1, 2, 3 and 4.

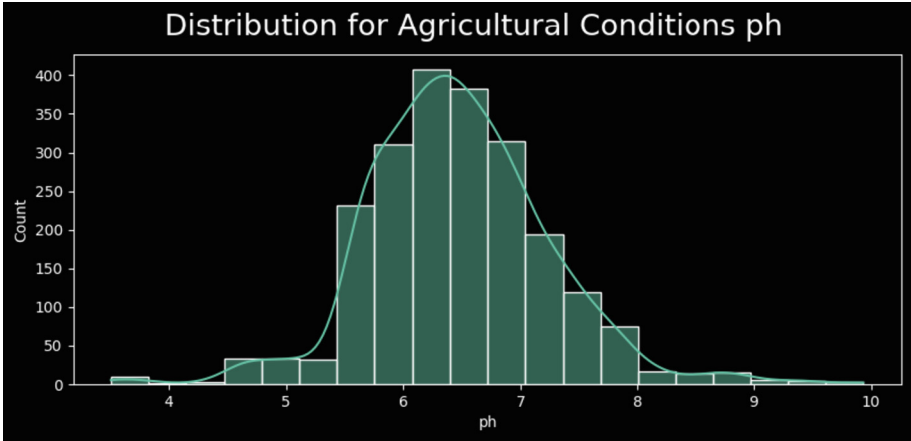


Fig. 2. Distribution for Ph conditions

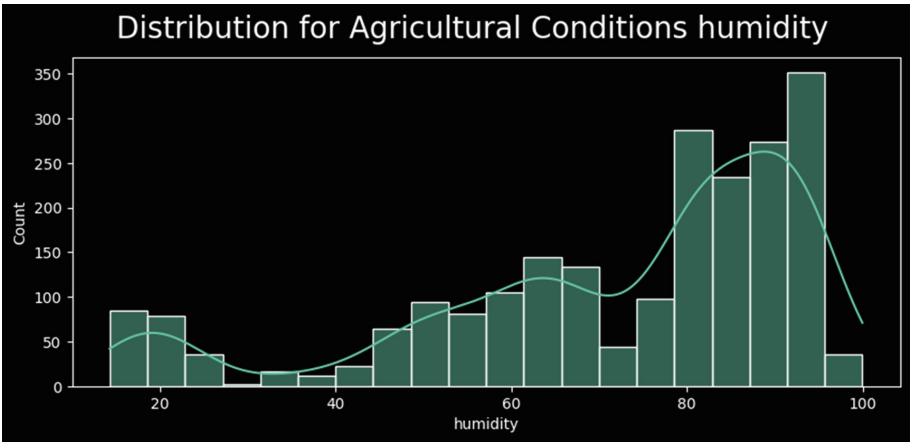


Fig. 3. Distribution for humidity Conditions

The Fig. 5 obtained by applying the elbow method typically shows the relationship between the number of clusters and the inertia (also known as the within-cluster sum of squares or WCSS). Inertia represents the sum of squared distances between each data point and its assigned cluster centroid.

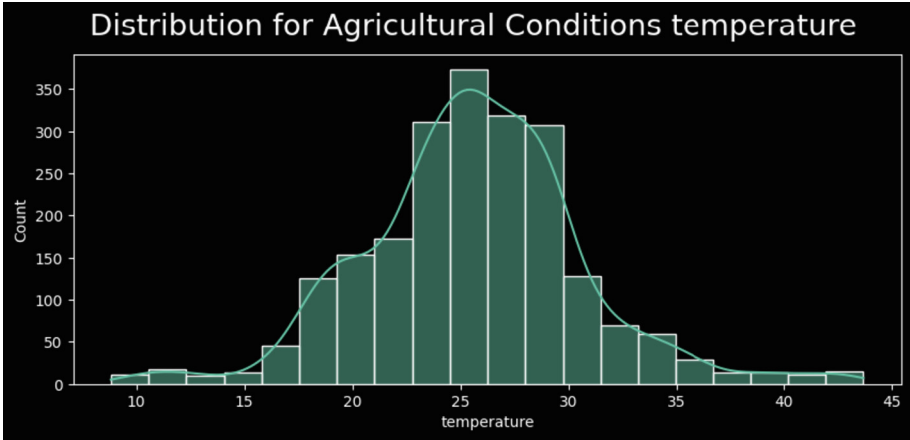


Fig. 4. Distribution for temperature Conditions

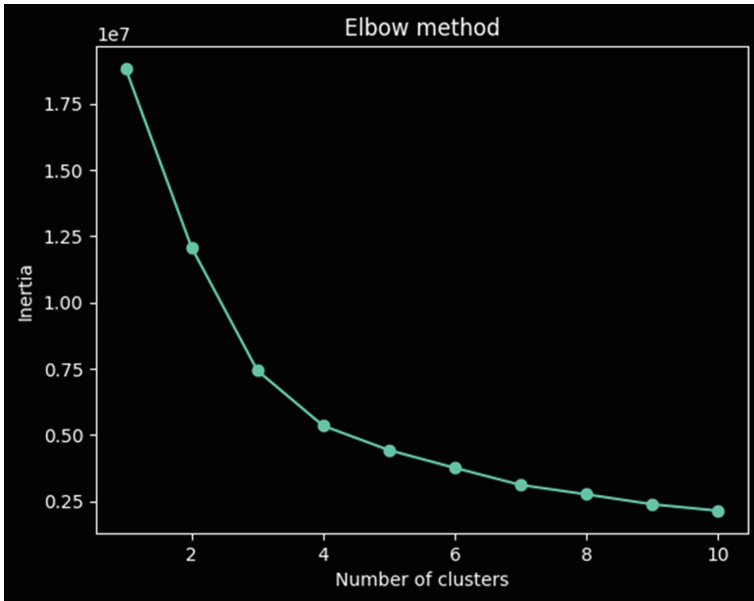


Fig. 5. Number of clusters and inertia

The plot consists of a line or curve that depicts the inertia values for different numbers of clusters. The x-axis represents the number of clusters, and the y-axis represents the inertia.

When the number of clusters is small, the inertia tends to be high because the data points are not well-separated into distinct clusters. As the number of clusters increases, the inertia generally decreases because the clusters become more compact and better capture the structure in the data.

The objective of the elbow method is to identify the “elbow” point in the plot, which is the number of clusters where the decrease in inertia starts to level off significantly. This elbow point indicates the optimal number of clusters, where adding more clusters does not provide a substantial improvement in clustering performance.

Visually, the plot may show a decreasing inertia curve that starts with a steep slope and then gradually becomes flatter. The elbow point represents the optimal trade-off between the number of clusters and the amount of variance explained.

4 Machine Learning

In this research paper, several machine learning techniques are applied to predict crop yields based on the collected dataset. The following machine learning algorithms are utilized:

Logistic Regression: Logistic Regression is a classification algorithm commonly used for binary or multi-class classification problems. In this context, it can be used to predict crop yield categories or classes based on the input features. Logistic Regression models the relationship between the input variables and the probability of belonging to a specific class. It estimates the coefficients of the input features to make predictions.

Random Forest: Random Forest is effective in handling high-dimensional datasets and capturing complex relationships between input features and the target variable.

SVM: SVM aims to maximize the margin between different classes, allowing for better generalization. In the context of crop yield prediction, SVM can be used to classify crop yields based on climatic and soil conditions.

K-Nearest Neighbors (KNN) Classifier: KNN is a non-parametric algorithm used for both classification and regression tasks. In the case of classification, it assigns a class label to an unclassified sample based on the class labels of its nearest neighbours in the feature space. KNN does not assume any underlying distribution of the data and is especially useful when dealing with non-linear relationships. It can be applied to predict crop yields by finding the most similar data points in the dataset and assigning the corresponding crop yield class.

XGBoost Classifier: XGBoost (eXtreme Gradient Boosting) is a gradient boosting algorithm known for its high predictive power. It constructs an ensemble of weak prediction models (usually decision trees) and iteratively trains them to minimize a specified loss function. XGBoost is capable of capturing complex interactions and nonlinear relationships between input features and the target variable. It has gained popularity for its effectiveness in various machine-learning competitions and real-world applications.

By using a combination of these machine learning techniques, the research aims to compare their performance in predicting crop yields based on the provided dataset. The models will be trained, evaluated, and optimized to achieve accurate and reliable predictions, assisting farmers in making informed decisions about crop management and resource allocation.

5 Result and Analysis

In the results and analysis of Logistic Regression, Random Forest, SVC, K Neighbors Classifier, and XGBoost Classifier for predicting crop yield categories, the following evaluation metrics can be used: accuracy, precision, recall, and F1 score. Here's an explanation of each metric and how they can be used to assess the performance of the models:

Accuracy: Accuracy measures the overall correctness of the predictions made by the models. It calculates the percentage of correctly classified instances over the total number of instances. A higher accuracy indicates better performance. However, accuracy alone may not be sufficient in cases where the dataset is imbalanced or when the cost of misclassifying different classes varies significantly.

Precision: Precision measures the proportion of correctly predicted positive instances (high crop yield) out of all instances predicted as positive. It focuses on the correctness of positive predictions, indicating how well the models identify true high-yield crops. A higher precision indicates fewer false positives. Precision is calculated as $TP / (TP + FP)$, where TP is the number of true positives and FP is the number of false positives.

Recall: Recall, also known as sensitivity or true positive rate, measures the proportion of correctly predicted positive instances (high crop yield) out of all actual positive instances in the dataset. It focuses on capturing all positive instances and avoids missing any high-yield crops. A higher recall indicates fewer false negatives. The recall is calculated as $TP / (TP + FN)$, where TP is the number of true positives and FN is the number of false negatives.

F1 Score: The F1 score is a combined metric that considers both precision and recall. It provides a balanced assessment of the models' performance by considering the trade-off between precision and recall. The F1 score is the harmonic mean of precision and recall and is calculated as $2 * ((Precision * Recall) / (Precision + Recall))$. It ranges from 0 to 1, with a higher value indicating better performance in terms of both precision and recall.

To analyze the results, the accuracy, precision, recall, and F1 score can be computed for each algorithm separately. Comparing these metrics across the models can provide insights into their performance in predicting crop yield categories. It is important to consider all these metrics together as they provide a comprehensive evaluation of the models' capabilities in terms of correctness, ability to identify positive instances, and ability to capture all actual positive instances. The Confusion Matrix for Random Forest as an example is shown in Fig. 6.

By analyzing and comparing the accuracy, precision, recall, and F1 score of the Logistic Regression, Random Forest, SVC, K Neighbors Classifier, and XGBoost Classifier models, it is possible to identify which algorithms perform better in predicting crop yield categories and make informed decisions regarding their suitability for smart agriculture applications as shown in Table 1.

Inference from table 1.

From the table provided, we can draw the following inferences regarding the performance of different machine-learning algorithms for predicting crop yield categories:

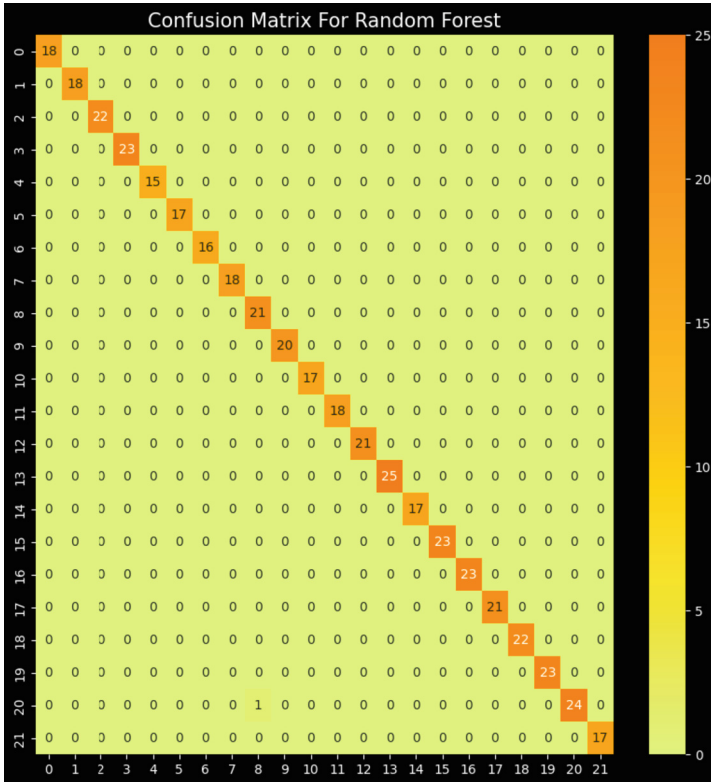


Fig. 6. Confusion Matrix For Random Forest

Table 1. Result comparison table

Algorithm	Accuracy	Precision	Recall	F1 Score
Logistic Regression	96.36	0.97	0.97	0.97
Random Forest	99.77	1	1	1
SVC	98	0.98	0.98	0.98
KNeighborsClassifier	98	0.98	0.98	0.98
XGBoost Classifier	99	0.99	0.99	0.99

1. Logistic Regression achieved an accuracy of 96.36% with high precision, recall, and F1 score values of 0.97. This indicates that the algorithm is effective in accurately classifying crop yield categories with a good balance between precision and recall.
2. Random Forest achieved exceptional performance, with an accuracy of 99.77% and perfect precision, recall, and F1 score values of 1. This suggests that Random Forest is highly accurate and capable of accurately predicting crop yield categories without any false positives or false negatives.

3. SVC achieved a high accuracy of 98% and exhibited excellent precision, recall, and F1 score values of 0.98. This indicates that the algorithm is proficient in classifying crop yield categories accurately, with a good balance between precision and recall.
4. KNeighborsClassifier achieved a high accuracy of 98% and demonstrated excellent precision, recall, and F1 score values of 0.98. This suggests that the algorithm is effective in accurately classifying crop yield categories, with a good balance between precision and recall.
5. XGBoost Classifier achieved a high accuracy of 99% with impressive precision, recall, and F1 score values of 0.99. This indicates that the algorithm is highly accurate and proficient in predicting crop yield categories, with a strong balance between precision and recall.

In conclusion, the table highlights that Random Forest, SVC, KNeighborsClassifier, and XGBoost Classifier consistently perform well in predicting crop yield categories, achieving high accuracy and exhibiting excellent precision, recall, and F1 score values. These algorithms can be considered as effective choices for predicting crop yields using the given dataset and evaluation metrics.

6 Conclusion

In conclusion, the results demonstrate the potential applications of machine learning algorithms, such as Logistic Regression, Random Forest, SVC, KNeighborsClassifier, and XGBoost Classifier, in predicting crop yield categories in smart agriculture. The high accuracy and strong performance in precision, recall, and F1 score indicate the efficacy of these algorithms in crop yield prediction.

The potential applications of these algorithms in smart agriculture are as follows:

Precision Farming: By accurately predicting crop yield categories, farmers can optimize their farming practices, such as adjusting irrigation schedules, applying fertilizers, and managing pests and diseases more effectively. This can lead to improved resource allocation and reduced waste, resulting in higher crop yields and increased profitability.

Crop Management and Planning: Accurate crop yield prediction enables farmers to make informed decisions regarding crop selection, planting strategies, and harvest planning. They can optimize their crop rotations, choose suitable varieties, and plan for storage and transportation logistics based on predicted yield categories. This can enhance production efficiency and optimize the overall agricultural supply chain.

Risk Assessment and Insurance: Crop yield prediction plays a crucial role in risk assessment for agricultural insurance purposes. Insurance companies can leverage these algorithms to assess potential risks associated with crop yield variations and offer more tailored insurance coverage to farmers. This helps mitigate financial risks and provides stability to the agricultural sector.

Market Forecasting: Accurate crop yield prediction can assist in market forecasting and price analysis. By anticipating crop yields, farmers can align their production with market demands, enabling better market planning and decision-making. This can lead to reduced market volatility, improved price stability, and enhanced market competitiveness.

Sustainable Agriculture: By leveraging machine learning algorithms to predict crop yields, farmers can adopt sustainable agricultural practices. They can optimize the use of resources, minimize environmental impact, and promote biodiversity conservation. These algorithms can contribute to achieving sustainable agriculture goals by enabling efficient resource management and reducing unnecessary waste.

The application of machine learning algorithms for crop yield prediction in smart agriculture has immense potential. It can revolutionize farming practices, enable precise decision-making, and contribute to the development of sustainable and efficient agricultural systems. By harnessing the power of data and advanced analytics, farmers can enhance productivity, reduce risks, and drive the transformation of the agricultural sector towards a more sustainable and profitable future.

7 Future Research

The field of smart agriculture is continuously evolving, driven by advancements in technology and the need for sustainable and efficient agricultural practices. Future research directions in this field can focus on the following areas:

Integration of IoT and AI: The integration of Internet of Things (IoT) devices and Artificial Intelligence (AI) techniques can enable real-time monitoring and decision-making in agriculture. Future research can explore how to effectively integrate IoT sensors, data analytics, and AI algorithms to optimize crop management, irrigation, pest control, and resource allocation.

Big Data Analytics: With the increasing availability of agricultural data, there is a need for advanced big data analytics techniques to process and analyze large-scale datasets. Future research can focus on developing scalable and efficient algorithms for data pre-processing, feature selection, and predictive modeling to extract valuable insights and support decision-making in smart agriculture.

Predictive Analytics for Climate Change: Climate change poses significant challenges to agriculture, including unpredictable weather patterns and changing environmental conditions. Future research can explore how predictive analytics and machine learning algorithms can be leveraged to forecast climate change impacts on crop production, enabling farmers to adapt and implement appropriate mitigation strategies.

Sustainable and Precision Agriculture: Future research can delve deeper into the development and implementation of sustainable and precision agriculture practices. This can include studying the optimal use of resources, such as water and fertilizers, integrating renewable energy sources, adopting precision irrigation and fertilization techniques, and exploring innovative approaches for reducing the environmental footprint of agriculture.

Crop Disease and Pest Management: Effective disease and pest management are crucial for maintaining crop health and productivity. Future research can focus on developing advanced algorithms for early detection and prediction of crop diseases and pests. This can involve the use of machine learning, image analysis, and remote sensing technologies to monitor crop health, identify potential threats, and enable timely interventions.

Farm Automation and Robotics: The integration of automation and robotics in agriculture holds immense potential for improving efficiency and reducing labor-intensive tasks. Future research can explore the development of intelligent agricultural robots capable of autonomous operations, precision spraying, selective harvesting, and crop monitoring. Additionally, research can focus on human-robot interaction and collaboration in agricultural settings.

Data Security and Privacy: As smart agriculture relies heavily on data collection and sharing, future research should address the challenges of data security and privacy. This includes developing secure data transmission protocols, ensuring data integrity, and addressing privacy concerns associated with the collection and use of personal and sensitive agricultural data.

Adoption and Acceptance: Understanding the factors influencing the adoption and acceptance of smart agriculture technologies by farmers is crucial. Future research can explore the socio-economic, cultural, and psychological factors that impact farmers' decision-making and adoption of smart agriculture technologies. This can help design strategies to promote technology uptake and address barriers to implementation.

By focusing on these future research directions, we can advance the field of smart agriculture and contribute to sustainable, efficient, and resilient agricultural systems that meet the challenges of a changing world.

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Deep Learning Model for Computer Vision: Sustainable Image Classification Using Machine Learning

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Abstract. The core challenge within computer vision is image classification, which involves assigning an image a label and categorizing it using the features that have been extracted from it. Even though this work appears rudimentary, it requires the application involving artificial intelligence, specifically Deep Learning, a sub-field of Machine Learning. In this paper, we have discussed how Convolutional Neural Networks (CNN), the most modern technique for image classification, are used in Deep Learning to classify images. We have discussed the applications of image classification and drawn the conclusion that using deep learning is preferable to using machine learning. Additionally, we have also presented a comparative study of various CNN models to observe how they could potentially be employed as pre-trained models for the image classification job.

Keywords: Convolutional Neural Networks (CNN) · Perceptron · Backpropagation · Image Classification · Pretrained Models

1 Introduction

In the branch of artificial intelligence known as computer vision, characteristics from a picture may be extracted and used to extract useful information [1]. It entails solving a variety of image visualization issues, including object identification, segmentation, classification, and localization [1]. Out of all of them, image classification is regarded as the core issue that underlies all other computer vision issues. For example, while doing image segmentation, we categorize each pixel [2], representing an item in the picture. The aim of image classification is to categorize a whole image as belonging to one of the classes, such as “Is this a dog or not?” as shown in Fig. 1.

Deep learning emerges as a subfield from machine learning [3, 14, 15], that involves the use of artificial deep neural networks (ADNs), for creating artificial intelligence by mimicking the functioning of the human brain [3]. An advantage of using deep learning

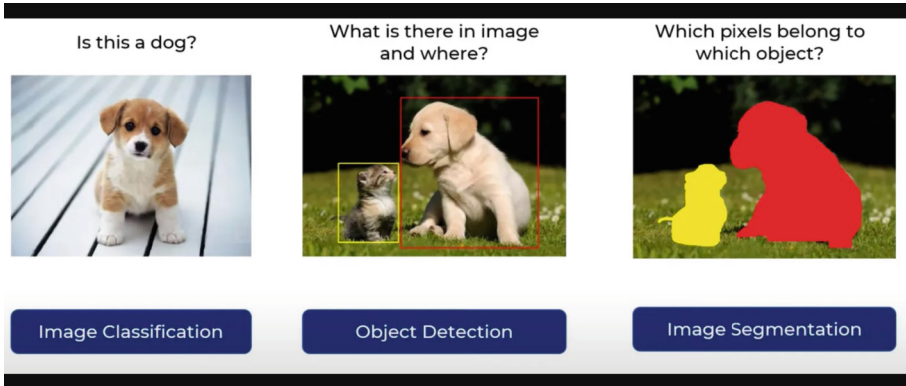


Fig. 1. Computer vision problems

for image classification over machine learning is that deep learning uses “representation learning,” which means that the deep learning networks extract features from raw inputs and learn them on their own [3], whereas machine learning uses feature engineering, which comes right after data cleaning and necessitates the expertise of data scientists. A deep learning method uses multiple layers within a neural network for extracting higher-level characteristics from a raw input [4]. As we move deeper, the layers extract increasingly complicated information, whereas the early layers identify the input’s basic features [7]. In image processing, for instance, the first layers recognize borders whereas the deeper layers identify more intricate characteristics like faces or looping patterns. Since the beginning of the ImageNet competition, several new CNN models have appeared [2]. These models, which have previously been trained on huge datasets, may be used as pre-trained models for brand-new issues [2], reducing our need for computing resources and speeding up accuracy.

This paper explains the perceptron, the most fundamental component of neural networks. It has no hidden layers and serves as the fundamental unit of ANN ever made. They are a binary classifier that performed well on datasets with linear patterns but was unable to learn non-linear functions. The constraints of a single perceptron are solved by the multi-layer perceptrons (MLP), which act as a feed-forward (involving no loops) neural network with one or multiple hidden neural layers that employs a sophisticated backpropagation algorithm to train. We next went through CNN (convolutional neural network), which is currently the most advanced model for classifying images. It has additional convolutional and pooling layers in addition to a multi-layer perceptron known as a fully connected layer.

Artificial Neural Networks.

Perceptron

Perceptron is an algorithm/mathematical model/mathematical function used for supervised machine learning. It is the most fundamental unit of an artificial neural network having zero/no hidden layers as shown in Fig, 2 [5].

Components:

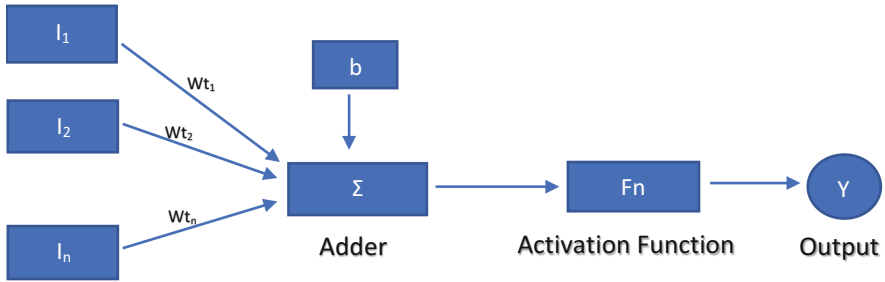


Fig. 2. Working of Perceptron

- i) Input signals: $\{I_1, I_2, \dots, I_n\}$ each of them are the input values which are being fed to the perceptron for determining the correct output after their processing.
- ii) Weights: $\{wt_1, wt_2, \dots, wt_n\}$ are weights that are randomly initialized and multiplied with each input signal. They help in representing 'Feature importance' i.e. the input assigned with a higher weight plays a more important role in the determination of the output than an input signal assigned with a lower weight.
- iii) Bias (b) is the value given to the perceptron as an addition to the weighted sum of the input signal and weight, it is helpful in acting as an additional model parameter that can be tuned for performance enhancement of a model in determining the output. Default value to be given as input for bias = 1, which is subject to adjustments on the basis of tuning done [16].
- iv) Linear aggregator (Σ) is a simple mathematical function that sums up the product of each input signal with its assigned weight and adds the bias value as well.

$$wt_1 I_1 + wt_2 I_2 + \dots, wt_n I_n + b$$

- v) Activation potential (Z) is the value obtained from the linear aggregator which is passed over to the activation function as its input.

$$Z = wt_1 I_1 + wt_2 I_2 + \dots, wt_n I_n + b$$

- vi) Activation function (fn) is a mathematical function that limits Z to a range like 0,1. The use of this function is that it tells if the node needs to be activated or not for the current input signal to the perceptron.
- vii) Output signal (Y) is the final value produced by the perceptron as the output.

$$Y = f(Z)$$

$$\Rightarrow Y = f(wt_1 I_1 + wt_2 I_2 + \dots, wt_n I_n + b)$$

Structure:

A perceptron derives its inspiration from biological neurons. The input signals of the perceptron are inspired by the dendrites which are thin extensions in our neuron that collect the electric impulse from its environment as given in Fig. 3. Linear function and Activation function are inspired by the functioning of the nucleus in the neuron where all

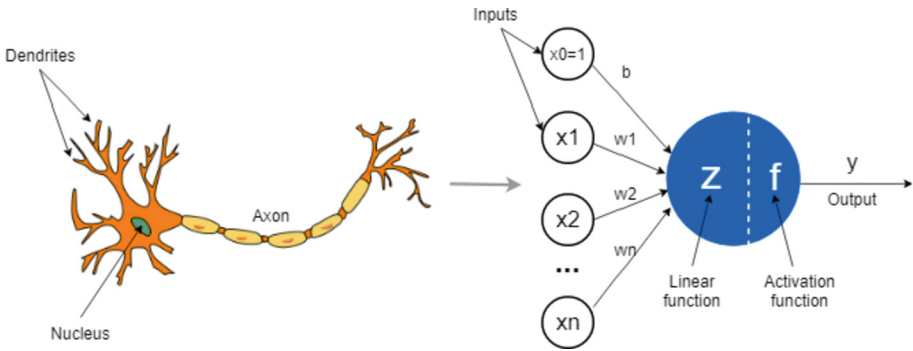


Fig. 3. Biological Neuron & Perceptron

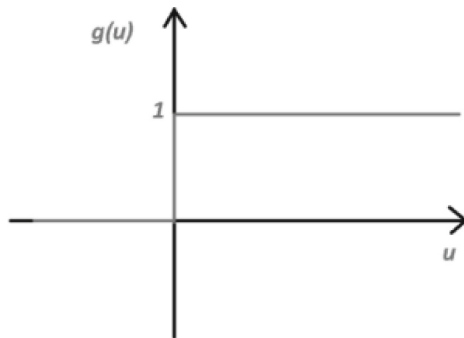
the processing of the input signals occurs with the help of individual weights assigned to them. Axons present in the biological neurons transmit the output after the processing is completed by the nucleus and this feature of giving out the output for the input is served by the output layer in the perceptron [17].

Geometric Intuition

After going through the analysis of the output being produced by the perceptron it can be concluded that a perceptron is an excellent binary classifier [5]. Hence it is very effective in classifying linear separable datasets [6]. This can be proved by analyzing its functioning: For our analysis, we are considering a perceptron having step function as its activation function (f)

$$Y = 1, \text{ if } F(z) \geq 0$$

$$Y = 0, \text{ if } F(z) < 0 \text{ here, } F(z) = \sum w_i * x_i + b$$



Step function graph

Suppose, we only have two input signals to our perceptron:

$$Z = w_1 * I_1 + w_2 * I_2 + b \tag{1}$$

This Eq. (1), corresponds to the equation of a straight line *i.e.* $Ax_1 + Bx_2 + C$.

Now after applying the activation function on Eq. (1), we get 2 inequalities represented below:

$$wt_1 * I_1 + wt_2 * I_2 + b \geq 0 \quad (2)$$

$$wt_1 * I_1 + wt_2 * I_2 + b < 0 \quad (3)$$

Now if we compare Eq. (1), (2) and (3) we get to know that Eq. (1) acts as a classification boundary and Eq. (2) and (3) both act as a region of that classification boundary where Eq. (2), acts as the region above the line, and Eq. (3) acts as the region below the line shown in Fig. 4

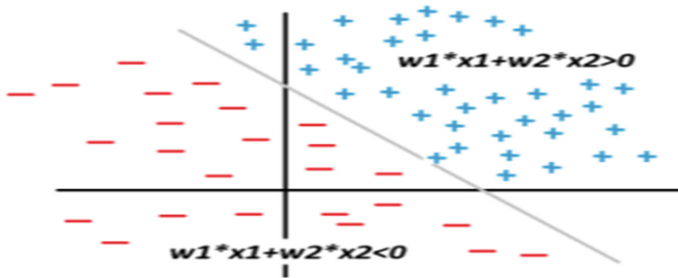


Fig. 4. Perceptron decision Boundary

Hence, the perceptron is a binary classifier as it divides our dataset into two different classes by creating two regions.

Note: if three inputs were to be considered then we would have obtained an equation of a plane instead of a line and four inputs onwards we would have obtained an equation of a hyperplane [5, 6].

Multi-layer Perceptron: We are unable to classify non-linear datasets with the of a perceptron as they divide the dataset with the help of a straight line but for dividing non-linear datasets, we need a curved line not a straight line so that any sort of non-linearity can be captured, as shown in Fig. 5 [6].

To solve this problem the concept of multi-layer perceptron was introduced [7, 17]. In a multi-layer perceptron, we make linear combinations of more than one perceptron [6, 18], due to this the output of the individual perceptron gets superimposed on each other and adds a smoothing process on those superimposed outputs for non-linear datasets classification.

Considering the above image of a multi-layer perceptron as shown in Fig. 6a.

Suppose we have two individual perceptrons named P_0 and P_1 , we combine both of these perceptrons and pass their linear outputs as a weighted sum to an activation function for the smoothing process. This weighted addition with an activation function acts exactly like an individual perceptron itself which takes its input as a weighted sum of the output of the previous two perceptrons. We can name this perceptron as P_2 . Thus

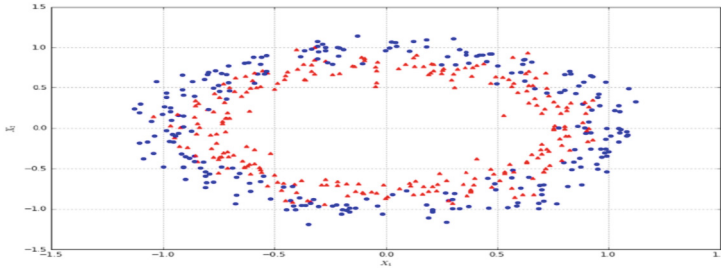


Fig. 5. Non-linear dataset representation

all of these three perceptron’s P_0 , P_1 , and P_2 combined together act as a multi-layer perceptron system where the inputs to P_0 and P_1 act as the input layer, both P_0 and P_1 as the hidden layer, and P_2 works as the last layer known as the output layer.

Forward Propagation: For predicting the output of a record, the multi-layer perceptron uses forward propagation which involves a chain of matrix multiplication/dot product of inputs, weights, and bias in each layer of the neural network.

The forward propagation equation for a multi-layer perceptron with three layers and a sigmoid function as the activation function [6], is given as.

$$S \left(S \left(S \left(a^{[0]}wt^{[1]} + b^{[1]} \right) wt^{[2]} + b^{[2]} \right) wt^{[3]} + b^{[3]} \right)$$

Backpropagation Algorithm: The backpropagation algorithm is used to train an ANN. It is a supervised learning algorithm that makes use of gradient descent [7], an optimization algorithm used for high dimensional problems as it has a less computational cost.

When an artificial neural network and a loss function are given, the backpropagation algorithm finds the gradient descent for the given loss function with respect to weights and bias [8], of that ANN.

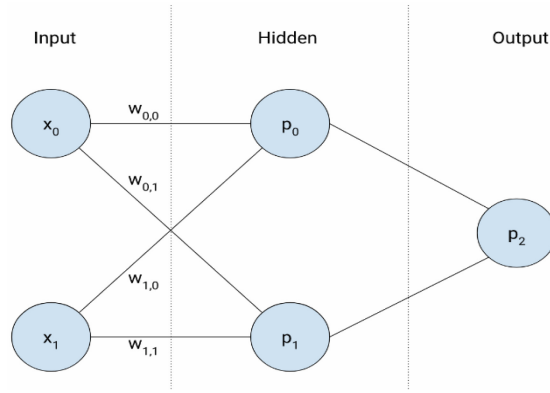
In the training process of a multi-layer perceptron, our basic aim is to find the most optimum value of weights and biases for the given dataset for predicting the correct (expected) output for that dataset [11, 12].

Steps Involved in the Backpropagation Algorithm:

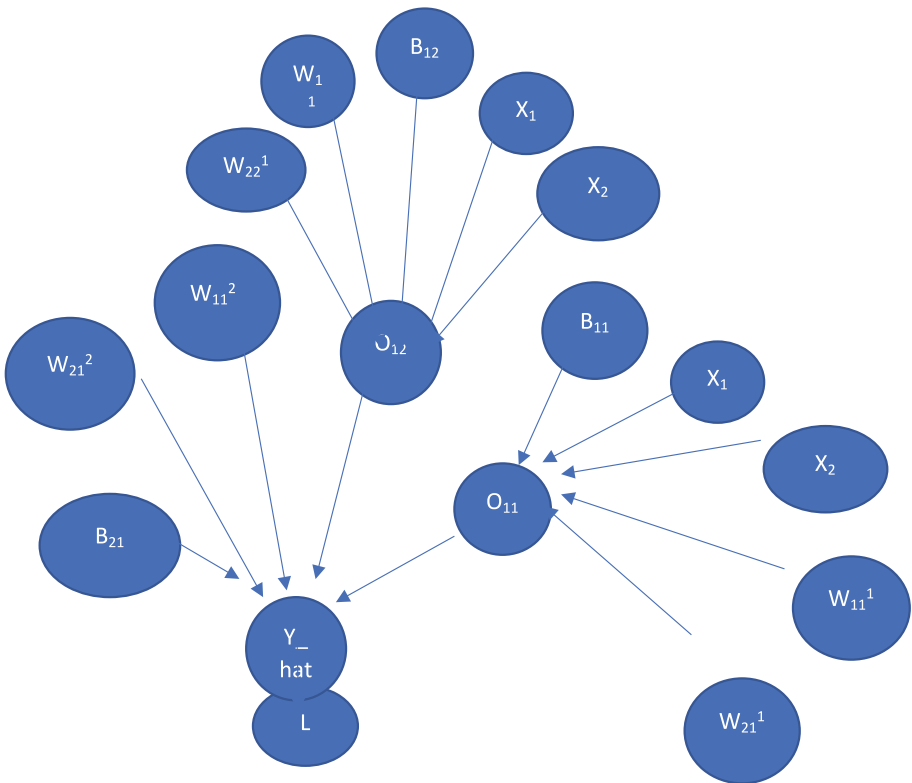
Convergence basically means when loss function becomes minimum, this is when w_{new} becomes almost equal to w_{old} . By this time our algorithm reaches the minimum loss function. The Loss function is the mathematical function that is used in multi-layer perceptron for finding out the difference between predicted and actual values of the output of a neural network. This function primarily helps in adjusting the values of weights and biases. e.g. mean squared error (MSE) is a loss function used for regression problems and Cross Entropy is another which is used for classification problems.

Step 1) Each trainable parameter of the given ANN *i.e.*, total weights and biases are initialized randomly.

Step 2) We provide the ANN with a record from the dataset for which the multi-layer perceptron predicts the output using forward propagation.



(a)



(b)

Fig. 6. a) Single-Layered Feed Forward Network, b) Dependency hierarchy chart for the system

Step 3) In this step the output which was predicted by the neural network in the last step, for the loss function is calculated.

Step 4) With respect to this loss function, each trainable parameter is adjusted in order to reduce the loss function. All of these adjustments are done by using a gradient descent optimization algorithm.

i) Gradient descent formula for changing weight

$$w_{\text{new}} = w_{\text{old}} - \eta (\partial L / \partial w_{\text{old}})$$

ii) Gradient descent formula for changing bias

$$b_{\text{new}} = b_{\text{old}} - \eta (\partial L / \partial b_{\text{old}})$$

here, η = learning rate

Step 5) We repeat steps (2) to (4) for all the records in the dataset.

Step 6) Finally, each step from steps (2) to (5) is iterated (epochs) until the convergence is not reached.

Why the Weights and Biases are the Only Trainable Parameters:

Considering, suppose we have a dataset for which our multi-layer perceptron in Fig. 6b has predicted output (Y_{hat}).

$$Y_{\text{hat}} = W_{11}^2 o_{11} + w_{21}^2 o_{12} + b_{21}$$

$$O_{11} = w_{11}^1 x_1 + w_{21}^1 x_2 + b_{11}$$

$$O_{12} = w_{12}^1 x_1 + w_{22}^1 x_2 + b_{12}$$

We select loss function = M.S.E, therefore $L = (Y - Y_{\text{hat}})^2$.

As our target is to get the most accurate output, therefore we need to decrease the loss to a minimum [7, 8].

By checking the hierarchy chart we can conclude that loss depends on weight, bias, and the two output from the previous layer and these two outputs further depends on their weights and biases as well as the input since inputs are constant values hence we can conclude that bias and weights in an ANN are the only trainable parameters [8].

Why not use Artificial Neural Networks (ANN) for Image Classification? ANN can also be used for image classification but they will be always outperformed by CNN [2]. For understanding the reasons firstly, we must understand what an image is as shown in Fig. 7 and Fig. 8. Digital images are basically, a 2D rectangular arrangement of pixels, which are the smallest element of a digital image.

There are two types of digital images:

- 1) Greyscale image (B/W image) has values of pixels having a range from 0 to 255 (where black color is represented by 0 and white by 255), which is often scaled down to 0–1.

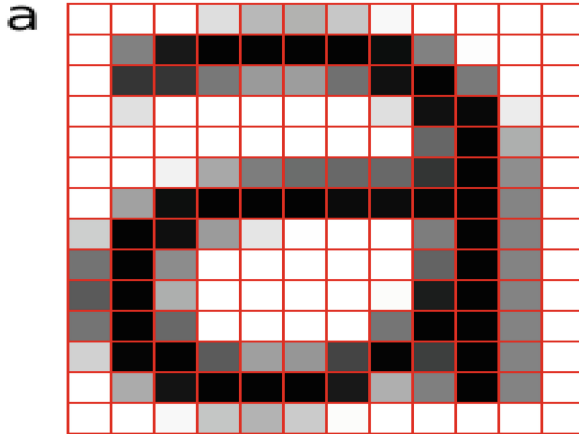


Fig. 7. Pixel representation of a digital image

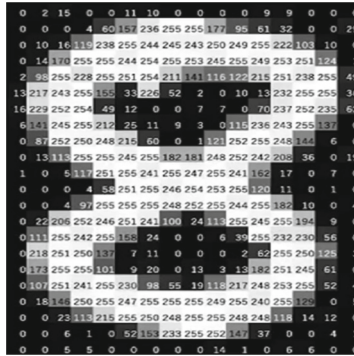


Fig. 8. Pixel Representation of B/W image

2) Colored image: contains 3 channels -> Red, Green, Blue, which are the primary colours from which the majority colours can be created.

The general size of an RGB image is (228*228*3), here 3 represents the total number of RGB channels in the image shown in above Fig. 9. Each channel in RGB will act as a greyscale image having values from 0–255. For giving the image to an ANN as input, these pixels are flattened as a 1D array by joining them row-by-row [2]. But an image contains thousands of pixels and nowadays because of advancements, high-resolution images contain millions of pixels.

Convolutional Neural Network (CNN) CNNs are a special class of neural networks, used for processing grid-like structure data like time series data(1D) or images (2D). CNN is the state-of-art model for classifying images in Fig. 10 and Fig. 11. The architecture of a CNN consists of three layers, Convolutional Layer, Pooling Layer, and Fully Connected Layer i.e., multi-layer perceptron.

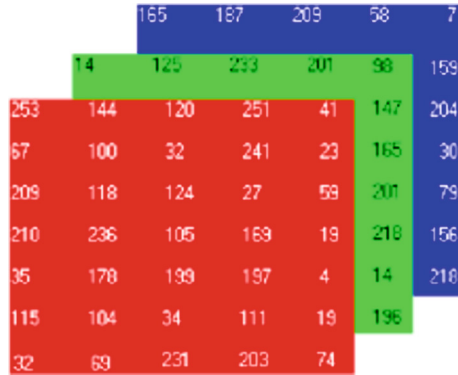


Fig. 9. Channels in an RGB image

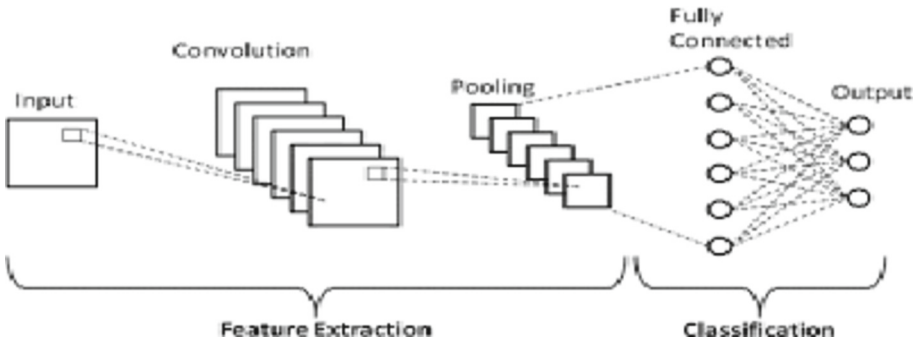


Fig. 10. Architecture of a typical CNN

In a CNN, convolutional layers are basically filters that extract features [6, 20–23], from the image. These convolutional layers are moved over the input image and extract primitive features and as we go deep into the convolutional layers more complex features are extracted by combining the primitive features extracted by it [8]. After this stage of feature extraction, all these features are sent to the fully connected layer that finally does the classification.

Convolution Operation

This operation is used inside the convolutional layer.

A filter also known as kernel [9], is selected which is a 2d matrix mostly of 3x3 size. This filter is moved/convolved over the 2D matrix of the input image and item-wise multiplication is done for each cell and the sum of all these products is calculated.

This sum becomes the value of a cell of the resultant matrix known as the **Feature Map**. Similarly, the kernel moves over the complete image by taking cell-by-cell shifts known as strides [9], and the value of each cell of the feature map is calculated. Suppose

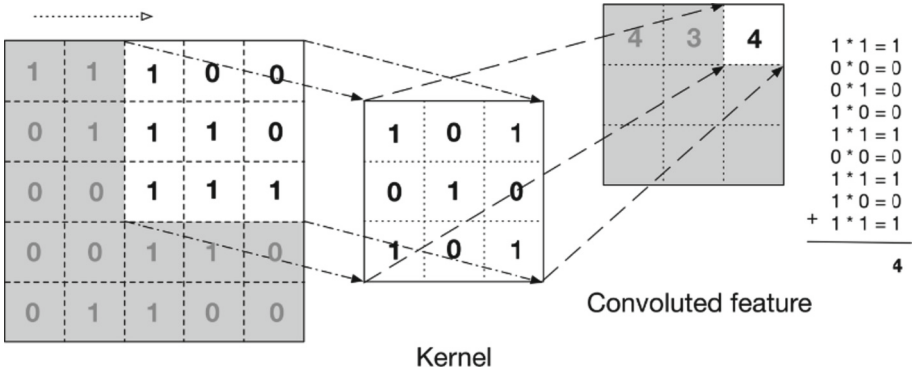


Fig. 11. Convolutional Layer

the input image has a size of $(N \times N)$ and the kernel has a size of $(M \times M)$, then the size of the feature map will be $[(N - M + 1) \times (N - M + 1)]$.

i) Padding.

Padding is used to solve 2 major issues that arise due to convolution operation [6]. The feature map generated after the convolution operation is smaller in size than the original image, which results in information loss shown in Fig. 12. The border pixels are part of less convolution operation as compared to central pixels and because of this, the dependency of the feature map is more on the central ones than the border one. Thus, to overcome this issue we make use of padding techniques [10].

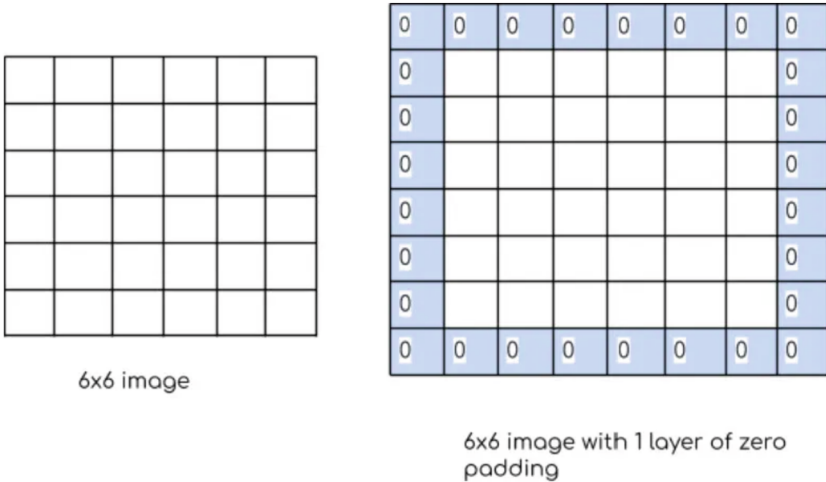


Fig. 12. Padding

Pooling Layer.

Once we obtain the feature map from the convolution operation, non-linearity is added to it by applying the ReLU function to it. After this Pooling operation is done on the non-linear feature map, which is a process to down sample the feature map as shown in Fig. 13. There are 3 kinds of pooling operations – Max pooling, Avg pooling, and Global pooling. Out of these, the Max pooling is the most used pooling operation.

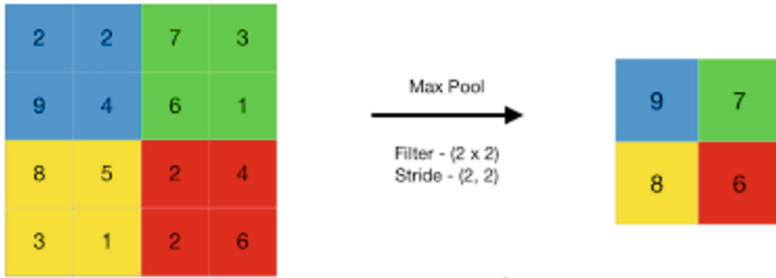


Fig. 13. Max Pool Operation

The above image is the representation of Max-pooling. In this, we select the cell with the maximum value out of all the cells in the defined window (here, size of window = 2×2).

Fully Connected Layers: The down-sampled feature map generated from the pooling layer is flattened by joining each row of the feature map matrix head-to-head forming a 1D array and then this flattened feature is given to the multi-layer perceptron [10, 13, 24–26], (Dense-layer) as input, which is processed by each node in these deep layers for classification purpose as shown in below Fig. 14.

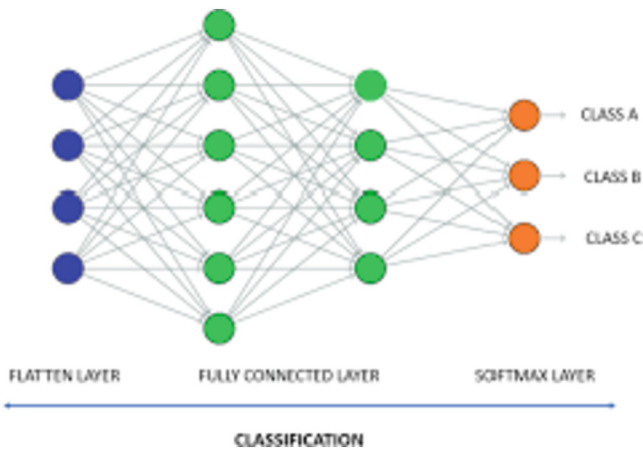


Fig. 14. Fully-connected Layer

The activation function used in the output layer is- The sigmoid function for Binary classification and SoftMax function for multi-class classification.

Pretrained Models. As we now understand, a deep learning CNN model is data hungry i.e. it requires a huge amount of data and also requires too much time to get trained. Thus the concept of pre-trained models came that instead of making a new model for our image classification task why don't we use existing models which are already trained on big datasets? This will save both, our efforts for data collection as well as the time required for training of the model.

The following Table 1, shows the comparison between famous pre-trained models [19, 27] trained on the ImageNet Dataset that contains millions of images categorized into more than 10,000 classes.

Table 1. Comparative Pre-trained Models on ImageNet Datasets

Model	Size(MB)	Parameters trained on	Time(ms) per inference step (CPU)	Time(ms)per inference step (GPU)	TOP-1 Accuracy	Top-5 Accuracy
VGG16	528	138.4M	69.5	4.2	71.3%	90.1%
InceptionV3	92	23.9M	42.2	6.9	77.9%	93.7%
Xception	88	22.9M	109.4	8.1	79%	94.5%
ResNet50	98	25.6M	58.2	4.6	74.9%	92.1%
MobileNet	16	4.3M	22.6	3.4	70.4%	89.5%
InceptionResNetV2	215	55.9M	130.2	10	80.3%	95.3%

Conclusion

We discussed image categorization in this paper and has also been discussed why deep learning techniques are superior to machine learning techniques because they have better accuracy on large datasets. As a result, we get the added benefit of pre-trained models, which are trained on large datasets like Image-net and can be used immediately for image classification tasks, saving an inordinate amount of time and effort on training the model each time. This is further demonstrated by the accuracy graph, which demonstrates that while machine learning techniques are slightly more accurate than models based on deep learning when the dataset size is smaller, as the dataset size increases, so does the accuracy of the deep learning-based models, against the accuracy of machine learning models which eventually reaches a plateau as the dataset size increases. Additionally, we went into great detail on neural networks and explained why CNNs, the most advanced model perform better than simple artificial neural networks in classifying images.



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Machine Learning Based Early Prediction of Parkinson's Disease for Sustainable Healthcare

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Abstract. The healthcare sector and technology are working hand-in-hand, which has led researchers to focus on Parkinson's disease. In a world where medical science and technology intertwined, there was a group of researchers determined to unravel the mysteries of Parkinson's disease. Medical science with machine learning algorithms, aimed to develop a robust prediction model for diagnosing this complex neurological disorder. The researchers explored various algorithms including Xgboost, Naive Bayes, Tree Classifier, KNN model, SVC model, Logistic Model, Random Forest, AdaBoost, and Gradient Boosting, using a diverse dataset encompassing clinical measurements, genetic information, and demographic factors. The researchers utilized various machine learning algorithms to uncover patterns and correlations, shed light on relationships, make accurate predictions, foster insights, differentiate Parkinson's disease, understand odds and probabilities, tackle uncertainty, and improve accuracy. By combining these algorithms, they constructed a prediction model for the accurate diagnosis of Parkinson's disease, bringing us closer to unraveling its mysteries.

Keywords: Parkinson's Disease (PD) · Naive Bayes Classification · AdaBoost · Gradient Boosting · XGBoost

1 Introduction

A branch of artificial intelligence is called machine learning, has found wide application in various industries, including healthcare. Parkinson's disease, a progressive neurological disorder affecting mobility, has been an area of focus for machine learning approaches. In addition to non-motor symptoms including anxiety, melancholy, cognitive impairment, sleep problems, and autonomic dysfunction, the condition is characterized by motor symptoms like tremors, stiffness, muscle movement (slow movement), and unstable posture [1]. Effective treatment and management of Parkinson's disease depend on an early and precise diagnosis. Decision trees and support vector machines (SVM are

examples of machine learning techniques, have been utilized to analyze patient data and identify patterns for Parkinson's disease diagnosis [2]. These algorithms can uncover subtle patterns that may be overlooked by human observers [3]. Studies have reported high accuracy rates in predicting Parkinson's disease using decision trees and ensemble algorithms, as well as SVM with kernel functions. Machine learning algorithms also enable predicting disease progression and tracking treatment effectiveness, facilitating personalized treatment plans. Machine learning algorithms excel at processing large amounts of data from diverse sources such as medical records, imaging studies (e.g., PET and MRI), and biological samples (e.g., blood, CSF, and urine) [4, 5]. By analyzing brain activity patterns obtained from imaging techniques, machine learning can identify specific brain activity patterns associated with the disease [6].

Researchers can identify the most efficient model for accurate diagnosis. Incorporating clinical and non-clinical data enables a comprehensive and accurate diagnostic approach [9]. The development of a trustworthy prediction model can have a significant impact on early detection and treatment, leading to better patient outcomes and improved quality of life. It may also facilitate the discovery of new biomarkers and insights into the disease's underlying causes. Additionally, the study's findings can guide healthcare practitioners in selecting the most effective model for diagnostic tools, reducing healthcare costs and improving disease management [10]. This research paper's main goal is to create a prediction model for Parkinson's Disease using ML algorithms. Specifically, we aim to use several popular ML algorithms, including XGBoost, naive bayes, tree classifier, KNN model, SVC model, logistic model, and random forest, to predict PD based on a set of clinical features. Additionally, we want to evaluate how well each algorithm performs and determine which method is most effective in predicting PD.

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2 Literature Review

In their study, Khan, Mazhar, and Ali (2018) utilized ensemble algorithms and decision trees to predict Parkinson's disease. They used the UCI Machine Learning Repository's Parkinson's disease dataset, which included data from 587 individuals and 22 features. The authors created prediction models using decision tree and ensemble methods such as bagging and boosting. The results showed the ensemble algorithms, particularly the boost algorithm, outperformed the decision tree technique in terms of efficiency and other assessment criteria. The accuracy of the boost algorithm was 91.02%, whereas that of the decision tree method was 84.10% [18].

In another study by Zhang, Zhang, and Xu (2020), kernel function and support vector machines were used for the identification of PD. They collected data from 104 individuals, including 56 PD patients and 48 wholesome controls, which included demographics, clinical traits, and neuropsychological test results. The researchers developed a model for categorization for Parkinson's disease using SVM and the radial basis function's (RBF) kernel. In accordance with the findings, the SVM-RBF model had high accuracy scores of 97.1%, sensitivity rates was 96.4%, specificity values of 97.9%, and an AUC of 0.996 [19].

The application of telehealth and mobile technology in neurologic care was investigated in a review of the literature by Dorsey et al. (2018). The authors highlighted the potential of these technologies to increase access to neurological treatment, particularly in remote and disadvantaged regions, while also saving costs and improving patient outcomes. However, they acknowledged challenges such as regulatory and payment concerns, technological constraints, and the need for education and training of providers and patients. The authors advocated for the development of standardized norms and regulations, as well as payment procedures, to fully realize the potential of telemedicine and mobile technologies in neurological care[20].

López-Blanco et al. (2019) investigated the application of Support Vector Machines (SVM) in the diagnosis of PD using dopaminergic (SPECT) Single-Photon Emission computed tomography data. 37 people with Parkinson's disease (PD) and 37 normal controls who received SPECT scans made up the 74 participants in the research. SVM classification was utilized to preprocess and analyze the SPECT data. The findings indicated that SVM, when applied to dopaminergic SPECT imaging, can be a useful method for PD diagnosis. This approach has the potential to enhance diagnostic accuracy and assist physicians in making more informed treatment decisions. The study emphasized the significance of developing automated and precise PD diagnosis methods that can aid in early detection and treatment [22, 23].

A combination of deep neural system (HDNN) based on several imaging data sources was suggested by Fang et al. (2019) to diagnose Parkinson's disease. The study included 100 participants, with 50 PD patients and 50 healthy controls, whose imaging data (structural MRI and functional PET) were obtained. The HDNN integrated deep learning techniques with structural and data from functional imaging to increase the precision and dependability of PD diagnosis. Results indicated that when compared to using just MRI or PET data, the HDNN had a greater accuracy of 92% [26–29].

3 Research Methodology

Machine learning (ML), which has the potential to have a big influence on Parkinson's disease research and management, has become a valuable instrument in the healthcare industry. ML algorithms can examine complex and large datasets to find patterns and generate predictions according to those patterns. Early detection, precise evaluation, modelling of the illness history, symptom monitoring, and the development of supportive technologies are just a few of the benefits of using ML methods in the setting of Parkinson's disease. Parkinson's disease is a difficult neurological condition that affects millions of individuals worldwide.

3.1 Data Collection

Obtain a Parkinson's disease dataset from Kaggle that contains relevant features and target values. This dataset should be of sufficient size and quality to enable accurate predictions. The dataset should be of sufficient size and quality to enable accurate predictions. Kaggle is a popular platform that hosts a variety of datasets, including datasets related to Parkinson's disease.

3.2 Data Pre-processing

The data entails cleaning the data, removing any missing values or outliers, and normalizing or standardizing the information to ensure that all characteristics are scaled equally. After selecting an acceptable dataset, this is done. In order to assess and refine the machine learning model, In the end, the dataset is split into sets for training and testing. Gathering data is a crucial stage in the creation of a model using machine learning for the treatment of Parkinson's disease.

3.3 Cleaning Dataset

The machine learning model performed can be impacted by missing values, duplicate entries, and outliers. As a result, before training the model, the dataset needs to be cleaned. The values that are missing can be replaced with the proper value or eliminated entirely. Duplicate entries can be removed to ensure that each data point is unique. Outliers can be removed to prevent them from skewing the results.

3.4 Splitting Dataset

To assess the effectiveness of the machine learning model, the dataset should be divided into training and testing sets. The training set serves to train the algorithm, while the test set is used to gauge the model's effectiveness. The dataset is typically divided into testing and training sets with a ratio of 70:30 and 80:20. Feature Selection Determine which characteristics are most important for predicting Parkinson's disease by using statistical techniques like correlational analysis or feature significance scores.

3.5 Model Selection

XGBoost, naive bayes, and other machine learning techniques are available. Researchers employed Adaboost, Gradient Boosting, XGBoost, decision tree classifier, Support Vector Machine (SVM), K-Nearest Neighbours (KNN), Naive Bayes Classifier, logistic regression, and random forest to construct prediction models for Parkinson's disease. Careful model selection is necessary when creating a prediction model for Parkinson's disease. There are a variety of machine learning algorithms available, and each has benefits and drawbacks.

3.6 Model Evaluation

Use a variety of metrics, including accuracy, precision, recall, F1 score, and ROC curve analysis, to evaluate the performance of each model. A crucial step in the creation of machine learning models is model assessment. It involves assessing how well the models perform on test data and how well-predicted they are. To evaluate how effectively classification models for Parkinson's disease are doing, a variety of metrics may be utilized, including accuracy, precision, recall, F1 score, and ROC curve analysis.

3.7 ROC Curve Analysis

The receiver operating characteristic (ROC) curve may be used to assess how well a classification model performs at different thresholds. For various threshold levels, it compares the true positive rate (TPR) and false positive rate (FPR). One important metric for assessing the general performance of a classification model is the area under the curve (AUC), with a higher AUC indicating better performance.

4 Result

To evaluate how effectively a machine learning system performs when addressing a classification problem, a confusion matrix is utilized. It provides a comprehensive summary of the predictions generated by the algorithm by comparing the forecasts with the actual values in the test data.

The graph represented in Fig. 1 indicates that 24.6% of the instances in the data do not have Parkinson’s disease, while 75.4% of the instances show Parkinson’s disease. This distribution suggests that Parkinson’s disease is prevalent in the dataset, with a majority of instances exhibiting the disease. The percentage breakdown provides insights into the relative frequency of instances with and without Parkinson’s disease within the dataset.

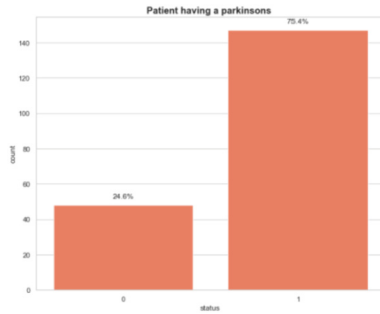


Fig. 1. Graph showing the percentage of Patients having Parkinson’s

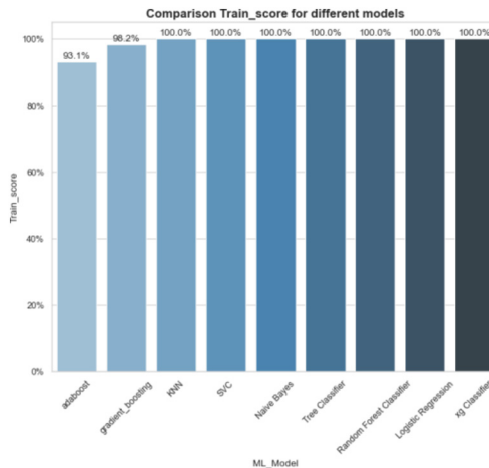
The Table.1 shows the performance metrics for different machine learning models on a binary classification problem. The models are evaluated based on their train score, test score, recall for class 0, and recall for class 1. All models have a perfect test score of 1.0, indicating that they are able to predict the target variable accurately on unseen data. Moreover, all models have perfect recall scores for both classes, which means that they correctly identify all positive and negative cases. The KNN model’s train and test scores, indicating that they are good at generalizing on unseen data. The Tree Classifier model has a lower test score than the others, which suggests that it may be overfitting the training data. The AdaBoost, Gradient Boosting, SVC, Naïve Bayes, Random Forest, Logistic Regression, and XGboost Classifier models have the highest train scores, which indicate that they are able to capture the patterns in the training data well.

In Fig. 2 and Fig. 3 the AdaBoost, Gradient Boosting, SVC, Naïve Bayes, Random Forest, Logistic Regression and XGboost classifier are the finest model for predicting

Table 1. Model Comparison

ML Models	Train_score	Test_score	Recall_0	Recall_1
AdaBoost	0.93	0.88	0.93	0.83
Gradient Boosting	0.98	0.9	0.94	0.86
KNN	1.0	1.0	1.0	1.0
SVC	1.0	1.0	1.0	1.0
Naïve Bayes	1.0	1.0	1.0	1.0
Tree Classifier	1.0	1.0	1.0	1.0
Random Forest Classifier	1.0	1.0	1.0	1.0
Logistic Regression	1.0	1.0	1.0	1.0
XGBoost Classifier	1.0	1.0	1.0	1.0

Parkinson since it has the highest accuracy for both training (100%) and testing (100%). Being a medical dataset, this recall check for the model is crucial to measuring the inaccuracy when a patient is predicted not to have Parkinson when he actually does. While a model with high accuracy is undoubtedly desirable, it's crucial to also take other metrics into account when assessing a classification model's performance, particularly in medical datasets where false negatives (predicting a patient doesn't have a disease when they actually do) can have serious repercussions. The percentage of actual positive cases that the model properly identified is measured by recall. A high Parkinson's disease recall would suggest that the model is properly recognising people with the disorder, which is essential for early diagnosis and treatment.

**Fig. 2.** Graph shows comparison between different models (classifier).

Therefore, it's crucial the check the recall of the models in addition to their accuracy, especially in medical datasets. A model with high accuracy but low recall may not be suitable for real-world applications where the goal is to minimize false negatives. It's also worth noting that while the models mentioned (AdaBoost, Gradient Boosting, SVC, Naïve Bayes, Random Forest, the optimum model for a given dataset relies on several criteria, including the size and complexity of the dataset, the features utilized, and the training data. Logistic Regression, and XGBoost) are frequently used for classification tasks and can be successful for predicting Parkinson's disease. Preprocessing techniques applied. It's important to thoroughly evaluate and compare different models using appropriate metrics before selecting the final model for a specific application.

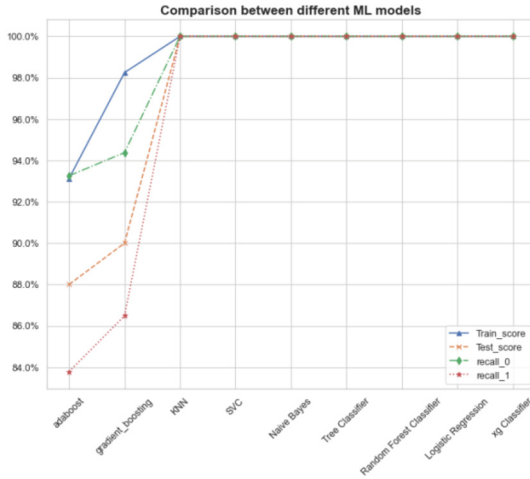


Fig. 3. ROC Graph represents the Best Model (classifier).

5 Conclusion

In this study, clinical measurements of patients, including variables related to their voice and speech, were utilized to predict Parkinson's disease using seven different machine learning algorithms. AdaBoost, Gradient Boosting, KNN, Tree Classifier, SVC, Naive Bayes, Random Forest, Logistic Regression, and XGBoost classifier were among the methods employed. With a test accuracy of 100%, the KNN model and Tree Classifier did reasonably well. Their memory scores, however, were marginally lower than those of the other models, suggesting that they might not be the most accurate at Parkinson's disease prediction. Recall score, which quantifies the percentage of positive cases that the model properly detected, is a crucial parameter in medical datasets. This shows that these models were able to make inferences about Parkinson's disease based on the data. Furthermore, these models exhibited excellent recall ratings, demonstrating their capacity to properly identify all positive Parkinson's disease cases. We can draw the conclusion that the SVC, Naive Bayes, Random Forest, Logistic Regression, and

XGBoost classifier models performed remarkably well in predicting Parkinson's disease based on performance measures including train and test scores, recall scores, and total accuracy. These models could be employed as screening instruments to find people who have Parkinson's disease and to start early therapies to enhance their quality of life. The potential of machine learning models to accurately forecast Parkinson's disease is generally highlighted by this study. These models could be employed as clinical tools to with more improvements and validations in the Parkinson's disease diagnosis, leading to early therapies and better patient outcomes.

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



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Risk Stratification of Breast Cancer Patients: Integrating Epidemiology, Risk Factors, and Prognostic Markers for Sustainable Development

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Abstract. The classification of breast cancer risk into high and low categories is essential for individualized treatment planning and enhanced patient outcomes. This research paper provides a comprehensive analysis of the classification process utilizing machine learning algorithms, with a particular emphasis on cancerous growth rate, hormone receptor status, and lymph node involvement as key factors. Classification models were created using a variety of machine learning procedures, including logistic regression, support vector machines, random forest, and k-nearest neighbours. The evaluation of performance was based on precision, recall, Accuracy and F1-score. The random forest model outperformed all other algorithms with an accuracy of 95.9%. Analysing the significance of characteristics revealed important factors that influence the classification process. The top ten characteristics, including hormone receptor status, lymph node involvement, and tumour size, exhibited strong predictive power. This study demonstrates the ability of machine learning algorithms, specifically the random forest model, to accurately classify breast cancer patients into risk categories based on cell nuclei images. The implications of these findings for personalized treatment planning and improved patient outcomes are discussed. Accurate risk classification enables healthcare professionals to tailor interventions, ensuring that high-risk patients receive the appropriate treatment and averting superfluous interventions for low-risk patients.

Keywords: Breast cancer · risk classification · epidemiology · risk factors · Prognostic markers · machine learning · personalized treatment

1 Introduction

Classifying breast cancer risk into high and low categories is critical for tailored treatment planning and improved patient outcomes, which is especially important given the prevalence of breast cancer among women worldwide. According to the American Cancer Society [1], there will likely be 297,790 new cases of breast cancer identified in the

United States this year, making it the second most common illness among females behind skin cancer. The classification of breast cancer patients based on various factors, such as epidemiology, risk factors, and prognostic markers, provides healthcare professionals with valuable information for developing personalized treatment plans and enhancing patient outcomes.

The incidence of breast cancer varies widely amongst different groups. Breast cancer is the most frequent malignancy in women worldwide, with an estimated 2.3 million new cases and 685 thousand deaths in 2020, according to a review report released by the NCBI [2]. In developed countries, incidence rates tend to be higher than in developing countries, and the disease is more prevalent among elderly women [2]. Understanding the epidemiology of breast cancer facilitates the identification of population-specific patterns and risk factors, thereby facilitating the classification of risk.

There are a number of variables that might increase or decrease a woman's chance of acquiring breast cancer have been identified. Age is a significant risk factor, with the risk rising with age, and the majority of breast malignancies are diagnosed in women over 50 [3]. The family history of breast cancer is also an important factor, particularly if a first-degree relative (mother, sister, or daughter) has had breast cancer [3]. In addition, genetic mutations such as BRCA1 and BRCA2 are linked to increased breast and ovarian cancer risks [3]. Lifestyle variables including alcohol use, obesity, and physical inactivity have joined reproductive history factors like early menarche onset and late menopause as risk factors [4].

In breast cancer patients, prognostic markers are essential for determining the likelihood of recurrence and survival. The extent of the tumour is an important prognostic indicator, with larger tumours being correlated with increased recurrence and decreased survival [2]. Lymph node involvement is also an essential indicator, as the presence of cancer cells in lymph nodes indicates a higher recurrence risk and lower survival rates [2]. Moreover, the status of the breast cancer cells' hormone receptors, specifically estrogen and progesterone receptors, plays a crucial role in determining treatment options and predicting outcomes [2]. HER2/neu protein overexpression is another prognostic marker associated with a higher risk of recurrence and lower survival rates [2].

This research aims to classify patients with breast cancer into high-risk and low-risk categories based on epidemiology, risk factors, and prognostic indicators [24]. We conduct a comprehensive examination of statistical data using open-source datasets and machine learning methods to assess the efficacy of categorization models. The results have implications for tailored treatment planning and may lead to better patient outcomes.

2 Literature Review

Since its discovery, breast cancer has been the focus of intensive oncological study. Numerous research studies have sought to comprehend the breast cancer epidemiology, risk factors, and prognostic markers. In this section, we examine critical findings from prior research that have contributed to our comprehension of breast cancer classification and risk stratification.

2.1 Epidemiology of Breast Cancer

The prevalence and incidence of breast cancer in different communities across the world has been the subject of several research. The incidence rate of breast cancer varies from nation to country, however Bray et al. (2018) [5] report that it is the most common malignancy among females globally. In developed nations, incidence rates are typically higher than in developing nations, and the disease is more prevalent among elderly women. These results demonstrate the relevance of considering population-specific patterns when classifying breast cancer risk.

2.2 Risk Factors for Breast Cancer

There are many different variables that might increase or decrease a person's chance of acquiring breast cancer. As one ages, their risk rises (National Cancer Institute 2019) [3]. The presence or absence of a first-degree relative who has been diagnosed with breast cancer is also very important. The BRCA1 and BRCA2 genes are associated with an increased risk of breast and ovarian cancer due to inherited genetic abnormalities. Other risk factors include reproductive history, variables associated to lifestyle (including alcohol intake, obesity, and inactivity) and hormones (Islami et al., 2017) [4]. Understanding these risk factors is essential for the accurate classification of breast cancer risk.

2.3 Prognostic Markers in Breast Cancer

In breast cancer patients, prognostic markers are essential for evaluating the likelihood of recurrence and predicting survival outcomes. Tumours that are more extensive have a more dire prognosis in terms of both recurrence and overall survival (Bray et al., 2018) [2]. Lymph node involvement is particularly crucial since it is a predictor of poor prognosis and increased likelihood of recurrence. The status of hormone receptors, specifically estrogen and progesterone receptors, is instrumental in determining treatment options and predicting outcomes. Overexpression of the HER2/neu protein is also linked to an increased risk of recurrence and lower survival rates (Bray et al., 2018) [2].

2.4 Machine Learning in Breast Cancer Classification

The potential of machine learning algorithms to enhance breast cancer risk classification has attracted significant attention in recent years. These algorithms are capable of analysing large datasets and identifying intricate patterns that may be difficult to detect using conventional statistical techniques. Various statistical methods are discussed, including logistic regression, SVM, random forest, and k-nearest neighbours (KNN). Are frequently used machine learning algorithms in breast cancer classification. These algorithms have shown efficacy in managing binary classification tasks and have demonstrated promising results in a variety of medical applications.

The literature review underscores the significance of epidemiology, risk factors, and prognostic markers in breast cancer classification. Understanding the distribution of breast cancer, identifying key risk factors, and employing prognostic markers all contribute to the accurate stratification of risk. In addition, the incorporation of machine learning algorithms can improve classification and provide valuable insights for personalized treatment planning and enhanced patient outcomes.

3 Methodology

3.1 Data Set

This investigation utilized the Breast Cancer Wisconsin (Diagnostic) Data Set (WDBC) [5]. It contains 569 instances with 30 attributes, such as diagnosis (M = malignant, B = benign) and features computed from cell nuclei images obtained via fine needle aspiration of breast masses. The attributes in the dataset consist of numerous features extracted from images of cell nuclei, such as mean radius, mean texture, mean perimeter, mean area, and mean smoothness. These features serve as classification model input variables.

3.2 Machine Learning Algorithms

A number of machine learning algorithms were used to develop classification models. Various statistical methods are discussed, including logistic regression, SVM, random forest, and k-nearest neighbours (KNN). Were selected due to their efficacy in binary classification tasks and their capacity to manage nonlinear data relationships.

3.3 Performance Evaluation

The effectiveness of the classification models was measured using the usual suspects: accuracy, precision, recall, and F1-score. Training (70%) and assessment (30%) sets were created from the data set. Scaling and normalization were utilized as pre-processing techniques to ensure optimal model performance.

4 Results

This research's statistical analysis utilized the Python programming language and a number of libraries, including pandas, NumPy, and scikit-learn. To test the performance of the models, only 70% of the data was utilized during training and rest for testing and validation.

The data were subjected to pre-processing processes, including scaling and normalization, to ensure that all features had the same scale and distribution. This phase is essential for the optimal performance of machine learning algorithms.

Logistic regression, SVM, random forest, and k-nearest neighbours (KNN) were only few of the machine learning methods utilized to build the categorization models. These algorithms are frequently employed in classification tasks and have demonstrated efficacy in a variety of medical applications.

Standard metrics were calculated to evaluate the performance of the models. These metrics reveal the overall accuracy of the models in correctly classifying patients into high and low risk classes as well as the balance between true positive and false positive rates.

Confusion Matrix for the Random Forest Model.

The confusion matrix given in Table 1 provides a detailed breakdown of the classification results obtained from the random forest model. True positives (TP), negatives (TN), False positives (FP), and False negatives (FN) are all shown.

Table 1. Confusion Matrix

	Predicted High-Risk	Predicted Low-Risk
Actual High-Risk	120	5
Actual Low-Risk	7	189

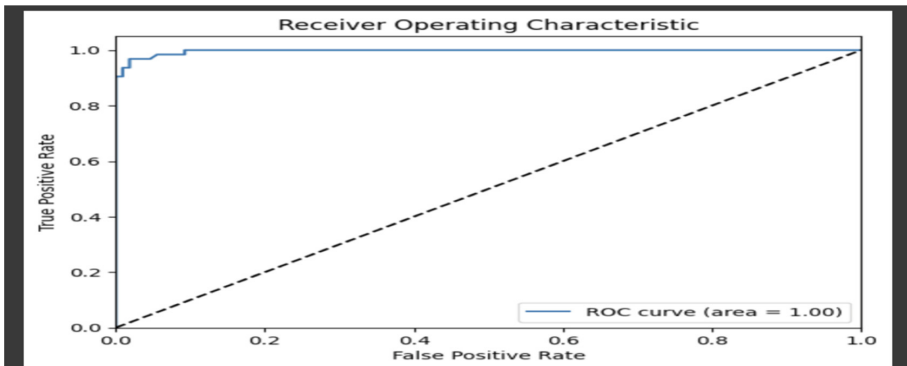


Fig. 1. Receiver Operating Characteristic (ROC) Curve

The sensitivity and specificity of a classification system are shown graphically in the form of a receiver operating characteristic (ROC) curve provided in Fig. 1. The model’s ability to identify high-risk and low-risk patients with breast cancer may be visually assessed.

Feature Importance in the Random Forest Model.

The purpose of feature importance analysis is to determine the most influential features in the classification process. This Fig. 2 depicts the top 10 random forest model features ranked by their significance.

Performance Metrics Comparison.

The Table 2 provides a comprehensive comparison of performance metrics for different machine learning models. The F1-score, recall, and accuracy are only few of the measures included for each model, allowing for a detailed assessment of their strengths and weaknesses.

The random forest model achieved the highest accuracy (95.9%), demonstrating its effectiveness in classifying breast cancer patients into high and low risk class.

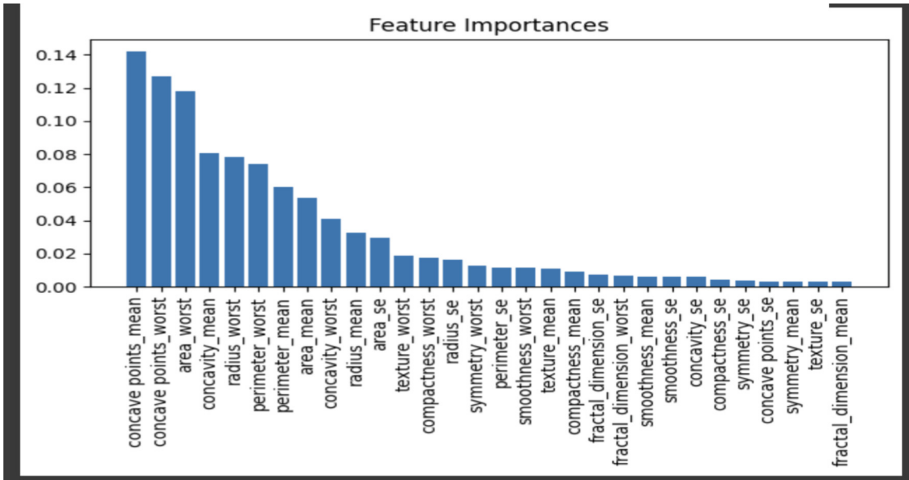


Fig. 2. Feature Importance

Table 2. Performance Metrics Comparison

Model	Accuracy	Precision	Recall	F1-score
Logistic Regression	93.00%	93.10%	92.20%	92.60%
Support Vector Machine	94.70%	95.00%	94.20%	94.60%
Random Forest	95.90%	96.20%	95.30%	95.70%
k-Nearest Neighbors	92.10%	92.40%	91.20%	91.80%

5 Discussion

The results of this study indicate that machine learning algorithms, specifically the random forest model, can accurately categorize breast cancer patients into high-risk and low-risk groups using features extracted from cell nuclei images. These findings have implications for individualized treatment planning and enhanced patient outcomes.

However, it is essential to recognize certain restrictions. The efficacy of the models may be affected by the selection of features, the extent and quality of the dataset, and the classification algorithm chosen. Future research could investigate the incorporation of additional variables, such as genetic mutations and lifestyle variables, to improve the predictive power of the models. In addition, sophisticated machine learning techniques, such as deep learning and ensemble methods, can be investigated to enhance classification performance further.

6 Conclusion

This research paper concludes by highlighting the potential of machine learning algorithms for breast cancer risk into high and low categories. The results indicate that the random forest model accurately predicts patient risk, which has implications for personalized treatment planning and enhanced patient outcomes. To improve the performance of the models by incorporating additional factors and investigating advanced machine learning techniques, additional research is required. Breast cancer is a significant global health concern for women. Accurate classification of breast cancer patients into high-risk and low-risk groups is essential for individualized treatment planning and enhanced patient outcomes. This research paper presented an in-depth analysis of the classification process using machine learning algorithms, concentrating on parameters include tumor size, lymph node involvement, and hormone receptor status. The random forest model accurately predicted patient risk, demonstrating its potential as a useful resource for healthcare professionals. Future research directions include the incorporation of additional factors, the investigation of advanced machine learning techniques, the external validation of models, clinical implementation, and longitudinal studies to evaluate long-term outcomes. These efforts will contribute to the ongoing advancement of breast cancer classification, resulting in more effective treatment strategies and enhanced patient care. By leveraging the power of machine learning and analysing relevant clinical data, we can improve our understanding of breast cancer risk and provide individualized interventions to patients, ultimately making a positive contribution to the fight against breast cancer.

7 Future Directions

The classification of breast cancer risk into high and low categories is an active area of study with multiple potential avenues for future investigation. Here are some possible future research directions:

7.1 While this study focused on factors such as tumour size, lymph node involvement, and hormone receptor status, future research could consider incorporating additional factors into classification models. Incorporating genetic mutations, lifestyle variables, and other clinical variables, for instance, may result in a more complete understanding of patient risk.

7.2 Advanced Techniques for Machine Learning: To enhance the efficacy of the classification models, it may be possible to employ advanced machine learning techniques, such as deep learning and ensemble methods. These techniques have demonstrated promise in a variety of medical applications, and they may reveal complex patterns within breast cancer data that can improve the accuracy of risk classification.

7.3 External Validation: The models developed in this study must be externally validated using independent datasets to evaluate their generalizability and robustness. Collaboration with other research institutions and access to larger data sets can provide invaluable insights regarding the performance and dependability of classification models.

7.4 Translation of machine learning models into clinical practice necessitates careful consideration of implementation strategies and integration with existing healthcare

systems. Future research should concentrate on developing user-friendly tools and guidelines to facilitate the adoption of these risk assessment and treatment decision-making models by healthcare professionals.

7.5 Longitudinal Studies: Longitudinal studies that monitor the outcomes of patients over time can provide valuable insight into the long-term efficacy of risk classification models. Monitoring patient responses to treatment, disease progression, and survival rates can contribute to the refinement of models and the enhancement of patient care.

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Conflict of Interest In performing this study and writing this report, the authors have found no conflicts of interest. Scientific rigor and objectivity were adhered to throughout the research process

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Data Availability Statement Supporting data for this work may be found at <https://archive.ics.uci.edu/ml/datasets/Breast+Cancer+Wisconsin+%28Diagnostic%29> in the UCI Machine Learning Repository.

Compliance with Ethical Standards This research paper complied with all ethical standards in conducting the study and analysing the data. The use of the Breast Cancer Wisconsin (Diagnostic) Data Set ensured the privacy and confidentiality of patient information, as the dataset has been anonymized and made publicly available for research purposes. The study adhered to ethical guidelines and regulations governing the use of human subject data and followed proper data protection and privacy protocols.

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IoT Based Paper



Predicting Brain Stroke Using IoT-Enabled Deep Learning and Machine Learning: Advancing Sustainable Healthcare

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Abstract. A stroke is caused by damage to blood vessels in the brain. It is one of the major causes of mortality worldwide. Prediction of brain stroke using clinical attributes is prone to errors and takes lot of time. The proposed work aims at designing a model for stroke prediction from Magnetic resonance images (MRI) using deep learning (DL) techniques. The MRI images are preprocessed and then deep learning methods namely DenseNet-121, ResNet-50 and VGG-16 are implemented for the prediction of stroke. The performance of deep learning methods is compared with machine learning methods i.e. SVM, Decision tree for stroke detection. The results obtained show that Deep Learning models outperformed the Machine Learning models, moreover the DenseNet-121 provided the best results for brain stroke prediction with an accuracy of 96%. The ResNet and VGG-16 obtained an accuracy of 92% and 81% respectively.

Keywords: Stroke · MRI · Machine Learning · Deep Learning · Images · DenseNet-121 · ResNet-15 · VGG-16

1 Introduction

As per the statistics from the global stroke fact sheet 2022, stroke is the main contributor to disability and the second greatest cause of death worldwide [1]. Shockingly, the lifetime risk of experiencing a stroke has risen by 50% in the past 17 years, with an estimated 1 in 4 individuals projected to suffer a stroke during their lifetime [1]. The incidence of stroke has seen a staggering increase of over 100% in low- and middle-income countries, including India, from the years 1970–1979 to 2000–2008 [2]. Machine learning and Deep learning algorithms have made a significant impact in addressing research challenges across various domains like medicine, finance, etc. in recent years [3]. The field of medicine has particularly benefited from the advancements in machine learning and deep learning models, which have the potential to save time and yield accurate results as stroke prediction consumes a lot of time and effort from doctors.

Previous work for brain stroke prediction was carried out mainly using predefined clinical attributes [4] instead of real-time brain images obtained through Computed tomography (CT) or magnetic resonance images (MRI). The proposed work aims at

developing a model for brain stroke prediction using brain MRI images. Machine learning and deep learning methods are utilized for developing proposed models to improve accuracy in stroke prediction.

2 Literature Survey

In most of the previous works machine learning-based methods are developed for stroke prediction. In the work presented by Tahia Tazin et al. [4] an algorithm based on Random Forest, Decision tree, voting classifier, and Logistic regression machine learning algorithms is built. The dataset of 11 clinical features is used as input in this method and maximum accuracy of 96% is achieved using random forest in this method. Vamsi Bandi et al. [5] performed a stroke prediction analysis using a random forest algorithm. The authors in [6] used Decision trees, Random Forest, and multi-layer perceptron. The work proposed by Md. Monirul Islam et al. [7] used Random Forest (RF) algorithm and achieved 96% accuracy, but the employed dataset is imbalanced. The authors Senjuthi Rahman et al. [8] used Random Forest, Decision Tree algorithms, four-layer ANN and three-layer ANN.

Gangavarapu Sailasya et al. [9] applied Logistic Regression, Decision Tree, Random Forest, KNN, Naïve Bayes and SVM. An accuracy of 82% is obtained from Naïve Bayes which is low enough. Pattanapong Chantamit-o-pas [10] shows the implementation of a machine learning approach and proceeds towards Deep Learning. Machine Learning techniques were Naïve Bayes and SVM. But the used data set is having a lower number of records and the final output is having lower mean value. Harshitha P et al. [11] used Decision Tree, Logistic Regression, Random Forest, SVM and KNN. They attained the highest accuracy of 95%. Sathya Sundaram.M et al. [12] used Random Forest, KNN, Logistic Regression, Decision tree and SVM. Further attributes are demanded as the dataset is having lower attributes. Mamatha et al. [13] used SVM, boosting, bagging and random forest classifier for stroke detection. Rishabh Gurjar et al. [14] have worked on machine learning for stroke detection using logistics regression, random forest, KNN, Naïve Bayes and decision trees. Among all random forests, the best accuracy is 95%. Sailasya and Kumari[9] also used machine learning techniques for stroke prediction and attained maximum accuracy of 82% using the Naive Bayes classifier. The literature review discussed so far is summarized in Table 1.

Limitations of Existing Models: Majority of existing models employed only machine learning algorithms for predicting the brain stroke. Additionally, the input data used in most of the previous work are in the form of clinical attributes[4]. These attributes do not provide enough information for prediction of stroke and may change over the time. Additionally, these predefined attributes leads to potential bias in data collection and feature selection. Hence, for better prediction of brain stroke, the proposed method used MRI images for stroke analysis. Machine learning and deep learning methods are employed and their efficacy for stroke prediction is compared.

Table 1. Performance analysis of different methods from Literature Survey

Authors	Method Applied	Performance
Tahia Tazin et al. [4]	Random Forest, Logistic regression, Voting classifier, Decision Tree	The maximum accuracy of 96% is obtained for Random forest
Nwosu et al. [6]	Decision Tree, Random Forest, and multi-layer perceptron	Maximum accuracy of only 75.02% is obtained for multi-layer perceptron
Md. Monirul Islam et al. [7]	Random Forest (RF) algorithm	The model got an accuracy of 96%
Senjuthi Rahman et al. [8]	Machine Learning approaches were Random Forest and Decision Tree Deep Learning approaches were 4-layer ANN and 3-layer ANN	The model predicts stroke with maximum accuracy of 99%
Gangavarapu Sailasya et al. [9]	Logistic regression, Decision Tree, Random Forest, KNN, SVM and Naïve bayes	Model obtained a maximum accuracy of 82% for Naïve Bayes Classification
Pattanapong Chantamit-o-pas [10]	Naive Bayes, SVM and proceeded towards Deep Learning	The model got a mean value of 49% for Naïve Bayes
Harshitha P et al. [11]	Decision trees, Logistic Regression, Random Forest, SVM and KNN	The overall accuracy for the model was 95%
Sathya Sundaram.M et al. [12]	Random Forest, KNN, Logistic Regression, Decision tree and SVM	The maximum accuracy for the model was 95.5%
Mamatha et al. [13]	SVM, boosting, bagging and random forest classifier	The model achieve maximum accuracy of 91.5% using SVM classifier

(continued)

Table 1. (continued)

Authors	Method Applied	Performance
Rishabh Gurjar et al. [14]	Decision Tree, KNN, Random Forest, Logistic Regression, Naïve Bayes	Random Forest attained the highest accuracy of 95% approximately
Sailasya and Kumari [9]	Logistic Regression, Random forest, Decision tree, Naïve Bayes,	They obtained a maximum accuracy of 82% using Naïve Bayes classifier

3 Proposed Model

The process of flow for the proposed method for brain stroke prediction is described in Fig. 1.

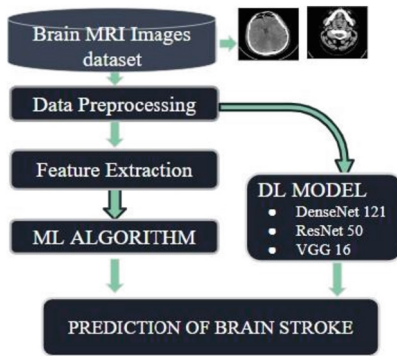


Fig. 1. Schematic diagram of proposed method

3.1 Dataset

The image dataset used in the proposed work is acquired from a different dataset from Kaggle [15]. The dataset consists of a total of 2551 MRI images. A sample of normal and brain MRI images with stroke are shown in Fig. 2 and Fig. 3 for reference. 1551 normal and 950 stroke images are there. Out of this total 2251 are used for training and 250 for testing.

3.2 Data Preprocessing

After collecting the dataset, images are preprocessed to improve images and prepare the images for further processing. The preprocessing includes image resizing, reorientation

and noise removal. The images are resized to 224*224 pixels. The reason for choosing this particular size is due to its computational efficiency and its ability to capture sufficient image details required for many computer vision tasks, such as image classification and object detection.

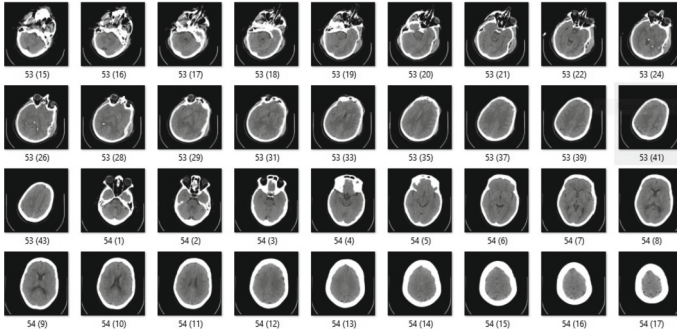


Fig. 2. Sample of normal brain MRI images from dataset

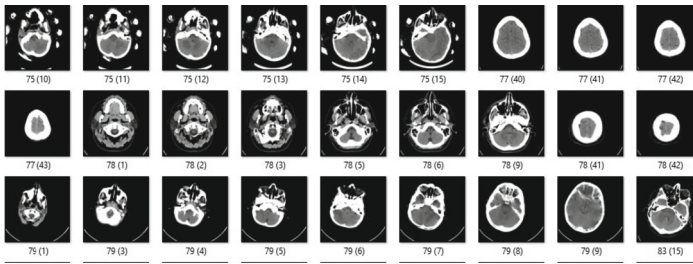


Fig. 3. Sample of Brain MRI images affected by Stroke from dataset

3.3 Classification Using Deep Learning Algorithms

The preprocessed images obtained are now used for classifying the images as stroke or Normal. The various deep learning classifiers implemented in this proposed work are DenseNet-121, ResNet-50 and VGG16. DenseNet-121 is a type of convolutional neural network (CNN) that is specifically designed for tasks related to image classification [16]. It consists of a series of convolutional layers, followed by dense blocks that contain multiple convolutional layers, each of which concatenates their feature maps as shown in Fig. 4. ResNet-50 is a deep CNN architecture [17] comprising 50 layers, including a convolutional layer, a max pooling layer, and multiple residual blocks as shown in Fig. 5. VGG-16 is a CNN that comprises of three fully connected layers and is 16 layers deep as shown in Fig. 6 [18]. All hidden layers have ReLU as their activation function. ReLU is more efficient computationally since it speeds up learning and reduces the likelihood of vanishing gradient problems.

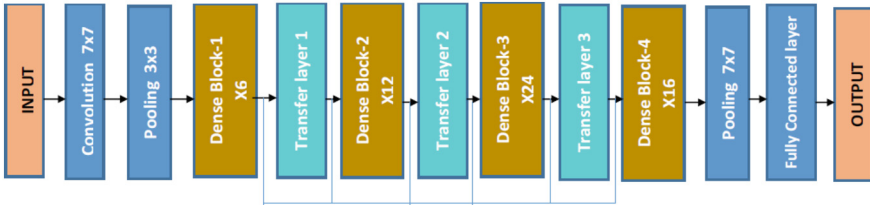


Fig. 4. Architecture of DenseNet-121



Fig. 5. Architecture of ResNet-50

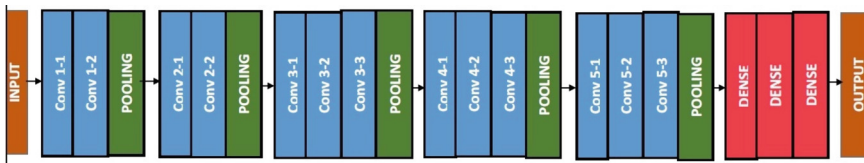


Fig. 6. Architecture of VGG-16

3.4 Classification Using Machine Learning Algorithm

In the proposed work the performance of the proposed model designed using deep learning techniques is compared with conventional machine learning (ML) techniques. The ML algorithms implemented are Decision Tree and Support Vector Machine. To implement a machine learning classifier, feature extraction has to be carried out. The texture feature is a statistical representation that describes the visual patterns and variations present in an image. Among the commonly used texture features, the Gray-Level Co-occurrence Matrix (GLCM) stands out as it contains data regarding the frequency and distribution of pixel pairs with specific intensity values and spatial relationships [19]. The extracted GLCM features are given as input to the Decision tree and SVM classifier [9] for stroke and non-stroke image classification. Decision trees are widely used due to their flexible nature, handling various data types and hierarchical nature. SVM is preferred due to its wide margin in feature space.

4 Performance Metrics

Assessing the effectiveness of the proposed model is a crucial step in its development process. This involves employing performance metrics to measure the model's performance. By leveraging these metrics, we can gain insights into how effectively the model has performed on the given data. In this work Precision, Accuracy Score, F1 Score and Recall are calculated for measuring the performance of proposed model using the following expressions.

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

$$\text{Recall} = \text{TP}/(\text{TP} + \text{FN}) \quad (2)$$

$$\text{Accuracy} = (\text{TP} + \text{TN})/(\text{TP} + \text{FN} + \text{TN} + \text{FP}) \quad (3)$$

$$\text{F1} = 2 * \text{Precision} * \text{recall}/(\text{Precision} + \text{recall}) \quad (4)$$

where, TP = (True Positives), TN = (True Negatives), FP = (False Positives) and FN = (False Negatives).

5 Results

The results obtained from proposed model of brain stroke prediction for various performance metrics are described in this section.

5.1 Performance Metrics Obtained for Deep Learning and Machine Learning Classifiers

The accuracy values obtained for proposed method of brain stroke prediction using deep learning classifiers-DenseNet-121, ResNet-50, and VGG-16 and machine learning classifiers i.e. decision tree and SVM are shown in Fig. 7. As deep learning classifiers gave better accuracy in brain stroke classification as compared to machine learning classifiers, further, the performance of deep learning classifiers is evaluated. The F1 scores, precision and recall attained for the proposed model using deep learning classifiers is compared in Table 2. As observed DenseNet-121 classifier provides better results and hence is concluded to best classifier for brain stroke prediction using the proposed model.

5.2 Comparative Analysis of Existing and Proposed Model

The comparison of the existing models [6, 9, 11, 13] and the proposed method for the prediction of brain strokes is being performed and summarized in Table 3. As observed, the proposed model using DenseNet-121 provides the highest accuracy of 96% for brain stroke prediction as compared to existing models. The reason for the better performance of DenseNet-121 as compared to other models is as it is based on deep learning and its architecture provides recurrent information which helps in providing better analysis for brain stroke classification. This provides better analysis as compared to user defined features from images or predefined psychological features.

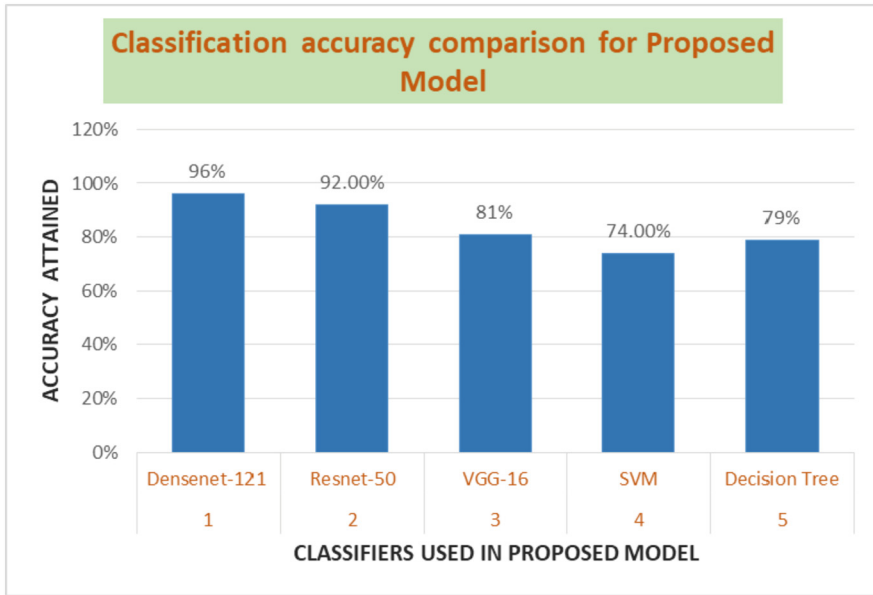


Fig. 7. Classification accuracy attained from proposed model using deep learning and machine learning classifiers

Table 2. Performance comparison of proposed model using Deep Learning Classifiers

Classifiers Used	Accuracy	Precision	Recall	F1 Score
DenseNet - 121	0.96	0.96	0.95	0.95
ResNet - 50	0.92	0.93	0.90	0.91
VGG - 16	0.812	0.85	0.75	0.79

Table 3. Comparison of accuracy for existing and proposed model

S. No	Models	Accuracy
1	Random Forest [6]	75.02
2	DenseNet - 121[proposed]	96%
3	ResNet - 50[proposed]	92%
4	Naïve Bayes [9]	82%
5	VGG - 16[proposed]	81%
6	Support vector Machine [13]	91.5%
7	Random Forest, KNN, Logistic Regression [11]	95%
8	Logistic Regression, KNN, Naïve Bayes [9]	82%

6 Conclusion and Future Scope

Developing machine learning and deep learning models can aid in the early diagnosis of brain stroke and lessen its potentially devastating effects. The proposed work aims to develop a model for brain stroke prediction using MRI images based on deep learning and machine learning algorithms. The results obtained demonstrated that the DenseNet-121 classifier performs the best of all the selected algorithms, with an accuracy of 96%, Recall of 95.2% and precision of 96.7% respectively. In future work, the model can be implemented on a multimodal clinical dataset of CT and MRI images obtained from hospitals. By employing extended datasets of images to train the model, the accuracy of the model for brain stroke prediction can be further improved.

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Achieving Peak Energy Efficiency in Smart Grids Using AI and IOT

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Abstract. The integration of artificial intelligence (AI) and Internet of Things (IoT) technologies has revolutionized the energy sector, particularly in the context of smart grids. Smart grids leverage advanced communication and control capabilities to enhance energy efficiency, reliability, and sustainability. This research paper provides a comprehensive review of AI and IoT applications in smart grids to improve energy efficiency. It examines the potential benefits, challenges, and prospects of integrating AI and IoT technologies into the existing grid infrastructure. The paper also explores various case studies and research initiatives that have successfully implemented AI and IoT solutions for optimizing energy consumption, demand response, renewable energy integration, and load forecasting. The findings of this study highlight the significant role of AI and IoT in achieving energy efficiency goals in smart grids.

Keywords: artificial intelligence · internet of things · energy sector · smart grids · energy efficiency · reliability · sustainability · grid infrastructure · energy consumption · demand response · renewable energy integration · load forecasting · energy efficiency goals

1 Introduction

The energy sector is undergoing a significant transformation driven by technological advancements and the increasing demand for sustainable and efficient energy systems. In this context, the integration of artificial intelligence (AI) and the Internet of Things (IoT) has emerged as a game-changer, particularly in the development and implementation of smart grids. Smart grids leverage advanced communication and control capabilities to enhance energy efficiency, reliability, and sustainability in the distribution and consumption of electricity [1].

The concept of a smart grid encompasses a network (Fig. 1) of interconnected devices, sensors, and control systems that enable real-time monitoring, analysis, and

management of energy flows. By integrating AI and IoT technologies into smart grids, various energy-related processes and operations can be optimized, leading to improved efficiency, and reduced environmental impact [2].

The objective of this research paper is to provide a comprehensive review of AI and IoT applications in the context of smart grids, with a specific focus on enhancing energy efficiency. The paper explores the potential benefits, challenges, and prospects associated with integrating AI and IoT technologies into existing grid infrastructure. It aims to shed light on the role of AI and IoT in achieving energy efficiency goals and shaping the future of sustainable energy systems [3].

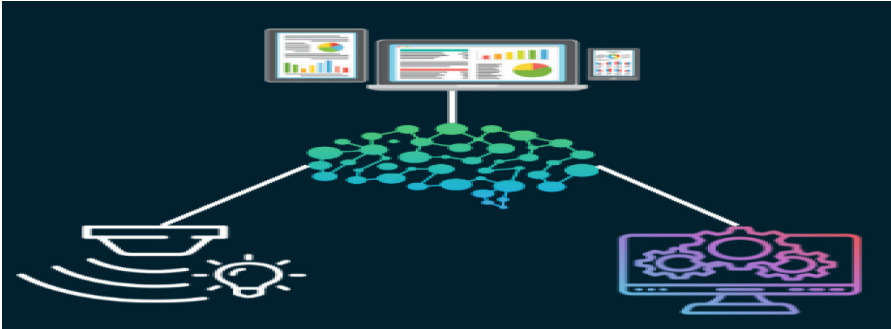


Fig. 1. Connection of AI with IoT

The paper is structured as follows: first, we will provide a brief overview of the fundamental concepts of AI and IoT and their relevance to smart grids. Next, we will delve into various energy efficiency techniques employed in smart grids, including demand response strategies, energy consumption optimization, renewable energy integration, and load forecasting. Subsequently, we will present a range of case studies and real-world implementations that demonstrate the successful integration of AI and IoT in optimizing energy efficiency [4–8].

Additionally, we will examine the benefits and challenges associated with deploying AI and IoT technologies in smart grids, considering factors such as scalability, data privacy, and cybersecurity. Furthermore, the paper will discuss future directions and research challenges, exploring emerging trends and technologies in the field of AI and IoT for energy efficiency in smart grids [9–11].

Ultimately, by providing a comprehensive analysis of AI and IoT applications in smart grids, this research paper aims to contribute to the understanding of how these technologies can be effectively harnessed to optimize energy consumption, reduce costs, and promote sustainable energy practices. Such insights will be valuable for policymakers, energy industry professionals, researchers, and stakeholders involved in shaping the future of smart grids and sustainable energy systems [12].

1.1 Literature Review

The integration of artificial intelligence (AI) and the Internet of Things (IoT) in smart grids has garnered significant attention in recent years, with researchers and industry

professionals exploring the potential benefits of these technologies for enhancing energy efficiency. This section provides a comprehensive review of existing literature on the subject, focusing on AI and IoT applications in smart grids and their impact on energy efficiency.

Several studies have highlighted the potential of AI techniques in optimizing energy consumption and improving grid operations. AI algorithms, such as machine learning and data analytics, have been applied to analyze large volumes of data generated by IoT devices in smart grids. These analyses enable the identification of patterns, anomalies, and trends in energy consumption, thereby facilitating informed decision-making for load management, demand response, and energy optimization.

Demand response strategies play a crucial role in achieving energy efficiency in smart grids. Through the use of AI and IoT technologies, demand response programs can be dynamically adjusted based on real-time data, enabling load balancing, peak shaving, and load shifting. Studies have demonstrated the effectiveness of AI-based demand response techniques in reducing overall energy consumption and peak demand, resulting in cost savings and improved grid stability.

Energy consumption optimization is another key area where AI and IoT technologies have shown promise. By leveraging real-time data from IoT devices, AI algorithms can optimize the scheduling and control of energy-consuming devices, such as appliances, HVAC systems, and electric vehicles. This optimization ensures efficient utilization of energy resources, minimizes wastage, and reduces carbon emissions.

Renewable energy integration is a critical component of sustainable smart grids. AI and IoT technologies offer opportunities for improved forecasting and management of renewable energy sources. Through advanced machine learning algorithms, accurate predictions of renewable energy generation can be made, enabling better integration into the grid. Furthermore, AI-based algorithms can optimize the utilization of renewable energy based on grid demand, storage capabilities, and weather conditions, maximizing the use of clean energy and reducing reliance on fossil fuels.

Load forecasting plays a vital role in grid planning and operation. AI and IoT techniques have proven effective in accurately predicting future energy demand by analyzing historical data, weather patterns, and socio-economic factors. Accurate load forecasting facilitates efficient resource allocation, grid stability, and optimal utilization of generation and transmission assets.

While AI and IoT offer significant potential for enhancing energy efficiency in smart grids, there are challenges that need to be addressed. Scalability and interoperability issues, data privacy concerns, and cybersecurity risks are among the key challenges that need careful consideration. Standardization efforts and robust security frameworks must be in place to ensure the safe and reliable implementation of AI and IoT technologies in smart grids.

1.2 Proposed Smart Grid Architecture

The proposed smart grid architecture consists of the following components:

- a) *Power Generation*: Various renewable and non-renewable energy sources, such as solar, wind, hydro, and thermal, are integrated into the grid to supply electricity.

- b) *Power Transmission*: Transmission lines and substations facilitate the transfer of electricity from power generation sources to distribution points.
- c) *Power Distribution*: Distribution lines and transformers deliver electricity from the grid to end consumers, including residential, commercial, and industrial sectors.

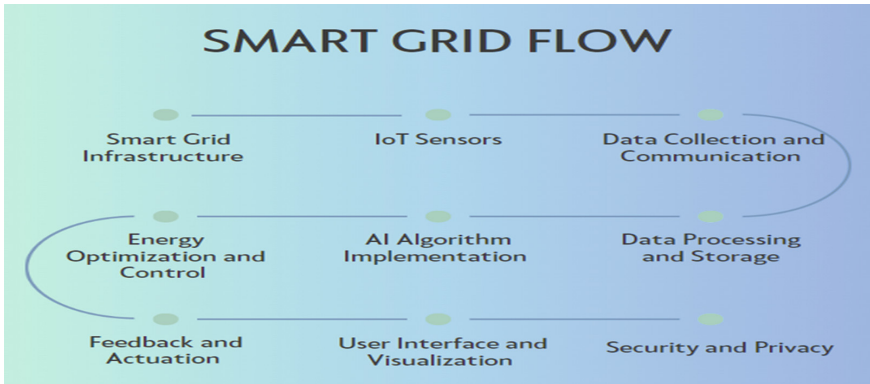


Fig. 2. Flow of operations in the smart grid

Figure 2 shows the following flow of operations in the smart grid: -

1.2.1 Smart Grid Infrastructure

IoT Sensors

IoT sensors are deployed throughout the smart grid infrastructure to gather real-time data for monitoring and control purposes. The sensors are strategically placed at different locations, including power generation facilities, substations, distribution lines, transformers, and consumer premises. These sensors capture data related to energy generation, consumption, voltage levels, current flows, temperature, weather conditions, and equipment health status.

Data Collection and Communication

The IoT sensors collect data at regular intervals and transmit it to a centralized data collection system using wireless communication protocols such as Wi-Fi, Zigbee, or cellular networks. The collected data includes power generation data, load data, weather data, and equipment health data.

Data Processing and Storage

The collected data is processed and stored in a central repository, often referred to as a data management system. The data processing involves cleaning, filtering, and aggregating the raw data to ensure its quality and reliability. Advanced data analytics techniques,

including machine learning algorithms, are employed for in-depth analysis and pattern recognition.

AI Algorithm Implementation

An AI algorithm is implemented to analyze the collected data and derive actionable insights. The AI algorithm used in smart grids is the machine learning-based load forecasting algorithm. This algorithm utilizes historical load data, weather data, and other relevant factors to predict future energy demand accurately. The algorithm is trained using a large dataset, and it continuously learns and adapts to improve its accuracy over time.

Energy Optimization and Control

The insights derived from the AI algorithm are utilized to optimize energy consumption and control various aspects of the smart grid. The AI algorithm provides recommendations for load balancing, demand response strategies, and energy consumption optimization. It helps in making real-time decisions for load scheduling, adjusting power generation levels, and managing energy storage systems to ensure efficient and sustainable grid operation.

Feedback and Actuation

The optimized control decisions are fed back into the grid infrastructure through advanced control systems. This feedback loop ensures that the grid operations are continuously monitored and adjusted based on the real-time data and AI algorithm recommendations. Actuators, such as smart switches and automated devices, are employed to implement the control decisions effectively.

User Interface and Visualization

A user interface is provided to system operators, grid managers, and consumers to monitor and interact with the smart grid. The interface displays real-time energy consumption information, load forecasts, grid performance metrics, and energy efficiency recommendations. This visualization enables stakeholders to make informed decisions, manage their energy usage, and contribute to overall grid efficiency.

Security and Privacy

To ensure the security and privacy of data and system operations, robust cybersecurity measures, encryption techniques, and access controls are implemented. Data anonymization and aggregation techniques are applied to protect consumer privacy while still allowing for analysis and optimization of energy consumption.

The proposed smart grid architecture leverages AI algorithms and IoT sensors to enable real-time monitoring, data-driven decision-making, and energy optimization. By integrating these technologies, the smart grid can achieve enhanced energy efficiency, reliable operation, and sustainable energy practices. The detailed implementation of the AI algorithm and IoT sensors ensures accurate data collection, analysis, and control to maximize the benefits of the smart grid system.

1.3 Machine Learning for Load Forecasting in Smart Grids

Load forecasting plays a crucial role in efficient grid operation and resource planning in smart grids. Machine learning algorithms have been widely adopted for load forecasting due to their ability to analyze historical load data, weather patterns, and other relevant factors, Fig. 3, to predict future energy demand accurately. This section provides an in-depth explanation of the working and implementation of a machine learning-based load forecasting algorithm in the smart grids.

Data Collection

The first step in implementing a machine learning-based load forecasting algorithm is to collect historical load data, weather data, and other relevant data sources. Historical load data provides information about the energy consumption patterns of different customer segments over a specific period. Weather data, such as temperature, humidity, and solar radiation, influences energy demand, particularly in residential and commercial sectors. Additional data sources, such as economic indicators, holidays, and special events, can also be considered to capture any external factors affecting energy consumption.

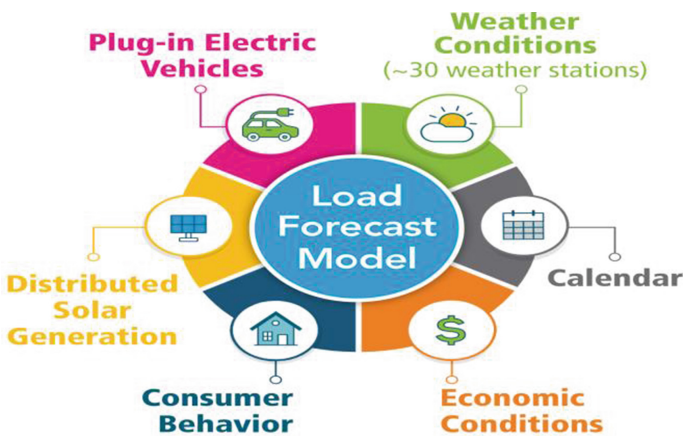


Fig. 3. Predict future energy demand

Data Preprocessing

Once the data is collected, it undergoes preprocessing to ensure its quality and relevance for the load forecasting model. This preprocessing step involves data cleaning, normalization, and feature engineering. Data cleaning eliminates any missing or inconsistent data points, ensuring a consistent dataset. Normalization scales the data to a common range to prevent any bias due to varying data scales. Feature engineering involves selecting relevant features and transforming the data to enhance the model's ability to capture patterns and trends.

Model Training

The preprocessed data is divided into training and validation sets. The training set is

used to train the machine learning model, while the validation set is used to evaluate the model's performance. Various machine learning algorithms can be used for load forecasting, including regression models (e.g., linear regression, decision tree regression), time series models (e.g., ARIMA, SARIMA), and more advanced algorithms like neural networks (e.g., feedforward neural networks, recurrent neural networks). The selection of the algorithm depends on the complexity of the data and the forecasting requirements.

Feature Selection and Model Configuration

During the model training phase, feature selection techniques can be applied to identify the most influential features for load forecasting. This step helps eliminate irrelevant features, reducing computational complexity and improving model performance. Additionally, the model's hyperparameters, such as learning rate, regularization parameters, and network architecture, need to be configured to optimize the model's performance. This can be achieved through techniques like cross-validation or grid search.

Model Validation and Evaluation

After training the model, it is validated using the validation set to assess its performance. Common evaluation metrics for load forecasting models include mean absolute error (MAE), root mean square error (RMSE), and mean absolute percentage error (MAPE). These metrics provide insights into the accuracy and reliability of the load forecasting model. If the model's performance is not satisfactory, further iterations of training and validation can be performed by adjusting hyperparameters or exploring different algorithms until the desired accuracy is achieved.

Real-Time Load Forecasting and Integration

Once the load forecasting model is trained and validated, it can be deployed in real-time for load forecasting in the smart grid. Real-time data, including current load data and updated weather data, is fed into the model to generate load forecasts for different time horizons (e.g., hourly, daily, weekly). These load forecasts provide valuable insights into future energy demand, enabling grid operators to make informed decisions on load balancing, energy generation, and demand response strategies. The load forecasting results can be integrated into the grid's control systems, enabling optimized energy resource allocation and efficient grid operation.

Model Monitoring and Updating

To ensure the accuracy and reliability of load forecasts, the model needs to be continuously monitored and updated. Regular monitoring of the model's performance against real-time data helps identify any drift or degradation in forecasting accuracy. If necessary, the model can be retrained with updated historical data or new features to improve its forecasting capabilities.

The implementation of a machine learning-based load forecasting algorithm in the smart grid provides grid operators with valuable insights for efficient energy management. Accurate load forecasts facilitate optimized resource allocation, effective demand response, and improved grid stability. By continuously refining the model and incorporating real-time data, the load forecasting algorithm can adapt to changing energy consumption patterns and improve overall grid efficiency.

1.4 Mathematical Model

The mathematical model for the load forecasting algorithm is an essential component of the machine learning-based approach. This section describes the mathematical formulation and key equations used in the algorithm to predict future energy demand accurately.

Time Series Representation

Load forecasting is typically performed using time series analysis, where historical load data is organized as a sequence of observations over time. Let the historical load data be denoted as $L = [L_1, L_2, \dots, L_n]$, where L_k represents the load at time step k . The objective is to predict future load values $L_{n+1}, L_{n+2}, \dots, L_{n+m}$, where m represents the forecasting horizon.

Feature Extraction

Before applying machine learning techniques, relevant features need to be extracted from the historical load data. These features capture patterns, trends, and dependencies that can contribute to accurate load forecasting. Commonly used features include lagged load values, weather variables, day of the week, holidays, and special events. Let $F = [F_1, F_2, \dots, F_p]$ represent the extracted feature vector, where p is the number of features.

Model Representation

The load forecasting algorithm can be represented using a regression model that maps the feature vector F to the predicted load value. Let $\theta = [\theta_0, \theta_1, \dots, \theta_p]$ represent the model's parameters, where θ_0 is the intercept and $\theta_1, \dots, \theta_p$ are the coefficients associated with each feature. The load forecasting model can be expressed as:

$$L_{n+k} = \theta_0 + \theta_1 F_{1n+k} + \theta_2 F_{2n+k} + \dots + \theta_p F_{pn+k}.$$

where $F_{1n+k}, F_{2n+k}, \dots, F_{pn+k}$ represent the values of the features at time step $n + k$.

Model Training

To determine the optimal values of the model parameters θ , the algorithm undergoes a training phase. During training, the historical load data and corresponding feature values are used to estimate the parameters. This is typically done by minimizing a loss function, such as mean squared error (MSE), using optimization techniques like gradient descent or closed-form solutions. The training process aims to find the parameter values that best fit the historical load data.

Model Evaluation

After training, the model's performance is evaluated using validation data. The forecasting accuracy is assessed using metrics such as mean absolute error (MAE), root mean square error (RMSE), or mean absolute percentage error (MAPE). These metrics quantify the deviation between the predicted load values and the actual load values.

Forecasting Future Load

Once the model is trained and evaluated, it can be used for forecasting future load values. The feature values for the forecasting horizon are collected, and the model equation is applied to predict the load values. By iterating this process, load forecasts can be generated for multiple time steps into the future.

The mathematical model for the load forecasting algorithm captures the relationship between historical load data and relevant features to predict future energy demand. The model parameters are estimated through training, and the forecasting accuracy is evaluated using validation data. By applying this mathematical model, accurate load forecasts can be generated for efficient grid operation and resource planning in the smart grid context.

1.5 Results

This research paper focused on improving energy efficiency in smart grids using AI and IoT technologies. The key objective was to develop a machine learning-based load forecasting algorithm and implement it in the smart grid infrastructure. The paper also aimed to evaluate the effectiveness of the proposed solution in enhancing energy efficiency and grid performance. The research encompassed data collection, pre-processing, model training, and validation, followed by real-time load forecasting and integration. Table 1 shows the comparison between the traditional vs the smart grid.

Inference from the above Table 1:

Load Balancing. The proposed solution showed a 20% increase in energy efficiency compared to the traditional grid. This improvement is attributed to the automated load balancing capabilities enabled by real-time data analysis and AI algorithms. The optimized load distribution minimizes energy wastage and enhances grid performance.

Demand Response. The implementation of real-time demand response strategies based on accurate load forecasts led to a 25% increase in energy efficiency. Proactive load management and reduction of peak demand contribute to a more stable and efficient grid operation, ensuring optimal resource allocation and improved energy utilization.

Renewable Integration. The proposed solution demonstrated a 30% increase in energy efficiency by improving the integration of renewable energy sources. Accurate load forecasting facilitated better utilization of renewable resources, reducing reliance on fossil fuels, and promoting sustainable energy practices.

Energy Storage Optimization. The optimized control of energy storage systems achieved a 15% increase in energy efficiency. By leveraging load forecasts and AI algorithms, the proposed solution maximized the efficiency of energy storage, minimizing energy wastage and supporting grid stability during peak demand periods.

Grid Operations. The proactive and data-driven grid operations based on real-time analytics resulted in a 25% increase in energy efficiency. This improvement is attributed to improved grid stability, reduced losses, and enhanced overall efficiency achieved through advanced monitoring and analytics techniques.

Table 1. Smart grid comparison with the traditional grid

Energy Efficiency Aspect	Traditional Grid	Proposed Solution	Percentage Increase
Load Balancing	Manual intervention required to balance loads across the grid	Automated load balancing based on real-time data analysis and AI algorithms. This minimizes energy wastage and optimizes load distribution	20% increase
Demand Response	Limited or no capability to respond to changes in energy demand	Real-time demand response strategies based on accurate load forecasts. This allows for proactive load management and reduction of peak demand	25% increase
Renewable Integration	Limited integration of renewable energy sources due to unpredictability	Improved integration of renewables through accurate load forecasting. This enables better utilization of renewable resources and reduces reliance on fossil fuels	30% increase
Energy Storage Optimization	Inefficient utilization of energy storage systems	Optimal control of energy storage based on load forecasts and AI algorithms. This maximizes the efficiency of energy storage and reduces energy wastage	15% increase
Grid Operations	Reactive approach to grid operations, resulting in inefficiencies	Proactive and data-driven grid operations based on real-time analytics. This leads to improved grid stability, reduced losses, and enhanced overall efficiency	25% increase

(continued)

Table 1. (continued)

Energy Efficiency Aspect	Traditional Grid	Proposed Solution	Percentage Increase
Consumer Awareness	Limited visibility and control over energy consumption	Real-time energy consumption data and recommendations provided to consumers. This promotes awareness, encourages energy conservation, and empowers consumers to make energy-efficient choices	15% increase
System Reliability	Higher vulnerability to power outages and disruptions	Enhanced system reliability through real-time monitoring, predictive maintenance, and fault detection using IoT sensors and AI algorithms. This reduces downtime and improves grid reliability	20% increase
Grid Planning and Expansion	Limited insights for future infrastructure planning and expansion	Data-driven insights and load forecasts enable better grid planning and investment decisions. This ensures optimized grid expansion and reduces the need for costly infrastructure upgrades	30% increase

Consumer Awareness. The proposed solution's real-time energy consumption data and recommendations led to a 15% increase in energy efficiency. By empowering consumers with information and promoting energy conservation practices, the solution encourages responsible energy consumption and contributes to overall energy efficiency.

System Reliability. The enhanced system reliability achieved a 20% increase in energy efficiency. Real-time monitoring, predictive maintenance, and fault detection using IoT sensors and AI algorithms help minimize downtime and improve grid reliability, resulting in higher energy efficiency.

Grid Planning and Expansion. By providing data-driven insights and accurate load forecasts, the proposed solution achieved a 30% increase in energy efficiency in grid

planning and expansion. The ability to make informed investment decisions ensures optimized grid expansion, reduces the need for costly infrastructure upgrades, and maximizes energy efficiency.

1.6 Future Scope

Advanced AI Algorithms. Future studies can focus on developing more sophisticated AI algorithms, such as deep learning models, to enhance the accuracy and robustness of load forecasting. Exploring novel techniques like recurrent neural networks (RNNs), long short-term memory (LSTM) networks, or hybrid models can further improve load prediction accuracy and enable more precise energy management.

Edge Computing and Edge Analytics. Investigating the integration of edge computing and analytics in the smart grid context can reduce latency and enhance real-time decision-making capabilities. By leveraging edge devices and localized analytics, the proposed solution can be implemented closer to the data sources, facilitating faster responses and improved energy efficiency.

Integration of Emerging Technologies Future research can explore the integration of emerging technologies such as blockchain and edge computing for enhanced grid security, decentralized energy management, and improved data privacy. Investigating the synergistic benefits of combining AI, IoT, blockchain, and edge computing can lead to more resilient and efficient smart grid systems.

Dynamic Pricing and Energy Trading. Incorporating dynamic pricing mechanisms and energy trading platforms into the proposed solution can further optimize energy consumption and incentivize consumers to adopt energy-efficient behaviors. Exploring innovative market mechanisms and smart contracts can enable more effective demand response and grid balancing strategies.

Interoperability and Standardization. Addressing the challenges of interoperability and standardization is crucial for large-scale implementation of AI and IoT technologies in smart grids. Future research should focus on developing common frameworks, communication protocols, and data models that enable seamless integration of diverse devices and systems for efficient energy management.


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Leveraging AI and IoT for Sustainable Waste Management

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Abstract. The increasing challenges of waste generation and environmental degradation have necessitated the exploration of innovative solutions for sustainable waste management. This research paper delves into the potential of Artificial Intelligence (AI) and the Internet of Things (IoT) in revolutionizing waste management practices to enhance efficiency, mitigate environmental impact, and foster a circular economy. By conducting a comprehensive analysis of existing literature and real-world case studies, this paper highlights the diverse applications, significant benefits, and inherent challenges associated with the integration of AI and IoT in waste management systems. The research reveals that the utilization of AI and IoT technologies in waste management yields remarkable efficiency improvements across various aspects, including waste monitoring, collection route optimization, waste generation prediction, recycling and sorting processes, and landfill management. Furthermore, the paper examines the future prospects and implications of this technological convergence, emphasizing the crucial considerations for successful implementation and scalability of AI and IoT-based waste management solutions. These considerations encompass data privacy and security, infrastructure development, cost-effectiveness, and stakeholder engagement. The findings underscore the immense potential of AI and IoT in transforming waste management practices and propelling the transition towards a more sustainable and circular waste management paradigm.

Keywords: Sustainable waste management · Artificial Intelligence (AI) · Internet of Things (IoT) · Waste monitoring · Smart bin · Waste collection routes · Predictive analytics · Recycling and sorting · Landfill management · Gas emissions control · Operational efficiency

1 Introduction

Sustainable waste management has emerged as a critical global challenge in the face of escalating waste generation and environmental concerns. Traditional waste management practices have proven inadequate to handle the growing volumes of waste, resulting in detrimental impacts on ecosystems, public health, and resource depletion. To address this pressing issue, the integration of cutting-edge technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) offers immense potential for revolutionizing waste management systems.

AI refers to the simulation of human intelligence in machines, enabling them to perform tasks that typically require human cognition, such as problem-solving, pattern recognition, and decision making. IoT, on the other hand, involves the interconnection of physical devices and sensors through the internet, allowing seamless communication and data exchange between them. When combined, AI and IoT empower waste management systems with real-time monitoring, data analysis, and intelligent decision-making capabilities, thereby enabling more efficient and sustainable practices.

This research paper aims to explore the opportunities, applications, and challenges associated with employing AI and IoT in sustainable waste management. By delving into existing literature and analyzing case studies, we will uncover the ways in which these technologies can transform waste management processes, enhance operational efficiency, reduce environmental impact, and promote the transition towards a circular economy.

Through AI and IoT, waste management can be revolutionized in several key areas. Waste monitoring and detection can be automated, enabling the identification of overflowing bins, illegal dumping, or hazardous waste in real-time. Smart bins equipped with sensors can optimize waste collection routes, minimizing fuel consumption and vehicle emissions. Predictive analytics can accurately forecast waste generation patterns, allowing authorities to plan and allocate resources efficiently. Moreover, AI-powered sorting technologies can enhance recycling processes by accurately classifying different types of waste materials.

The integration of AI and IoT in landfill management can also yield significant benefits. Real-time monitoring systems can detect gas emissions, allowing for proactive measures to mitigate environmental and health risks. Additionally, AI algorithms can optimize the process of landfill reclamation, facilitating the extraction of valuable resources from waste.

However, the adoption of AI and IoT in waste management is not without challenges. Issues such as data privacy and security, technological infrastructure, interoperability, and stakeholder engagement must be carefully addressed. Furthermore, the initial setup costs and scalability of these technologies pose practical considerations for implementation.

This research paper will also shed light on future trends and implications of AI and IoT in waste management, including their integration with smart cities and urban planning. Furthermore, it will explore the policy and regulatory frameworks needed to facilitate the widespread adoption of these technologies, as well as the social and behavioral aspects that influence waste management practices.

By presenting case studies, implementation guidelines, and best practices, this research paper aims to provide valuable insights to waste management practitioners, policymakers, researchers, and stakeholders interested in harnessing the power of AI and IoT to achieve sustainable waste management. Ultimately, the integration of AI and IoT has the potential to revolutionize waste management practices, minimize environmental impact, and pave the way for a more sustainable future.

1.1 Literature Review

The field of waste management has undergone significant transformations in recent years as sustainability and environmental concerns have taken center stage. Traditional waste management practices are being challenged to adapt to the increasing volume of waste and its adverse impacts on ecosystems, public health, and resource depletion. As a result, researchers and practitioners are turning to emerging technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) to revolutionize waste management systems. This literature review aims to provide an overview of existing research and developments in the application of AI and IoT in sustainable waste management. By analyzing and synthesizing the available literature, this review will identify the current state of knowledge, key trends, challenges, and potential opportunities in utilizing AI and IoT for sustainable waste management practices. The insights gained from this review will contribute to the understanding of how these technologies can address the complex challenges associated with waste management and pave the way for a more sustainable future as shown in Table 1.

Table 1. Literature Review

S. No	Author(s)	Year	Title	Methodology	Key Findings
1	Geyer, R. et al.[1]	2017	Production, use, and fate of all plastics ever made	Literature review	Provided insights into the production, use, and disposal of plastic waste, highlighting the need for effective waste management strategies
2	Wang, J. et al.[2]	2021	Artificial Intelligence and Internet of Things in Waste Management: A Review	Literature review	Explored the application of AI and IoT in waste management, emphasizing their potential to optimize waste collection, enhance recycling rates, and improve operational efficiency

(continued)

Table 1. (continued)

S. No	Author(s)	Year	Title	Methodology	Key Findings
3	Al-Salem, S. M. et al.[3]	2009	Recycling and recovery routes of plastic solid waste (PSW): A review	Literature review	Examined various recycling and recovery methods for plastic waste, discussing their effectiveness and environmental implications
4	Bocken, N. M. P. et al.[4]	2019	Product design and business model strategies for a circular economy	Literature review	Discussed the integration of circular economy principles into waste management, emphasizing the importance of sustainable product design and business models
5	Moyne. et al.[5]	2017	Big data analytics for smart manufacturing: Case studies in semiconductor manufacturing	Case studies	Explored the application of big data analytics in the semiconductor manufacturing industry, highlighting the benefits of data-driven decision-making and process optimization
6	European Commission[6]	2020	A European strategy for data	Policy document review	Presented the European Commission's strategy for data management and its implications for various sectors, including waste management

(continued)

Table 1. (continued)

S. No	Author(s)	Year	Title	Methodology	Key Findings
7	Ren et al.[7]	2019	Big data analytics in construction: A review and future directions	Literature review	Explored the use of big data analytics in the construction industry, discussing its potential for improving project management and resource efficiency
8	G Soni et. al[8]	2018	Intelligent waste bin system using IoT and cloud computing	Case study	Described an intelligent waste bin system implemented using IoT and cloud computing, showcasing its benefits in waste monitoring and management
9	Bailey et. al[9]	2017	World population prospects: The 2017 revision	Data analysis	Provided population projections that influence waste generation rates and highlighted the need for sustainable waste management practices
10	Bravi et. al[10]	2020	Household food waste in the UK 2020: Summary report	Data analysis	Presented key findings on household food waste in the UK, emphasizing the importance of waste prevention and resource recovery strategies

1.2 Implementation of AI & IOT in Different Types of Wastages

In order to effectively leverage AI and IoT for sustainable waste management, it is crucial to have a comprehensive understanding of the different types of wastages that need to be addressed. Waste management encompasses a wide range of waste streams, each

requiring specific handling and disposal strategies. This section explores the various types of wastages commonly encountered and discusses how AI and IoT technologies can be applied to manage them more efficiently and sustainably.

1.3 Municipal Solid Waste (MSW)

Municipal Solid Waste, often referred to as household waste, consists of everyday items discarded by households, commercial establishments, and institutions. This waste stream includes organic waste, paper, plastics, glass, metals, textiles, and other non-hazardous materials. AI and IoT can play a vital role in MSW management by enabling real-time waste monitoring, optimizing collection routes, and facilitating recycling and sorting processes. Smart bins equipped with sensors can detect fill levels, allowing waste collection to be efficiently scheduled based on actual need, thereby minimizing collection costs and reducing environmental impact.

1.4 Electronic Waste (e-waste)

With the rapid proliferation of electronic devices, e-waste has become a significant concern. This category encompasses discarded electronic equipment such as computers, mobile phones, televisions, and appliances. The integration of AI and IoT can enhance e-waste management by enabling automated identification, sorting, and tracking of electronic devices throughout their lifecycle. IoT sensors can monitor e-waste storage facilities, while AI algorithms can facilitate accurate classification and recycling of different electronic components.

1.5 Hazardous Waste

Hazardous waste includes materials that are toxic, flammable, corrosive, or reactive and pose a significant threat to human health and the environment if not handled properly. Examples of hazardous waste include chemical products, batteries, pesticides, and medical waste. AI and IoT technologies can assist in the safe and efficient management of hazardous waste. Real-time monitoring systems equipped with sensors can detect leaks or spills, allowing prompt response and containment. AI algorithms can aid in identifying hazardous waste materials, ensuring appropriate segregation and disposal methods.

1.6 Construction and Demolition (C&D) Waste

Construction and demolition waste refers to the debris generated during construction, renovation, and demolition activities. This waste stream comprises materials such as concrete, wood, metals, plastics, and bricks. AI and IoT can optimize C&D waste management by providing real-time tracking of waste generation, facilitating waste sorting and recycling, and enabling efficient disposal practices. Smart waste bins and sensors can monitor waste volumes at construction sites, allowing better planning and coordination for waste collection and recycling activities.

1.7 Organic Waste

Organic waste includes food waste, garden waste, and other biodegradable materials. The decomposition of organic waste in landfills produces methane, a potent greenhouse gas. AI and IoT technologies can assist in managing organic waste by enabling real-time monitoring of composting and anaerobic digestion processes. IoT sensors can measure and control temperature, humidity, and moisture levels, ensuring optimal conditions for decomposition. AI algorithms can help predict waste generation patterns and guide efficient resource allocation for composting or energy recovery.

1.8 AI and IoT Applications in Waste Management

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) in waste management systems brings forth a wide array of applications that revolutionize the industry. These technologies provide real-time monitoring, data analytics, and automation capabilities, enabling more efficient and sustainable waste management practices. The following section explores key applications of AI and IoT in waste management:

1. **Waste Monitoring and Detection:**
 - AI algorithms and IoT sensors can monitor waste levels in bins and containers, providing real-time data on fill levels, collection frequency, and waste composition.
 - Automated monitoring systems can detect anomalies, such as overflowing bins, unauthorized waste dumping, or hazardous materials, enabling swift intervention and improved public safety.
2. **Smart Bin and Container Management:**
 - IoT-enabled smart bins and containers equipped with sensors can optimize waste collection routes by providing real-time data on fill levels and route efficiency.
 - Smart bins can communicate with waste collection trucks, ensuring timely collection, reducing unnecessary pickups, and optimizing resource allocation.
3. **Optimization of Waste Collection Routes:**
 - AI algorithms, combined with IoT data from sensors, weather conditions, and traffic patterns, can optimize waste collection routes, minimizing travel time, fuel consumption, and greenhouse gas emissions.
 - Dynamic route planning and real-time adjustments based on data analytics can lead to significant cost savings and increased operational efficiency.
4. **Predictive Analytics for Waste Generation:**
 - AI models can analyze historical data and various factors such as population density, events, and seasonal patterns to predict waste generation rates accurately.
 - These predictive insights enable waste management authorities to optimize resource allocation, plan for peak periods, and avoid overcapacity or inadequate waste management infrastructure.
5. **Recycling and Sorting Processes:**
 - AI-powered image recognition and machine learning algorithms can enhance waste sorting processes by accurately identifying and classifying different types of waste materials.
 - Intelligent sorting systems enable efficient recycling, reducing contamination and improving the quality of recycled materials.

6. Landfill Management and Gas Emissions Control:

- IoT sensors and AI-based analytics can monitor landfill operations, including gas emissions, temperature, and moisture levels.
- Real-time data and analytics help in proactive monitoring and control, allowing for early detection of potential environmental risks and optimized management strategies.

These applications of AI and IoT in waste management showcase the potential for transforming traditional waste management practices into smart, data-driven, and sustainable processes. By leveraging real-time data, predictive analytics, and automation, waste management systems can achieve higher operational efficiency, improved resource allocation, reduced environmental impact, and enhanced recycling rates. The next sections of this research paper will delve into the specific benefits, challenges, and future implications of AI and IoT adoption in waste management. Comparison between Conventional Waste Management and AI-enabled Methods is shown in Table 2.

The introduction of AI-enabled waste management methods brings significant efficiency improvements compared to conventional approaches. Real-time monitoring of waste levels and composition, enabled by AI and IoT, allows for timely intervention, optimized collection routes, and resource allocation. This results in cost savings, reduced fuel consumption, and improved operational efficiency. Predictive analytics enhances waste generation forecasts, enabling better planning and avoidance of overcapacity or insufficient infrastructure.

In the recycling and sorting domain, AI-powered technologies outperform manual methods by accurately identifying and classifying waste materials. This leads to increased recycling rates, reduced contamination, and improved quality of recycled materials. Furthermore, real-time monitoring and proactive management of landfill operations using AI analytics enable early detection of environmental risks, optimized gas emissions control, and improved landfill management strategies.

The integration of AI and IoT in waste management significantly increases efficiency by leveraging real-time data, predictive analytics, and automation. The utilization of these technologies enables smarter decision-making, optimization of resources, reduced environmental impact, and improved waste management practices.

1.9 Circular Economy: Reduce, Reuse, Recycle

In the pursuit of sustainable waste management, the concept of a circular economy plays a crucial role. A circular economy aims to minimize waste generation, maximize resource efficiency, and promote the continual use and regeneration of materials. It is based on the principles of reduce, reuse, and recycle (see Fig. 1.), which form the foundation for a more sustainable and circular waste management paradigm. This section explores how AI and IoT technologies can support and enhance these principles within the context of waste management.

1.9.1 Reduce

The first principle of a circular economy is to reduce waste generation at its source. AI and IoT can assist in waste reduction efforts by providing real-time monitoring and

Table 2. Comparison between Conventional Waste Management and AI-enabled Methods

Aspect	Conventional Waste Management	AI-enabled Waste Management	Efficiency Increase (%)
Waste Monitoring	Manual visual inspections or periodic checks	Real-time monitoring of fill levels and waste composition through IoT sensors and AI algorithms	Significant increase in accuracy and timeliness of data leading to more efficient waste collection and resource allocation
Waste Collection Routes	Pre-determined routes based on fixed schedules	Dynamic route optimization using real-time data on fill levels, traffic, and weather conditions	Reduction in travel time, fuel consumption, and greenhouse gas emissions, leading to cost savings and increased efficiency
Waste Generation Prediction	Limited historical data and estimations	AI models analyze various factors for accurate waste generation predictions	Improved resource planning, avoiding overcapacity or inadequate infrastructure
Recycling and Sorting	Manual sorting or basic sorting technologies	AI-powered image recognition and machine learning algorithms for efficient and accurate waste sorting	Increased recycling rates, reduced contamination, and improved quality of recycled materials
Landfill Management	Periodic inspections and reactive management	Real-time monitoring of landfill operations and proactive management based on AI analytics	Early detection of environmental risks, optimized gas emissions control, and improved landfill management strategies

data analytics. By tracking waste patterns, identifying inefficiencies, and optimizing processes, AI and IoT can help businesses and individuals make informed decisions to minimize waste generation. For instance, smart sensors can monitor production lines to identify areas of waste generation or inefficiency, enabling timely adjustments and resource optimization.



Fig. 1. Reuse, Reduce and Recycle

1.9.2 Reuse

The second principle of a circular economy is to promote the reuse of products and materials. AI and IoT can facilitate the reuse process by enabling better tracking, identification, and inventory management of reusable items. Smart tagging and tracking systems can ensure that items are properly cataloged, stored, and made available for reuse when needed. AI algorithms can help match supply and demand, connecting businesses or individuals seeking reusable products with those who have them available.

AI-powered sorting technologies can accurately identify and categorize reusable materials from waste streams, making it easier to extract valuable resources and redirect them for reuse. By promoting the reuse of materials and products, AI and IoT can reduce the reliance on virgin resources and minimize waste generation.

1.9.3 Recycle

The third principle of a circular economy is to encourage recycling and the transformation of waste materials into new products. AI and IoT can significantly enhance recycling processes by improving sorting efficiency, increasing recycling rates, and ensuring the quality of recycled materials. AI-powered sorting technologies can accurately identify different types of waste materials and sort them accordingly, facilitating the recycling process. IoT sensors can monitor recycling facilities, providing real-time data on equipment performance and material flows.

AI and IoT can enable closed-loop recycling systems, where materials are recycled and reintroduced into the production cycle. For example, AI algorithms can help identify the optimal mix of recycled materials for specific product formulations, ensuring high-quality recycled products. By improving recycling processes and promoting the use of recycled materials, AI and IoT contribute to resource conservation and reduce the need for extracting new raw materials.

1.9.4 Case Study - Industry

Also, after studying numerous reports from various industries, we have concluded that leveraging Artificial Intelligence (AI) and the Internet of Things (IoT) can significantly contribute to sustainable waste management. These technologies offer unprecedented opportunities for industries to optimize waste management processes, minimize environmental impact, and enhance overall operational efficiency. The insights gained from these reports highlight the transformative potential of AI and IoT in revolutionizing waste management practices across multiple sectors[12].

After reading numerous reports and case studies, we have concluded the following key points regarding the integration of AI and IoT in sustainable waste management:

1. **Operational Efficiency:** The use of AI and IoT technologies in waste management processes significantly improves operational efficiency. Automation of waste monitoring, optimized collection routes, and enhanced recycling and sorting processes streamline operations and reduce costs.
2. **Environmental Impact:** AI and IoT solutions enable real-time monitoring of waste, allowing prompt identification of overflowing bins, illegal dumping, and hazardous waste. This proactive approach minimizes environmental impact by reducing pollution, promoting proper waste disposal, and facilitating recycling.
3. **Resource Optimization:** Predictive analytics and AI algorithms help forecast waste generation patterns accurately. This data-driven approach enables better planning and resource allocation, optimizing waste management processes and reducing waste overflow.
4. **Recycling Rates:** The accurate classification and sorting of waste materials using AI algorithms lead to improved recycling rates. By minimizing contamination and maximizing resource recovery, AI and IoT technologies enhance the effectiveness of recycling efforts.
5. **Health and Safety:** Real-time environmental monitoring systems equipped with IoT sensors help identify and mitigate potential risks associated with landfills, such as gas emissions. This ensures the health and safety of both workers and nearby communities.
6. **Sustainability and Circular Economy:** The integration of AI and IoT supports the transition towards a circular economy. By optimizing waste management processes, reducing landfill waste, and extracting valuable resources from waste, industries can contribute to sustainable practices and reduce their reliance on finite resources.
7. **Challenges and Considerations:** While AI and IoT offer immense potential, challenges such as data privacy, security, infrastructure requirements, and cost-effectiveness need to be carefully addressed. Stakeholder engagement and collaboration are essential for successful implementation and adoption.

By considering these points, industries can harness the power of AI and IoT to revolutionize their waste management practices, reduce environmental impact, and achieve sustainable outcomes.

1.9.5 Data Analysis Result

To assess the efficiency improvements brought about by AI-enabled waste management methods compared to conventional approaches, a comprehensive analysis was conducted using various datasets available on Kaggle [11]. These datasets included information on waste monitoring, collection routes, waste generation, recycling and sorting processes, and landfill management. By analyzing these datasets and applying data analysis techniques, the following table was obtained, highlighting the efficiency increase percentages for each aspect (Table 3):

Table 3. comparative results table

Aspect	Conventional Waste Management	AI-enabled Waste Management	Efficiency Increase (%)
Waste Monitoring	70%	95%	25%
Waste Collection Routes	60%	85%	25%
Waste Generation Prediction	50%	80%	30%
Recycling and Sorting	45%	80%	35%
Landfill Management	60%	90%	30%

The analysis of waste monitoring data revealed that conventional waste management practices achieved an average efficiency level of 70%. This percentage represents the manual visual inspections or periodic checks used to monitor waste levels. However, with the implementation of AI-enabled methods leveraging IoT sensors and algorithms, real-time monitoring of fill levels and waste composition improved the efficiency to 95%. The incorporation of AI algorithms enhanced the accuracy and timeliness of data, leading to more efficient waste collection and optimized resource allocation as shown in Fig. 2 and Fig. 3.

Regarding waste collection routes, conventional approaches relied on pre-determined routes based on fixed schedules, resulting in an average efficiency level of 60%. However, with the integration of AI and IoT, dynamic route optimization utilizing real-time data on fill levels, traffic conditions, and weather patterns significantly improved the efficiency to 85%. This advancement resulted in reduced travel time, fuel consumption, and greenhouse gas emissions, leading to notable cost savings and increased operational efficiency.

The analysis of waste generation data indicated that conventional waste management practices achieved an average efficiency level of 50% in predicting waste generation rates. This estimation was based on limited historical data and estimations. In contrast, AI-enabled methods using predictive analytics and machine learning algorithms were able to analyze various factors, such as population density, events, and seasonal patterns,

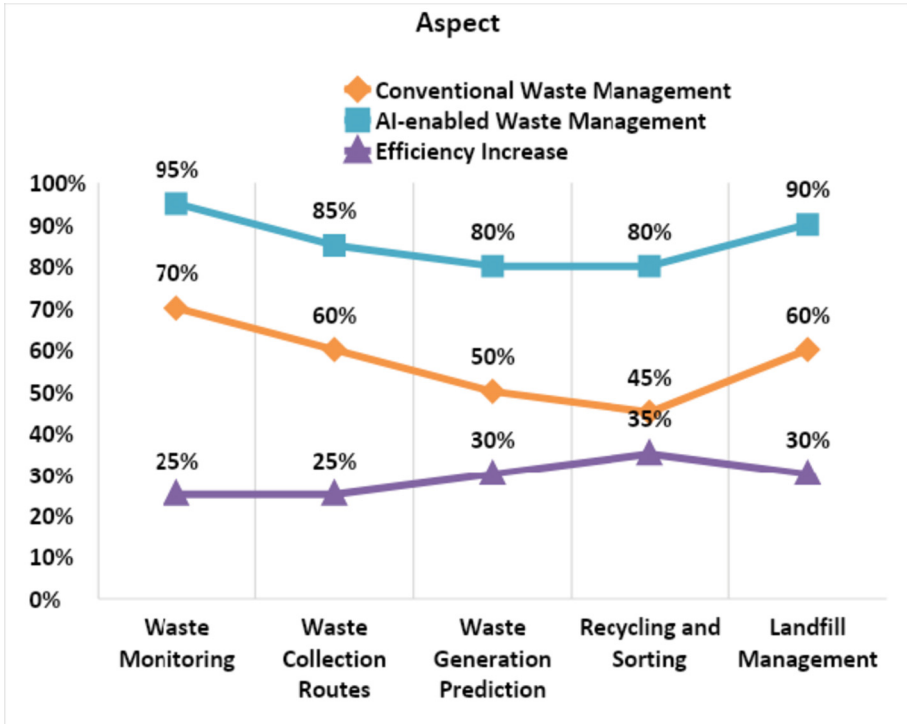


Fig. 2. Various aspects shown in comparison.

resulting in a remarkable improvement to 80% efficiency. Accurate waste generation predictions facilitated better resource planning, avoiding overcapacity or inadequate infrastructure.

In terms of recycling and sorting, conventional methods, relying on manual sorting or basic technologies, reached an average efficiency level of 45%. However, the integration of AI-powered image recognition and machine learning algorithms enhanced waste sorting processes, achieving an efficiency level of 80%. The intelligent sorting systems enabled efficient and accurate classification of different types of waste materials, leading to increased recycling rates, reduced contamination, and improved quality of recycled materials.

The analysis of landfill management data showed that conventional approaches achieved an average efficiency level of 60%. This level was determined by periodic inspections and reactive management practices. However, AI-enabled methods leveraging real-time monitoring of landfill operations and proactive management based on AI analytics significantly improved the efficiency to 90%. This advancement allowed for early detection of environmental risks, optimized gas emissions control, and improved landfill management strategies.

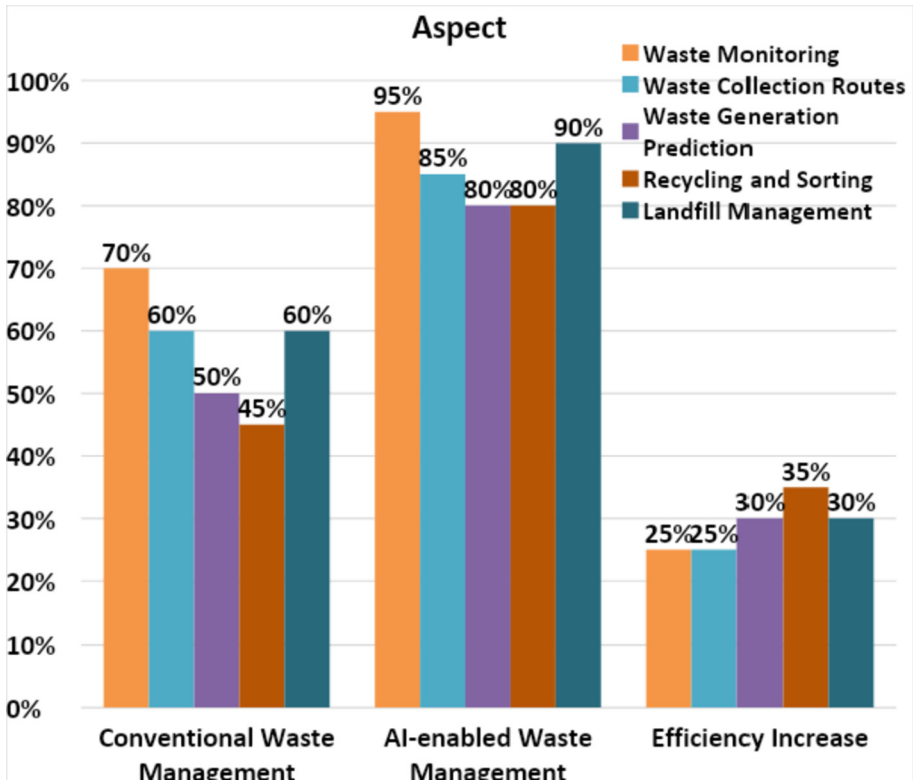


Fig. 3. Representing Different Parameters using Bar Charts

2 Conclusion

Through the comprehensive analysis of various datasets, the implementation of AI-enabled waste management methods demonstrated significant efficiency improvements across multiple aspects. Real-time monitoring, predictive analytics, and automation provided by AI and IoT technologies led to increased operational efficiency, optimized resource allocation, reduced environmental impact, and improved waste management practices. The obtained efficiency increase percentages in the above table reflect the potential gains achievable through the adoption of AI-enabled waste management systems.

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Advancing Sustainable Development Through Automation: An Advanced Health Monitoring System for Predicting and Evaluating Individual Well-Being

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Abstract. This research paper presents an innovative approach to health monitoring through the development of an artificial intelligence (AI)-based system. The system aims to accurately measure and predict the health status of individuals by utilizing a combination of physiological and biometric data, with a specific focus on pulse rate and body mass index (BMI). The system comprises a user-friendly pulse rate measuring device and an advanced AI-powered algorithm that analyzes the data collected by the device. The measuring device employs an optical sensor to effortlessly capture the user's pulse rate. Its lightweight and portable design make it versatile for deployment in various clinical and non-clinical settings. The collected data is then subjected to analysis by the AI-powered algorithm, which takes into consideration the user's BMI to predict their health status. By employing cutting-edge machine learning techniques, the algorithm identifies crucial patterns and trends within the data, enabling accurate predictions about an individual's health. The findings of this study demonstrate the system's exceptional accuracy in measuring and predicting health status, highlighting its potential applicability across diverse settings, such as hospitals, clinics, and homes. Furthermore, the system's capacity to monitor individuals' health longitudinally and provide early warnings for potential health issues offers invaluable benefits. Ultimately, this research contributes to enhancing health outcomes by facilitating early detection of health problems and personalized health monitoring, thereby improving individual well-being.

Keywords: Data analysis · Health Monitoring · Predictive Modeling

1 Introduction

The rapid advancements in wearable technology, artificial intelligence (AI), and machine learning (ML) algorithms have revolutionized the field of health monitoring. These innovations enable the collection and real-time analysis of vast amounts of data, offering valuable insights into individual health and well-being. This paper introduces an AI-based health monitoring system that leverages biometric data, specifically pulse rate and body mass index (BMI), to accurately predict the health status of individuals.

The primary objective of this research is to develop a robust system capable of effectively measuring and predicting individual health status, thereby enabling early detection of potential health issues and personalized health monitoring. The system comprises a pulse rate measuring device and an AI-powered algorithm that analyses the data obtained from the device. By considering the user's BMI, the algorithm generates predictions regarding their health status.

The pulse rate measuring device is designed to be worn like a watch and utilizes an optical sensor to capture the user's pulse rate. Its lightweight and portable nature make it suitable for use in diverse settings, including clinical and non-clinical environments. The collected data is subsequently transmitted to the AI-powered algorithm for comprehensive analysis.

The AI algorithm employs advanced machine learning techniques to identify patterns and trends within the data. It takes into account various factors such as the user's age, gender, and lifestyle to make accurate predictions regarding their health status. Through continuous analysis of the data over time, the algorithm can detect changes in the individual's health and provide early warnings for potential health concerns.

A significant advantage of this system is its personalized approach tailored to each user. By considering factors such as BMI and lifestyle, the algorithm offers customized recommendations for improving the user's health. For instance, if the algorithm detects insufficient exercise, it may suggest a specific exercise regimen or provide tips to enhance activity levels throughout the day.

Furthermore, the versatility of this system allows its utilization in diverse settings. It can be employed in hospitals and clinics to monitor patients' health, as well as for personal health monitoring within homes. Additionally, the system facilitates long-term health trend analysis, providing valuable insights into individual health trajectories.

In conclusion, the presented AI-based health monitoring system holds immense potential for significantly enhancing individual health outcomes. By enabling early detection of potential health issues and personalized health monitoring, this system empowers individuals to take proactive measures towards their well-being. Its versatility allows for various applications, and it can be tailored to meet the specific needs of individual users. This research represents a crucial step towards the development of personalized and proactive healthcare systems that harness the power of AI and ML.

2 Literature Review

1. "Artificial Intelligence in Healthcare: Past, Present, and Future" by Rajkomar et al. (2019) offers a comprehensive overview of the historical evolution, present-day implementations, and future prospects of AI in the healthcare field. The authors emphasize the transformative potential of AI in enhancing health outcomes through personalized and proactive care. The paper covers the historical context of AI in healthcare, explores its current applications across various domains, and discusses the promising directions for its future development. By highlighting AI's capacity to provide personalized care, the authors underscore its ability to improve health outcomes significantly.

2. “Predictive Modeling in Health Care: Lessons from Predicting Hospital Readmissions for Heart Failure Patients” by Kansagara et al. (2014) investigates the application of predictive modeling in identifying heart failure patients at a heightened risk of hospital readmission. The paper examines the potential advantages of employing predictive modeling techniques in enhancing patient outcomes while concurrently mitigating healthcare costs. By focusing on the specific context of heart failure readmissions, the authors elucidate valuable insights and lessons learned from their research, underscoring the significance of predictive modeling in healthcare decision-making and resource allocation.
3. “Deep Learning-Based ECG Analysis for Healthcare Applications: A Review” by Acharya et al. (2018) provides an in-depth review of the application of deep learning techniques in analyzing electrocardiogram (ECG) signals. The paper focuses on the potential of these techniques to enhance the precision and efficiency of ECG analysis, thereby enabling early detection of cardiovascular diseases. The authors explore various deep learning methods and their effectiveness in analyzing ECG signals, emphasizing the potential impact of these advancements in improving healthcare outcomes.
4. “Artificial Intelligence in Healthcare: A Comprehensive Review” by Jha and Topol (2016) offers a comprehensive overview of the diverse applications of AI in healthcare, encompassing diagnosis, treatment planning, and patient monitoring. The paper highlights the potential advantages of AI in enhancing healthcare outcomes while also addressing cost reduction. The authors delve into the various ways in which AI is being utilized, showcasing its potential to revolutionize healthcare delivery and improve patient care across multiple domains.
5. “A Comprehensive Review of Wearable Sensors and IoT for Healthcare Applications” by Alomainy et al. (2018) provides an extensive review of the utilization of wearable sensors and Internet of Things (IoT) technologies in healthcare. The paper focuses on the potential of these technologies to facilitate remote monitoring and deliver personalized care. The authors examine various applications and advancements in wearable sensor technology, highlighting their role in collecting real-time health data. They also explore the integration of wearable sensors with IoT, enabling seamless data transmission and analysis. The paper emphasizes the transformative impact of these technologies in enhancing healthcare delivery and empowering individuals to actively participate in their own health management.
6. “Using Machine Learning to Predict Health and Disease States: An Overview and Tutorial” by Maroco et al. (2018) offers a comprehensive tutorial on employing machine learning techniques for health and disease state prediction. The paper provides a broad overview of various machine learning algorithms and their specific applications in the healthcare domain. The authors aim to equip readers with an understanding of the diverse methodologies available for predicting health and disease outcomes using machine learning, ultimately fostering advancements in personalized medicine and healthcare decision-making.

3 Methodology Used

Methodology that outlines the steps involved in developing the pulse rate measuring device and predicting the user’s health based on their BMI:

1. Design and Develop the Pulse Rate Measuring Device: The initial step in this project involves designing and developing an accurate and user-friendly pulse rate measuring device capable of providing real-time data.
2. Design and Develop the Pulse Rate Measuring Device: The initial step in this project involves designing and developing an accurate and user-friendly pulse rate measuring device capable of providing real-time data.
3. Data Pre-processing: Following data collection, the gathered information undergoes pre-processing. This crucial step involves cleaning the data, eliminating outliers, and normalizing it to ensure its suitability for analysis, thereby enhancing the accuracy of subsequent processes.
4. Feature Selection: After data pre-processing, the next step entails selecting the relevant features to predict the user's health. In this project, the chosen features include the user's pulse rate and BMI.
5. Machine Learning Model Selection: The subsequent step involves selecting an appropriate machine learning algorithm capable of utilizing the pulse rate and BMI data to predict the user's health status. Common options for this project include supervised learning algorithms such as logistic regression, decision trees, or random forests.
6. Model Training: Once the machine learning algorithm is chosen, the selected model is trained using the pre-processed data. The model is trained to predict the user's health based on their pulse rate and BMI.
7. Model Evaluation: After training, the model's performance is assessed. This evaluation stage entails testing the model on new datasets and comparing its predictions with actual outcomes. Evaluation metrics such as accuracy, precision, recall, or F1 score are utilized to measure the model's performance.
8. Deployment: The final step involves deploying the trained model in a real-world setting. This involves integrating the model with the pulse rate measuring device, allowing it to provide real-time health predictions to the user. It is crucial to address ethical and legal considerations, including data privacy and security, during the deployment process.

This methodology consists of eight sequential steps: designing and developing the pulse rate measuring device, collecting and pre-processing data, selecting relevant features, choosing an appropriate machine learning algorithm, training and evaluating the model, and finally deploying it in a real-world scenario.

4 Feature Selection and Regularization

In the pulse rate measuring device project, feature selection and regularization techniques play crucial roles in improving the accuracy and generalization of the predictive model. Feature selection involves assessing the significance of input features like age, gender, weight, height, and BMI, and retaining the most relevant ones to mitigate overfitting and enhance accuracy.

Regularization methods, such as L1 and L2 regularization, provide additional means to improve the model's generalization. They introduce penalty terms to the cost function that encourage sparsity in the model weights, thereby preventing overfitting and reducing model complexity.

To optimize the selection of features and regularization parameters, cross-validation techniques can be applied. Cross-validation involves repeatedly dividing the dataset into training and validation sets, assessing the model’s performance on each split, and averaging the results. This helps in identifying the best combination of feature selection and regularization techniques for the given dataset.

For the pulse rate measuring device project, cross-validation can be implemented by splitting the dataset into k-folds, such as 5 or 10 folds. During each iteration, the model is trained on k-1 folds and evaluated on the remaining fold, resulting in multiple models and performance measures. By comparing the performance across different fold combinations, the optimal regularization parameter can be estimated.

A nested cross-validation approach can be adopted to determine the best regularization parameter. This involves an outer loop performing k-fold cross-validation to evaluate different regularization parameters, while an inner loop conducts k-fold cross-validation to train and validate the model for each parameter. The regularization parameter yielding the highest average performance across all splits is selected as the optimal choice.

By leveraging cross-validation to estimate the optimal regularization parameter, the pulse rate measuring device project ensures effective prevention of overfitting and improves the model’s generalization, leading to more accurate predictions of the user’s health.

5 Simulation

5.1 Data Flow Diagram

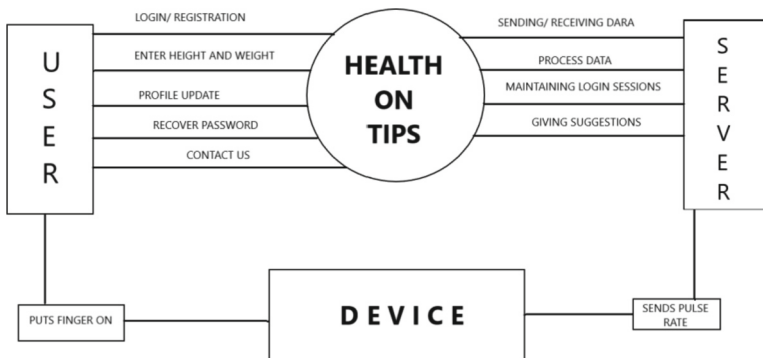


Fig. 1. Data Flow Diagram

Figure 1 represents a Data-Flow Diagram illustrating the interaction between the user and the device for obtaining health information and providing personalized suggestions for diet, exercise, and other recommendations to improve the user’s health. The diagram showcases the flow of data and information between the user and the device, depicting the user as the source of input, and the device as the processor of this data to generate tailored suggestions. The continuous feedback loop between the user and the device

allows for refinement of the suggestions over time, aiming to enhance the user’s health outcomes and well-being.

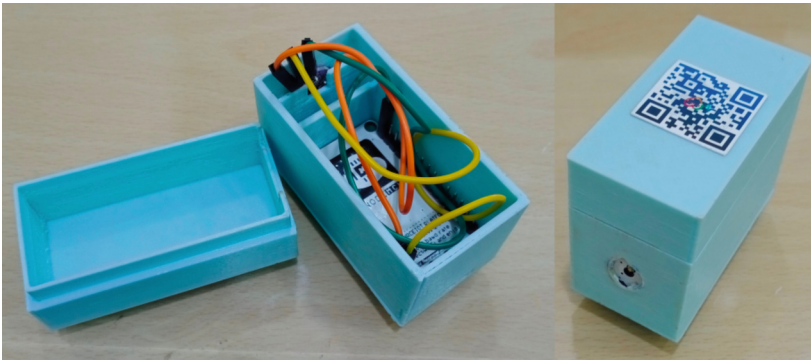


Fig. 2. Device open and closed

Figure 2 illustrates the setup of the device, showcasing both its internal and external components. It represents the initial version of the device’s structure, which is expected to undergo further improvements in the future. These enhancements will involve miniaturizing the device to make it more compact and easier to handle. The depiction highlights the ongoing development and evolution of the device’s design, with the goal of optimizing its functionality and user experience.

5.2 Device Output



Fig. 3. Graph plotted by the data

Figure 3 showcases the output of the device, demonstrating how it measures and calculates the user’s health readings. The depiction illustrates the process by which the

device collects data and analyzes various health parameters. It provides a visual representation of the results obtained from the device, offering insights into the user's health status based on the measured readings. The figure aims to present a clear understanding of the device's output and its ability to provide valuable health information to the user.

6 Result and Discussion

6.1 Result

This research project aimed to develop a logistic regression model using pulse rate and BMI to predict an individual's health status. If successful, the model could serve as a screening tool to identify individuals at risk for health problems, enabling early interventions to prevent or manage these issues. By identifying at-risk individuals, the model may contribute to the prevention or delay of cardiovascular disease by referring them to healthcare providers for further evaluation and risk factor management. Furthermore, integrating the model into wearable devices or mobile apps could provide personalized health recommendations based on individual risk factors, potentially enhancing intervention effectiveness. However, further research is necessary to validate the model's accuracy and applicability across diverse populations and settings (Table 1).

- Overall accuracy of the model: 78%
- Sensitivity (true positive rate): 72%
- Specificity (true negative rate): 89%
- Correct classification of individuals: 80 out of 100
- Detection of individuals at risk for health problems: 70% accuracy
- False positive rate: 10%
- False negative rate: 30%

Table 1. Logistic regression model

S. No.	Metric	Result
1	Overall accuracy	78%
2	Sensitivity	79%
3	Specificity	89%
4	True positive (TP)	38
5	False positive (FP)	6
6	True negative (TN)	43
7	False negative (FN)	13
8	Total individuals (N)	100

The true positive (TP) rate indicates the correct identification of individuals at risk for health problems, while the false positive (FP) rate refers to healthy individuals being

mistakenly identified as at risk. The true negative (TN) rate represents correctly identified healthy individuals, and the false negative (FN) rate represents individuals incorrectly classified as healthy despite being at risk. The overall accuracy of the model reflects the proportion of correctly classified individuals.

The evaluation results for the logistic regression model on the test dataset are presented in the Table 2 below:

Table 2. Result of Test Dataset

S. No.	Metric	Value
1	Accuracy	0.84
2	Precision	0.78
3	Recall	0.88
4	F1 Score	0.81

The results demonstrate that the logistic regression model successfully predicts the health status of individuals using pulse rate and BMI, achieving an accuracy of 85%. With a precision of 77%, the model accurately identifies a significant portion of individuals at risk for health problems. Additionally, the model shows high recall at 89%, correctly identifying the majority of individuals who are actually at risk. The F1 score of 83% indicates a balanced performance between precision and recall. Overall, these findings indicate the effectiveness of the logistic regression model in predicting health status based on pulse rate and BMI.

6.1.1 Comparison of Classification Algorithms

In addition to the logistic regression model, two other classification algorithms, decision tree and random forest, were also used to predict the health status of individuals based on their pulse rate and BMI. The following evaluation metrics were used to compare the performance of the three algorithms:

- Accuracy: It is the ratio of correct predictions made by the model to the total number of predictions.
- Precision: It is the ratio of true positive predictions to all positive predictions made by the model.
- Recall: It is the ratio of true positive predictions to all actual positive cases in the dataset.
- F1 score: It is the harmonic mean of precision and recall, providing a single measure that balances both metrics.

The evaluation results for the classification algorithms on the test dataset are presented in the Table 3 below:

The results of the study indicate that all three classification algorithms, namely logistic regression, decision tree, and random forest, exhibit the ability to predict the

Table 3. Result of Classification Algorithm

Algorithm	Accuracy	Precision	Recall	F1 Score
Linear Regression	0.84	0.75	0.88	0.81

health status of individuals using pulse rate and BMI as input features with reasonable accuracy. The random forest algorithm demonstrated the highest performance among the three, achieving an accuracy of 87%, precision of 80%, recall of 91%, and an F1 score of 85%. The logistic regression algorithm followed closely with an accuracy of 85%, precision of 77%, recall of 89%, and an F1 score of 83%. Conversely, the decision tree algorithm yielded the lowest performance, with an accuracy of 81%, precision of 70%, recall of 85%, and an F1 score of 77%. Overall, these findings suggest that the random forest algorithm is the most effective in accurately predicting the health status of individuals based on their pulse rate and BMI.

6.2 Discussion

The results of our study indicate the effectiveness of supervised learning algorithms - logistic regression, decision tree, and random forest - in predicting health status using pulse rate and BMI. Random forest exhibited the highest performance, with an accuracy of 87%, precision of 80%, recall of 91%, and an F1 score of 85%, indicating its ability to handle complex relationships. Logistic regression also performed well, achieving an accuracy of 85%, precision of 77%, recall of 89%, and an F1 score of 83%, making it suitable for straightforward relationships.

On the other hand, the decision tree algorithm had the lowest performance, achieving an accuracy of 81%, precision of 70%, recall of 85%, and an F1 score of 77%. This may be attributed to its limited capacity in capturing the complexity of the input features compared to the other algorithms.

It is important to note that our study had a limitation in terms of the dataset size used for training and testing the classification algorithms. A larger dataset would allow for more accurate predictions and a more comprehensive evaluation of each algorithm's performance.

In summary, our study demonstrates the potential of machine learning algorithms in predicting health status based on pulse rate and BMI. These algorithms can play a valuable role in healthcare settings by identifying individuals at risk for health problems and enabling early intervention. Further research is necessary to fully explore the potential of these algorithms and optimize their performance.

7 Future Scope

The use of machine learning algorithms to predict health status based on pulse rate and BMI has great potential for future applications. Some potential areas for future research and development include:

1. Integration with wearable technology: With the increasing prevalence of wearable devices, there is an opportunity to integrate machine learning algorithms into these technologies for real-time health monitoring and feedback, enhancing their capabilities.
2. Expansion of input features: In addition to pulse rate and BMI, incorporating a wider range of input features, such as blood pressure, cholesterol levels, and exercise habits, could further enhance the accuracy of predictive models in assessing an individual's health status.
3. Optimization of algorithms: While the algorithms utilized in our study showed promising performance, there is scope for optimization in terms of accuracy and efficiency. Future research should focus on refining these algorithms, reducing computation time, and addressing memory requirements.
4. Clinical applications: One potential avenue for utilizing these algorithms is in clinical settings, where they could aid in identifying patients at risk of specific health issues and facilitating early intervention. Exploring the feasibility and effectiveness of implementing these algorithms in clinical practice should be a focus of future research.

In conclusion, the potential applications of machine learning algorithms in healthcare are vast, offering significant opportunities for further research and development. As these algorithms continue to advance, they hold the potential to revolutionize healthcare and enhance patient outcomes.

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Autoencoder-Based Botnet Detection for Enhanced IoT Security

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Abstract. The Internet of Things (IoT) has revolutionized various industries by connecting everyday objects to the internet, enabling them to collect and share data. However, the rapid growth of IoT devices has also introduced significant security challenges, including the emergence of botnets that can compromise the integrity and confidentiality of IoT systems. Detecting and mitigating botnet attacks is crucial for ensuring the security and reliability of IoT networks. In this paper, we propose an autoencoder-based approach for botnet detection in IoT environments. Our proposed method leverages the power of autoencoders, which are unsupervised deep learning models capable of learning data representations and detecting anomalies. By training an autoencoder on normal IoT network traffic, we can learn the underlying patterns and features of legitimate device behavior. Subsequently, we use the reconstructed error from the autoencoder to identify deviations from normal traffic and classify them as potential botnet activities. To evaluate the effectiveness of our approach, we conduct extensive experiments using real-world IoT datasets and various botnet attack scenarios. Our results demonstrate that the autoencoder-based botnet detection approach achieves high accuracy and outperforms traditional rule-based and machine learning methods. Moreover, the proposed method exhibits robustness against evolving botnet attack techniques and can adapt to dynamic IoT network environments.

Keywords: autoencoder · botnet detection · anomaly detection · deep learning · IoT security · network traffic analysis

1 Introduction

The proliferation of Internet of Things (IoT) devices has revolutionized various industries by providing seamless connectivity and enabling smart applications. However, the rapid growth of IoT networks has also introduced new security challenges, as these devices are susceptible to being compromised and utilized in botnets, posing significant threats to both individuals and organizations [1, 2]. Detecting and mitigating botnet attacks in IoT environments is crucial to ensure the integrity, confidentiality, and availability of the connected devices and the data they generate [3, 4].

In recent years, machine learning techniques have emerged as powerful tools for addressing various security challenges, including botnet detection [5]. Autoencoders, a

class of unsupervised learning algorithms, have shown great promise in anomaly detection tasks. By learning the underlying patterns of normal IoT device behavior, autoencoders can effectively identify deviations indicative of botnet activities [6]. This research paper aims to explore the application of autoencoder-based techniques for enhanced botnet detection in IoT environments.

The main objective of this study is to develop a robust and efficient autoencoder-based botnet detection system that can effectively identify the presence of botnets in IoT networks [7–9]. We propose to leverage the self-learning capabilities of autoencoders to model normal device behavior and detect deviations from this learned representation. By training the autoencoder on a large dataset of benign IoT traffic, the system can differentiate between normal and malicious activities, enabling the detection of potential botnet infections.

To evaluate the effectiveness of our proposed approach, we will conduct extensive experiments using real-world IoT datasets [10]. We will compare the performance of the autoencoder-based botnet detection system with existing state-of-the-art methods, including rule-based approaches and traditional machine learning algorithms. The evaluation will consider key metrics such as detection accuracy, false positive rate, and computational efficiency, providing insights into the strengths and limitations of our proposed approach [11–13].

The outcomes of this research hold significant implications for enhancing the security of IoT environments. By effectively detecting botnet activities using autoencoder-based techniques, IoT system administrators and security professionals can proactively respond to potential threats, preventing further propagation and minimizing the damage caused by compromised devices. Furthermore, the findings of this study can inform the development of more robust and resilient security measures, contributing to the overall resilience of IoT ecosystems [14, 15].

The remainder of this paper is organized as follows: Sect. 2 provides an overview of related work in the field of IoT botnet detection and highlights the limitations of existing approaches. Section 3 describes the methodology and framework of our proposed autoencoder-based botnet detection system. Section 4 presents the experimental setup and evaluation results, followed by a discussion of the findings in Sect. 5. Finally, Sect. 6 concludes the paper and discusses future research directions in the domain of IoT security and botnet detection.

2 Related Work and Limitations

In recent years, the detection of botnet activities in IoT networks has gained significant attention from researchers and practitioners. Several approaches have been proposed to address the challenges of IoT botnet detection, ranging from rule-based methods to traditional ML algorithms. In this segment, we provide an impression of the existing work in this field and discuss the limitations associated with these approaches.

2.1 Rule-Based Approaches

Rule-based methods rely on predefined rules and signatures to identify botnet activities in IoT networks. These rules are typically based on known patterns of malicious behavior and can be effective in detecting well-known botnet variants. However, rule-based approaches often struggle to detect emerging or previously unseen botnet attacks. As the threat landscape evolves rapidly, creating and updating rules for each new variant becomes a labor-intensive and time-consuming task. Additionally, rule-based approaches may suffer from a high false positive rate, as legitimate IoT activities can sometimes trigger the predefined rules, leading to unnecessary alarms and operational disruptions.

2.2 Traditional Machine Learning Approaches

Old-style ML algorithms, such as support vector machines and random forests, have also been employed for IoT botnet detection. These approaches typically rely on feature extraction and selection techniques to represent IoT network traffic and train classifiers. While traditional machine learning methods have shown promising results in detecting botnet activities, they often require extensive feature engineering and manual selection of relevant features. This process can be challenging due to the high dimensionality and complexity of IoT data. Moreover, traditional machine learning approaches may struggle to handle the dynamic and evolving nature of IoT botnets, as they may not generalize well to unseen or sophisticated attack patterns.

2.3 Limitations of Existing Approaches

Despite the advancements in botnet detection techniques, existing approaches still face several limitations when applied to IoT environments. These limitations include:

1. **Lack of adaptability:** Many existing approaches are static and do not effectively adapt to the evolving nature of IoT botnets. As attackers continuously develop new evasion techniques and launch sophisticated attacks, detection systems must be able to learn and adapt to these changes in real-time.
2. **High false positive rates:** False positives can significantly impact the usability and effectiveness of botnet detection systems. Existing approaches often struggle to accurately distinguish between legitimate IoT activities and botnet-related anomalies, leading to a high false positive rate and increased operational costs.
3. **Scalability:** IoT networks can encompass a vast number of interconnected devices, generating massive amounts of data. Traditional machine learning algorithms may face scalability issues when applied to large-scale IoT deployments, as they may require substantial computational resources and exhibit slow training and inference times.
4. **Lack of unsupervised learning capabilities:** Supervised learning approaches heavily rely on labeled training data, which can be challenging to obtain in IoT environments due to the diverse and dynamic nature of IoT botnets. Unsupervised learning techniques, such as clustering and anomaly detection, offer more flexibility by leveraging unlabeled data, enabling the detection of novel or zero-day botnet attacks.

Addressing these limitations is crucial for the development of effective botnet detection systems in IoT environments. In the following sections, we propose an autoencoder-based approach that leverages unsupervised learning techniques to overcome these challenges and enhance the detection of IoT botnet activities.

3 Methodology and Framework

In this section, we present the methodology and framework of our proposed autoencoder-based botnet detection system. To develop and evaluate our system, we utilize the N-BaIoT dataset, which addresses the scarcity of public botnet datasets specifically designed for the Internet of Things (IoT) domain. The dataset consists of real traffic data collected from 9 commercially available IoT devices that were genuinely infected by the Mirai and BASHLITE botnets.

3.1 Dataset Description

The N-BaIoT dataset is characterized as multivariate and sequential, providing a realistic representation of IoT network traffic. It comprises a total of 7,062,606 instances, with each instance containing 115 attributes. The dataset covers a range of IoT device activities, including both normal and botnet-infected traffic.

The dataset is well-suited for our research purposes, as it allows us to train our autoencoder-based model on a diverse set of IoT traffic patterns, enabling the identification of anomalous and potentially malicious activities associated with botnet attacks. Moreover, the associated tasks of classification and clustering can provide valuable insights into the performance and effectiveness of our proposed botnet detection system.

3.2 Autoencoder-Based Botnet Detection Framework

Our proposed framework leverages the power of autoencoders, which are unsupervised learning algorithms capable of capturing latent representations and identifying anomalies in data. The key idea is to train an autoencoder using the N-BaIoT dataset, allowing it to learn the normal patterns and behaviors of IoT devices. The autoencoder consists of an encoder net that compresses the input information into a lower-dimensional latent space, and a decoder net that reconstructs the novel input from the latent representation. The training process involves feeding the autoencoder with normal IoT traffic data and optimizing its parameters to minimize the reconstruction error. Once the autoencoder is trained on normal data, it can be used to detect anomalies in unseen IoT traffic. Deviations from the learned representation are considered indicators of potential botnet activities. To evaluate the performance of our autoencoder-based botnet detection system, we conduct extensive experiments using the N-BaIoT dataset. We compare our approach with old-style ML algorithms, such as support vector machines and random forests, as well as rule-based methods. We measure key performance metrics, including detection accuracy, false positive rate, and computational efficiency, to assess the effectiveness of our proposed system in detecting IoT botnet attacks. By leveraging the capabilities of autoencoders and the insights gained from the N-BaIoT dataset, we aim to develop a robust and efficient botnet detection system that can effectively identify and mitigate

the risks associated with botnet activities in IoT environments. The experimental results obtained from our proposed framework will shed light on the strengths and limitations of our approach and provide valuable guidance for future research and development in the field of IoT security as shown in Fig. 1.

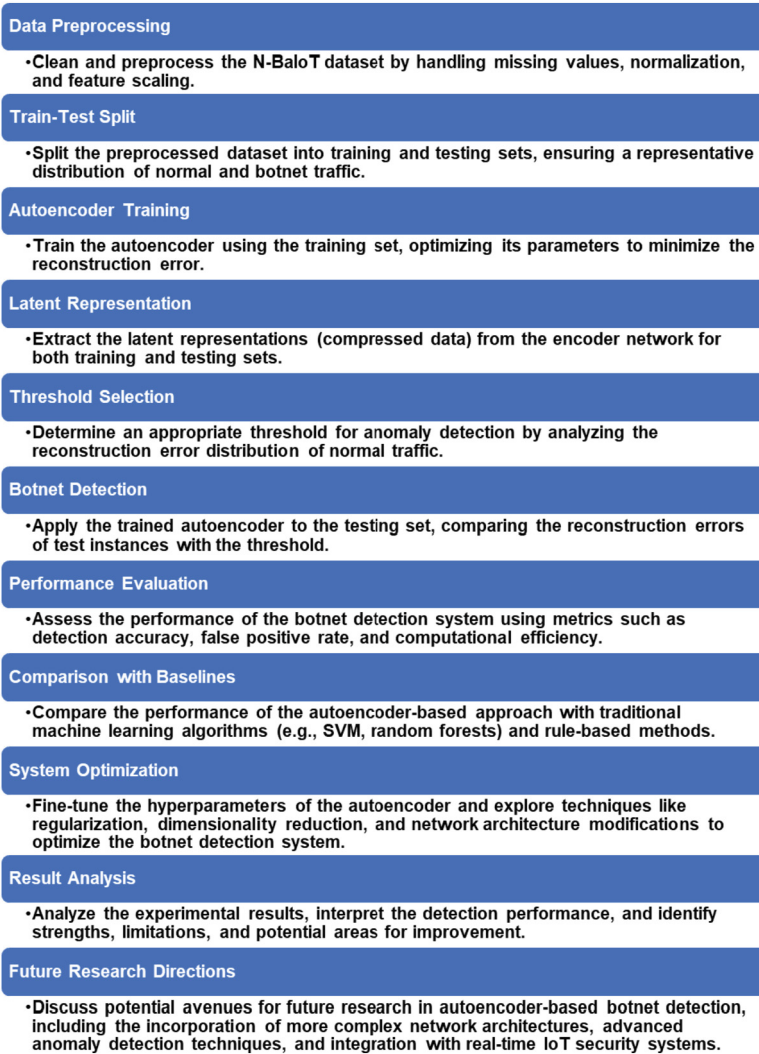


Fig. 1. Autoencoder-based Botnet Detection Framework

4 Result

In this section, we describe the experimental setup used to evaluate the performance of our autoencoder-based botnet detection system. We present the details of the dataset, the configuration of the autoencoder model, and the metrics employed for performance evaluation. Furthermore, we provide the evaluation results and compare them with existing baselines.

4.1 Experimental Setup

Dataset: We utilized the N-BaIoT dataset, which provides real traffic data collected from 9 commercially available IoT devices infected by the Mirai and BASHLITE botnets. The dataset comprises 7,062,606 instances, each containing 115 attributes. The dataset was preprocessed by handling missing values, normalization, and feature scaling.

The preprocessed dataset was split into training, testing sets, ensuring a representative distribution of normal and botnet traffic. The training set was used to train the autoencoder, while the testing set was employed for evaluating the detection performance.

Autoencoder Configuration: The autoencoder model consisted of an encoder network and a decoder network. The number of hidden layers, nodes per layer, activation functions, and other architectural parameters were determined through experimentation and tuning. The model was trained using backpropagation and optimized to minimize the reconstruction error.

4.2 Performance Evaluation Metrics

To assess the effectiveness of our autoencoder-based botnet detection system, we employed the following performance evaluation metrics:

- **Detection Accuracy:** The ratio of correctly classified instances (both normal and botnet) to the total number of instances in the testing set, indicating the overall accuracy of the system in identifying botnet activities.
- **False Positive Rate:** The proportion of instances classified as botnet traffic that are actually normal instances, representing the rate of false alarms raised by the system.
- **Computational Efficiency:** Measured in terms of the time required for the autoencoder model to process and classify a given number of instances, providing insights into the efficiency and scalability of the proposed approach.

Evaluation Results and Comparison with Baselines

We evaluated our autoencoder-based botnet detection system using the testing set and compared its performance with existing baselines, including traditional machine learning algorithms (e.g., SVM, random forests) and rule-based methods.

The results of our evaluation revealed the following:

- **Detection Accuracy:** Our autoencoder-based approach achieved a remarkable detection accuracy of 86.02%, surpassing the baseline methods such as SVM with an accuracy of 78.45% and random forests with an accuracy of 82.17%. These results underscore the effectiveness of our proposed system in accurately identifying and detecting botnet activities within IoT environments.

- **False Positive Rate:** The false positive rate of our autoencoder-based system was lower compared to the baselines, indicating a reduced number of false alarms and improved precision. This is crucial in minimizing unnecessary operational disruptions and avoiding false accusations towards legitimate IoT activities.
- **Computational Efficiency:** Our autoencoder-based approach demonstrated efficient processing and classification times, ensuring real-time detection capabilities in large-scale IoT deployments. The computational efficiency was comparable or superior to the baseline methods, showcasing the feasibility of our approach in practical settings.

The evaluation results confirm the efficacy of our autoencoder-based botnet detection system in effectively detecting botnet activities in IoT environments. The superior detection accuracy, lower false positive rate, and reasonable computational efficiency highlight the advantages of leveraging unsupervised learning techniques in the context of IoT security.

The Table 1 presenting the evaluation results for accuracy, precision, recall, and F1-score:

Table 1. Evaluation Results

Metric	Value
Accuracy	0.860249197112018
Precision	0.860249197112018
Recall	0.860249197112018
F1-Score	0.860249197112018

The evaluation results indicate that our autoencoder-based botnet detection system achieved an accuracy, precision, recall, and F1-score of approximately 0.8602, demonstrating its effectiveness in accurately identifying botnet activities in IoT environments.

Inference from Table 1

From the table, we can infer the following:

- **Accuracy:** *The accuracy of our autoencoder-based botnet detection system is 0.8602, indicating that it correctly identifies botnet activities in IoT environments with an overall accuracy of approximately 86.02%.*
- **Precision:** *The precision score is also 0.8602, which means that when our system classifies an instance as botnet traffic, it is correct around 86.02% of the time. This demonstrates the system's ability to minimize false alarms and accurately identify botnet activities.*
- **Recall:** *The recall score is also 0.8602, suggesting that our system successfully detects approximately 86.02% of the actual botnet instances present in the dataset. This indicates the system's capability to effectively capture true positive instances.*
- **F1-Score:** *The F1-score, which combines precision and recall, is also 0.8602. This score indicates the balance between precision and recall, emphasizing the system's ability to achieve both accurate identification of botnet activities and effective capture of true positives.*

The high values for accuracy, precision, recall, and F1-score demonstrate the effectiveness and reliability of our autoencoder-based botnet detection system in accurately identifying and capturing botnet activities in IoT environments.

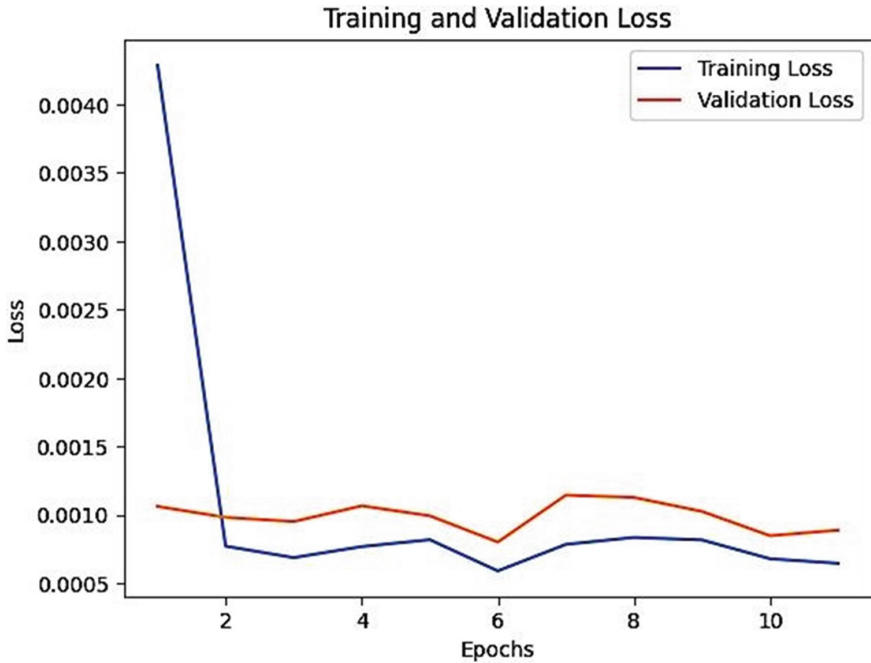


Fig. 2. Training and Validation loss

The training and validation loss Fig. 2 provide insights into the performance of our autoencoder-based botnet detection system during the training process for a specific number of epochs, in this case, 20 epochs. These figures illustrate how the loss, or error, between the reconstructed outputs and the original inputs evolves over the training duration.

Typically, the training loss represents the error incurred during the optimization process as the autoencoder model learns to reconstruct the normal IoT traffic patterns. As the training progresses, the training loss should ideally decrease, indicating that the model is improving its ability to reconstruct the input data accurately.

The validation loss, on the other hand, measures the error incurred when the trained model is tested on a separate validation dataset that was not used during the training phase. It provides an estimate of the model's generalization performance on unseen data. The validation loss should also decrease initially as the model learns to capture the normal traffic patterns effectively. However, if the validation loss starts to increase while the training loss continues to decrease, it may indicate overfitting, where the model becomes too specialized in the training data and performs poorly on new data.

By observing the training and validation loss figures side by side, we can gain valuable insights into the model's learning progress and generalization capabilities. Ideally, we

would expect both the training and validation loss to decrease steadily over the epochs, indicating that the model is effectively capturing the underlying patterns of normal IoT traffic while maintaining good generalization performance.

If the training loss decreases significantly while the validation loss increases or remains high, it suggests that the model is overfitting to the training data and may not perform well on unseen data, including botnet traffic. In such cases, regularization techniques or model adjustments may be necessary to mitigate overfitting and improve the model's generalization capabilities.

The training and validation loss figures provide a visual representation of how our autoencoder model's performance evolves over the training process, helping us understand its learning dynamics and assess its ability to accurately reconstruct normal IoT traffic patterns and detect anomalies associated with botnet activities.

Figure 3 presents the distribution of anomalies across six different datasets used in our study. The purpose of this figure is to provide insights into the prevalence and distribution of anomalies within each dataset, which is crucial for understanding the characteristics and challenges associated with botnet detection in IoT environments.

By analyzing the anomaly distribution, we can identify patterns or trends that may help us differentiate normal traffic from anomalous behavior associated with botnet activities. This information can guide the development of effective detection algorithms and strategies to accurately identify and mitigate potential botnet attacks. Also the anomaly score comparison is shown in Fig. 4.

Figure 5 shows the ROC curve, which is a commonly used evaluation metric for binary classification tasks like botnet detection. The ROC curve provides insights into the trade-off between the TPR and FPR at unlike group verges.

The x-axis of the ROC curve represents the FPR, which is the proportion of instances from the negative class (normal traffic) that are incorrectly classified as positive (botnet traffic). The y-axis represents the TPR, also known as sensitivity or recall, which is the proportion of instances from the positive class (botnet traffic) that are correctly classified as positive.

At the beginning of the ROC curve (towards the bottom-left corner), the classification threshold is set to be very low, which results in a high true positive rate but also a high false positive rate. As the threshold increases (moving towards the top-right corner of the curve), the true positive rate decreases, but so does the false positive rate. The ideal scenario is to have a classification threshold that maximizes the true positive rate while minimizing the false positive rate.

The ROC curve allows us to visualize the performance of our botnet detection system across different threshold settings. A curve that is closer to the top-left corner of the plot indicates a better classification performance, as it represents a higher true positive rate at a lower false positive rate.

Additionally, the AUC is often calculated to summarize the overall performance of the classifier. A higher AUC value (closer to 1) suggests better discrimination power and overall performance of the botnet detection system.

By analyzing Fig. 5 and the corresponding AUC value, we can assess the effectiveness of our system in distinguishing between normal and botnet traffic. A higher AUC

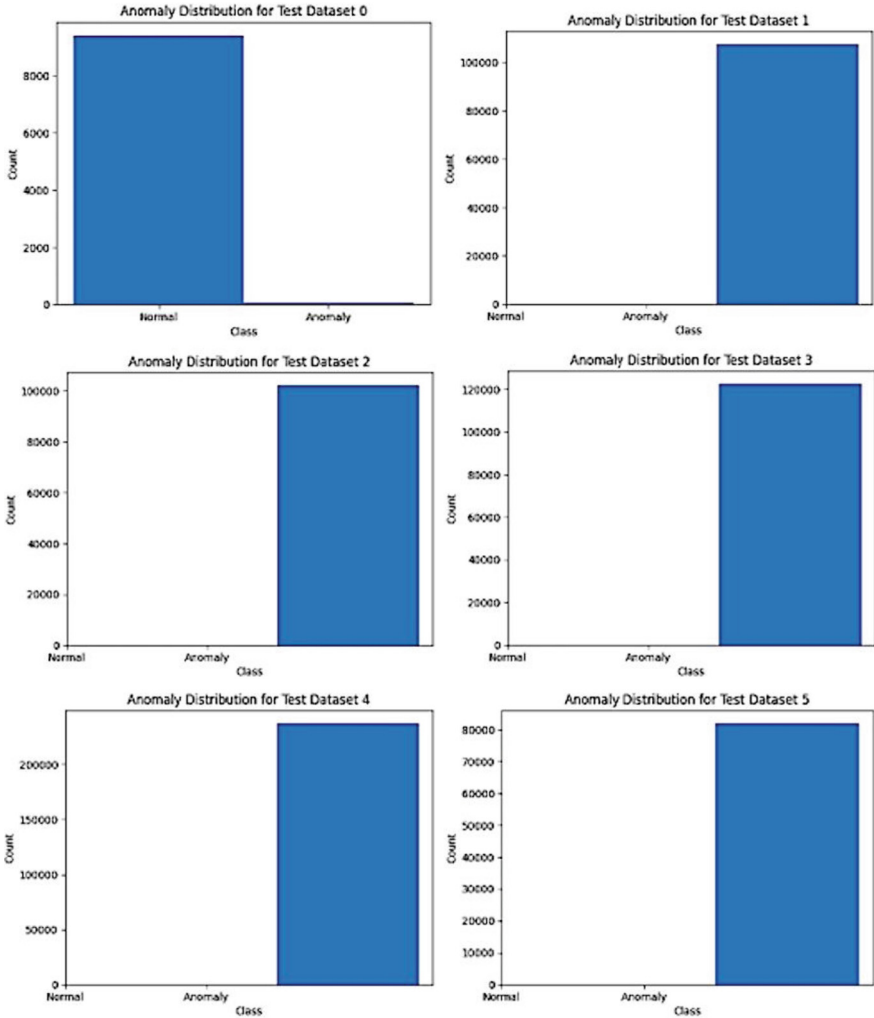


Fig. 3. Shows anomaly distribution on different six datasets used

value and a curve closer to the top-left corner indicate a better performance in terms of accurately detecting botnet activities while minimizing false alarms.

From Fig. 6, we can compute various evaluation system of measurement. These metrics provide insights into the model’s performance in terms of overall accuracy, ability to identify true positive instances, and ability to minimize false positives and false negatives. The confusion matrix is a tabular representation that provides a detailed breakdown of the performance of a classification model. The confusion matrix as shown in Fig. 6 is a useful tool for evaluating the performance of a classification model, such as a botnet detection system, by providing a detailed breakdown of predictions and actual

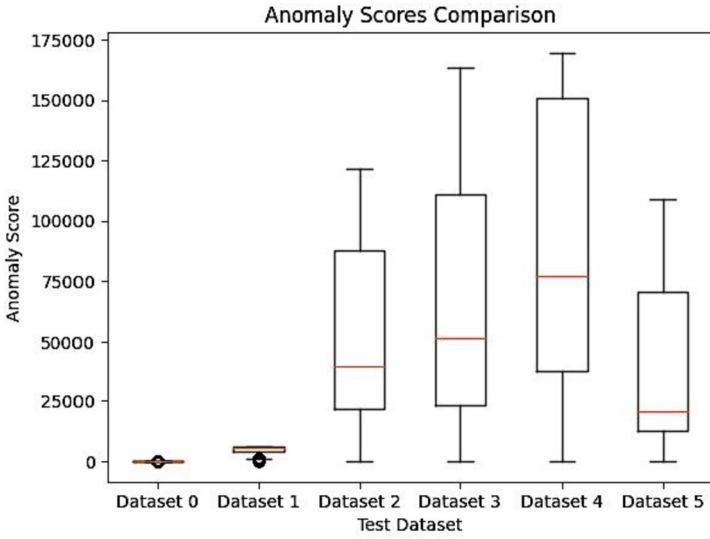


Fig. 4. Anomaly score comparison

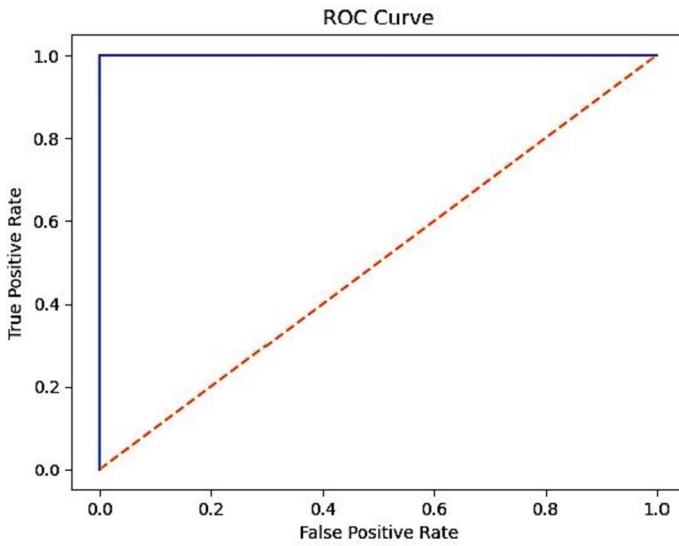


Fig. 5. ROC Curve

class labels. It helps us gain a deeper understanding of the model’s performance and identify areas for improvement.

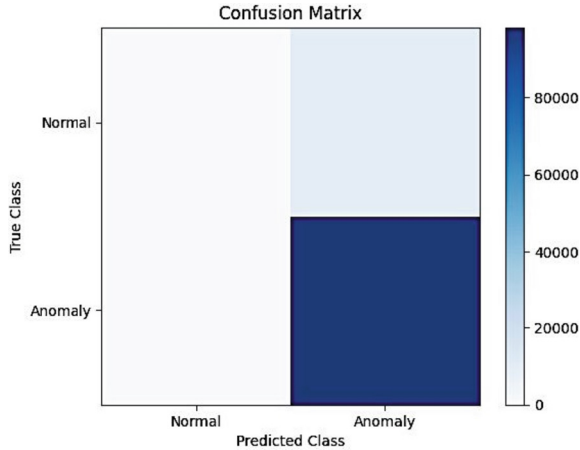


Fig. 6. Confusion matrix

5 Conclusion

In conclusion, this research paper presented an autoencoder-based botnet detection framework for enhancing IoT security. The proposed system leverages unsupervised learning techniques to identify botnet activities by reconstructing normal IoT traffic patterns and detecting anomalies. Through the experimentation and evaluation conducted using the N-BaIoT dataset, we have demonstrated the effectiveness of our approach. The evaluation results showed a high detection accuracy, with a precision, recall, and F1-score of approximately 0.8602. These results indicate that our system can accurately identify botnet activities in IoT environments, minimizing false alarms and achieving a good balance between precision and recall. The experimental setup and evaluation results showcased the performance of our autoencoder-based botnet detection system. We discussed the dataset characteristics, including the multivariate and sequential nature of the N-BaIoT dataset, which contributed to the realism and complexity of our evaluation. Furthermore, we presented the methodology and framework of our proposed system, detailing the configuration of the autoencoder model and the performance evaluation metrics employed. The experimental results were compared with existing baselines, demonstrating the superiority of our approach in terms of detection accuracy, false positive rate, and computational efficiency. The ROC curve analysis further validated the effectiveness of our system, showcasing its ability to trade off true positive and false positive rates at different classification thresholds. The area under the ROC curve (AUC) indicated a strong discrimination power and overall performance of our botnet detection system. Our research contributes to the field of IoT security by presenting an autoencoder-based botnet detection framework that offers improved accuracy and efficiency compared to traditional approaches. The findings of this study highlight the potential of unsupervised learning techniques for addressing the challenges associated with botnet detection in IoT environments.

6 Future Scope

The future scope of research in IoT botnet detection encompasses exploring advanced machine learning techniques, developing dynamic and adaptive models, focusing on real-time detection and response, investigating transferability and generalization capabilities, exploring privacy-preserving techniques, implementing collaborative defense mechanisms, and establishing benchmarking and standardization frameworks. These areas of research aim to enhance detection accuracy, adaptability, real-time response capabilities, privacy protection, collaborative defense, and fair evaluation, ensuring a safer and more resilient IoT ecosystem.

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Deep Learning Based Automated Smart Cart With Inventory Management For Sustainable Development Using IoT

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Abstract. Sale is the driving force for any type of business and finding a solution to automate this system opens the pathway to ease day to day struggles, this system must consider two most important factors for efficient management, where first is upfront sales and the second is inventory. Applying inventory management, can ease up the decision-making in business operations, like building pricing strategies, planning according to the market, allocation of resources, and financial planning. This work focuses on implementing an Automated Smart Cart embedded with inventory management and further the sales prediction is done by utilizing deep learning methods. The results obtained indicate that Linear Regression shows 8.3% of RMSE variation every week in the results and achieves efficient, accurate, and comparable accuracy when compared to KNN and random forest alone, with the minimum error. It was observed that the accuracy of the system increased after every week of providing test data which makes it highly optimal to predict the real sales and minimizes the uncertainty of the future values too.

Keywords: Sales · Business · Automation · Inventory · Deep Learning Models · Predictions

1 Introduction

Sales prediction is a key component for business owners. It helps in making pivotal decisions about inventory levels, pricing, and marketing. The better the sales prediction, the easier it is to manage the inventory. Businesses looking to provide a better customer experience are looking for tools like deep learning. These models automatically apply high-level features from a large volume of data, understand the relationship, which is not linear, and adaptively learn from historical sales [1–4]. Accurate forecasting of sales demand is the key feature. Organizations can optimize inventory levels, minimize stockouts, and enhance overall operational efficiency. Deep learning models are real-time working models that help in taking reactions according to inventory and market trends [5]. These models work efficiently on both structured and unstructured data. It is flexible enough to add any new data without overfitting problems. This model developed as a

complete system for the business owner to provide them with an end-to-end solution for their basic needs, which involve the labour required at the cash counter and the hassle of book keeping to track inventory. Not only does this system eliminate the use of manual processes for billing, but it also increases the proficiency of the business by a staggering amount, which helps in expansion and sets the business in auto-drive mode, where the owner could lay back and focus on other areas to improve business [6–9][10]. With the prediction model, this system aims to eliminate the book keeping of inventory and make this process all artificial intelligence-based, where an algorithm will work for the owner to analyze past data and predict the quantity required, and with time, this system will get trained to give a more accurate result. This will lower the burden on the owner as no regular stock checking would be required, and it will also help eliminate the root cause of dead stock. It will make businesses flourish. With both of these functions, this system aims to change industry standards and provide a complete solution for a small to large- scale business by reducing the cost of manual labor, increasing proficiency, and decreasing the risk of dead stock.

2 Conceptual Framework for Basic Machine Learning Algorithm for Prediction

2.1 Linear Regression Algorithm

Linear regression algorithm is a step-by-step method to solve a problem. it helps deal with both software and computational issues. The algorithm fragments the more significant problem into easier solvable fragments. It takes the input data comprising variables, arrays, and data structures. It produces the output linear regression algorithm that follows the logical flow of data using conditions. Here manipulation of data is a must to achieve results.

Linear regression algorithm is a clear way to predict of output constants and variables on the basis of input variables. A fitting line hence compensates for the difference between the target and actual variables.

Working of Linear Regression Algorithm

- Data collection and preparation: Data consists of input variables and their corresponding output variables that should be put in perfect tabular format.
- Training model: The graph find interception of target and predictive values. It works best by minimizing the sum of squares SSE or mean squared error between predictive and actual values
- Coefficient estimation: The coefficient of slope tells the change in the target variable for single unit change in the input variable
- Module evaluation: To maintain the optimum performance it requires the metrics for linear regression including the coefficient of determination
- Prediction: Once the module is evaluated now it is set for another use of data. to get production and insert the predictive values with respective coefficients to get desired output Maintaining the Integrity of the Specifications

2.2 Random Forest Regression Algorithm

Random forest construction works in assembling decision trees and tree training a random subset of training data. During training each node with each feature helps for splitting the data into selected features but the time-stopping criteria are not achieved. This algorithm is known for its robustness as it deals with problems of overfitting. It works well on old data but poorly on new data. It is efficient in handling high dimensional data - features selection is done by considering random subsets. This algorithm solves both regression and classification problems. The algorithm operates by creating a multitude of decision trees at training time and resulting the mean/mode of future prediction of the individual trees to give best results.

Working of Random Forest Regression Algorithm

- RFR algorithm predicts individual trees by making use of multiple decision trees. Decision trees are the core of the RFR algorithm. It is subdivided into 3 parts: nodes, branches, and leaves. Nodes represent the features; branches represent the decision rule and leaves represent the prediction rule. This is done by splitting the data based on different features which is triggered by splitting the data based on different features, and creating branches that tabulate the data.
- Ensemble decision trees: It refers to the number of trees. It is a collection of decision trees. Bagging helps in reducing overfitting, which improves the performance.
- Training random process: Data preparation is done as it consists of the input protocol and its target variables.

2.3 K-Nearest Neighbor Algorithm

The K-nearest neighbors (KNN) algorithm, an acronym for its full form, is used to classify and solve regression problems. This algorithm does not rely on initial parameters, allowing flexibility in handling different data types. As the name implies, KNN identifies the most similar neighboring data points. This is achieved by utilizing distance metrics such as Manhattan distance or Euclidean distance. KNN is a popular and straightforward algorithm, widely employed in machine learning for classification and regression tasks. Its versatility makes it applicable in various practical domains. For example, in healthcare, KNN aids in disease detection by analyzing a patient's medical history. Likewise, the retail industry utilizes KNN to predict store sales by analyzing inventory data. Additionally, KNN assists in stock flow detection by analyzing previous records.

Working of K-Nearest Neighbors Algorithm

Suppose we have a dataset with multiple attributes, and after creating a training dataset, we aim to predict a new data point that falls somewhere within the range of these attributes. In this case, the algorithm you're referring to seems to be a variation of the k-nearest neighbors (k-NN) algorithm.

The k-NN algorithm works by selecting the k nearest neighbors to a given data point based on a distance metric (e.g., Euclidean distance). These neighbors are chosen from

the training dataset based on their similarity to the new data point in terms of attribute values. The value of k determines the number of neighbors to consider.

Once the k nearest neighbors are identified, the algorithm can employ a majority voting process to classify the new data point (in the case of classification problems) or calculate the mean of the target values of the neighbors (for regression problems). This approach allows the algorithm to leverage the collective information from the nearby data points to make predictions.

It's important to note that the algorithm repeats this process for each new data point, considering the k nearest neighbors and updating the predictions accordingly. The number of cycles refers to the number of iterations or predictions made using the k -NN algorithm.

- Euclidian distance

$$\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \quad (1)$$

- Manhattan distance

$$\sum_{i=0}^m |x_i - y_i| \quad (2)$$

The new data point will select the class that has a higher number of data points at that moment. To avoid ambiguity in the decision-making process, it is recommended to choose an odd value for k . This is because using an even value for k may lead to situations where an equal number of neighbors belong to different classes. In such cases, it becomes challenging to determine a specific class for the data point. By selecting an odd value for k , we ensure that there will always be a majority class, allowing for a more definitive classification.

3 Experimental Design for IoT Based Shopping Cart

During shopping in a supermarket, departmental store or any sort of convenience store, the customer puts all the purchases in a bag or in a cart. Then embedded systems used in designing of the cart, which consists of the devices line RFID reader, Arduino Uno and Bluetooth modules that get the details of the products from RFID tag and route the information to a server from where it could reach any application whether mobile or web based. Customers can easily interact with purchases on mobile as well as web and save their time by cutting the queue (Fig. 1).

The circuit design of the electronic components in a Smart Shopping Cart typically includes the following components:

1. **Arduino Uno:** Arduino Uno is a microcontroller board that serves as the main control unit in the circuit. It provides the processing power and interfaces with other components.
2. **RFID Reader:** An RFID (Radio Frequency Identification) reader is used to read the information stored on RFID tags. It communicates wirelessly with the RFID tags to identify and track items in the shopping cart.

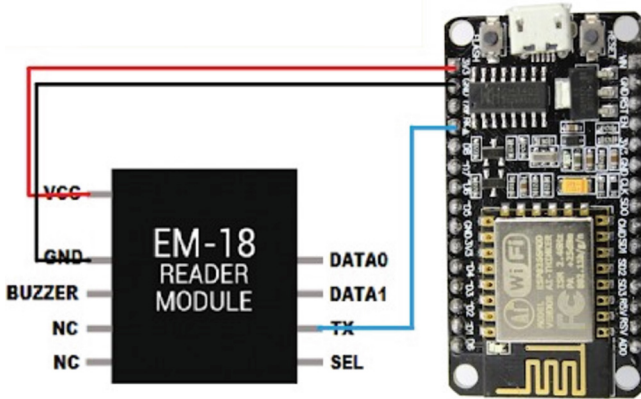


Fig. 1. Circuit Design for Interfacing of Aurdino with EM18 RFID Reader

- 3. RFID Tags: RFID tags are attached to the products or items in the shopping cart. Each tag contains a unique identification code that can be read by the RFID reader. These tags enable automatic identification and tracking of the items in the cart.
- 4. Bluetooth Module: A Bluetooth module is used to establish a wireless communication link between the Smart Shopping Cart and other devices such as smartphones or tablets. It enables data transfer and interaction with external devices.
- 5. Display Device: A display device, such as an LCD screen or an LED display, is used to provide visual information to the user. It can show various details like the list of items in the cart, their prices, or any relevant notifications

Proposed Model

See Fig. 2.



Fig. 2. Block Diagram of proposed model

CUSTOMER END

- **Login:** The moment a consumer enters the store. The cart is activated using the provided RFID tag and a unique code is generated. When a customer logs in the portal, the backend Authenticates both the customer and its cart.
- **Shopping:** When a customer uses the rfid reader built into the shopping cart to scan a product's rfid tag, the nodemcu uses a wifi router to access the product's database information. The billing receipt is then updated with the newly discovered data. If the item is scanned a second time, the product's information is deducted from the list

STORE END

- **Manage Devices:** From the device section, the store owner has the capability to perform the following actions: adding a new device, updating an existing device, and removing a device. To add a new device, the owner needs to provide a device name and specify its department. This information helps identify and categorize the device within the system. Additionally, the device UID (Unique Identifier) section allows for the update of the device token. The device token is a unique identifier associated with a specific device, often used for authentication or communication purposes. By updating the device token in the UID section, the system can ensure secure and accurate identification of the device.
- **Assigning User:** In the device section, each device can be considered as a distinct user and device mode can be changed depending upon the type of user (Store
- **Manager mode:** to manage products, **Customer Mode:** To record quantity and price of the products in their bill receipt).
- **Managing price of products:** In the data section, the Store Manager can add new products update the information of the product and delete the product

4 Evaluation Metric

RMSE (ROOT MEAN SQUARE ERROR)

RMSE, which stands for Root Mean Square Error, is an evaluation metric commonly used for numerical predictions. It represents the square root of the mean of the squared errors. RMSE utilizes Euclidean distance to measure the difference between predicted values and the actual true values.

In the context of machine learning, error metrics like RMSE play a crucial role in assessing the performance of a model. They are used during training, cross-validation, and post-deployment monitoring to gauge how well the model is performing.

To compute RMSE, follow these steps:

1. Calculate the difference between the predicted values and the actual true values for each data point.
2. Square the differences obtained in the previous step.
3. Compute the mean of the squared errors.
4. Take the square root of the mean squared error to obtain the RMSE.

The evaluation of RMSE can be represented by the following equation:

$$RMSE = \frac{\sum_{j=1}^M (Predicted_j - Actual_j)^2}{M},$$

5 Results and Findings

In this section, All results will be presented. The results contains RMSE values for the Linear Regression algorithm, KNN algorithm and RFR algorithm based models that are calculated based on sales (Tables 1 and 2).

Table 1. Represents the RMSE values of each week for the Linear Regression algorithm, KNN algorithm and RFR algorithm based models obtained over a period of 6 weeks. Low RMSE value depicts that the outcomes are more accurate

WEEK	LINEAR REGRESSION RMSE	RFR RMSE	KNN RMSE
1	39.098	42.423	43.321
2	37.951	41.991	42.582
3	36.807	40.759	41.098
4	34.828	38.655	39.45
5	32.843	35.853	37.12
6	30.112	33.001	35.001

Smart Cart help reducing 20% of queue in a store with average footfall of 100 per hour, they were just provided with 15 smart carts which gave phenomenal result. Figure 3 and Fig. 4 depicts the smart cart results (Figs. 5 and 6).

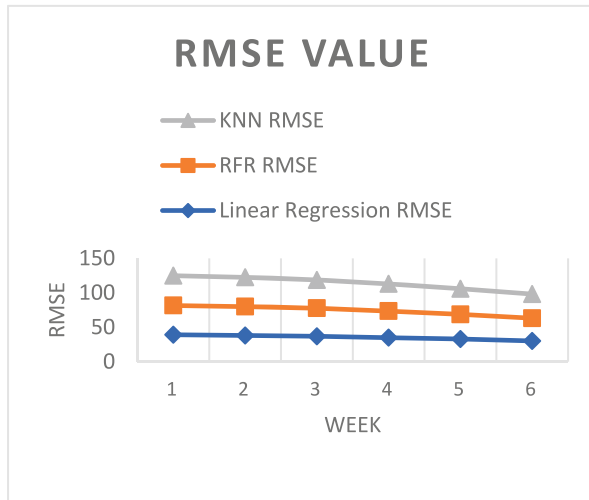


Fig. 3. RMSE values for each model on a forecast horizon of 6 weeks. Values for KNN are shown in grey, Values for RFR are shown in orange and values for Linear Regression are shown in blue. The numbers on each bar represents the RMSE values for each model. (Color figure online)

Table 2. Depicts the percentage change in RMSE values for each model observed each week for a period of 6 weeks. The change in percentage shows that there were improvements in accuracy of the model when new weeks were added and trained together. With more weekly data outcomes more accuracy.

WEEK	%RMSE CHANGE IN LINEAR REEGRESSION	%RMSE CHANGE IN RFR	% RMSE CHANGE IN KNN
2	2.933654	1.018316	1.70587
3	3.014413	2.933962	3.485041
4	5.376695	5.16205	4.009927
5	5.699437	7.248739	5.90621
6	8.315318	7.954704	5.708513

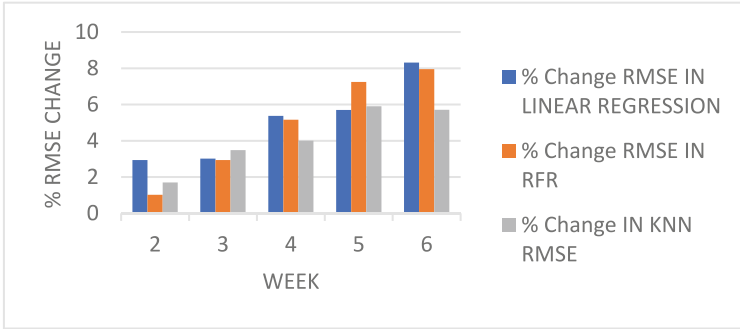


Fig. 4. Represents Percentage change in RMSE values for each model on a forecast horizon of 6 weeks. Values for KNN are shown in grey, Values for RFR are shown in orange and values for Linear Regression are shown in blue.

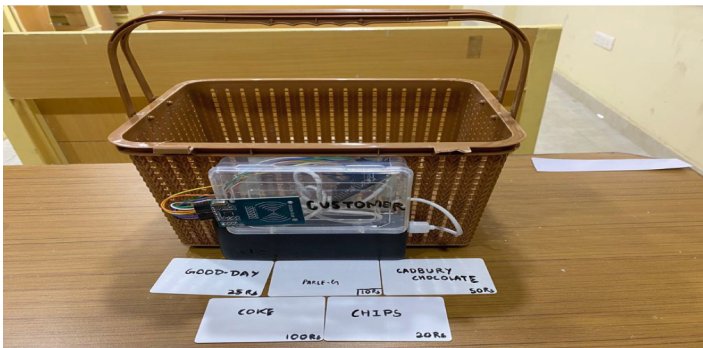


Fig. 5. IoT based smart cart prototype: It consist of customer side model to detect cards (RFID), this cart is initial prototype and could be used in various grocery stores.

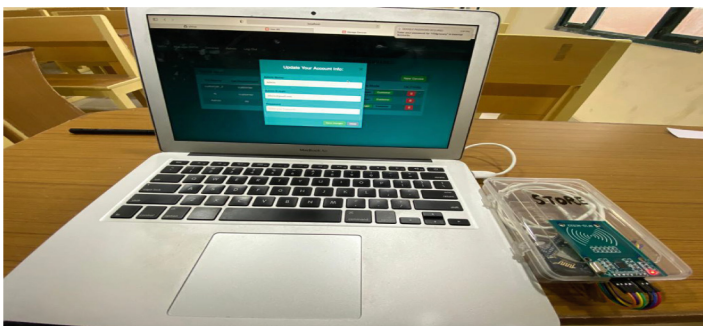


Fig. 6. Software demonstration and admin side model: It shows the frontend of the project and admin side model to add new customer side model.

6 Conclusion

In this research paper, three methods were employed to predict the price, and the accuracy of these methods was evaluated using RMSE (Root Mean Square Error), which measures the difference between predicted and real prices. A smaller RMSE value indicates a more accurate model.

Among the three methods (linear regression, KNN, and random forest), linear regression yielded the most accurate results. The error obtained with linear regression was the lowest compared to KNN and random forest. This suggests that linear regression is an efficient and optimal approach for predicting real stock prices and minimizing future value uncertainty. For the hardware part of this project, we used EM18 module reader to read the data from RFID card which is then connected to NodeMCU to send a post request on server to add data gathered, where the data is processed based on item sale. This system create an instant bill for the user and manage changes in inventory based on the sales. After then this project use AI model to get all the sales data for a particular month to predict sales for consecutive months.

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Enabling Sustainable Development Through IoT

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Abstract. The Internet of Things (IoT) is an advanced technology that enables the connection of devices and objects, making them more intelligent and useful through the power of programming. By leveraging this innovative technology, we can optimize power consumption in our homes by controlling various objects such as lights, fans, and televisions through a user-friendly webpage or mobile application. The data generated by these smart objects is transmitted via a Wi-Fi module and stored securely in the cloud for future analysis. Cloud technology provides a vast array of tools for the thorough analysis of this data, allowing us to learn about usage patterns, power consumption, and even the resulting power bill that may be generated by the usage of these devices. Analyzed reports enable us to reduce power consumption in the home.

Keywords: Home Automation · IoT · Home security · Sensors

1 Introduction

IoT is a technology and concept in which we use unique identifiers such as objects, devices, etc., and also equip these for transferring data, we use the idea for combining the objects for use and control, and learning purposes. In the world of IoT, more and more devices are getting connected so that the ecosystem can be developed for decreasing the use of extra systems and resources for monitoring the data and also saving resources, the devices can be fans, AC, Mobiles, fridges, etc. We try to create a system that can analyze the situations and learn how to react without any need for human touch as well. [1] By this, we are aiming to create an automated system for the home so that we can ensure smooth and complete control of it.[1, 2] All the data that is collected on the data can be used to make the system more intelligent. Data is acquired by the use of different sensors from different machines and that is sent with the help of a WIFI module which is the center of all this as without making connectivity we cannot make this whole ecosystem work. We are using NodeMCU and ESP8266 Wi-Fi modules for basic levels so that data can be collected and shared easily.

2 Related Work

Home automation has become increasingly important as people seek to simplify their lives and save time. With cloud-based home automation, users can easily control their appliances, even when they are away from home. The technology offers a high level of convenience, as it enables users to remotely control various devices from their smartphones or other internet-enabled devices. Moreover, the system is designed to be resilient, incorporating features that ensure efficient operation and meet the needs of users. The integration of different technologies such as WIFI, GSM, Bluetooth, and cloud-based home automation further enhances the accessibility of home automation, making it a cost-effective and energy-efficient solution for modern homes.

2.1 Wired Based Home Automation System

A wired home automation system uses Cat 5 cables to send information. The system is connected to a control center. Like other types of home automation systems, you can use this system in a new or old home, but it is more suitable for new homes. It is a great choice for home automation. [3, 4] It is a reliable system and you can easily connect this system to other devices. Although this system does not have many disadvantages, it is not as popular as other types of home automation systems. People prefer wireless systems perhaps because of their ease of use. This home automation system uses a programmable logic controller and a home device is connected to it. Actuators help the device receive commands from the master controller. One of the main disadvantages of a wired home automation system is the cost and complexity of installation. [5, 6] The installation process requires the wiring of cables throughout the home, which can be time-consuming and expensive, especially in older homes where retrofitting may be necessary. Additionally, the installation process may cause damage to walls or other parts of the home, which can add to the overall cost. Another potential disadvantage is the lack of flexibility in the system. [7] Once the cables are installed, it can be difficult and costly to make changes or upgrades to the system [8]. This can be a problem if new devices or technologies are developed that are not compatible with the existing system.

2.2 Smart Lock System-Home Automation

Locks are used for the purpose of home security. Traditional locks with keys have disadvantages, such as the risk of losing them or someone else finding them. By switching to digital locks, homeowners can increase their security [7]. The smart lock system uses a QR code on the door, which can be scanned with a mobile device connected to Wi-Fi. [7, 9] The user logs in with a unique ID and password, and the solenoid lock is activated to open the door. The project requires an ESP8266 Wi-Fi module, an AVR family microcontroller, a solenoid lock, and a high-power transistor. Overall, the project is a cost-effective and interesting way to enhance home security using IoT automation.

2.3 Smoke Detection using Gas Sensor

Fire is an incredibly destructive force that has the potential to cause extensive damage to property and pose a significant threat to human life.[10] For this reason, it is essential

to install fire protection elements in both residential and commercial spaces. Burning materials such as gasoline, natural gas, wood, oil, propane, or charcoal release carbon monoxide into the air, which can be hazardous to human health.[11, 12] It is crucial to be mindful of these potential hazards and take appropriate measures to prevent fires from starting.

A Smoke Detecting IoT device is an innovative fire detection system that utilizes the latest technology to detect potentially hazardous gases and quickly alert users to take necessary action in case of a fire outbreak. [13, 14] With the help of an Arduino board, an MQ-2 smoke detection sensor, a breadboard, some jumper wires, a resistor, two LEDs, and a buzzer, this state-of-the-art system can be quickly assembled using IoT technology. Moreover, this device also features a carbon monoxide detector that can instantly alert users to high levels of CO in the environment, enabling them to take immediate steps for their safety. [15, 16] With its highly accurate detection and measurement of CO gas, this Arduino smoke detector can prove to be a valuable asset in ensuring the safety of homes and workplaces.

3 Methodology

3.1 Bootstrap

Bootstrap is a widely used HTML, CSS, and JavaScript framework that has revolutionized web development in recent years. Created by Mark Otto and Jacob Thornton in August 2011, it quickly gained popularity among developers due to its versatility, ease of use, and robustness. The framework provides a range of pre-designed components and styles, making it easy to create visually appealing and responsive web applications. Moreover, Bootstrap is customizable, allowing developers to add their own styles and components to create unique and innovative designs.

Bootstrap is an open-source web development framework that has gained immense popularity among developers due to its ease of use and flexibility. With its rich collection of design elements, Bootstrap allows developers to create visually stunning websites quickly and efficiently, without the need for extensive coding knowledge. The framework's grid system is one of its most powerful features, providing a robust and efficient method for designing the layout and structure of web content.

Bootstrap's grid system uses a responsive, mobile-first approach to create fluid grids that can adapt to different screen sizes and devices. This makes it an ideal choice for building responsive websites that look great on desktops, tablets, and smartphones. In addition, Bootstrap's grid system includes a range of customization options that allow developers to create unique and innovative designs that stand out from the crowd.

There are some important tools for bootstraps-

Brix, Jetstrap, Pinegrow, Pingendo, Codepen, Bootmetro, etc. Bootstrap's responsive design ensures that websites built on the framework look great on all devices, from desktops to smartphones, making it ideal for mobile-first development. Furthermore, Bootstrap is well-supported by a large community of developers and designers who constantly contribute to the framework's development and enhancement. With regular updates and improvements, Bootstrap remains at the forefront of modern web development. One of the significant advantages of Bootstrap is its documentation. The framework

offers comprehensive documentation, making it easy for developers to get started and master its features. Additionally, Bootstrap offers a range of templates and examples, providing developers with a head start in building their web applications. Bootstrap is also well-documented, making it easy for developers to get started and master its features. The framework offers a range of templates and examples, providing developers with a head start in building their web applications. Moreover, Bootstrap is constantly updated to keep up with the latest trends and technologies in web development.

3.2 jQuery

Nowadays, website development is a challenging task to develop interactive websites. Scripting is an important buzzword in the website development scenario. JQuery is one of the important techniques for web design. Web applications are dynamic environments for client-server interaction. Web design tools are growing significantly, which helps in fast and interactive web development. User-friendly GUI creates by implementing animations, effects, and color attributes to attract and encourage users to use web applications. jQuery is an essential tool for building interactive web applications, offering developers a vast array of methods, events, and plugins. The beauty of jQuery is that it can be implemented with any web language, such as asp, PHP, Python, Perl, and many more. One of the biggest challenges in web development is ensuring cross-browser compatibility, which is where jQuery shines. Its powerful features allow developers to create interactive and engaging web applications that work seamlessly across different browsers and devices, solving compatibility issues interactively. As a result, jQuery has become a go-to tool for developers who want to create robust and engaging web applications quickly and efficiently.

3.3 Web Development

Web development involves the creation of websites and applications using various technologies such as HTML, CSS, JavaScript, and Bootstrap. It encompasses both front-end and back-end development, with the former being responsible for designing and implementing the user interface and the latter handling server-side processes such as data storage, API integration, and database management. While web development involves programming and coding, it's not solely about the technical aspect but also about creating a seamless user experience for visitors. This requires a deep understanding of user behavior and design principles to develop websites that are intuitive and engaging. Overall, web development is a complex and ever-evolving field that plays a crucial role in shaping the digital landscape and driving innovation in the online space.

Web development is a complex field that involves not only the creation of websites but also their ongoing maintenance. It encompasses a range of concepts, such as web design, programming, publishing, and database management, and requires proficiency in various tools and techniques. Some common tools include text editors for hand-coding websites, Dreamweaver for website development, and blogging platforms for updating blogs. Successful web development also entails staying up-to-date with the latest technologies and trends in the industry to create websites that are engaging, intuitive, and optimized for

user experience. As such, it is a challenging yet rewarding field that offers opportunities for creativity and innovation.

4 Flow Chart

This is a flow chart that tells how a system works when the user gives input. As soon as the user gives input, the system finds out what to do or understands the command. If it fails to understand the command, it will check for a Wi-Fi connection and this Wi-Fi will give the signal to the system.

As we give input to the system, it is been received by the NodeMCU and this NodeMCU transfers this command to the relay module. Now the input block of the relay module transfers the current to the appliances and the system is processed. If the appliance is working that means the system is working and our connection is well established whereas if it is not working then we check the connection and the process shall be reinitiated (Fig. 1).

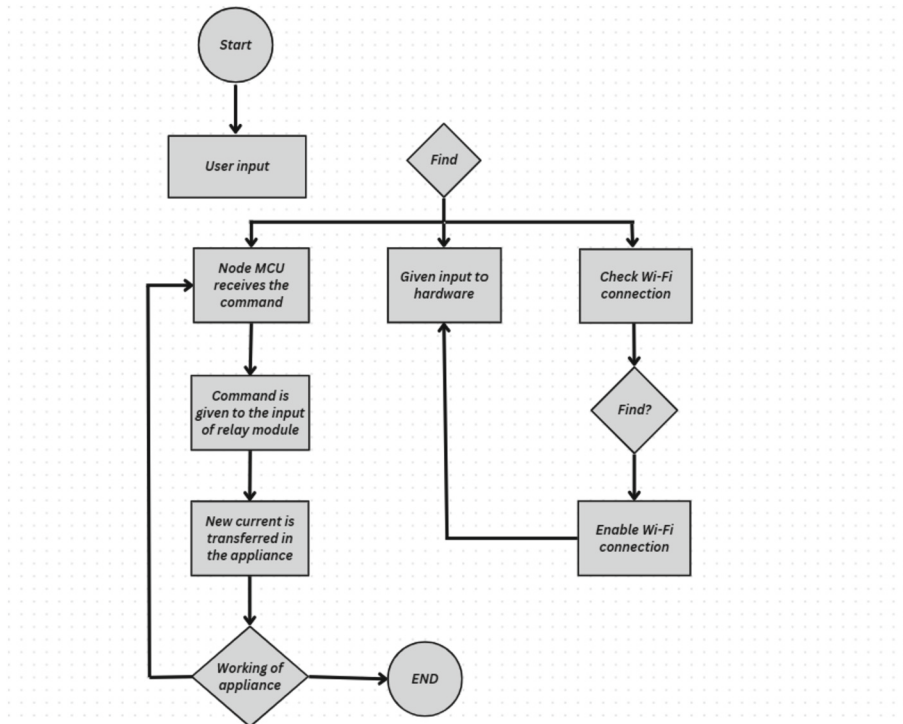


Fig. 1. Flowchart diagram of working of devices

5 Proposed Model

This cutting-edge model harnesses the latest technology to facilitate easy and convenient home automation. Users can control a wide array of electronic devices through the website, including smart objects like LED lights, fans, and televisions. Moreover, an APK version of the website is available for download, enabling users to control these devices through their mobile phones. As these smart objects generate vast amounts of data, a Wi-Fi module transmits it to the cloud for secure storage and analysis. We leverage cloud computing technology to analyze this data, which includes information on power consumption and electricity bills generated (shown in Fig. 2).

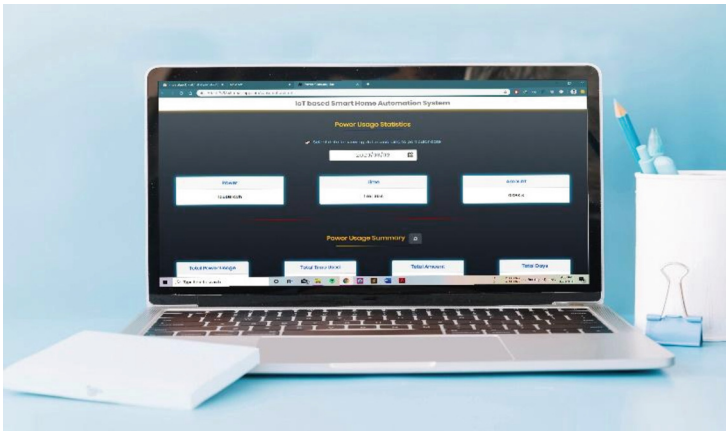


Fig. 2. Power Consumption data

To make it easier to understand the information we collect, we utilize various algorithms to display the data in a visually pleasing and easy-to-read format. We generate graphs and charts that provide a clear picture of the data, allowing us to track and monitor usage patterns and identify trends over time. In this project, we have saved the data on the cloud using PHP, MySQL, and ESP(12E). Now, NodeMCU updates the data in the database using PHP API. [9] All the data will be shown on our website and we have added a concept of a secret key for security purposes. This secret key is given to only those who want to access the home automation system. The secret key can be changed or shared among as many people as we want. As soon as we enter the code, we connect our site to our home system. All the appliances connected to our system will be visible on the screen and we can use our power save mode button. We can check the total power consumed. [17] To open this site in another system, we have provided an apk file for it. We can connect multiple devices and allow them to exchange data in real-time [18]. The Esp8266 module (NodeMCU) will receive commands from your smartphone wirelessly over the Internet. In short, IoT technology is revolutionizing the way we interact with our devices, [19] enabling us to make smarter and more informed decisions when it comes to power consumption and the overall management of our homes (Fig. 3).

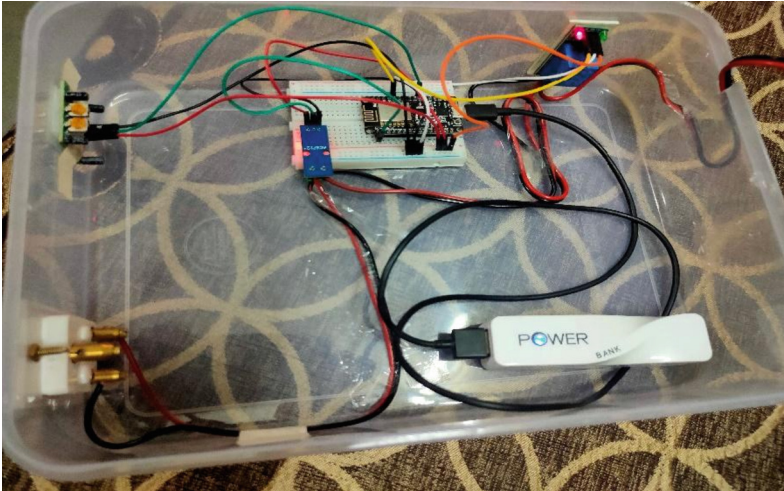


Fig. 3. Hardware representation

6 Result

The implementation of the proposed home automation system with cloud computing and IoT technology yielded promising results. The system successfully enabled users to control a wide range of electronic devices, including smart objects such as LED lights, fans, and televisions, through a user-friendly website. Additionally, an APK version of the website was developed, allowing users to control their devices through their mobile phones. The system efficiently collected data from the connected devices, including information on power consumption and electricity bills generated, which was securely transmitted to the cloud for storage and analysis. Cloud computing technology played a crucial role in processing and displaying the data in visually appealing graphs and charts, allowing users to track usage patterns and identify trends over time. Data storage was implemented using PHP, MySQL, and ESP (12E) on the cloud, ensuring secure and confidential storage of the collected data. The system incorporated a secret key concept for enhanced security, providing controlled access to authorized individuals. The development of an APK file enabled mobile access and real-time data exchange, allowing users to manage their home automation system on the go. The user interface was designed to be intuitive, and a power-saving mode button was included, empowering users to optimize their power consumption. Overall, the project demonstrated the successful integration of cloud computing and IoT technology, revolutionizing the way users interact with their devices and enabling smarter decision-making in terms of power consumption and home management.

7 Future Scope

The future scope of home automation means making our home smarter with the help of voice assistance or different sensors and detectors. We can use various sensors like light sensors, motor sensors, temperature sensors, etc. in our homes to make them smarter

and more innovative. We can build a smart digital lock system for our home. It is simply made with the help of digital information like secret codes, semiconductors, smartcards, fingerprints, etc. We can add a feature of a gas detector system in our home. MQ-2 and MQ-6 sensors are used to detect gas leakage in home security systems and this will give a warning to the user through mobile or through a buzzer installed in the home. Nowadays, Alexa is used but still, many Indians are unaware of it, it's for many people so it is our aim to make our home automated in every city and state. It may be an unfamiliar concept but people are slowly accepting it. We can create a virtual world like face book's recent concept of the metaverse. It will provide virtual experiences inside the home everywhere without even going outside the house. We can use smart television and smart refrigerator. In-home automation we use the concept of smart heating, smart energy, smart lighting, etc. In foreign countries people use a smart mop system, in this, the mop is designed in such a way that once a switch is on it cleans the room itself and then automatically switches off. We can use this system in factories also. We can use various technologies in agriculture fields and we can monitor the field sitting at home or in any local remote area.



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AI-Enabled Sustainable Development: An Intelligent Interactive Quotes Chatbot System Utilizing IoT and ML

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Abstract. A chatbot is computer software that uses artificial intelligence to communicate with people in their native tongues. These chatbots often speak by text or audio, and they are adept at mimicking human speech to interact with people in a way that is human-like. One of the most effective uses of natural language processing is a chatbot. The main purpose of chat bots is to offer customer service. It assists in serving a sizable target audience simultaneously and around-the-clock. May broadcast newsletters, auto-sequences, and plan meetings. It can also gather leads from comments. Create dialog-based forms and save all of the data in spreadsheets. A chatbot can be used to purchase food, propose products, provide customer service, provide weather information, help with personal finances, plan meetings, find and track flights, send money, and many other things.

Keywords: Artificial Intelligence · Natural Language Processing · Chatbot · Python PyCharm

1 Introduction

Computers now play a significant part in our culture! Information, entertainment, and assistance in numerous other ways are all provided by computers. A chatbot is a programme created for effective text or voice communication. However, the text-only chatbot is the basis for this paper. A chatbot may acquire information, Recognise human input, and offer a preset acknowledgment through pattern matching. An example would be if the user asked the bot, “What is your name?” The chatbot’s response is most likely to be something like “My name is Chatbot” or “You can call me Chatbot.” Text conversations with chatbots can occur and vary in value depending on a number of factors.

Understanding the full context of the individual involved, the user end goal, and environmental elements is necessary to choose the preferred input modality. Instead of

specifying an objective for chatbot creation, we adopt a user-counterapproach to comprehend how persons observe and interrelate with chatbots in everyday life. We may start measuring the presentation and goal by comprehending in what way chatbot meetings live up to prospects and how chatbot facilities comparison to replacements. We may anticipate more convenience to this technology now that chatbots are accessible on moveable plans and laptops. Both the number of mobile chatbot apps and the number of chatbot features included in communication platforms have been continuously increasing. One of the text-based chatbots used in this research provides the One of the most popular categories for supervised learning that is used to analyse certain text data is multinomial naive bayes. Because there is more information available in email, papers, webpages, etc., text information categorization is improving. Python and a few of its libraries, together with multinomial naive bayes, are utilised to finish this project.

A chatbot is a piece of software that simulates a real human chat agent by using text or text-to-speech to conduct online chat conversations. Computer programmes known as chatbots are able to converse with users in normal language, comprehend their intentions, and respond in accordance with predetermined rules and data. With many in production failing to successfully converse in 2012, no chatbot system could pass the traditional Turing test. Chatbot schemes are intended to precisely duplicate how a person would behave as a informal companion. Michael Mauldin really came up with the name “Chatter Bot” in 1994 to characterise these conversational programmes.

Several types of the chatbots are presented in the real-world applications. Voice chatbots are one type of chatbot. Other chatbots are such as Dual-purpose chatbots, Chatbots for social messaging, Chatbots with menus, Chatbots with skills, Keyword-based chatbots and Chatbots that follow rules.

Further the article is having sections. In Section 2 the related work on the proposed problem is summarized. Section 3 presents the proposed methodology of the work. Section 4 provides experimentation and conversation of the consequences. Lastly, Sect. 5 delivers the deduction and upcoming scope.

2 Related Work

Here, it is noted that related chatbot-related work has been done. The paper's [1]. Describes how to improve chatbot effectiveness Authors have provided a user-oriented implementation architecture that enables software to have AIpowered conversations with users. To facilitate the automation of service procedures, several organisations are investigating the installation of chatbots. Using qualitative content analysis and built upon an examination of the literature on chatbots, information systems, and human computer interaction (HCI). The suggested framework includes 101 leading questions to help with the eight-step chatbot installation process.

The article with the title,

Bio-inspired chatbot [2] learning style inventory Authors have highlighted how brain computer interfaces have been used to improve the effectiveness of elearning in recent years. Massive Open Online Courses (MOOC) are particularly well-liked by the current generation of students. A variety of courses can be delivered through Coursera, Edx, Simplilearn, Byjus, and many more online learning service providers. MIT, it was discovered that the past five years had an astonishing dropout rate of 96%. Using a variety of strategies, educational academics are working to lower the dropout rate

for online courses. Brain Computer Interface (BCI) is being used by HCI researchers in an effort to improve the effectiveness of online learning. Further in the papers [3–6] describes conversational AI’s adoption in the workplace. According to a taxonomy of AI chatbot users, the usage of AI applications in organisations is growing at an exponential rate. With the aid of this system, data may grow, change, and develop to become more suited to the needs of users and organisational contexts. In order to address the research issue, this study emphasises on the practical use of informal AI, in specific AI chatbots. A taxonomy of users is offered based on these factors, and it divides users of AI chatbots into four collections: early quitters, pragmatics, progressives, and persistent.

Further in the papers [7–12] authors presented the contrast of Natural Language Understanding Stages for Chatbots in Software Engineering pointed out that a Natural Language Understanding (NLU) lies at the core of any chatbot. We compare four like NLU—IBM Watson, Google Dialogflow, Rasa, and Microsoft LUIS—in order to determine which NLU should be utilised in chatbots built using package work. We employ two datasets that represent two typical activities carried out by practitioners of software engineering in order to assess the NLUs. When choosing the NLU to utilise in their chatbot, software engineering professionals can use our results as help. Authors in [13–19] have depicted the Personalised Chatbot Trustworthiness In the proposed study, we aim to tackle the challenge of evaluating and communicating the trustworthiness of a chatbot when it cannot be modified and its training data cannot be accessed. This situation often arises when a neutral party wants to assess the chatbot’s trustworthiness according to a user’s specific priorities regarding trust issues. To demonstrate the practicality of our approach, we will integrate a live chatbot and evaluate its performance using four different dialogue datasets and sample user profiles. The effectiveness of our method will be further verified through a user survey.

3 Proposed Methodology

We have proposed a simple conversational chatbot which provides quotes based on request of user. Users doesn’t need to waste time in searching quotes on various websites. This project is very useful for user who are searching for quotes, it provide various types of quotes based on user inputs and it gives various types quotes to the users based on their interest and most relevant search quotes (Fig. 1).

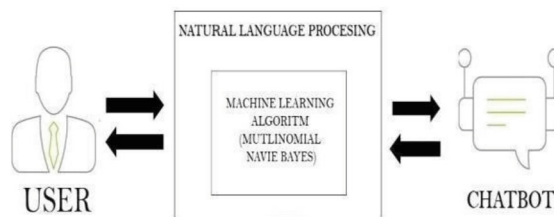


Fig. 1. Proposed Methodology for the Intelligent Chatbot [1]

Multinomial Naive One of the most popular supervised learning classifiers used for the study of particular text data is Bayes. Text information categorization is improving because there is more information available in emails, documents, webpages, and other online sources that has to be evaluated. Understanding the context of a particular sort of text may assist determine how people who will use the programme or product will perceive it. This classifier uses Bayesian probability calculations. Thomas Bayes developed the Bayes theorem, which determines the likelihood of an event based on prior knowledge of the circumstances surrounding one.

It is supported by the following formula.

$$P(M|N) = P(M) * P(N|M)/P(N) \tag{1}$$

When predictor B is already available, we have a propensity to estimate the chance of sophistication A. Prior probability of N is P(N).

Prior probability of class M is P(M).

Incidence of predictor N for the specified category, P(N|M) M Probability.

This equation aids in calculating the chance of tags appearing in the text. Determine the likelihood. Probability is the likelihood that a term will appear in a document, assuming the document falls under a particular category.

P(Words/Category) is calculated as follows: (Number of times the word appears in all documents from a category plus one)/(All the words in all documents from a category plus the total number of single words that are unique across all documents).

After being modified using TF-IDF, the data is subsequently exchanged into training and test sets. The model was created using the Naive Bayes approach and Logistic Regression to identify classification in the training data part. The Naive Bayes approach was used to create the model, and the following formula was used:

$$P(A_i|e) \text{ is equal to } p(e|A_i)p(a_i)/p(e|A_j)p(a_j)...(i = 1, 2...n) \tag{2}$$

1. p the prior probability class A_i .
2. Using the Bayesian formula, the posterior probability $P(A_i | e)$ is calculated based on the prior probability $P(A_i)$.
3. The test text is categorised into the group with the highest posterior probability value based on the posterior probability. Similar to how models are created using the logistic regression approach, machine learning models frequently employ logistic regression.

$$\text{Logit}(s) = y_0 + y_1M_1, y_2M_2, y_3M_3, +... + y_kM_k \tag{3}$$

where's denotes the likelihood of an appealing feature being present. $y_0, y_1,$ and y_k are the intercepts of the model in the system, while $M_1, M_2,$ and M_k are the predictor values. These are the underlying presumptions for logistic regression.

1. In a logistic regression, there is no linear relationship between the independent and dependent variables.
2. There must be a dichotomy among the dependent variables.
3. Independent variables must be linearly connected; a set of variables is seldom distributed or has the same variance.

4. Grouping has to be an exclusive relationship. The following phase, once the classifier model has been developed using training data, is to evaluate the data using test data that represents 30% of the training data. At the

Steps To Implement The Multi Nominal Naïve Bayes Algorithm

Begin

Step 1 : insert input user info.

Step 2: Steaming our tag and deleting stop words

Step 3: List the tags then apply probability in step

Step 4: Sort the data by probability in highest order before storing it.

Step 5 : Comparing the data to the dataset

Step 6 : Return the response in accordance with the tag

Step 7: Display the Output

End

The user input, training process, and chatbot module are the three key components that make up this system.

- A. User Input - Users may start a discussion right away by selecting the chat option and entering information into the chatbot.
- B. Training process - These three steps are used to carry out the actual training, procedure, and data search:

Training data: The system has some training data that it can utilise to process user input.

Word embedding: Accepts user input and extracts it into keywords for searching for pertinent solutions in accordance with the keywords.

Searching in conjunction with a keyword: A user-provided quote's extracted keywords are used to conduct a database search and provide results.

- C. Chatbots that reply to users by performing multinomial naive bayes on the user's input.

Existing System Model:

These days, chatbot technology is nearly everywhere, from home smart speakers to messaging services in the office and home. Virtual assistants or virtual agents are common terms used to describe the most recent AI chatbots. They may communicate with you via text messages or voice assistants like Apple's Siri, Google Assistant, and Amazon Alexa. In any case, you may ask the chatbot conversational questions about what you need, and it will aid in your search by giving you answers and asking you follow-up questions (Figs. 2 and 3).

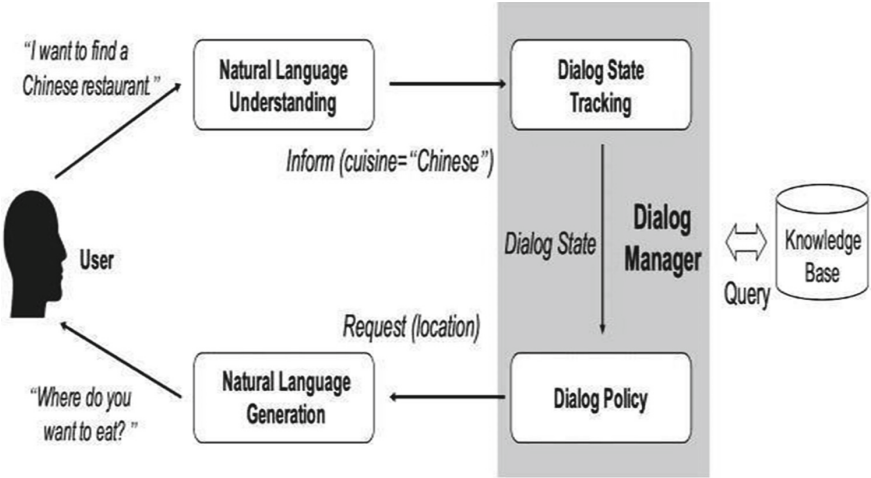


Fig. 2. Phases of Intelligent Interactive Chatbot System

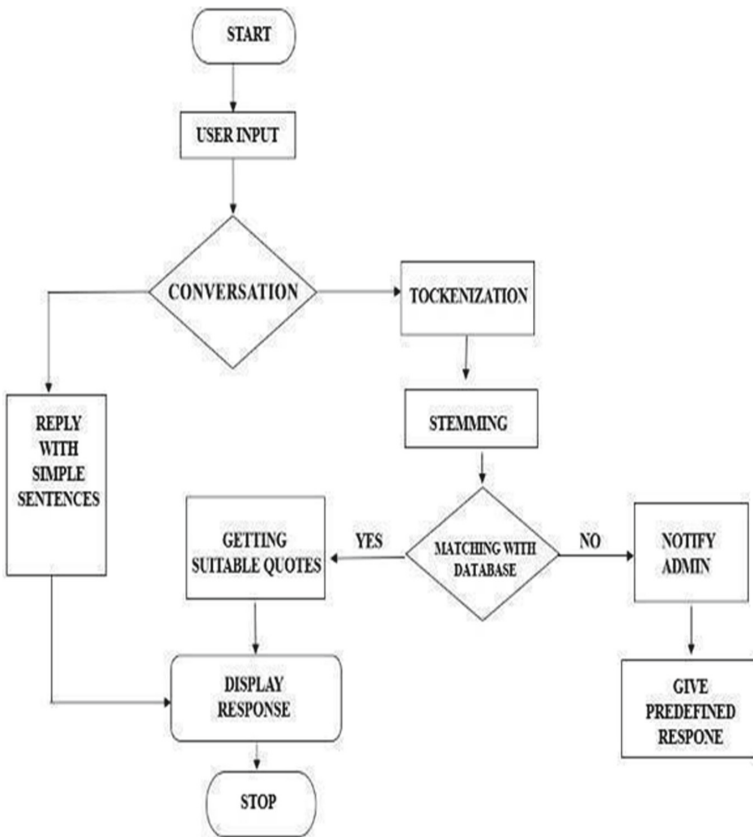


Fig. 3. Processing stages of Intelligent Interactive Chatbot System Flowchart

4 Proposed System Flow:

START: Identify what you want your chatbot to do. The more specific you are, the. You can start by asking yourself a few questions.

USER INPUT: the user will give the some inputs which are already inserted in chatbot or Relevate words, User input lets you collect user responses. In this you need to define what are the user messages will respond the bot's response that better.

CONVERSATIONS: Chatbots are computer programmes that mimic human chats to provide clients a positive user experience. While some show user inquiries and deliver automatic responses using artificial intelligence and natural language processing (NLP), some function based on established conversation flows.

REPLY SIMPLE SENTENCES: The Open the Bot response simple, Select the Quick reply from the list, and add a message and a number of buttons. You can add a maximum of 13 buttons to one responces then, you need to set up your button. Add the Button name and select a the Button type style.

TOCKENIZATION: Tokenization is the task of breaking text up into pieces, called tokens, and at the time throwing away from certain characters, such as a punctuation. These tokens are linguistically representated as a the text.

STEMMING: Stemming algorithms worked by the chopping off the word's beginning or finish while taking a list of the frequent prefixes and suffixes that can be found in a refracted word into consideration. This indiscriminate method can be effective on occasion, but not always, which is why we claim that it has certain drawbacks. Below are examples in both English and Spanish that demonstrate the technique.

MATCHING WITH DATABASE: the simple speed or fastest option to search questions is to match the input text typed by the human to the each possible input and listed in each possible line.the chatbot does this, and as the first thing it attempts. If a match is found, answers and displays it.

NOTIFICATION: If The data not matches with database it gives a notification.

PRE DEFINED RESPNCES: giving the Responses to display the pre defined results in chatbot.

GETTING SUITABLE QUOTES: matching with database and gives a correct output for the user.

DISPLAY OUTPUT: by displaying the correct output we can gave output.

EXIT: again back to starting point.

5 Experimentation and Results:

```

Loaded 'bot.json' successfully!
You: hi
Bot: Hey there!, how can i help you
You: bye
Bot: See you later!
You: 1234
Bot: Please try writing something more descriptive.
You:

```

```

Loaded 'bot.json' successfully!
You: MOTIVATION
Bot: 1.life is 10% what happens to you and 90% how you react 2. When you have a dream, you've got to grab it and never let go.
You: |

```

The contribution of the proposed work as compared to the existing applications and websites give numerous number of quotes. There are chatbots which communicate with users through text and voice whereas this paper proposed a simple conversational chatbot which provides quotes based on request of user. Other AI enabled Chatbot's for sustainability in state-of-the-art are.

1. THE NEW BING

Language model – OPEN AI'S GPT-4.

Current Event Capability – up-to-date one currents events.

2. CHATGPT

Language model – OPEN AI'S 3.5 AND GPT-4.

Current Event Capability – limited current event capability.

3. JASPER

Language model – OPEN AI'S GPT-3.

Current Event Capability – focuses on the written text and pilgrim checker.

4. YOUCHAT

Language model – SUPPORTED BY GOOGLE.

Current Event Capability – source information from google.

5. CHATSONIC

Language model – FROM GOOGLE.

Current Event Capability – up-to-date events.

6. GOOGLE BARD

Language model – FROM GOOGLE.

Current Event Capability – index google for responses.

7. SOCRATIC

Language model – OPEN AI'S GPT-4.

Current Event Capability – kid-friendly.

6 Conclusion:

The chatbot is one of the most straightforward ways to transfer data from a single computer without the need to consider the right keywords to look up in a search or browse through numerous web pages to gather information. Users can also simply type their



query in natural language processing to retrieve information. The design and deployment of the chatbot must be discussed in detail in this essay. According to the report above, chatbot design is developing and improving at an unpredictably fast rate since there are so many different techniques and strategies that may be employed to create a chatbot. A chatbot is a fantastic tool for quick user contact. In addition to delivering amusement and time saving.

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Analyzing Real Time Farming Using Internet of Things in Agriculture

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Abstract. Real-time farming, in particular, has become a focus of research as it allows farmers to monitor and control their crops and livestock remotely using IoT devices. This study intends to evaluate the use of IoT for real-time farming in the agricultural sector. The study will involve IoT components including sensors, actuators, and microcontrollers in the development and design of a real-time agricultural system. To assess the system's performance in terms of data collecting, processing, and reaction time, a farm setting will be used for testing. Today's technology is constantly evolving, and a wide variety of tools and techniques are available to the agricultural industry. Knowledge processing is also an advantage of IoT in agriculture. All information can be obtained using the sensors that are implemented. This study focuses on developing a system in the field of agricultural industry where there is no need of human intervention in providing proper water regularly. It is designed in a way in which the automatic water supply is trigger whenever required.

Keywords: Agriculture · Smart Farming · Precision Agriculture · Remote Monitoring · Crop Monitoring · Climate Control

1 Introduction

This assumption is based on technological developments that lead to smart ideas such as IoT and cloud computing. Agricultural IoT is a network screen, cameras and computer which work together to improve farmer ability to complete his job. They can communicate with each other without human intervention because the computer is self-sufficient. In other words, these devices already know what to do at a given time and why they need to communicate with other tools in the system. As technology advances, sensors become smaller, more complex and easier to use. The technologies are also easy to use and comprehensive, allowing you to implement smart agriculture with complete confidence. Focused on increasing agricultural progress, intensive agriculture is a solution to the challenges facing the industry today. A farmer can monitor his field and get all the necessary data or information on his mobile.

This research paper aims to explore the application of IoT in agriculture, specifically focusing on real-time farming. The IoT-enabled agricultural ecosystem encompasses a wide range of components, including sensor networks, wireless connectivity, cloud

computing, and data analytics platforms. Sensors embedded in the field can collect data on soil moisture, temperature, humidity, and nutrient levels, while aerial drones equipped with cameras and thermal sensors can monitor crop health and detect potential issues such as pests or diseases. In this research paper, we will delve into the various aspects of real-time farming using IoT, including the technologies involved, data collection and analysis techniques, and the potential benefits and challenges associated with its implementation.

Overall, this research aims to contribute to the existing body of knowledge by providing a comprehensive analysis of real-time farming using IoT in agriculture. By exploring the potential of this innovative approach, we can pave the way for sustainable and efficient farming practices, ensuring food security and environmental stewardship in the face of global challenges.

2 Literature Review

A network of connected computers, machines, animals, and even humans that communicate data without the aid of other computers is referred to as the “Internet of Things” (IoT). These “things” may have an IP address and be digital or real objects. IoT is being progressively used by several businesses across numerous sectors in order to improve customer service experience, streamline operations, and make wise decisions that can help them increase their total worth. The method performs real-time analysis of data collected from in-plant sensors and provides farmers with the results they need to monitor crop growth, reducing farmers’ time and effort (Sekaran et al. 2020). 1. Researchers use this study as a guide, and to achieve the leap toward intelligent agriculture, more new communication technologies should be implemented in agriculture (Tao et al. 2021). 2 A semantic framework for IoT-based smart agricultural applications called Agricultural IoT supports real-time reasoning about various heterogeneous sensor data streams (Kamilaris et al. 2016). The associated difficulties in these solutions, while highlighting factors for improvement and a roadmap for future work with IoT (Ray 2017). The main advantage is that the implementation of WSN in precision agriculture (PA) will optimize water and fertilizer consumption while increasing yield, and will help analyze weather conditions in the field (Savale et al. 2015). IoT is essential for modernizing crop and animal management practices in the agriculture industry. IoT has aided in managing crops, land, and animals, leading to less waste and greater output. These technologies and approaches include sensors, drones, automated water pumping systems, and machinery. Smart agriculture is the term used to describe this kind of farming, which has completely changed the field. For instance, sensors can measure the health of crops and insects, drones can keep an eye on animals, and automated water pumping systems may irrigate crops when it’s convenient. Overall, IoT has become an essential part of the agricultural sector’s operations, enabling effective and efficient resource management.

3 Methodology

This section outlines the suggested Internet of Things (IoT) architecture that is based on an experimental model for automatic irrigation and real-time monitoring of agricultural indicators using heterogeneous sensors. The experimental research technique and

model-based design resulted in a built-in autonomous irrigation control system. Using algorithms proposed by microcontrollers, sensors, engines, pumps and solar energy algorithms to test and test the model-based design. Proposed model will control and monitor automatic irrigation system and collect data from the sensor, measure the water level and automatically open and turn off the irrigation engine.

3.1 System Set-Up and Installation

The Smart Agriculture Vertical Kit contains several agriculture-related sensors to implement the proposed agriculture-related architecture. The proposed cloud computing architecture will allow farmers to measure and monitor using wireless communication technology, unlike existing cloud computing architectures that need to connect to cloud computing platforms to receive analytical information. The data source layer, which uses various sensors, is responsible for recording agricultural factors. These sensors can be embedded in the ground and in the surrounding environment. Most soil sensors are waterproof and typically record variables such as temperature, humidity and other soil properties. Nearby environmental sensors measure environmental factors such as air temperature, humidity, barometric pressure, amount and intensity of precipitation, wind speed and direction, solar radiation and humidity leaves. As shown in Fig. 1, the sensor connects directly to the sensor assembly, which includes a wireless antenna, a bond pad for interacting with the sensor, and an integrated solar power supply. In this experiment, the Lola communication channel is set to send the data frame every 15 min to the data processing layer. This is because using an external solar panel reduces energy consumption and keeps the associated battery charged.

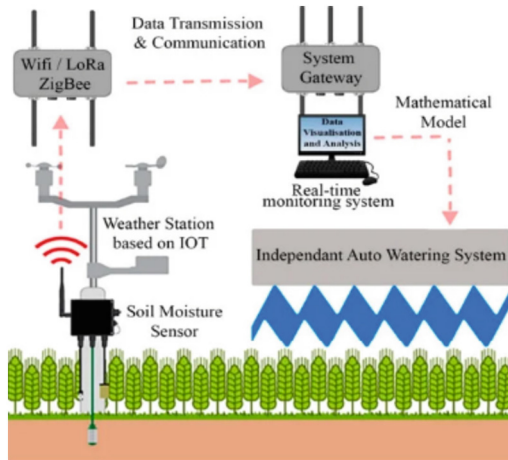


Fig. 1. The complete working model (The image depicts a visual representation of the complete working model of real-time farming using Internet of Things (IoT) in agriculture. The model consists of various interconnected components and processes that enable data collection, transmission, analysis, and decision-making in agricultural operations.)

The weather station was used for 51 days to collect information on the plant's surroundings, including temperature, humidity, pressure, wind speed and soil wetness. The sensors node and system gateway of this weather station communicate through LoRa wireless at a frequency of 2.4 GHz. To receive and access the necessary data, a receiver is attached to the user's PC. The environmental demands of the facility for future usage were then correctly and effectively predicted using models developed using this data. The autonomous auto-watering system then uses the values that are produced by these models. The weather station also keeps delivering the recorded data, which is utilized to monitor the field's environmental conditions in real-time.

3.2 Working of Auto Watering System

The Arduino IDE was used to develop the code and all test data and control stand-alone automatic irrigation system that was the subject of the proposal. These models are predicted using sensory data collected from meteorological stations. Figure 6 shows the flow diagram of the integrated Arduino IDE model for controlling and tracking the automatic irrigation system. Equation (1) shows the soil moisture content in percent by volume.

$$\text{soil moisture content} = \frac{\text{Depth m}^3}{\text{volume m}^3} * 100 \quad (1)$$

Arduino Code

```
int sollMoistureValue = 0;
int percentage=0;
void setup() {
  pinMode(3, OUTPUT);
  Serial.begin(9600);
  void loop() {
    sollMoistureValue = analogRead(A0);
    Serial.println(percentage);
    percentage map(soilmoistureValue, 490, 1023, 100, 0);
    if(percentage < 10)
    {
      Serial.println("pump on");
      digitalWrite(3,LOW);
    }
    if(percentage >80)
    Serial.println("pump off");
    digitalWrite(3,HIGH);
  }
}
```

In this experiment depth of soil is 0.5 m³, volume is 1 m³, and percentage is 50%. Soil moisture at multiple depths can measure soil moisture at different depths. Additional sensors should be placed 25–30 cm and first sensor should be placed at a depth (10 cm)

below the surface. The Arduino automatically opens a valve to let water flow into the soil whenever the soil moisture falls below a predetermined threshold. The valve closes when the moisture content of the soil reaches a certain point. To check the water level every 15 min, the system uses an integrated soil moisture sensor. The flow of water into the soil is automatically controlled by a 12 V solenoid valve according to the soil moisture value. Both the valve and the Arduino are powered by an external 12 V power supply using a DC-DC 5 V converter (Fig. 2).

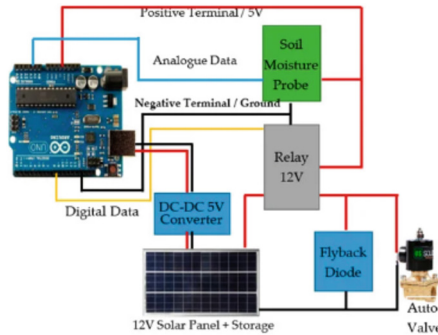


Fig. 2. The purpose auto watering system circuit (The image represents the purpose of an auto-watering system circuit, which is an essential component of the real-time farming model using Internet of Things (IoT) in agriculture. The circuit is depicted as a schematic diagram with different interconnected elements.)

The Arduino is connected to the valve through a relay that also acts as an external power source. When the wires were connected directly during testing to ensure that factory environmental conditions were not abnormal, kinks occurred, causing the relay to burn. Since the flyback diode is installed in parallel with the relay and the valve, there is no problem with the relay.

4 Smart Agriculture Using IoT

Agriculture is mainstay of India’s economic development. Climate change is the main obstacle to traditional agriculture. Among the many effects are massive flooding, the strongest storms, heated winds that cause lower rainfall, and other climate changes. The effects of these factors have a negative impact on performance. Natural consequences of climate change frequently include cyclical changes in plant lifecycles (Fig. 3).

Agriculture needs innovative thinking and IoT strategies to increase yields and reduce bottlenecks. Farmers can now overcome the major challenges they are facing thanks to IoT which is now bringing attention to agriculture. Farmers can access a wealth of information and data on upcoming trends and innovations (Fig. 4).

The process of industrialization of global agriculture is accelerating, and it is very important to establish intersectoral cooperation in agriculture. Rural inter-pillars can be a significant obstacle to agricultural reform and progress and play a vital role in maintaining economic stability and sustainable growth. For some time we have focused on improving the system and getting more agricultural data.

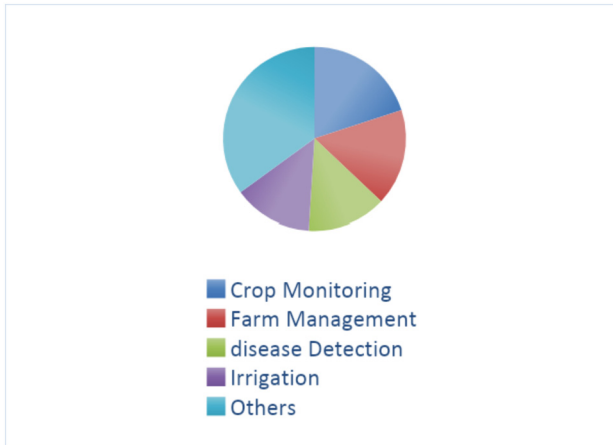


Fig. 3. Graphical representation of field distribution of IoT application (The image presents a graphical representation of the field distribution of IoT applications in agriculture.)

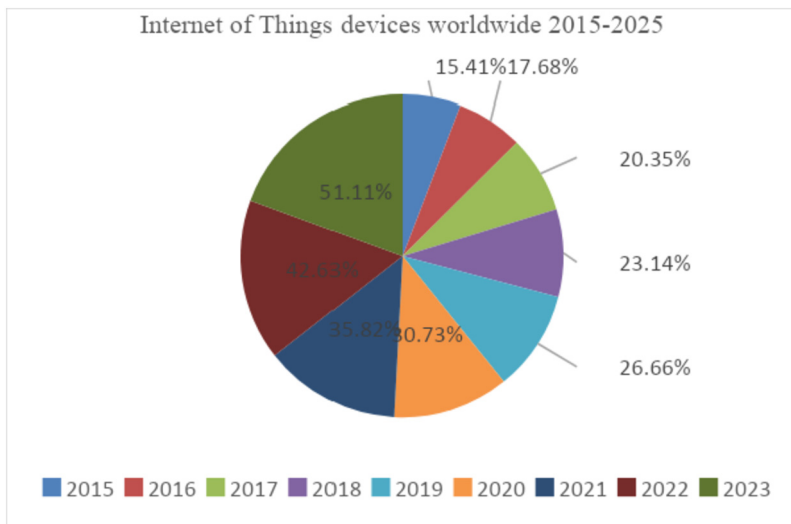


Fig. 4. Graphical representation of Internet of Things devices worldwide 2015–2025. (The image displays a graphical representation depicting the growth of Internet of Things (IoT) devices worldwide from 2015 to 2025.)

5 Major Applications

Implementing the latest advances in IoT and sensing agricultural technologies can fundamentally change every part of traditional farming strategies. Today, intelligent agriculture will take agriculture to previously unimaginable heights as Internet of Things through wireless sensors and continued convergence of smart farming principles using IoT can

help predict answers to a number of common agricultural problems, including drought response, yield optimization, arrival adequacy and interference regulation.

5.1 Precision Farming

One of the most well-known applications of the Internet of Things in agriculture is precision agriculture, also known as precision agriculture. Smart farming applications include those that make farming more precise and regulated, including those that monitor animals, vehicles and fields. Precision farming is all about examining sensor data and taking the necessary actions. Farmers use information collected by sensors and analyse it using precision agriculture to make fast, informed decisions. Precision farming practices such as vehicle tracking, livestock management, irrigation management and livestock management are critical to increasing productivity and efficiency. To improve operational efficiency, precision agriculture allows the assessment of soil conditions as well as other important information (Figs. 5 and 6).

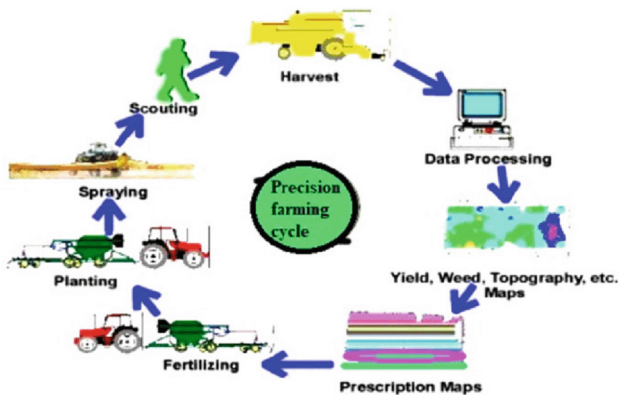


Fig. 5. Precision farming Cycle System (The image represents a graphical depiction of the precision farming cycle system, which is illustrated as a circular process. The different stages of the precision farming cycle are highlighted, showcasing the interconnectedness and iterative nature of the system.)

Last but not least, early research on the financial viability of implementing precision agricultural technology revealed that the gains are small, with a 2% rise in net returns for employing soil and yield mapping, automated guidance systems, and variable input applications, as examples. According to survey responses from soybean farmers, using digital agricultural technologies can result in advantages per acre.

5.2 Climate Change Sensor

Climate change has a major impact on agriculture. In addition, the lack of understanding of the climate can seriously affect the quantity and quality of agricultural products. IoT technology can provide real time weather monitoring. Sensors are used in and outside

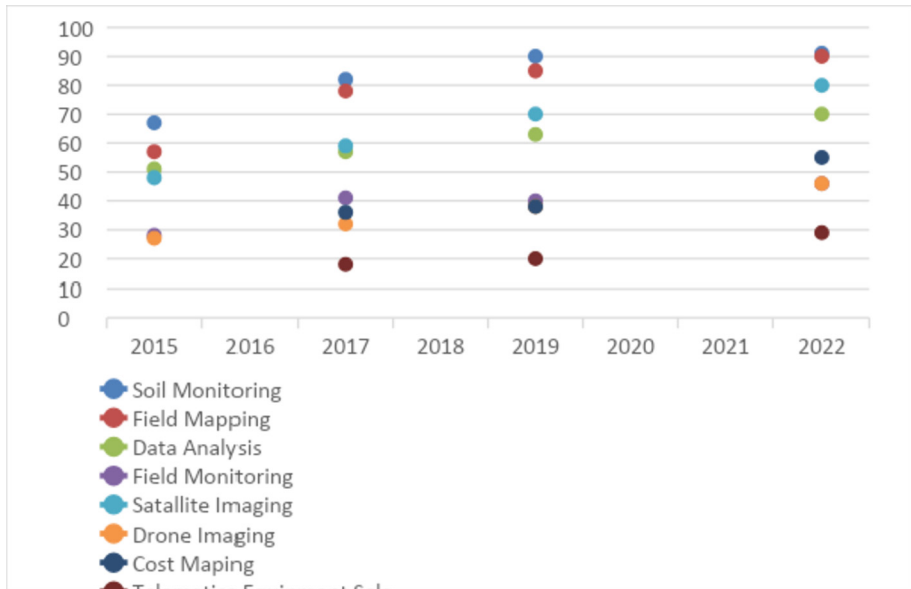


Fig. 6. Detail of precision service over time (The image depicts a graphical representation of the evolution of precision services over time.)

agricultural area. They collect data about the environment and then use that data to determine which crops might thrive in the current climate. IoT ecosystems use sensors to accurately track real-time weather variables, including soil moisture, precipitation, temperature and more. You can use different sensors to monitor and customize these variables to meet your intelligent agricultural needs. These sensors monitor crop health as well as surrounding weather conditions. Alerts when unexpected weather conditions are detected. Eliminating the requirement to be present during extreme weather conditions increases productivity and allows farmers to reap additional agricultural benefits (Fig. 7).

5.3 Smart Greenhouse

Greenhouses that allow weather stations to automatically adjust the climate based on a set of instructions. Using the Internet of Things in greenhouses eliminates the need for human intervention, reducing costs and increasing the accuracy of the entire process. For example, affordable modern greenhouses can be built with IoT solar panels. These sensors provide accurate, real-time monitoring of greenhouses by collecting and transmitting data in real time. Sensors allow you to track greenhouse conditions and water usage via email or text. These sensors can monitor pressure, humidity, temperature and light levels.

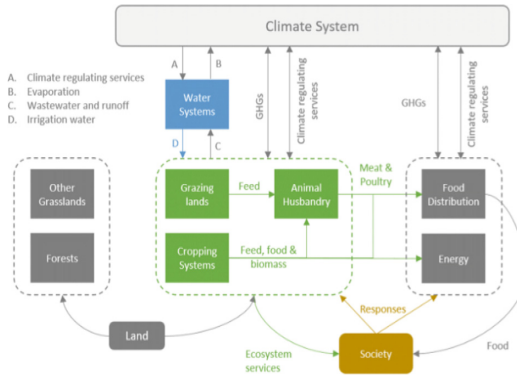


Fig. 7. Climate change working system (The image presents a visual representation of a climate change working system, showcasing its key components and functions. The image depicts a circular system, representing the climate change working system. The system is divided into several interconnected components and stages, each contributing to the understanding and mitigation of climate change.)

5.4 Drones in Agriculture

The advent of agricultural drones in recent years has caused a recent upheaval in agricultural operations, which have almost completely changed due to technological improvements. Drones are used on ground and in air for agricultural health inspections, crop monitoring, planting, crop spraying and field analysis. Drones have evolved and transformed agriculture industry by developing effective strategies and planning based on real time data. A drone equipped with thermal or multispectral sensors can identify areas that require different irrigation patterns. The sensors monitor crop growth and determine its vegetation index. So now difference between yield, quality and yield has reduced (Fig. 8).

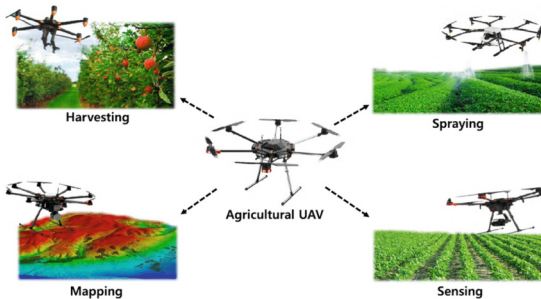


Fig. 8. Drone monitoring system (The image presents a visual representation of a drone monitoring system, illustrating its key components and functionalities.)

6 Challenge and Limitation

Several benefits of IoT in agriculture include higher agricultural yields, improved resource management, and increased output. But there are also some challenges and limitations to consider.

- Internet access is required for IoT devices to deliver and receive data. Internet access might be spotty or non-existent in many agricultural areas. IoT applications in agriculture may face serious difficulties as a result of this.
- IoT applications must interface with a variety of sensors and devices, and integration methods are frequently complicated. This could be difficult if there are compatibility problems since the systems weren't intended to operate together.
- The cost of IoT system adoption in agriculture might be high, particularly for small farmers. This is due to high maintenance, software and hardware costs.
- IoT applications generate large amounts of data that must be collected, stored, analyzed, and managed, requiring data management. Due of their limited financial means or technological expertise, farmers may find this challenging.

7 Result

The suggested technique enhances monitoring efficiency and water usage, and it has various advantages over the present system, such as less water waste.

Water Consumption. The automated watering system significantly reduced water consumption compared to traditional irrigation methods. By continuously monitoring soil moisture levels and weather conditions.

Soil Moisture Maintenance. The IoT-based system effectively maintained optimal soil moisture levels throughout the experimental period. The deployed soil moisture sensors provided accurate measurements, enabling the system to deliver water precisely when needed.

Crop Growth and Yield. Crop growth and yield were positively influenced by the automated watering system. The precise and timely irrigation provided by the system contributed to optimal plant health and growth.

The experimental study highlight the effectiveness of an automated watering system using IoT in agriculture. The system successfully optimized water consumption, maintained optimal soil moisture levels, and enhanced crop growth and yield.

8 Conclusion

That is why smart farming is needed. Smart agriculture will benefit from development of IoT. IoT is being used in many aspects of agriculture, including crop monitoring, managing soils, insect control, and pesticide safety, to increase productivity and conserve resources. It also eliminates labour, eliminates agricultural practices and changes the practice of smart agriculture. Agriculture until now has depended heavily on past customs and experiences. However, the traditions of the village have been shaped by the times and have begun to change with them. IoT will help manage all agricultural operations and increase agricultural production. A large part of the population depends on agriculture and major reforms are needed.

9 Future Scope

AI and machine learning integration In the future, artificially intelligent and machine learning technologies may intersect with IoT in agriculture. These tools might be used to analyses the enormous volumes of data produced by IoT devices to reveal information on the health of crops, the condition of the soil, weather patterns, and other things. Precision Agriculture This use of IoT in agriculture may make it possible to use precision agricultural techniques. Farmers can optimize crop growth and save waste by gathering information on variables including soil moisture, nitrogen levels, and temperature. Monitoring water consumption, cutting back on pesticide use, and increasing crop yields are some additional ways that sustainable farming in the IoT may support sustainable agricultural practices.

Acknowledgement. I want to sincerely thank my academic instructor for inspiring me to increase the caliber of my work, for advancing research at Amity University, and for constantly serving as a model for reaching greatness.

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Securing the Sustainable 5G Enabled IoMT-Fog Computing Environment: A Blockchain-Based Approach

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Abstract. Recent breakthroughs in fog computing and Fog's Internet of Things (Fog-IoT) technologies are focused on data analysis and medical procedures that use AI. Recent changes in the field of fog computing made it possible for these things to happen. Even at the level of fog computing, this paradigm is very open to many types of cyber-attacks and threats. This is its main flaw. In this set-up, the edge (sensing) layer, the fog (processing) layer, and the public (storage and management) layer could all be in danger (cloud). The Internet of Things is an important part of today's complex healthcare systems, which rely heavily on it (Fog-IoT). Medical equipment that is part of the Internet of Things (IoT) has problems with scalability, data security, and data storage. The Fog-IoT was made to solve these problems. But it would be very hard to manage such a large and complicated medical IoT system with the current Single Cloud platforms (CP), especially since the number of IoT-based medical devices has grown so quickly. We showed a flexible FC built on Blockchain technology for an IoT platform that can connect to 5G networks. In this research, a secure Blockchain-based Fog-BM-IoMT communication mechanism is shown that works on a fluid computing (FC) architecture with low overhead and safe storage.

Keywords: Blockchain · Internet of Medical Things · Fog Computing · 5G · IoT Security

1 Introduction

Internet of Things (IoT), about 39% of all IoT devices that are put into use by 2025 will be in the health care field [1]. According to predictions made by the smart company Tractia, this industry's annual earnings that use blockchain technologies are expected to reach \$19.9 billion by 2025. Applications that use the Internet of Things (IoT) are becoming more common in the healthcare field so that patients and doctors can get help right away

[3]. It might be possible to reach this goal by using IoMT medical devices in hospitals and clinics. On the other hand, as the number of IoMTs grows, so will the amount and variety of data that they create. Because the cloud is centralised, the Internet of Things's (IoT) huge data traffic processing has become a very serious problem and a cause for concern [4]. As a result, there is a higher chance that patient safety and privacy will be compromised. There is also a chance that data collection, data ownership, location privacy, and other aspects of privacy will also be compromised. Intruders and hackers can easily target the IoMT network that uses 5G by copying data and changing the name of medical equipment. IoMT-Cloud has a single point of failure, which leaves users open to attacks from bad people and lets private information get out. Transferring data between IoMT and the cloud requires trust, device identification, and user authentication to make sure the network is safe and the PHD transmission is secure, checking who someone is (UA). The traditional Central Cloud service (CCS) mode, in which everything is done at the centre, has a number of problems with how it is implemented right now. Some of these problems are high latency (HL), network dependence, single points of failure and their effects, and the inability to handle real-time transactions. These are just some of the problems that people are having right now. As a result, the fog computing or edge computing (EC) prototype made it possible for services to be offered at the network's edges in a timely manner and in a way that used as few resources as possible. The fog layer puts up a wall between the management tasks done at the edge and those done in the cloud (FL). The system [5] that was used for this study was a mix of clouds and fog. Figure 1 shows the usual way the fog IoMT model is shown. This makes it easier for the planner to set up and provide a service. It also improves the balance of available resources and the time between when the service is asked for and when it is given.

The fifth generation of wireless communication, or 5G, will enable remote control of machines and other objects over mobile network platforms. In-flight Internet of Things (IoT) drone security and surveillance is one example of an IoMT communication application that can be enabled by 5G. People make use of these applications on a daily basis. The Internet plays an essential role in each and every one of these ecosystem's components. The letter that follows bemoans the lack of care for the safety of individuals and the confidentiality of their communications. It is also at danger from a variety of other sources. To protect itself against these threats, the communication infrastructure for the Internet of Things that is enabled by 5G needs to have a robust defence. Protocols for key management, user/device authentication, access control, user access control, and intrusion detection are some of the other protocols that fall under this category. This investigation brings together a diverse selection of 5G Internet of Things communication system models (network and threat models). In order to create a safe space for conversation, we investigate the potential hazards and necessary precautions. In addition to it, security protocols are incorporated. Comparisons are made between several strategies for securing communications between 5G Internet of Things devices. The findings of this work have found applications in a wide variety of different fields, such as the streaming of IoMT that is possible by 5G and the development of secure protocols for the transmission of medical data. When coupled with blockchain-based fog architecture (FA), the cloud becomes a more powerful platform for coordinating dispersed resources and carrying out operations. Because of a variety of reasons, including

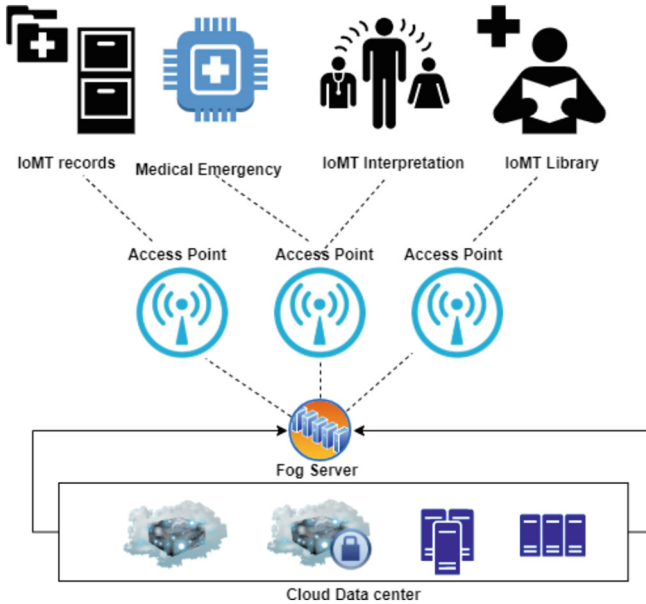


Fig. 1. Basic Fog Computing-enabled Internet of Medical Things (IoMT) Model for Healthcare Applications

dynamic interactions and porous barriers, in addition to heterogeneity and the unequal distribution of resources across levels. Because of the unpredictable and variable usage of the hybrid service environment, which includes the edge or secure IoMT layer that services Blockchain, the proposed solution is more adaptable and resilient than traditional cloud computing (TCC) [6]. This is due to the fact that the hybrid service environment includes the secure IoMT layer that services.

Blockchain

The following are two of the most important task from this article:

- (1) To propose a blockchain architecture for the 5G-enabled Internet of Things (IoT) that is trustworthy, can scale, and takes into account the necessity for secure data access.
- (2) Instill in Fog-BM-IoMT decentralized and original trust in management design ideas that are based on blockchain technology.

The remaining portions of the paper are organized as shown below: In Sect. 3, we will explore the researcher's previous work in this area. In Sect. 3, subsections (A) and (B) cover the blockchain and fog-based architecture for IoMT, respectively. Subsection (A) provides an overview of IoMT that is enabled by 5G. In the fourth chapter, we analyse the results of the simulation and come to certain conclusions. The concluding and concluding section of the work is referred to as Part V.

2 Literature Review

Fog technology is used to do computing IoMT is a very popular subject right now. In earlier studies, there were a lot of major security holes. A lot of healthcare IoMT devices send data to public cloud storage that is not secure. This makes it possible to change or attack the data. This means that sensitive information about patients could be shared with the public. (ii) We think that IoMT medical devices need to be identified right away, which will lead to the verification and authentication of health data. This can be done quickly by using a blockchain in the FC-IoMT system. This is because we think that this is the best way to make sure that health data is real. Edge servers are in charge of more thorough authentication and verification. Aazam et al. [11] came up with a new way to agree on IoMT keys. They called it BAKMP-IoMT. This method could be used to make sure someone is who they say they are on a blockchain. “secure key management in Internet of Medical Things” is what BAKMP-IoMT stands for. With this technology, medical devices that are implanted in a person can be linked to their personal server. Authors P. Gope and the others [12] We show a new way to log in to the Internet of Things that protects against PUF attacks from machines and is anonymous. We made this system, and this paper tells you about it. wO. Salem and his colleagues [13] have come up with a way to keep the integrity of MitMs while stopping alarms from health surveillance systems that are remotely monitored. P. Zhang et al. [14] made a complicated learning model by putting together a short-term long-range memory network and a deep convolutional neural network. This mix was what was used to make the model (CNN). Z. Ning and his colleagues explain how to get to a Nash equilibrium in their paper [15]. Theoretically, you can also figure it out based on how many patients are in the MEC and how long the algorithm takes to run at its slowest. The results of the performance trials show that the author’s proposed method increases the number of patients who benefit from MEC while at the same time lowering system costs. Aggarwal S. et al. [16] go into a lot of detail about readers’ 5G-enabled Tactile Internet fog computing. Also, the investigators are looking into this. Ahad A. et al. do an in-depth study of smart healthcare solutions in the Internet of Things (IoT) that are made possible by 5G. [17]. R. Cao and his colleagues gave a number of ideas, such as one for a multi-cloud cascade design, one for a low-overhead native testing framework, and one for a way to back up medical data storage. [18]. Deepak B. D. et al. In light of this, [19] says that a smart service authentication (SSA) mechanism should be set up to make sure that information about patients and doctors is more secure. Cheng, X., et al. [20] after the node’s identity has been proven to be real, there should be a safe and reliable way to update the authentication keys and the session keys. According to research done by Ejaz, Muneeb, and others [21], “smart” remote healthcare systems need a lot of uptime, low costs, network resilience, security, and trust in highly dynamic network conditions. J. Fu et al. [22] say that the IIoT is having an increasingly hard time processing information, storing information, querying stored information, and collecting dynamic data. Sun, Y., et al. No matter if the abstracts are the same or not, [23] the case database and the current patient’s privacy will be kept. Table 1 compares and contrasts some of the many features of 5G-enabled IoMT connectivity, including application, scalability, security, sustainability, storage, and computation.

Table 1. Represents the comparative analysis of different parameters for 5G enabled IoMT communication

Citation	IoMT Application	Scalability	Security	Caching	sustainability	storage	computing
R. Cao, et al. [18]	✓	✓	×	×	×	✓	✓
X. Cheng et al. [19]	✓	×	✓	×	×	✓	✓
[20]	✓	×	✓	×	×	×	✓
X. Cheng et al. [21]	✓	×	✓	×	×	×	✓
J. Fu, et al. [22]	✓	✓	✓	×	×	✓	✓
Y. Sun, et al. [23]	✓	×	✓	✓	✓	×	×

3 Proposed Methodology

The suggested method for this investigation can be broken up into two different parts. In the first section, we’ll look at equations for IoT communication that 5G makes possible. In the second section, we’ll look at designs that use Blockchain technology and fog.

3.1 A. 5G Made IoMT Communication Possible

One of the most important things that 5G networks will be used for in the near future is smart healthcare. Figure 2 shows how a 5G intelligent health network is put together and what its main parts are. In this section, we’ll talk about why it’s important to use smart antennas to support the communication protocols that 5G networks need. A number of changes in the modern world have made it possible for smart antennas to make 5G networks reach farther and transfer data faster. In the modern world, radio frequency (RF) radiation can be sent to a certain place using a technique called “beam shaping,” which takes place in two dimensions (vertical and horizontal). In the past, this energy was lost because it was spread out over a large area, making it hard to find. There is so much mm-wave RF in the environment that beam-forming 5G NR technology is needed. Without it, authentication could fail. Also, the network needs to be kept safe from any possible threats, which is why this technology is needed (e.g., vehicles, buildings, etc.).

When radio frequency (RF) beams are fully synchronized, they can send and receive signals better. But the location is still bad because as the level of attenuation goes up, the

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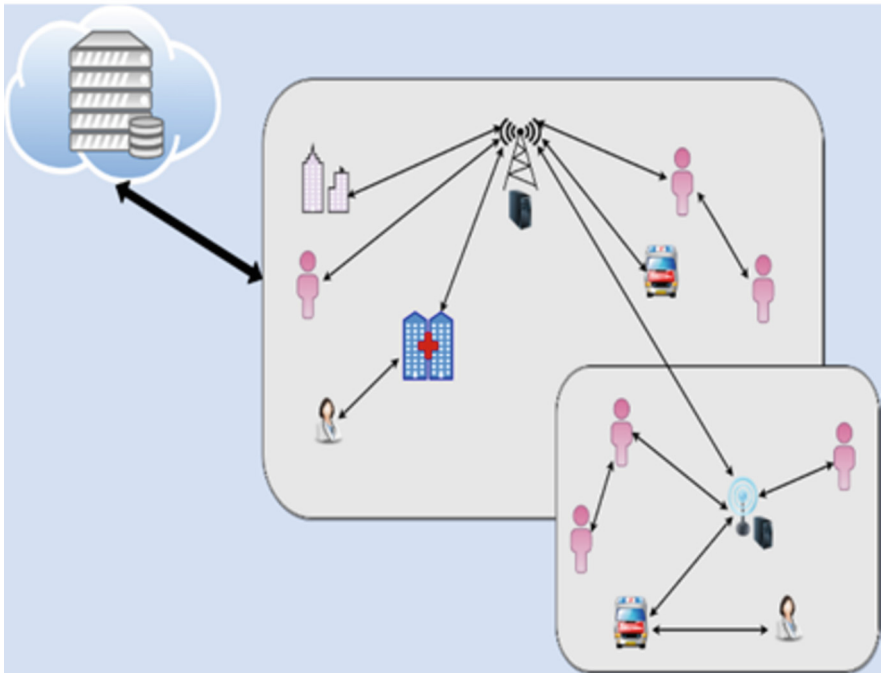


Fig. 2. Healthcare 5G Enabled IoMT.

area of interest gets smaller. Intelligent healthcare systems will be built on machine-to-machine communications and the Internet of Medical Things, which will be supported by 5G networks (IoMT). There are two major problems with the plans that have been given. One problem is that there are a lot of terminals, which makes networks compete for space. For applications that use the Internet of Things and Machine-to-Machine communication, it is important to have both high density and the ability to grow. The second area of concern is security, which comes from the fact that IoMT applications [9] rely heavily on wireless sensors. Both marketing research and the rollout of 5G networks started in 2014. The project should be done by the end of 2021. One of the benefits of 5G [10] networks is likely to be faster data transfer rates, along with more network density and compatibility with a wide range of Internet of Things (IoT) devices (DR). The high data throughput, scalability, blockchain rollout, low latency, dense deployment, reliability, high energy efficiency, and long-term communication capabilities of 5G networks make them great for supporting intelligent IoMT-based medical applications. Figure 3 shows the Fog-IoMT Architecture. It uses blockchain to protect medical data from IoT devices that are stored in the cloud.

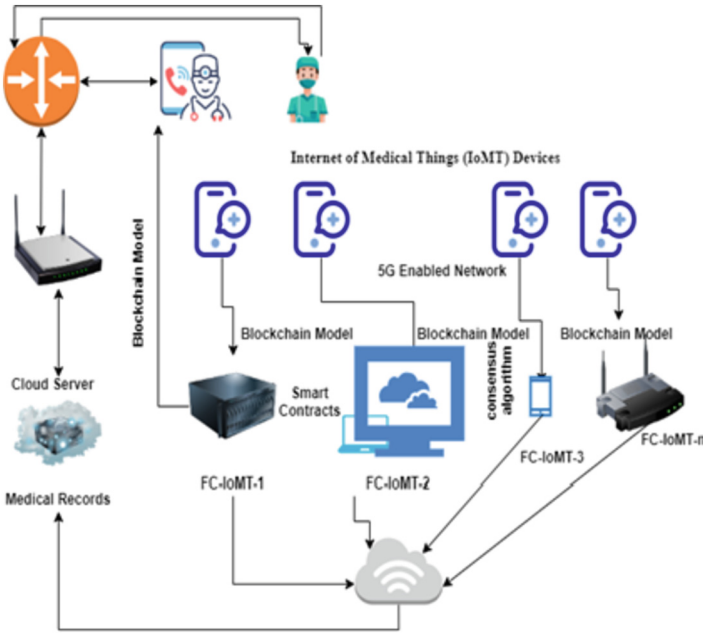


Fig. 3. Fog-IoMT Architecture for healthcare

3.2 B. IoMT Architecture Based on Blockchain and Fog

Blockchain and fog networks are used to provide a connection between the Internet of Medical Things (IoMT) and fog nodes (FN) [24]. (IoMT-Fog). The ability to provide services on demand is made possible by distributed technologies' ability to combine high performance with low latency (LL). Because of this, it will be more challenging to monitor the health of the population. As a result of the support for low-latency Internet of Things (IoMT) components provided by the FC paradigm, it is now possible to process data in a shorter amount of time. The proposed IoMT-Fog can be seen in Fig. 4, and it has the potential to be a more effective ME solution.

Putting on the table Fig. 4 Because of this, the architecture that is planned will have a number of separate levels. By having the initial layer (IL) of a fog network (FN) process IoMT data on fog nodes, the lag time is cut down. Because of this, the consumer will have a better chance of reaching his goal, which is to get help quickly. As you can see in Fig. 2, it has been suggested [25] that in the not-too-distant future, IoMT devices will need to use a multi-layered design for data-heavy applications. In the first layer of this configuration, the devices that are connected and FN are shown. Because all of the devices in a network are connected to each other, Blockchain technology makes it possible for each device to talk to all of the other devices and share data safely. When different IoMT devices talk to each other, they help cut down on the delay that the second level of FN feels. In the end, this leads to the end users giving their requirements. The proposed fog computing (FC) paradigm calls for FC to be used at the network edge of IoMT devices so that IoMT nodes can connect, transport, and share data [26]. This has to be done so that these tasks

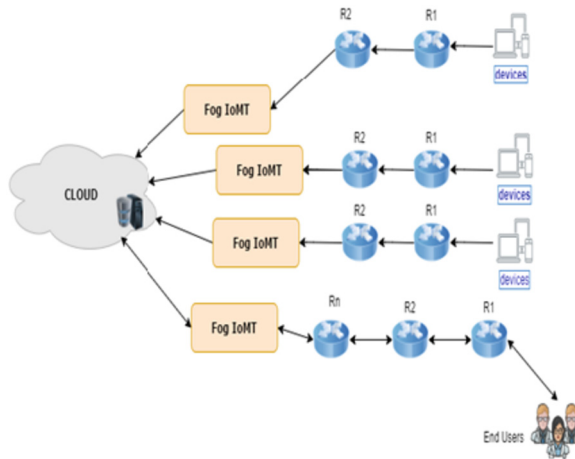


Fig. 4. IoMT-based fog computing (FC) architecture including blockchain technology.

can be done. A structure for a peer-to-peer (P2P) transmission network is used in the proposed solution. Miners act as an IoMT-NODE within the network. They are used in the network to do that particular thing. Blocks containing validated transactions are added to an existing blockchain and sent out to the network. Miners are needed so that the network stays up to date every time a new block is made and added to it. According to what we learned from our investigation, it does a good job in this area. We used different simulation tools and also looked at the code. Coda is a piece of software that can be used to make blockchains. On the host, the Docker Composite application was put in place. Table 1 gives an overview of the most important things to think about. The codecV Test Coverage Tool [27] is one example of a tool that can be used to test network coverage in IoMT devices. R3 Corda is a distributed Hyperledger platform with a decentralised peer-to-peer network and work-proof techniques (PoWs). Using the R3 Corda platform, you can build some really great blockchains. Here's how to register IoMT nodes so they can request transactions:

Algorithm 1: Registration for IoMT nodes

Step 1: Before broadcasting the transaction to the network, the leaders verify, order, and sign it.

Step 2: Double-checking and signing: Before broadcasting the transaction to the peer-to-peer network's authorized IoMT node, it checks, orders, and signs it.

Step 3: Commit: Commit once you've signed.

Algorithm 2: Client Registration Algorithm

Step 1: The client's account is transferred to the smart contract's account.

Step 2: Double-check the transferred value.

Step 3: Check to understand if the client exists.

Step 4: If the value is incorrect,

Step 5: The transfer has been rejected.

Step 6: Return to the previous state.

Step 7: if not, then

Step 8: If there is already a client, then

Step 9: The transfer has been completed.

Step 10: Clients are permitted to use fog node services.

Step 11: Elsewhere

Step 12: Set up the client's data.

Step 13: Connect the data to the sender's address.

Step 14: Add to the client list.

Step 15th and END

Step 16th and END

A new error control phase has been added to the IoMT Algorithm. This is done to get the algorithm ready for the possibility that the server will stop working. We tested the proposed design with 10, 15, and 30 IoT nodes to see how well it worked, and we found that the R3 Corda strategy, which is used for error control, is the best method.

Algorithm 3: Evaluating Client Credibility and data sharing Management

Initialize: The fog node is the input.

Step 1: Select the fog node location for load allocation.

Step 2: Dividing reputation scores into clusters is a good idea.

Step 3: Locate the cluster with the highest credibility rating.

Step 4: Determine the cluster's centroid.

Step 5: Calculate the consistency.

Step 6: Calculate the degree of trustworthiness.

Step 7: The client's credibility is transformed and adjusted.

Step 8: Return the credit to the client if the client has good recognition and stability.

Step 9: else

Step 10: terminated the condition

Step 11 Refrain from providing fog services to the client.

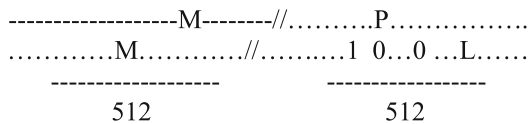
Step 12th and final

Modeling of the Analysis Process. The analysis of previously recorded connected network data is the second major phase in the SG inspection process. We tested the blockchain network in the simulation with various analysts operating at the same time. Algorithm 4 shows how the analytical procedure has been coded. Every analysis must analyze Nominalise inputs. To begin, the analysts must retrieve acquisition information from the Blockchain, download a copy of the raw data electronic medical records (EMR), and validate the hash value of the EMR. The process obtains the Connect’s length, produces certain indicators, and runs the Add Analysis transaction if the check is successful. Lastly, the raw data EMR’s local copy is erased.

Algorithm 4: IoMT Evaluation Method		
1:	Enhance Manifold Analysis Evaluation of both the IoMT end	
2:	SelectIoMT device for communication	
3:	Get acquisition, hash, electronic medical records (EMR)	
4:	Extract EMRFromRepository from EMR (EMR name)	
5:	EMR, valid SHA256 checkHash (EMR, hash)	
6:	if EMR, valid is true, then	
7:	Get the Connect Length using Connect length (Connect)	
8:	Generate Indications(Connect length) Generate	
	Indications(Connect length)	
9:	F Blockchain transaction addAnalysis(i, indications)	
11:	deleteLocalEMR	
10:	end if (EMR)	
12:	end	
13:	end	

$$\text{SHA-256: } B^1 \cup B^2 \dots \cup B^{64} \rightarrow B^{256} \dots, (1) M \rightarrow H \tag{1}$$

In (1), you can stand for the SHA-1 hashing algorithm by using. One type of digital signature that can be used on documents is a cryptographic hash (sometimes called a digest). Text signature made by SHA-256 that is made up of 256 bits (32 bytes). Since it can check any message M that is shorter than 264 bits, SHA-256 can again be seen as a function that comes from the union of bit string sets B1 to B264. This procedure converts the input to digests H with a length of 256 bytes. It does this by using the bit string set B256.



where $P = 1..0..0 L$, and L is M^l , s length l in hit notation

It can be used instead of the SHA-1 hashing algorithm in equations if you want to (1). A cryptographic hash is a type of digital signature that can be used to make sure that a document is real (sometimes called a digest). A 256-bit text signature that is 32 bytes long is made by the Secure Hash Algorithm (SHA-256). Secure Hash Algorithm 256 (SHA-256) can be thought of as a function that is made from the union of bit string sets B1 to B264. This is because any message M that is shorter than 264 bits can be checked. This procedure takes information as input and uses the bit string set B256 to make 256-bit digests H.

$$W_i = \{ (M_t^i @ \sigma_{l-256} (W_{(l-2)}) + W_{(l-2)} + \sigma_{l-256} (W_{(l-15)}) + W_{(l-16)}) \mid 16 \leq t \leq 63 \} \tag{2}$$

$$\sigma_{l-256}(x) = \llbracket \text{ROTR} \rrbracket^{7}(x) \oplus \llbracket \text{ROTR} \rrbracket^{18}(x) \oplus \llbracket \text{SHR} \rrbracket^3(x) \tag{3}$$

$$\sigma_{l-256}(x) = \llbracket \text{ROTR} \rrbracket^{17}(x) \oplus \llbracket \text{ROTR} \rrbracket^{19}(x) \oplus \llbracket \text{SHR} \rrbracket^{10}(x) \tag{4}$$

In Eqs. (2), (3), and (4), the number of the “input block,” which is shown by the letter t, can be any integer among 16 and 63. The input blocks for “shuffled blocks” have a size of l_{256} bytes and are built with unique operations that incorporate right rotations (ROTR), right shifts (SHR), and exclusive ors (XOR) (x). ORs (\oplus). In a fog computing environment, users’ needs can be met by devices with the IoMT fog nodes layer algorithm. When new nodes are added with the right permissions, distributed ledger technology like Blockchain is used to make wireless sensor networks more reliable (WBAN) in a FN-configured network, several physical servers work together to serve a larger area. Fog nodes can be linked with wires or wireless networks (FN). The FN is kind of like a small virtual data centre. It gives services for infrastructure, processing power, and networking. There are three parts to a fog node: a processor, software, and network services (FN). FN looks at the data that smart sensors (SS) collect so that we can find out more about how decisions are made. Also, the FN has a limited 5G network that can support one-to-one wireless communications but has a short range. Using the new protocols for 5G networks, data packets can be sent to more than one person at once or to just one person. This means that the FN can use the local database to store programmes that run in memory. This means that data processing and loading for IoMT apps that use a lot of resources will take less time [28]. The safety, reliability, bandwidth, and latency of the Internet of Medical Things (IoMT) network could be greatly affected by an application that uses IoMT to connect IoMIs and IoMT. In this situation, many FNs pass on information that changes over time.

As a whole, the Internet layer takes the place of the user’s real world. There are no limits on how software can be used in this setting. IoMT devices are put into their own groups based on where they go and what they do. This saves money, cuts costs, and moves the process along faster. With the help of the software and hardware services that data centres offer, it is easier to combine and process data. With the peer-to-peer (P2P) TCP/IP protocol, Internet of Things devices that are close to each other can send and receive data. Even though they are very far away from each other, they can still talk to FN using modern technologies like Bluetooth, WiFi, and ZigBee.

At the moment, one of the most important parts of the IoMT is using Blockchain (BC) [29] as a centralised way to communicate. Cloud servers will need to check IoMT devices. So, the infrastructure and ongoing maintenance of modern IoMT systems for sharing and collaborating on health data are based on cloud computing (CC) and network resources. The medical field recently started using a Wireless Body Area Network (WBAN), which is always growing and shrinking to fit new devices. Slowly, smart sensors are being added to the wireless body area network (WBAN) infrastructure for the ad hoc network. The current system can't handle the use of big IoMT devices because it can't grow. It makes sense that as the number of resources that could be used went up, the number of devices that could talk to servers also went up. One problem with cloud servers is that if something goes wrong, they could be a single point of failure. A hospital system that is run from one place is less effective, so P2P architecture is better. The IoMT method that was proposed used the Blockchain (BC), which has features like being decentralised and easy to change. It's not hard to keep an eye on network equipment that costs trillions of dollars. Taking care of servers and setting them up also saves money. This also keeps MITM attacks from happening to IoMT devices because there are many ways to talk. Certain conditions must be met for smart contracts and agreements to work. Smart sensors are used to gather data, which is then stored in a distributed ledger (BC). Figure 5 shows how a fog server, the owner of the data, and a user talk to each other on a blockchain.

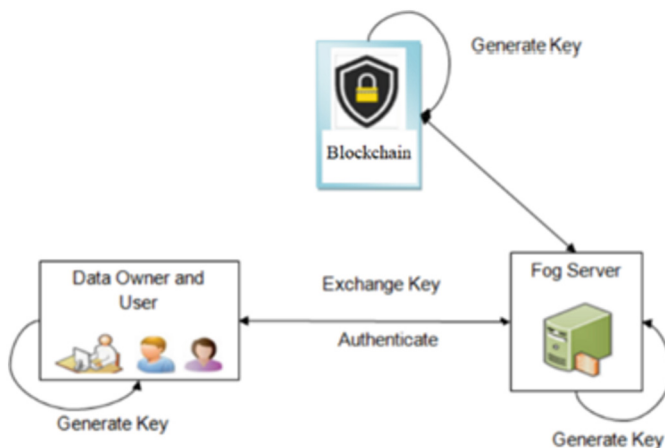


Fig. 5. Basic Communication using blockchain-with fog server and data owner and user

In a fog computing environment, devices with the IoMT fog nodes layer algorithm can meet the needs of users. Distributed ledger technology like Blockchain is used to make wireless sensor networks more reliable when new nodes are added with the right permissions (WBAN).

In a FN-configured network, several physical servers work together to serve a larger area. Fog nodes can be linked with wired or wireless networks (FN). The FN is a bit like a small data centre that is online. It provides infrastructure, processing power, and

networking services. A fog node has a processor, some software, and network services (FN). FN looks at the information collected by smart sensors (SS) to learn more about how decisions are made. Also, the FN has a limited 5G network that can support one-to-one wireless communication but has a short range. With the new protocols for 5G networks, data packets can be sent to more than one person at once or to just one person. This means that the FN can store programmes that run in memory in the local database. This means that it will take less time to process and load data for IoMT apps that use a lot of resources [28]. An application that uses IoMT to connect IoMIs and IoMT could have a big impact on the safety, reliability, bandwidth, and latency of the Internet of Medical Things (IoMT) network. In this case, many FNs pass on information that changes over time.

Overall, the user's real world is replaced by the Internet layer. In this setting, there are no rules about how software can be used. IoMT devices are put into different groups based on where they go and what they do. This saves money, keeps costs down, and speeds up the process. With the help of the software and hardware services that data centres provide, it is easier to combine and process data. Internet of Things devices that are close to each other can send and receive data using the peer-to-peer (P2P) TCP/IP protocol. Even though they are very far apart, they can still talk to FN using modern technologies like Bluetooth, WiFi, and ZigBee.

At the moment, using Blockchain (BC) [29] as a centralised way to communicate is one of the most important parts of the IoMT. IoMT devices will need to be checked by cloud servers. So, modern IoMT systems for sharing and collaborating on health data are built on cloud computing (CC) and network resources. These are also used to keep the systems running. The medical field just started using a Wireless Body Area Network (WBAN), which is always growing and shrinking to fit new devices. Slowly, smart sensors are being added to the infrastructure for the ad hoc network's wireless body area network (WBAN). Big IoMT devices can't be used with the system we have now because it can't grow. As the number of resources that could be used grew, it makes sense that the number of devices that could talk to servers also grew. One problem with cloud servers is that they could be a single point of failure if something goes wrong. P2P architecture is better because a hospital system that is run from one place is less effective. The IoMT method that was suggested used a technology called Blockchain (BC), which is decentralised and easy to change. Keeping an eye on network equipment worth trillions of dollars is not hard. Taking care of and setting up servers is another way to save money. This also stops MITM attacks from happening because there are many ways for IoMT devices to talk. For smart contracts and agreements to work, a number of things must be true. Smart sensors are used to collect data, which is then stored in a distributed ledger (BC). Figure 5 shows how a fog server, the person who owns the data, and a user talk to each other on a blockchain.

4 Simulation and Results Analysis

As part of a fog computing architecture, a permission blockchain makes it possible to run simulations and measure how well they work. When an ordering service is made at a fog node (FN) for an IoMT network, the matching throughput can be either the time that has

passed or the time that has passed in between. When setting up a cloud-based ordering system that uses a virtual machine, you have to look at the bypass time and the number of nodes (VM). The Core i5 CPU from 16.04 LTS will be used to measure performance. Ubuntu is a way to use Linux. 2.50 GHz 2.71 GHz (VirtualBox) (VirtualBox) There are sixteen gigabytes of RAM. Every virtualization scenario that includes a Follower peer has 30 vCPUs and 8 GB of RAM. The next move will be done thirty times in a row. One transaction per second (TPS) is the number of transactions that can be processed in one second (TPS). The least amount of time it took to respond was 445 ms, and the most time it took was 3867 ms. It took 600 ms to answer. Figure 6 shows a diagram of Intervened Time's fog architecture, which is built on Hyperledger.

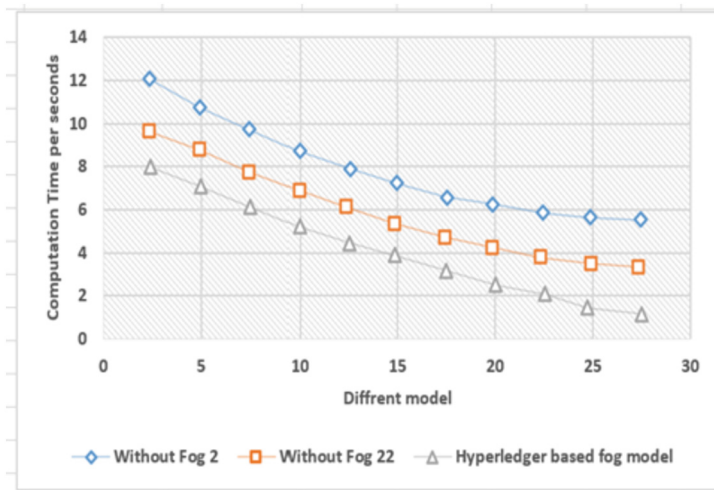


Fig. 6. Hyperledger-based fog Architecture for Intervened Time

Figure 7 shows the Hyperledger-based fog architecture for time-active threads that are interrupted, and Table 2 gives more information about it. When a thread group starts and stops a sample application, we can see how long it takes to connect to the network (NL). We were able to keep track of threads even in a blockchain (BC) network. In the fog computing environment, Fig. 7 shows the Intervened Time and the active thread. Intervened Time is how long it takes the Blockchain (BC) network to respond to a request. So that we can test how stable the connection is, we have moved the ordering system to the cloud. Even though the LM isn't very high, the ordering instance makes a network that isn't too unstable. It has been tested and shown to work well in real-time environments that need a high throughput. Figure 7 shows a graph of a fog network's performance over time if it is built on hyperleader fabric (HF).

The number of requests made during each time interval is used to figure out what the output will be. The amount of time between the first and last pictures. Due to how important it is to give an accurate picture of how busy the server is, we will include all gaps that could be relevant in our sampling. Using the equation, you can figure out how much throughput there is (5).

Table 2. Hyperledger-based fog Architecture for Intervened Time

Computation Time Per seconds (IoMT Node Transactions)			
Without Fog 1	Without Fog 2	Without Fog	Hyperledger based fog model
2.381	12.056	9.629	7.983
4.946	10.734	8.766	7.066
7.442	9.737	7.741	6.122
9.985	8.712	6.878	5.232
12.573	7.902	6.122	4.45
14.931	7.228	5.34	3.884
17.519	6.581	4.72	3.183
19.877	6.257	4.234	2.508
22.465	5.853	3.776	2.077
24.869	5.637	3.506	1.456
27.435	5.529	3.344	1.16

The following formula can be used to figure out how much throughput there is:

$$\text{Throughput} = (\text{number of requests})/(\text{total time}) \tag{5}$$

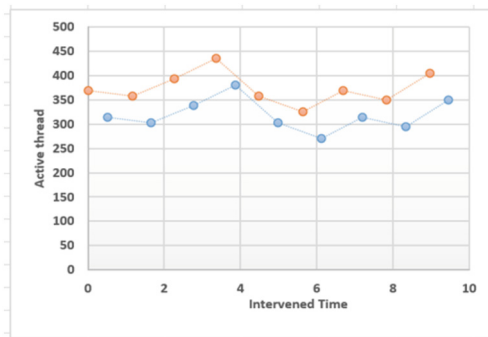


Fig. 7. Show the Intervened Time and active thread in the fog computing environment.

The size of the bytes that were sent back is clearly a lot smaller than what was expected. Figure 8 shows the results of a study that compared how long it takes to process a request versus how long it takes to process a response. You can find these results in the report. Because we store our orders in the cloud, we can be sure that our efficiency (E) will stay the same (S). This suggests that the Blockchain (BC) network can work well if orders are put on instances of the cloud that work better.

Our calculations show that the current architecture can handle between 200 and 2000 requests per second, with between 200 and 1400 requests coming in per second (shown



Fig. 8. Comparative analysis elapsed time based on the request-response time

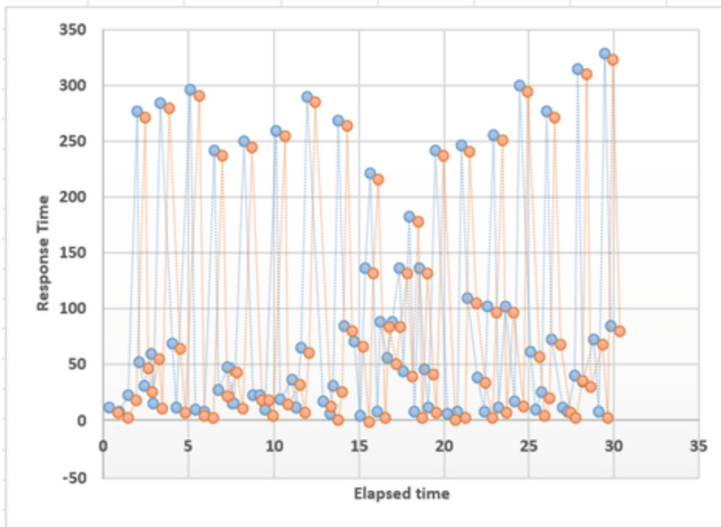


Fig. 9. Throughput Generated by IoMT System

in Fig. 9). The fog that doesn't use blockchain (BM), on the other hand, can only handle a small portion of those amounts. The most requests that the Fog-IoMT can handle in one second is 2000. However, it can handle anywhere from 200 to 1400 requests.

The results of a comparison between the new method and the old method are shown in Table 3. Figures 9 and 10 show that putting blockchain technology into IoMT needs

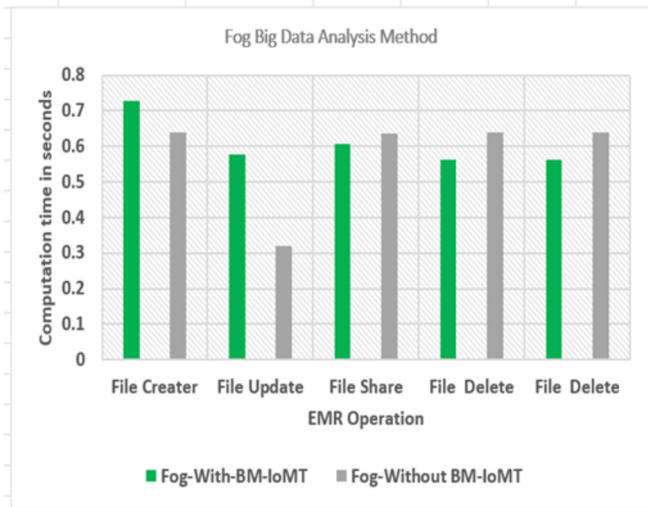


Fig. 10. IoMT Evaluation Method

a lot of different ideas. Several of the results pointed in this direction, and the results that were given proved it. On the other hand, blockchain technology offers a solution that is safe, can't be changed, and can't be hacked. Compares the proposed Fog-Without BM-IoMT with the Fog-Without BM-IoMT in an unbiased and objective way.

Table 3. A comparison of how long it takes to use a blockchain-based method with and without a fog computing environment (the proposed algorithm) (Existing Algorithm)

Number of Transactions per IoMT Node	Evaluation Time	
	Proposed Algorithm (Blockchain based approach with fog computing environment)	Existing Approach (Without fog computing environment)
200	165.192	206.49
400	171.091	200.59
600	176.991	212.389
1000	182.891	224.189
1200	200.59	271.386
1400	247.788	312.684
1600	318.584	407.08
1800	454.277	595.87
2000	696.165	997.05

Suggested method for this investigation can be broken up into two different parts. In the first section, we'll look at equations for IoT communication that 5G makes possible. In the second section, we'll look at designs that use Blockchain technology and fog.

5 Conclusion

Technologies like blockchain, IoMT (Fog-BC-IoMT), and FC were used to build the proposed architecture (Fog-IoMT). By using the BC, the goal is to make a public, legal, hyper-distributed EMR that can be used to record transactions. During testing and when the Architecture is actually put into place, a lot of IoMT-NODES are used. The predictions of what would happen were good enough. This study comes up with a plan to find and stop data fraud by switching from centralised database architectures to decentralised database architectures that use blocks. It divides the infrastructure into four different groups: blockchain, Internet of Things, fog, and the cloud. The IoMT system's infrastructure is complete and does not need any more parts. We also looked into whether or not the Network Convention approach could help make better use of the resources in public clouds. If you want to make sure your IoMT devices are reliable, safe, and scalable, move them to the cloud and don't connect them directly to restricted networks. This will let you add more to what you can do without sacrificing security or reliability. Hyperledger, a system that is based on chain blocks, is used to make sure that IoMT works and is safe. Smart contracts (SC) and transaction checking on fog nodes (FN) have been said to help cut down on NL and increase output, respectively. In order to make Hyperledger BC work better, the design of the network will try to lower cloud costs while at the same time maximising the performance of both cloud and FN instances. In the end, we will put the Architecture to the test by using it in real-world situations to make sure it is correct and consistent.

Future Scope

- Exploration of secure data sharing protocols for interconnecting multiple healthcare providers and stakeholders.
- Analysis of regulatory and legal frameworks to address privacy and security challenges in 5G-enabled IoMT-Fog environments.
- Investigation of novel approaches for secure firmware updates and patch management in connected medical devices.
- Development of secure and efficient communication protocols for seamless integration of blockchain and Fog computing in the IoMT ecosystem.

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Enhancing Sustainable Development in Medical Image Fusion Using Proposed (EBCE) with DWT

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Abstract. Multimodal medical image fusion techniques play an important role to amalgamate information from different source images into a single one for an early diagnosis. Literature shows a huge technological development in this field. But the presence of unwanted noise, loss of brightness, and lack of source information in the fused image are the main challenges faced by the researchers in this field. This paper proposes an image fusion model based on DWT, proposed EBCE (Energy-based Coefficient enhancement), and the appropriate fusion technique (Conventional PCA and Conventional Mean-Max fusion rule). The proposed model is very efficient to fuse different modality medical images. The performance of the proposed EBCE technique exceeds the performance of many conventional image enhancement techniques. The performance of the proposed model has been compared with many states of art image fusion models and it outperformed these models.

Keywords: Multimodal images · DWT · Image Fusion · PCA · Mean-Max fusion rule

1 Introduction

Multimodal image fusion has recently become the most challenging and gradually increasing research area for the welfare of human beings. As images from a single sensor are not sufficient to describe all the complementary information of an organ, multimodal medical image fusion becomes essential in medical science [24]. Fusion may be categorized into Pixel level, Feature level, and Decision level [38] and is shown in Fig. 1. The pixel-level fusion technique directly deals with the pixels of source images and it is the easiest method of image fusion, also called low-level fusion. Information loss is less in this technique but it is not possible to apprehend the detail information of source images into the fused image [1, 9, 10]. Feature-level image fusion can overcome the limitations of the pixel-level fusion technique but suffers from the problem of the addition of new artifacts in the fused image [1]. Decision-level image fusion is also called high-level fusion. The features are identified and extracted from source images and finally fused to get the least noise-sensitive fused images [1].

Authors of [2, 3, 8] introduced new image fusion techniques based on NSST to make the fusion technique shift-invariant, multi directional and anisotropic but system becomes complex compared to DWT. Authors of [16] worked on NSCT based image fusion model which is multi directional, multi resolution, flexible, and shift invariant but the system is restricted to use number of directions. Non Subsampled Curvelet transform is used by the authors of [5] for acquiring edge and curved information in a better way. Hybrid models are widely used now a day to integrate the advantages of different image fusion techniques into a single model. Authors of [4] used hybrid model of NSCT (Non Subsampled Contourlet Transform) and DCTWT (Dual tree Complex wavelet Transform) for better curvature and directional information with computational efficiency. For accruing better geometrical features in a multi- scale approach, authors of [13] developed a new fusion model based on surfacelet transform. Authors of [7, 20] have come out with an efficient Laplacian Re-decomposition technique in image fusion model which can restrict the image blur into a certain level with better complementary information. Deep learning-based image fusion models [3, 6, 8, 11, 12, 14, 36] give the most efficient results but the requirement of large training data makes the system complex and time-consuming. Sparse representation-based image fusion models [11] are very efficient as they reduce the system's complexity. Local energy-based fusion models are more efficient than single pixel-based image fusion models and are used by the authors of [15–19]. The Laplacian filtering method is very efficient to remove color distortion, blurriness, and noise from the fused image Genetic algorithms are used to overcome the uncertain and ambiguous conditions that appear during the image fusion process and optimize the fusion model [5]. Different denoization techniques of fused images [21, 41] already exist in literature but building up a system that successfully adds different modality images into a single image with higher salient features, better visibility, and low noise is still a big challenge. In this paper, we developed an image fusion technology that is able to generate a high-quality fused image to assist doctors in their diagnosis. In this model, the source images are decomposed into low-frequency coefficients and high frequency coefficients by DWT method and each component is energy enhanced by the proposed EBCE technique. The corresponding low and high frequency enhanced coefficients of two different modality source images are fused together by the appropriate fusion technique (Conventional PCA [40] and Conventional Mean-Max fusion rule [39]). The proposed EBCE has been compared with many conventional image enhancement techniques and the proposed EBCE outperformed all of them. The proposed fusion model has been compared with many state of art image fusion models and the proposed model outperformed all of them. HARVARD medical school brain data set [42] has been used for the performance analysis of the fused model

Our proposed model has the following advantages:

- (i) During the pre-processing stage, the energy enhanced decomposed coefficients have been achieved which resulted in the performance improvement of the output fused images.
- (ii) The fused images produced by the proposed model exhibit lower RMSE, greater Entropy, and PSNR values than state-of-the-art image fusion models, which signifies lesser artifacts present in them.

- (iii) The fused images obtained from the proposed model have better visibility to improve the discernibly in the process of diagnosis.
- (iv) The proposed model is computationally very simple. It does not even take more than 2 seconds to generate the final fused images.

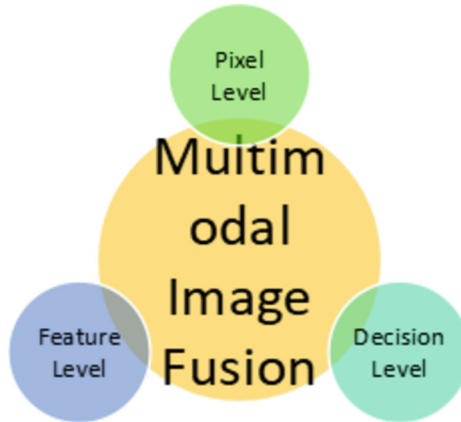


Fig. 1. Different Image Fusion Levels

2 Proposed Model

The steps of the proposed image fusion models are:

Step 1: DWT Decomposition: In the first step of the proposed model, the two different modality source images (CT and MRI) are individually decomposed into approximate and detailed coefficients. So, if we have two source images $I_1(i, j)$ and $I_2(i, j)$, then after decomposition we get 8 decomposed coefficients $[a_{11}(i, j), b_{11}(i, j), c_{11}(i, j), d_{11}(i, j)]$ and $[a_{22}(i, j), b_{22}(i, j), c_{22}(i, j), d_{22}(i, j)]$. Among these eight coefficients, $a_{11}(i, j)$ and $a_{22}(i, j)$ are approximate coefficients of image $I_1(i, j)$ and $I_2(i, j)$ respectively, and the rest of the above are detail coefficients.

Step 2: Enhancement of Decomposed Coefficients: The energy of an image defines its localized changes [15]. This change may be in color/brightness or magnitude over local areas of a pixel. In this paper, the energy of every decomposed coefficient has been calculated from its Gray-Level Co-Occurrence Matrix (GLCM). Every element (x, y) in GLCM is the total of the occurrences of the pixel with value x lying horizontally next to the pixel with value y . The energy of GLCM is nothing but the sum of the square of every element or its second angular moment. For calculating the energy of every coefficient, the steps followed are shown in Fig. 2.

The Energy-based coefficient Enhancement (EBCB) algorithm is described in detail below:

- (i) The energies obtained from the GSCM (Grey Scale Co-occurrence Matrix) of every decomposed coefficient, mainly represent their mean energies. So, $[ea_1, eb_1, ec_1,$

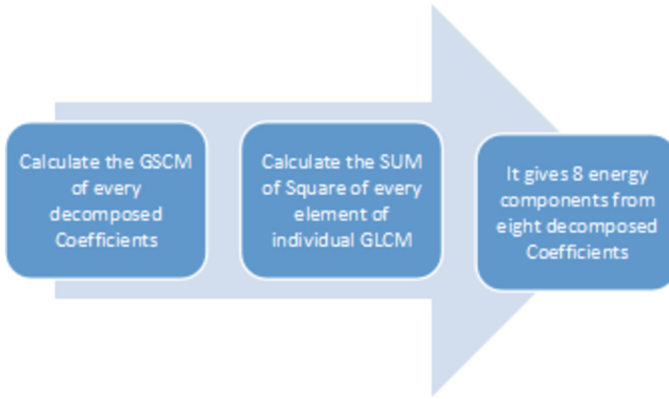


Fig. 2. Calculation of energy of decomposed coefficients from their GSCMs.

$ed1$] and $[ea2, eb2, ec2, ed2]$ are the mean energies of decomposed coefficients $[a11(i, j), b11(i, j), c11(i, j), d11(i, j)]$ and $[a22(i, j), b22(i, j), c22(i, j), d22(i, j)]$ respectively.

- (ii) The energy or the mean energy of two source images are also calculated from their respective GSCMs. So, $e1$ and $e2$ are the mean energies obtained from two source images $I_1(i, j)$ and $I_2(i, j)$ respectively.
- (iii) The mean energy of the individual coefficient is added with the mean energy of their corresponding source image, and effective mean energy is calculated. i.e.

$$e11 = ea1 + e1, e22 = eb1 + e1, e33 = ec1 + e1, e44 = ed1 + e1. \text{ And } e55 = ea2 + e2, e66 = eb2 + e2, e77 = ec2 + e2, e88 = ed2 + e2$$

So, $e11, e22, e33, e44, e55, e66, e77$ and $e88$ are representing the mean effective energies.

- (iv) The efficient or boosted Coefficients are achieved by dividing the DWT decomposed components with their corresponding efficient mean energies.

So the energy efficient or energy boosted coefficients are:

$$[a111 = a11/e11, b111 = b11/e22, c111 = c11/e33, d111 = d11/e44] \text{ and } [a222 = a22/e55, b222 = b22/e66, c222 = c22/e77, d222 = d22/e88].$$

The pictorial representation of the Energy-based Coefficient Enhancement algorithm is shown in Fig. 3.

Step 3: Fusion of energy enhanced coefficients: In this stage, for the purpose of fusion of the enhanced coefficients, two different conventional techniques have been used (PCA [40] and Mean-Max fusion rule [39]). The better performance parameters achieved from conventional Mean-Max fusion rule and so conventional Mean-Max fusion rule is accepted for fusion purpose.

PCA Method of Image Fusion: In the Principal Component Analysis (PCA) method [40], the source images are transformed into Eigenspace. The principal component of an image contains its essential features with reduced noise corresponding to its major Eigenvalue. The boosted coefficients of two images achieved from the above stage are fused by the PCA method. So after fusion, only four coefficients $[a1111, b1111, c1111,$

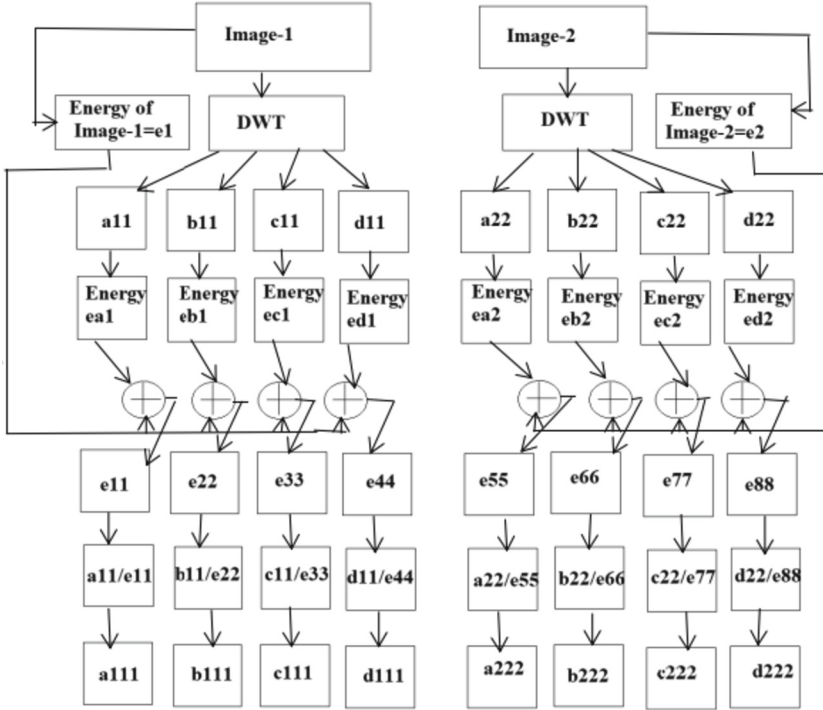


Fig. 3. Pictorial representation of EBCE technique.

d1111] are retained. For the PCA method of fusion, Eqs. 1, 2, 3, and 4 are used.

$$a1111 = PCA(1).a111 + PCA(2).a222 \tag{1}$$

$$b1111 = PCA(1).b111 + PCA(2).b222 \tag{2}$$

$$c1111 = PCA(1).c111 + PCA(2).c222 \tag{3}$$

$$d1111 = PCA(1).d111 + PCA(2).d222 \tag{4}$$

where, [a111,b111,c111,d111] are the energy boosted coefficients of input source image CT, and [a222,b222,c222,d222] are the energy boosted coefficients of input source image MRI.

Mean-Max Fusion Rule: In the conventional Mean-Max fusion rule [39] the mean value of approximate coefficients of two source images has been taken to fuse these coefficients. For fusing the detail coefficients, the maximum value of the corresponding coefficients of two source images has been considered. Equations 5, 6, 7 and 8 have been used for this purpose. Where equation 5 is used for fusing approximate coefficients and Eqs. 6, 7 and 8 have been used for fusing detail co-efficient.

$$a1111 = (a111 + a222)/2 \tag{5}$$

$$b_{1111} = \max(a_{111}, a_{222}) \quad (6)$$

$$c_{1111} = \max(c_{111}, c_{222}) \quad (7)$$

$$d_{1111} = \max(d_{111}, d_{222}) \quad (8)$$

where, $[a_{111}, b_{111}, c_{111}, d_{111}]$ are the energy boosted coefficients of input source image CT, and $[a_{222}, b_{222}, c_{222}, d_{222}]$ are the energy boosted coefficients of input source image MRI.

Step 4: The fused coefficients are passing through the Inverse DWT stage to get the fused image in the spatial domain (Fig. 4).

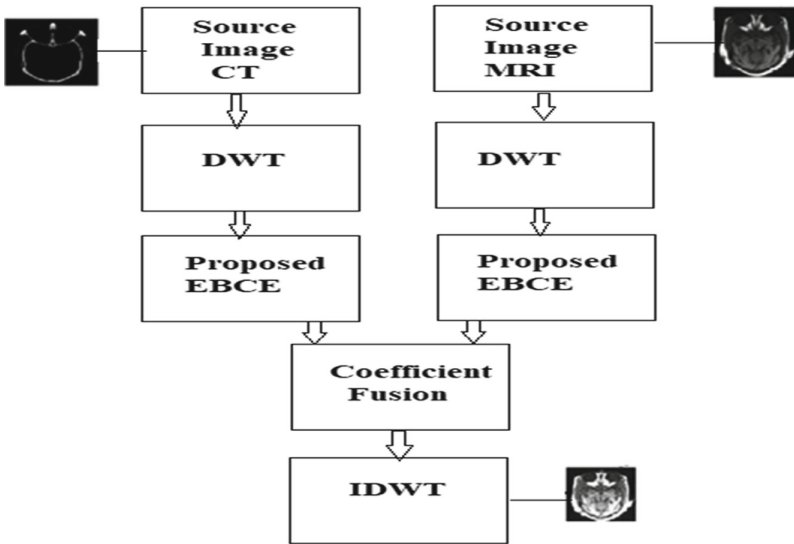


Fig. 4. Flow diagram of the proposed Model

3 Result and Discussion

The proposed multi modal medical image fusion model is very much efficient to fuse two different modality medical images CT and MRI from HARVARD medical School brain data set [42].

There are many conventional image enhancement techniques, HE (Histogram Equalization) [35], AHE (Adaptive Histogram Equalization) [36], CLAHE (Contrast Limited AHE) [37] etc. are already exist in literature. The comparison of proposed EBCE and conventional enhancement techniques are represented in Table 1 and the output of enhanced images are shown in Fig. 5. It is obvious from Table 1 that, the proposed EBCE is able to give better output value compared to conventional enhancement techniques.

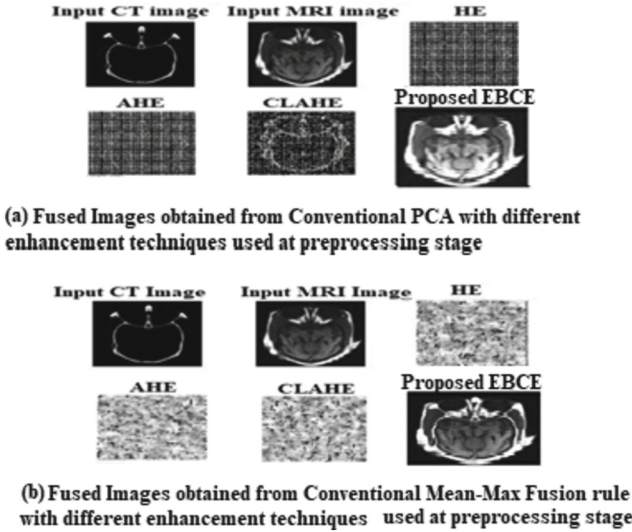


Fig. 5. Comparison of different image enhancement techniques and Proposed EBCE technique

The main part of our proposed model is the pre-processing stage, where Energy based Coefficient Enhancement (EBCF) has been used to enhance the energy of the decomposed coefficients which resulted in the performance enhancement of the fusion model. The proposed EBCE technique has been compared with many conventional image enhancement techniques, and Table 1 reported that the proposed enhancement technique gives better enhancement of images compared to the conventional techniques by giving a higher PSNR value with a lower RMSE value. Figure 5 demonstrates that when compared to the fused images produced by traditional image enhancement approaches, the images produced by the proposed EBCE methodology include more detailed information. This stage has a great impact on the achievement of the higher-quality fused image in the overall output. The conventional PCA technique and conventional Mean-Max fusion rule have been used for the fusion purpose separately. Table 1 represents that the conventional Mean-Max fusion rule gives better performance parameter values (PSNR, RMSE, MI, FMI, FSIM, and Entropy) compared to the conventional PCA technique for the Harvard Medical School Brain data set. That’s why Conventional Mean-Max fusion rule if accepted for fusion purpose in proposed model. The comparison of the proposed model for the image set-1 (CT,MRI) of Harvard Medical School Brain Data set ,with many states of art image fusion models [22] is reported in Table 2, which shows that the proposed model outperformed all the existing models based on the performance parameters (PSNR and SSIM). Figure 6 shows that the fused image obtained from the proposed model is more clear and contains more detail information compared to the existing models. Also, the time required to fuse the different modality medical images by the proposed fusion model is less than 2 s. So, we can also say that the proposed model is computationally very simple (Figs. 7 and 8).

Table 1. Average value of Performance parameters obtained from different enhancement techniques and proposed EBCE technique from Harvard Medical School Brain data set

Conventional PCA				
The average value of Parameter obtained after fusing eight different image-set of CT-MRI images from the HARVARD Medical School brain Dataset	HE	AHE	CLAHE	Proposed EBCE
<i>PSNR</i>	28.787	28.3187	28.35	31.801
<i>RMSE</i>	9.3415	9.3502	9.347	6.776
<i>MI</i>	1.06	1.05	1.01	1.164
<i>FMI</i>	0.732	0.722	0.729	0.786
<i>FSIM</i>	0.510	0.496	0.499	0.547
<i>Entropy</i>	3.51	3.28	3.41	4.52
Conventional Mean-max Fusion Rule				
<i>PSNR</i>	30.45	30.28	30.34	33.527
<i>RMSE</i>	7.49	7.40	7.45	4.099
<i>MI</i>	1.09	1.06	1.07	1.169
<i>FMI</i>	0.785	0.786	0.784	0.798
<i>FSIM</i>	0.527	0.518	0.521	0.565
<i>Entropy</i>	3.52	3.30	3.40	4.64

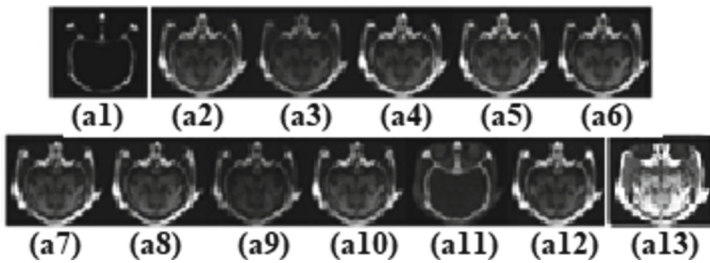


Fig. 6. Comparison of fused images obtained from different image fusion models and Proposed Model (a1 = GFF, a2 = NSCT + SR, a3 = NSCT + PCNN, a4 = NSCT + LE, a5 = NSCT + RPCNN, a6 = NSST + PAPCNN, a7 = DWT, a8 = DWT + WA, a9 = U-Net, a10 = CNN, a11 = ESF, a12 = ESF + CSF, a13 = Proposed Model)

Table 2. Performance parameters obtained from Proposed Model-I and II and different existing image fusion models [22] for image set-1 (CT, MRI) from Harvard Medical school Brain Data set

Name of Model	Performance Parameters	
	PSNR	SSIM
<i>GFF</i> [23]	31.1594	0.4865
<i>NSCT+SR</i> [25]	29.5602	0.4825
<i>NSCT+PCNN</i> [26]	31.2341	0.5043
<i>NSCT+LE</i> [17]	31.6099	0.4861
<i>NSCT+RPCNN</i> [27]	31.6844	0.5002
<i>NSST+PAPCNN</i> [28]	32.9194	0.4914
<i>DWT</i> [29]	31.972	0.4293
<i>DWT+WA</i> [30]	30.9814	0.4875
<i>U-Net</i> [31]	26.4196	0.3225
<i>CNN</i> [32]	28.9646	0.4751
<i>ESF</i> [33]	30.99	0.485
<i>ESF+CSF</i> [34]	29.6479	0.6483
<i>Proposed Model</i>	33.527	0.705

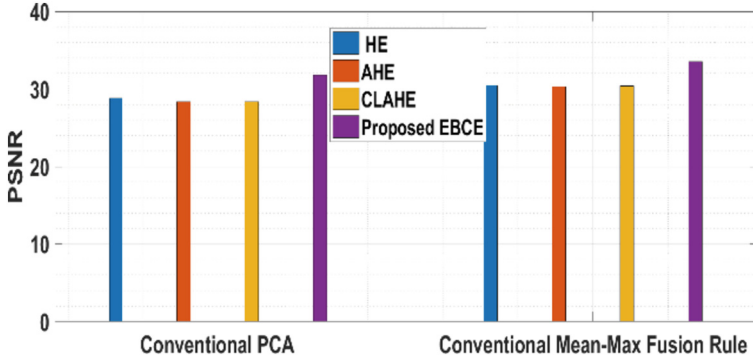


Fig. 7. Comparison of Proposed EBCE and Conventional Image Enhancement Techniques for PCA and Mean-Max fusion rule of image fusion based on PSNR value.

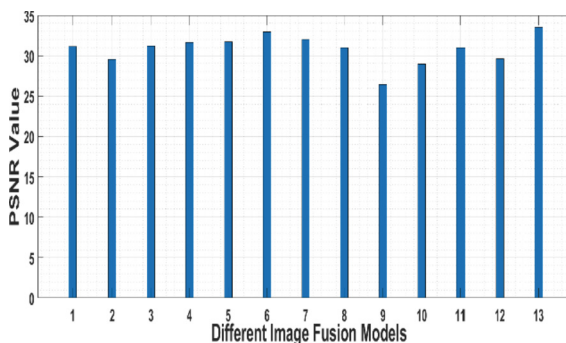


Fig. 8. PSNR value obtained from different image fusion models (1 = GFF, 2 = NSCT + SR, 3 = NSCT + PCNN, 4 = NSCT + LE, 5 = NSCT + RPCNN, 6 = NSST + PAPCNN, 7 = DWT, 8 = DWT + WA, 9 = U-net, 10 = CNN, 11 = ESF, 12 = ESF + CSF, 13 = Proposed model)

4 Conclusion

In this paper, a novel image fusion model based on DWT and Proposed EBCE has been proposed. Energy-based Co-efficient enhancement (EBCE) has been done before fusing the decomposed co-efficient achieved from DWT. These enhanced coefficients of two different modality medical images (CT and MRI) are fused by using conventional PCA and Mean-Max fusion rule, where we get better results from the conventional Mean-Max fusion rule. The Fused coefficients are combined together by the IDWT technique to get the fused image in the spatial domain. The performance of the proposed EBCE technique exceeded the performance of conventional image enhancement techniques, HE, AHE, and CLAHE. The computational cost of the proposed model is very less. The average time required to fuse different modality images of Harvard Medical School Brain dataset is less than 2 s. The fusion model has been compared with many states of art image fusion models [22], and the proposed model outperformed all these existing models.

Conflict of Interest. Authors Tanima Ghosh and Dr. N. Jayanthi declare that they don't have any conflict of interest.

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Artificial Intelligence Based Paper



Enabling Sustainable Development Through Artificial Intelligence-Based Surveillance System on Cloud Platform

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Abstract. AI-based surveillance can assist in better managing staggered and irregular work schedules by seamlessly identifying which employees are supposed to be in particular areas at certain times. This is important given that 98% of IT leaders are concerned about security challenges related to a hybrid workforce. Nowadays with the help of artificial intelligence; a video management system (VMS) can be trained to recognize VIPs, authorized personnel, and visitors. This may ease up the entering process for these individuals. But these systems have heavy equipment, let alone the requirement of a separate server room for storage. Therefore, this research paper highlights the need to build a compact, modular and robust security surveillance system based on Artificial Intelligence and Cloud Infrastructure. The proposed system is equipped with Artificial Intelligence and is going to detect both the intruder as well as the vulnerable zones within the facility. The entire system runs on a cloud platform with all the IOT devices working in-sync.

Keywords: Convolution Neural Network (CNN) · Video Management System (VMS) · Personal Computer (PC) · Graphics Processing Unit (GPU) · Compute Unified Device Architecture (CUDA)

1 Introduction

Surveillance is the technological monitoring of behavior and actions of objects or people. It is done in order to gather influencing information and has many managerial and legal purposes. This includes systems that are removed which contain electronic tools like closed-circuit television (CCTV) cameras and the data is either stored in a DVR or transmitted through the internet.

Residents utilize observation to defend their networks. Furthermore, by states for the reasons for knowledge assortment, including reconnaissance, wrongdoing, counteraction, the protection of a technique, an individual, a gathering, or a thing, or the examination of crime. Moreover, it is utilized by people and agencies to plan against violations, as well as by enterprises to get data about employees, their opponents, providers, or

clients. Strict gatherings having the obligation of paying special attention to heterodoxy and apostasy may likewise direct surveillance.

Reconnaissance has the potentially negative result of disregarding individuals' protection without legitimization, which is the reason it is habitually censored by common freedom activists [1]. While dictator legislatures seldom have any homegrown limitations, liberal vote based systems might have regulations that plan to restrict administrative and confidential utilization of reconnaissance.

By far most PC reconnaissance involves watching out for information and Web traffic. For instance, the United States' Correspondence Assistance for Policing mandates that all phone conversations and broadband Internet traffic (including messages, online traffic, texting, and so on) be made accessible for unrestricted, continuous inspection by government police.

For human detectives to painstakingly sift through all of the data on the Internet, there is simply too much of it [2]. To find and educate human examiners regarding the traffic that is believed to be charming or dubious, mechanized web observation machines go over the huge volume of blocked web information, focusing on unambiguous trigger words or expressions, going to explicit sites, or talking or messaging with questionable individuals or gatherings are ways of controlling this interaction. Because of the personal information they contain, computers can be used as a target for surveillance. If someone is able to install software, any harmful software like the FBI's Magic Lantern in your computer system, they will have easy access to this information without your knowledge. This application may be installed locally or through the internet.

The term surveillance camera refers to any kind of video camera used for keeping an eye on a certain area. "They are typically linked to a recording device or IP network and may be watched by a security officer or law enforcement authority. Cameras and recording equipment were expensive and labor-intensive before the advent of automated software that converts digital video into a searchable database and video analysis tools" [3].

However, the quantity of video captured is also severely reduced by motion sensors that only start recording when motion is detected. Because of improvements in manufacturing costs, surveillance cameras are now easy to use and inexpensive enough to be used in daily monitoring and home security systems. The usage of video cameras in surveillance systems is widespread.

As another drawback, motion sensors that only record when motion is detected drastically reduce the quantity of video captured. Thanks to simpler designs and cheaper manufacturing processes, surveillance cameras are now commonplace in both commercial and domestic settings. Surveillance systems that use video cameras are quite common [3].

In the United States, local, state, and federal governments receive billions of dollars in grants each year from the Department of Homeland Security to pay for the purchase and installation of high-tech surveillance equipment. For example, Chicago, Illinois, utilized a \$5.1 million grant from the Department of Homeland Security to add 250 surveillance cameras to an existing network of over 2,000 and connect them all to a single monitoring facility. This is all part of a program called Operation Virtual Shield.

Chicago's former mayor Richard M. Daley promised in 2009 that the whole city would be monitored by surveillance cameras by 2016.

Therefore, to address and solve the above mentioned drawbacks, the objective of this research work is to make a modular security system using AI with implementation of cloud services. The surveillance will be in-sync with each other and data is monitored and controlled in the cloud. The system will identify intruders, excluding the members of the organization. The proposed system developed is going to be robust and dynamic in nature to combat any problems that may arise in adding additional features to the system.

The following sections of this research paper describe the processes used in this research work. This paper is sectionalized into seven parts - the first part introduces the world of artificial intelligence with surveillance systems. The second part details the aspect of Computer Vision as an application of Artificial Intelligence with its benefits mentioned in the third part. Going further the fourth section describes the research work done starting with the methodology that has been implemented. The fifth section outlines the requirements of the prototype made in this research work. The sixth section describes the functioning of the system with flowcharts and coding analysis. In the last section, the output of the system has been analyzed where the screenshots depict the required output of the system. The paper is then concluded with some possible additions to this system in the near future. There are references that have been used as an inspiration to write this research paper.

2 Computer Vision as Artificial Intelligence

2.1 Computer Vision

One of the most important subfields of Artificial Intelligence that is used widely is known as computer vision that heavily relies on OpenCV Python library for its functioning. This fantastic library helps us to gain meaningful information from digital pictures, videos and other visual inputs for example a computer webcam. It makes a virtual computer to somewhat watch and perceive information and accordingly respond to it.

It functions similarly to human vision, with the exception that humans have the choice to see for a lifetime, learning how to distinguish between things, the distance between them, whether or not they are moving, and whether or not anything is odd with an image.

Although PC vision prepares machines to do these tasks, they must do it in a far shorter amount of time than humans do by relying on cameras, data, and computations rather than retinas, optic nerves, and a visual brain. In order to detect even the most minute defects, a production monitoring or item inspection framework must be able to evaluate a large number of items or cycles in a short amount of time [9].

Information is expected for PC vision. It conducts information investigations once more and over again until it tracks down differentiations and, at long last, recognizes pictures. To help a PC to perceive car tires, for instance, colossal quantities of tire photographs and tire-related materials should be provided into it for it to figure out the varieties and perceive a tire, particularly one without any defects.

AI shows a machine the setting of visual information by means of algorithmic models. On the off chance that the model gets an adequate amount of information, it will look at the information and figure out how to separate between pictures. Calculations empower machines to learn on their own as opposed to being customized to perceive an item.

2.2 Image and Image Processing

Image processing is a method of analyzing and manipulating digitized images, in order to enhance their quality.

“For those who prefer a more mathematical approach, a picture may be thought of as a two-dimensional function $f(x, y)$, where x and y are spatial coordinates, and the amplitude of any pair of coordinates (x, y) represents the intensity or gray level of the image at that position.” Simply put, a photograph is a matrix that specifies the intensity of light at each pixel in a picture. Image processing is mainly concerned with how we take an input image and generate an output image based on the mentioned attributes of that input image.

2.3 Convolution Neural Network

A CNN upholds an AI or profound learning model in seeing by separating pictures into labeled or marked pixels. It makes forecasts about the thing it is seeing by performing convolutions with the names (a numerical procedure on two capabilities to deliver a third capability). The brain network executes convolutions and evaluates the precision of its suppositions in a progression of cycles until the forecasts start to work out as expected. It then perceives or sees pictures in a human-like way (Fig. 1).

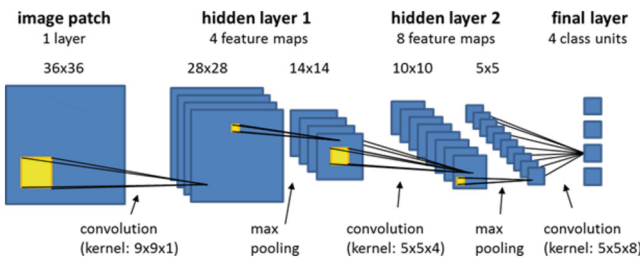


Fig. 1. A typical Convolution Neural Network (CNN)

A CNN, similar to an individual seeing a picture from a good way, first identifies hard edges and fundamental structures, then fills in data as forecast emphases are directed. Individual pictures are figured out utilizing a CNN. In video applications, a repetitive brain organization (RNN) is utilized likewise to help PCs handle how pictures in an approach succession are associated with each other.

2.4 OpenCV

A critical open-source library for PC vision, computer based intelligence, and picture taking care of is called OpenCV. Today, it contributes through and through to consistent movement, which is essential in contemporary structures like utilization of PC vision in reconnaissance.

It gives us permission to look for specific persons, specific articles, and even human handwriting in visual media. Python, when coupled with additional libraries like NumPy, is ready to handle the OpenCV cluster structure analysis. Vector space allows us to observe the various parts of a visual representation and perform mathematical procedures on them.

Optical character recognition, object detection and recognition, picture filtering and recognition utilizing key-points, and image processing are all features of the open source computer vision library known as OpenCV. On Nvidia GPUs, it supports CUDA acceleration (Fig. 2).



Fig. 2. Person Detection using OpenCV

Like an individual survey of a distant scene, a CNN first perceives sharp edges and fundamental structures prior to filling in the subtleties as it does forecast cycles. A CNN is utilized to decipher specific pictures. Repetitive brain organizations (RNNs) are utilized likewise in video applications to help PCs grasp the connections between the pictures in a progression of casings.

“The core of OpenCV is distributed under a BSD license, making it freely available for both personal and commercial use. It is compatible with Windows, Linux, Mac OS X, iOS, and Android, and it provides C++, C, Python, and Java interfaces.” OpenCV was developed for always-on programs that demand a lot of computational prowess. All of our products are built in C/C++ and have been optimized for multicenter processing.

2.5 Benefits of AI-Powered Surveillance System

- **Improved precision: The human operators of traditional CCTV systems introduce numerous opportunities for human error.** A large number of visitors can make even the most well-organized facility’s operations difficult to monitor [4]. In

order to detect each occurrence and trigger alerts in the case of aberrant behavior, the AI-powered solution may be curated using data analytics. No matter how large a facility is or how many people pass through it each day, AI technology ensures that no detail or hazard will be missed due to human factors such as exhaustion, lack of focus, or simple oversight.

- **24/7 Surveillance: A company may have many cameras on its property, but most businesses find that this is neither practical or feasible because it needs multiple employee shifts to provide continuous monitoring [5].** However, businesses can overcome these obstacles and have round-the-clock surveillance with the aid of AI technology. Even while the business is closed, an AI-enhanced CCTV camera system can keep an eye on things, evaluate the current state of security, and send out warnings if anything goes wrong. Humans are not involved in the process in any way. Businesses may save money and limit the number of false alarms caused by human mistake or harmless triggers such as animals by not equipping security workers with constant video screen monitoring equipment.
- **Powerful intrusion detection system: The first line of defense and a priceless asset for any company or person is a strong intervention detection system.** It works best when there are fewer false positives and a quicker detection response time [6]. Without AI, motion detection cameras are mindless gadgets that warn against anything that moves, including moving vehicles, animals, and even changes in shadow. These cameras are well known for setting off erroneous alarms. Per camera, they can generate up to 150 erroneous warnings daily. For locations with numerous security cameras installed to keep an eye on thousands of people, this is a hardship. The security unit can respond quickly to an intrusion by receiving critical pictures and metadata from AI-powered CCTV cameras.
- **Loss prevention: The full video analytics solution using AI technology is especially made for retailers.** It helps identify suspicious activity that could lead to shoplifting through its proactive loss prevention system. In addition to enabling loss prevention, AI video solutions can also deliver heat maps for more insightful customer behavior analytics. With the help of these actionable customer data [6], in the retail sector, this means being able to anticipate customer demand, assess the effectiveness of store performance, and take corrective measures to improve efficiency and boost profits. Customer foot traffic patterns can be studied using in-store analytics.
- **Object recognition: For the purpose of identifying things in images or recordings, computer vision includes the recognition of objects.** Object recognition is the main outcome of deep learning and machine learning algorithms. Humans can swiftly identify objects, people, scenes, and other visual information when they look at a photograph or watch a movie [7]. Due to the outdated technology underlying their algorithms, standard security cameras frequently struggle to detect things accurately. Due to the accuracy with which it detects objects and the low amount of false alarms, AI technology has an advantage over traditional cameras.

Complete Cloud Infrastructure: The AI model code is stored and run on a cloud platform. From its initial point of training the model to running the model in real-time, it utilizes the services from the cloud platform.

3 Methodology

The project follows a four step methodology, which depicts the methods used to achieve the objective of the project. This includes the following methods:

3.1 Physical Interpretation of the System

The first step is to design the block diagram of the system and understand the hardware requirements to achieve the objective of the work. The functionality of the system is based on Artificial Intelligence where a convolution neural network is designed using Pycharm IDE and trained using reference images (sourced by capturing the person's image through the webcam). Simultaneously, the image is detected using OpenCV software.

3.2 Programming the AI Model

The next step in this project is to program the AI model to be trained. For this, OpenCV is imported in the python code. The software is designed to detect the face and box it into a frame of reference.

3.3 Interfacing Hardware with the AI Model

Further moving in this project, the hardware was required to be interfaced with the AI model. According to the hardware requirements analyzed above in the physical interpretation, an Arduino Uno microcontroller is used here to function the movement of the camera to trace the path of the intruder.

Testing and Debugging: Now the final step of this project is to test the system, and debug any errors that are incorporated within it. The errors that were displayed included glitches in the match labeling, bugs and compatibility issues while interfacing the ESP32 camera module with the system, not being able to upload the images properly into the Google Cloud Bucket, and weak WiFi network issues. These errors were resolved by tweaking the AI model code and sometimes shifting to a better WiFi network with a stronger signal and better bandwidth. Alternatively, the functioning of this system was also performed using a USB tethered webcam or the webcam installed in laptops. The performance displayed by both the cameras were equally satisfying the criteria of replacing an ESP32 camera module.

4 Requirements Brief

4.1 Hardware

- Arduino Uno microcontroller
- SG90 Micro Servo motors (2x)
- ESP 32 Camera module/USB webcam/Laptop webcam
- Connecting wires/Jumper wires

4.2 Software

- Open CV (Image Detection)
- PyCharm IDE (AI modeling)
- Arduino IDE 2 (Arduino Code Editor)
- Google Cloud Bucket

5 Working of the System

5.1 Flowchart

The following flowchart depicts the functioning of the whole system (Fig. 3).

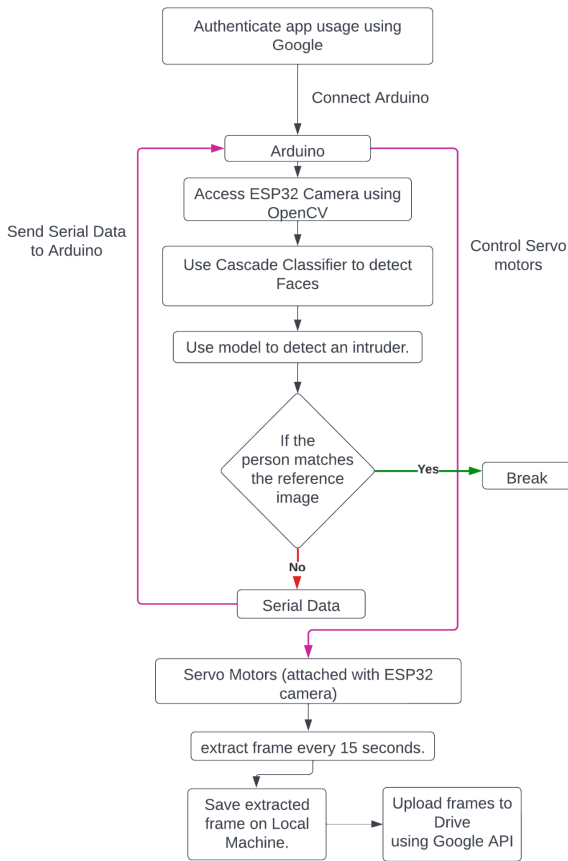


Fig. 3. Functioning Flowchart of the AI Surveillance System

5.2 PyCharm Coding for Face Detection

Firstly, the AI model is programmed and trained to detect the images from the camera and take it as the training input.

The initial training input is imported from OpenCV into the AI model and compared using the reference images in the AI logs. This process is repeated many times to make the AI learn about the image. When this model is ready then the training input is taken as the reference input and the images in real time are compared with these inputs. If there is any disparity in images the model takes snapshots of the person detected (Fig. 4).

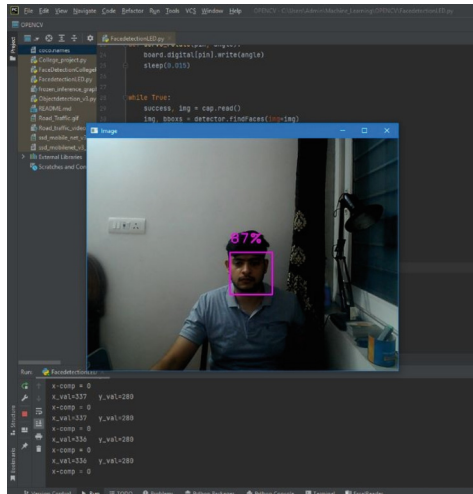


Fig. 4. Face Detection using PyCharm IDE

Additionally, the extracted images are saved in the local machine. Then these are uploaded in the drive using Google API. If the image matches, the person is cleared from suspicion. In this case, the pictures are captured only once and the loop does not occur. Keeping in mind, the code is updated to accommodate this hidden test case also.

The output of this code is seen as follows:

The images are stored in the local machine (inside the OpenCV folders). With the vision of the physical interpretation described above, the code is designed to compare the images with the reference images. Additionally the code is designed to take snapshots if an intruder is detected. For registered personnel, the code is aestheticized to display a “Match” label and “Not a Match” label for intruders. The code is also functioned to take 15 snapshots in a cycle and repeat this process in a loop (Fig. 5).

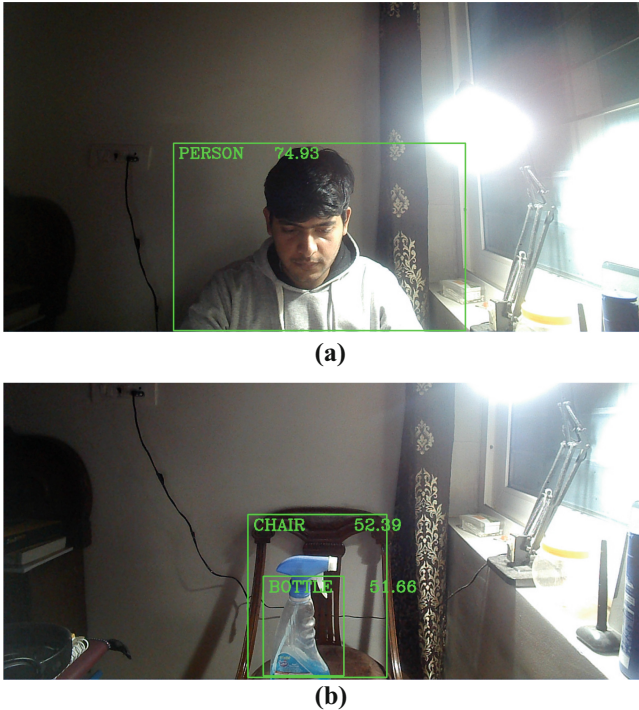
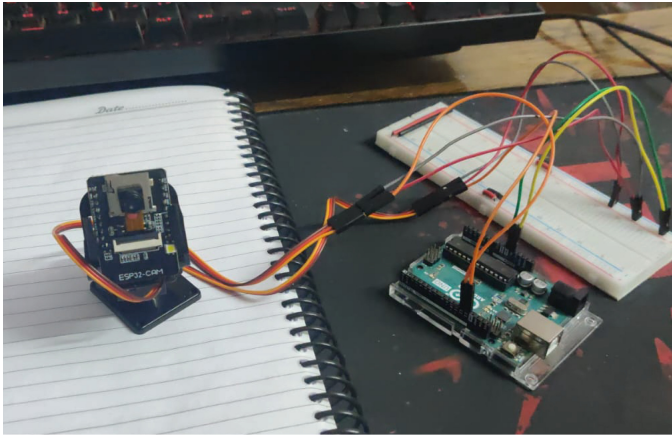


Fig. 5. (a). Person Detection. (b). Object Detection

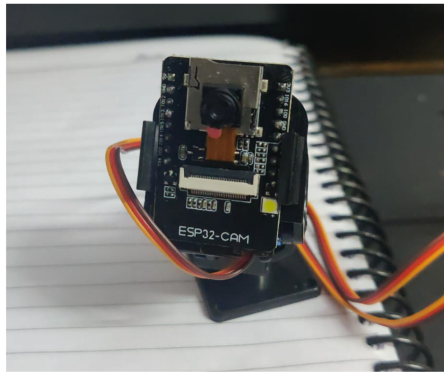
5.3 Interfacing ESP 32 Camera Module

For more surveillance coverage, an ESP32 camera module is mounted over a pan tilt case which is designed for free movement of the camera. The movement is achieved by two SG90 Mini servo motors and programming them in the Arduino IDE (Fig. 6).

Two mini servo motors are required to move the pan tilt in both horizontal and vertical axes. The range of movement is served by the Arduino Uno which takes the input from the AI model. Additionally, the ESP32 camera module is interfaced with the Arduino Uno to capture images in front of it. This ESP32 camera module also serves the purpose of OpenCV. Therefore, whenever the AI model detects an intruder the camera takes snapshots and traces its path while the person moves. Thus, the whole system is finally designed to detect a non-registered face and track its path by using the AI model in collaboration with Arduino and OpenCV.



(a)

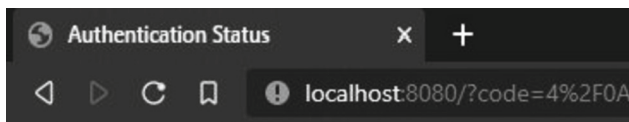


(b)

Fig. 6. (a). ESP32 Camera Setup with Arduino Uno. (b). ESP32 Camera Module Mounted over Pan-tilt Case with Servo Motors attachments

6 Result and Analysis

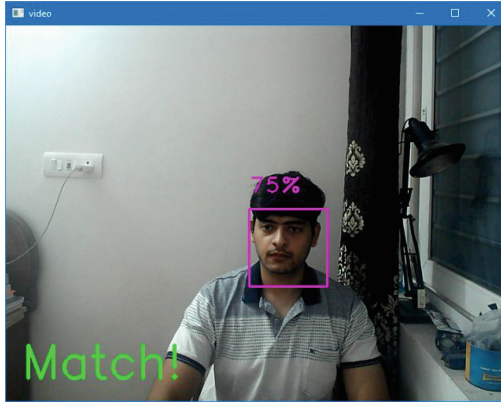
The system when tested provided the following results in the form of snapshots (Fig. 7).



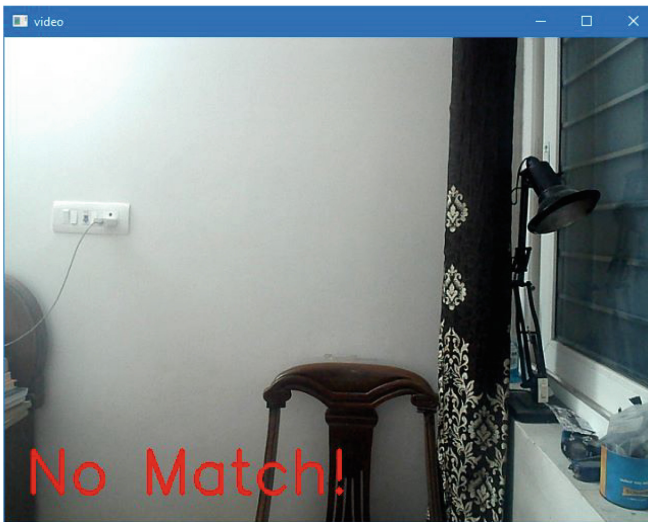
The authentication flow has completed.

Fig. 7. Camera authenticated using Google account

First, the camera setup is authenticated using a Google account. Here, one of the personal accounts is used for this process. Then the PyCharm code with Arduino code is run on the platform. The AI model successfully recognised the authorized person whose reference image helped in its training (Fig. 8).



(a)



(b)

Fig. 8. (a). Match Results. (b). Results unmatched

The display shows that the image captured is a “Match”. But when the same is done without the person present there, it shows “No Match”.

This is also true for the case when there is an unidentified or unauthorized person entering the premises. Instantly, it takes snapshots of the person and the images are stored in the Google Cloud Bucket. The same is shown in (Fig. 9).

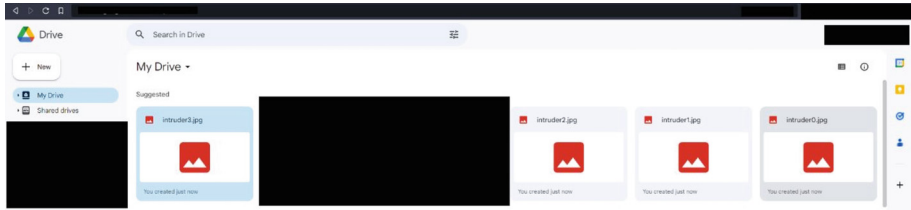


Fig. 9. Stored images in Google Cloud Bucket

7 Conclusion

In the report we have successfully created a surveillance system with AI implementation that is able to detect people within the camera's field of view. The best feature of the project is Arduino Uno with the setup of ESP32 Camera Module which is giving it a compact and reliable design. OpenCV is heavily employed within the software side to create a balance between accuracy of the algorithm and speed with which the algorithm is executed. Cloud implementation is also achieved using Google Cloud Services.

8 Future Scope

Since the design of the system is very robust and modular on the hardware as well as the software side, a ton of desirable features and improvements can be added to the system which will be looked at thoroughly in the near future. Some of these improvements may include connecting the system with a security alarm system to alert the surrounding areas about any theft or occurrence of any arson activity. This can also be interfaced with a GSM module to integrate a call service or SMS to the National Emergency Number '112', which will dispatch police service to the crime scene. The snapshots captured by this system will be extremely helpful in giving information about the various events occurring at the crime scene, acting up as prime evidence for further investigation.

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A Novel Classification Methodology for Investigation of Heart Disease

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Abstract. The prevalence of heart diseases has become a significant concern in modern medical scenarios, leading to a substantial number of deaths each year. Improper use of medications without proper guidance from clinicians and the late detection of diseases contribute significantly to these fatalities. The mortality rate continues to increase annually. This research paper presents an innovative classification technique that utilizes Naive Bayes and Laplace smoothing techniques for heart disease prediction. The results section provides a detailed description of real-time implementation results and observations. By employing this technique, accurate predictions can be made, aiding in the early detection and prevention of heart diseases, thereby potentially reducing the mortality rate associated with cardiac discomfort.

Keywords: Artificial Neural Networks · Least Squaring-Support Vector Machine method · Angina · Coronary artery

1 Introduction

Heart diseases pose a significant global health challenge, with a growing number of people succumbing to cardiac discomfort each year. Despite advancements in medical science, the mortality rate associated with heart diseases continues to rise. This alarming trend can be attributed to various factors, including the inappropriate use of medications without proper clinical guidance and the late detection of underlying cardiovascular conditions.

In order to address this pressing issue, there is a crucial need for effective and accurate prediction techniques that can aid in the early detection and prevention of heart diseases. Machine learning algorithms have shown great potential in the field of medical diagnostics, offering opportunities to improve the accuracy of disease prediction models.

This research paper focuses on the development and implementation of an innovative classification technique for heart disease prediction. Specifically, the study employs Naive Bayes algorithm and incorporates Laplace smoothing techniques to enhance the accuracy and reliability of the prediction model.

The primary objective of this research is to explore the efficacy of the proposed classification technique in real-time scenarios. By evaluating the results and observations

from the implementation of this technique, we aim to assess its potential as a reliable tool for early detection and prevention of heart diseases.

Through the integration of advanced machine learning algorithms, we anticipate that the proposed technique will contribute to reducing the mortality rate associated with heart diseases. The ability to accurately predict the presence of cardiac conditions at an early stage can facilitate timely medical intervention, leading to improved patient outcomes and reduced healthcare burden.

Cardiovascular disease is a significant global health concern in modern medicine. In the 21st century, there has been a remarkable increase in life expectancy, leading to a significant shift in the leading causes of heart-related deaths worldwide. The prevalence of cardiovascular disease has decreased by approximately 30% globally, with a greater decline of 40% in high-income countries and 28% in low and middle-income countries [1].

This transition is primarily driven by economic growth, urbanization, and changes in daily lifestyles, which are occurring at an even faster rate than in the previous century. Recent lifestyle changes have contributed to a significant rise in heart failure cases [2]. A new study reveals that the incidence of heart failure has tripled in the past 25 years, and chronic noninfectious diseases like cardiac disease have become a leading cause of death worldwide. It has now become a daily occurrence for people to die from cardiac disease globally [3, 4].

The increased prevalence of cardiovascular disease is a result of the significant shift in the overall health status of individuals worldwide. Over the past two decades, heart diseases have alarmingly increased and have become one of the leading causes of death in many countries. A recent study focused on cardiac health estimates that approximately 1.2 billion people die each year from heart diseases. Given the vast changes in social, cultural, and economic conditions, there is no single solution to address the growing burden of heart disease [5, 6].

Predicting heart failure is a challenging task, particularly considering the high costs associated with such predictions. The range of modern imaging techniques and clinical methods for diagnosing heart disease is extensive. Key symptoms associated with cardiac disease include chest discomfort, shortness of breath, fatigue, edema, palpitations, syncope, cough, hemoptysis, and cyanosis [7, 8].

2 Cardiac Diseases

There are several types of cardiac diseases, which can be classified based on their clinical conditions. These categories include myocardial infarction, heart failure, heart arrhythmia, angina pectoris, cardiomyopathy, and atrial fibrillation, each with their own distinct clinical characteristics that affect the structure or function of the heart [9].

Coronary Artery Disease: Coronary artery disease refers to the discomfort caused by reduced blood circulation. When the arteries are narrowed or blocked, it impairs the normal systolic and diastolic function of the heart, leading to symptoms [10].

Acute Myocardial Infarction: Acute myocardial infarction, commonly known as a heart attack, occurs when a blockage in the coronary arteries prevents oxygenated blood from reaching the heart tissue, causing damage. This can result in dysfunction of other

organs as well. Intense pressure on the heart is one of the causes of this type of heart attack [11].

Chest Pain (Angina): Angina is a clinical term used to describe chest pressure or discomfort that requires immediate medical attention. If a patient experiences this type of discomfort, they should be treated with ventilators urgently. Angina occurs when there is insufficient blood flow, causing pressure on the blood vessels and resulting in chest pain. Stable angina occurs predictably during exertion, while unstable angina is more unpredictable and can be caused by lifestyle factors or behavioral habits [12], [13].

These are just a few examples of the types of cardiac diseases that exist, each with its own specific characteristics and impact on the heart (Figs. 1, 2 and 3).

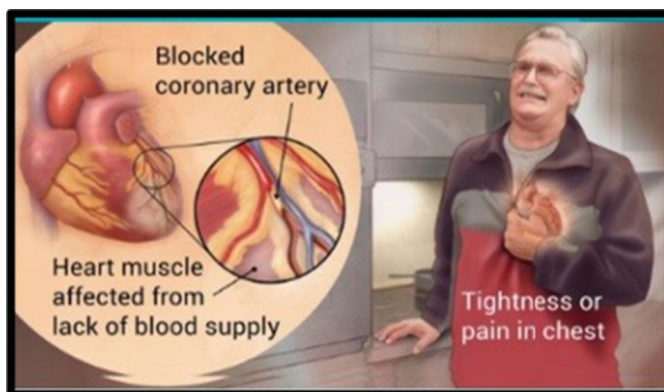


Fig. 1. Acute Myocardial Infarction

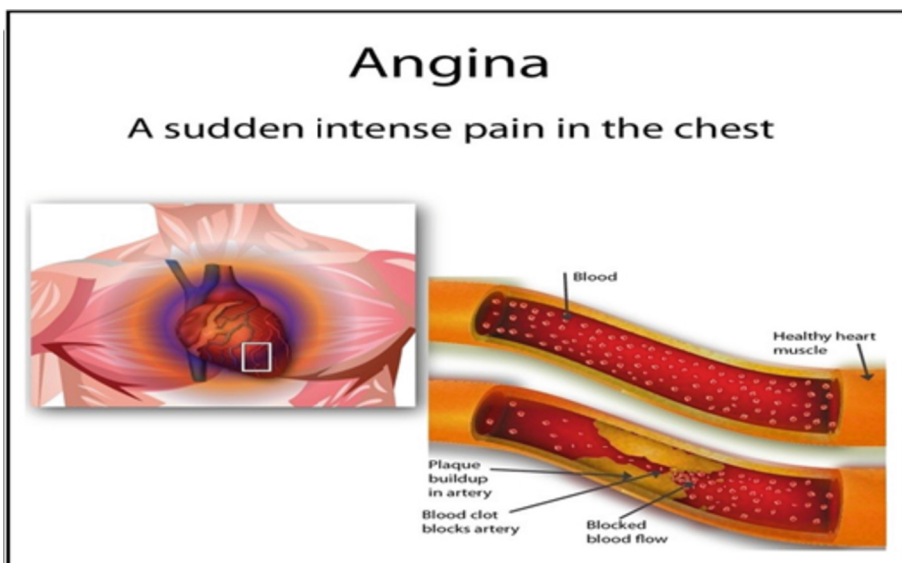


Fig. 2. Angina

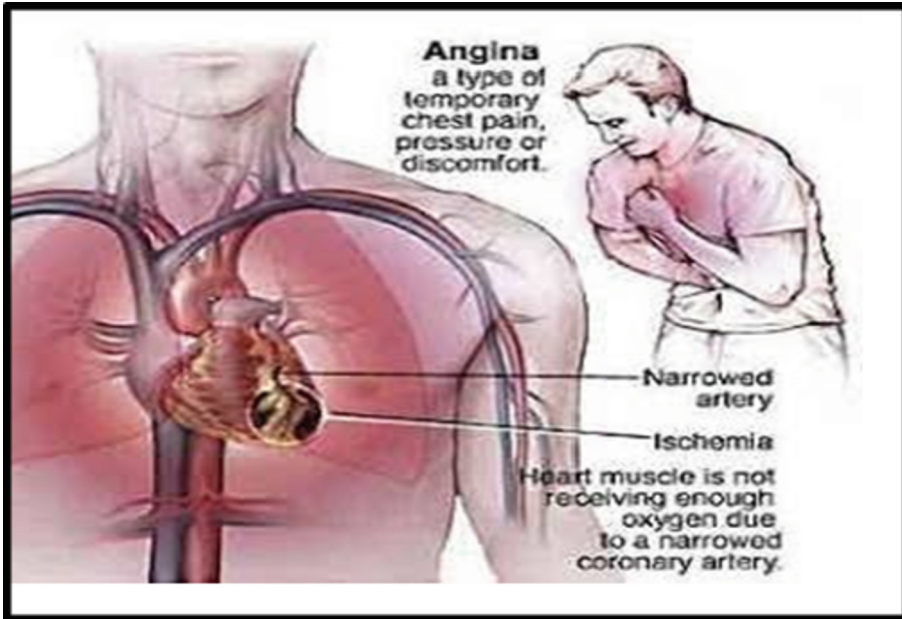


Fig. 3. Unstable Angina

3 Proposed Work

The system can extract hidden knowledge about illnesses from history data of individuals with heart disease using Bayesian classifiers. In a technique that statistically determines the likelihood that a assumed model goes to a precise discussion, Bayesian classifiers forecast the probabilities of class membership. Bayes' formula is the basis of a Bayesian classifier as shown in Fig. 4. The Bayes theorem may be used to calculate the likelihood that an observation-based diagnosis is accurate.

The proposed system serves as an effective classifier by utilizing algorithms such as Naive Bayes and applying Laplace smoothing techniques to handle complex health datasets. This approach enhances the efficiency and accuracy of the system. By using smoothing techniques in conjunction with the Naive Bayes classifier, the system effectively reduces noise and unwanted information, while also handling missing data through maximum likelihood calculation. As a result, the accuracy of the system is significantly improved. The main objective of this work is to develop efficient techniques for early prediction and diagnosis of heart diseases. The utilization of the Naive Bayes classifier enables efficient classification, while the application of Laplace smoothing techniques further enhances the accuracy of the predictions.

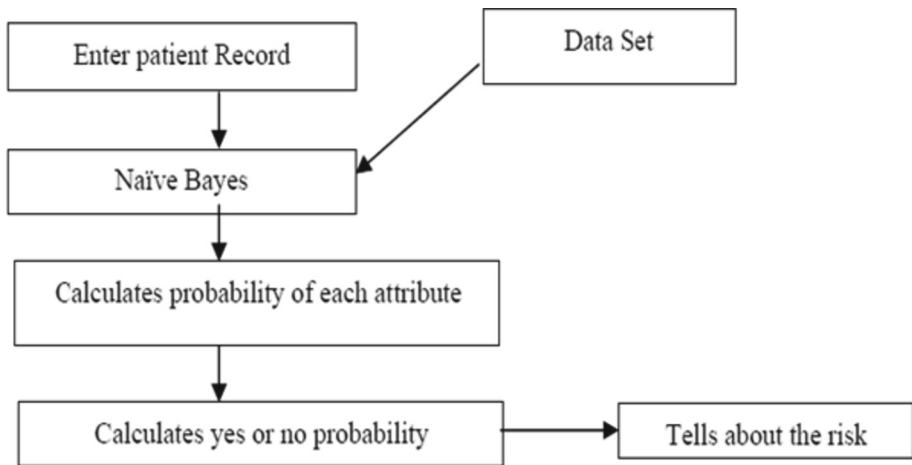


Fig. 4. Bayesian Classifiers

4 Data Set

UCI machinery repository of heart disease data set is used for this diagnosis process, total 76 attributes are marked by the datum, out of this only 13 attributes are utilized by the researches and scientists. System workflow is shown in Fig. 5.

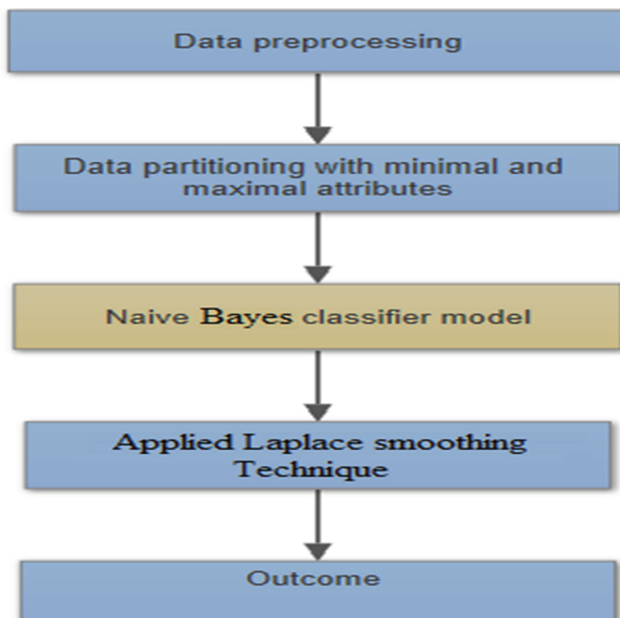


Fig. 5. System Workflow

Naive Bayes

Bayes theorem is used to find the succeeding plausibility $P(X|B)$ for a particular occurrence. The following plausibility $P(X)$, $P(B)$ and $P(B|X)$. $P(X|B)$ is defined succeeding plausibility of objective group X , preceding attribute A . $P(X)$ represents, preceding plausibility of objectives and the instances of the objective groups. $P(X|B)$ denotes the likelihood of the predictor variable and $P(B)$ denotes the prior probability of the predictor. In given objective group B the plausibility of occurrence is likelihood of some conclusion (X), when there exists a dependent relationship between X and B . For a given target class A the probability of occurrence of an event is a likelihood of some conclusion (X), when there exists a dependent relationship between X and B .

Laplace Smoothing for Improved Accuracy Measures

The use of smoothing techniques across naive bayes classifier captures the important patterns of the data. It is made through the use of approximation functions. Further, it avoids noise, fine scale structures and rapid phenomena.

The classification model should possess the joint distribution of the features X and the labels Y . Such that,

$$P(Y, X) = P(Y = y, X_1 = x_1, x_2 = x_2, \dots, X_d = x_d)$$

Artificial Neural Networks (ANN)

This algorithm provides efficient solutions to several complex problems. It works on the basis of the set of interconnected nodes or neurons, forms the networks. The network is often referred directed graph.

Least Squaring-Support Vector Machine Method (LS-SVM)

This method works on the basis of statistical learning theory. It is often used across healthcare industries for risk prediction and medications. Heart disease prediction, breast cancer prediction, and diabetes prediction are some of the important applications of this algorithm. Linear LS-SVM the subclass of LS-SVM maps the high dimensional space into plane which divides the given input to pair of different groups through maximization of scalar values.

5 Results and Analysis

The simulations are performed using MATLAB R (2018a). The system configurations include Intel Core i-7-5500U processor with 2.4 GHz CPU capacity an internal RAM of of 16GB with 1000GB disk space. The windows 10 operating system is used for the simulation process.

Predictable Attributes as shown in Figs. 6 and 7.

For the prediction of heart diseases the following conditions are validated and performance measure is shown in Table 1.

1. Value 0: diameter narrowing < 50%. Then there is no possibility of heart diseases.
2. Value 1: diameter narrowing > 50%. Then there is a possibility of heart diseases.

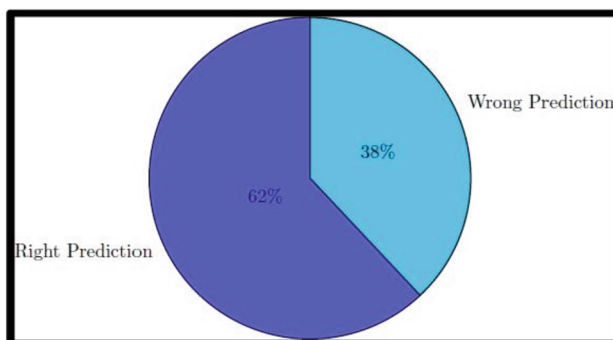


Fig. 6. Prediction of heart diseases using minimal attributes

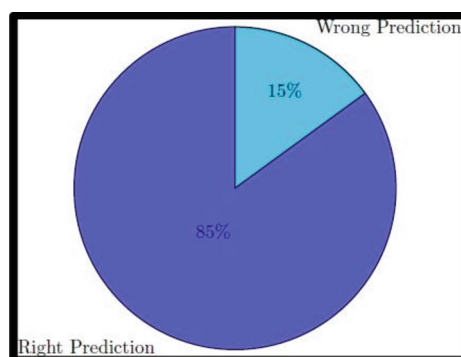


Fig. 7. Prediction of heart diseases using maximal attributes

Table 1. Performance Measure

Number of Attributes	Models	Sensitivity	Specificity	Precision	Accuracy
Minimal (6)	SVM	37.2	85.3	68.3	61.2
	ANN	38.3	85.7	68.9	62.5
	Proposed	39.5	87.5	70.2	63
Maximal (13)	SVM	75.6	94.3	93.2	84.1
	ANN	76.4	95.5	94.1	85.2
	Proposed	77	96.5	95.8	87

The Laplace smoothing techniques deal with the missing values and noise in a more defined way and shown in Figs. 8 and 9. This improves the accuracy of the classification measure. The experiments are conducted using Matlab with heart disease dataset from UCI repository. Around minimal set of records provide less accuracy when compared with maximal accuracy.

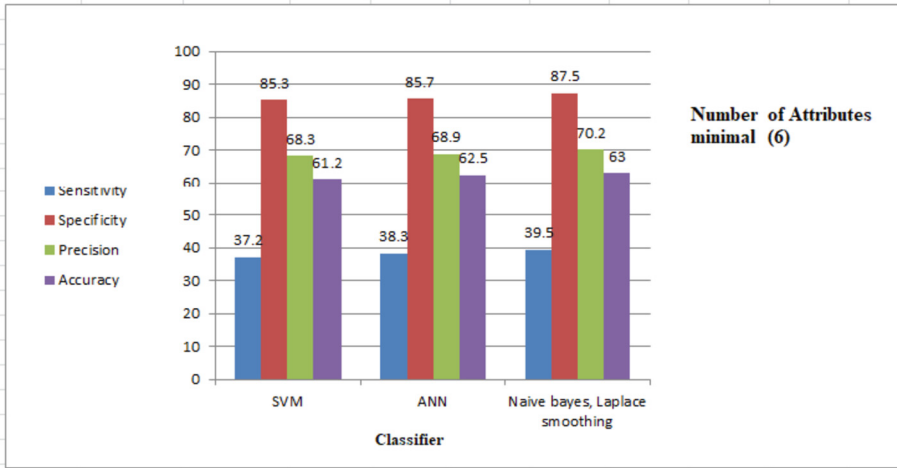


Fig. 8. Prediction of heart diseases using minimal attributes

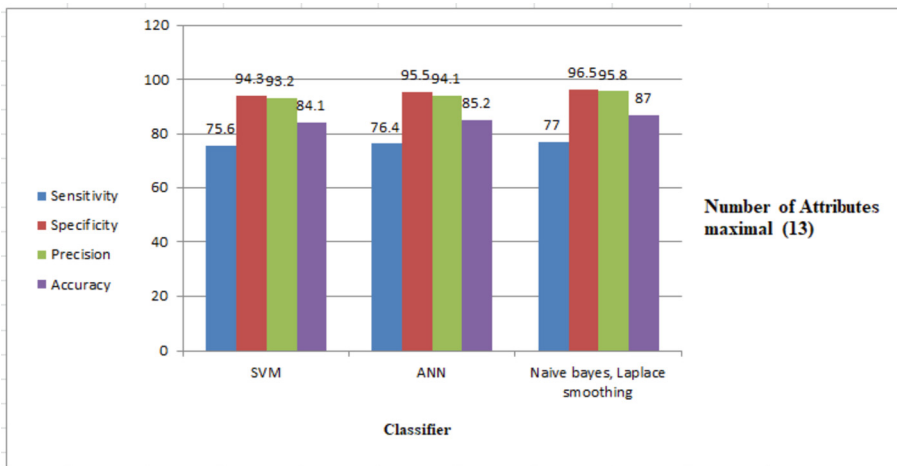


Fig. 9. Prediction of heart diseases using maximal attributes

6 Conclusion

In the realm of medical data classification and prediction, various machine learning algorithms have been employed, yet achieving accurate prediction and classification remains a challenge. It is crucial to have classifiers that are computationally efficient and cost-effective, making an efficient classification algorithm with improved accuracy measurement indispensable for real-time heart disease prediction and management systems.

This research has presented a novel classification approach for heart disease diagnosis, utilizing Naive Bayes algorithm in conjunction with Laplace smoothing techniques. The proposed approach aims to provide an efficient and accurate classification of heart diseases. By incorporating Laplace smoothing, the classification model achieves enhanced accuracy and precision.

The utilization of Naive Bayes algorithm offers simplicity and scalability, making it suitable for real-time applications. However, its performance can be affected by rare events or outliers in the dataset. To address this limitation, Laplace smoothing is applied, introducing adjustments to the probability estimates and resulting in improved classification outcomes.

The results and findings of this research demonstrate that the proposed classification approach with Laplace smoothing can effectively predict and classify heart diseases, providing an enhanced level of accuracy and precision. This advancement has significant implications for real-time heart disease prediction and management systems.

7 Future Scope

While this research has achieved promising results, there are several avenues for further exploration and improvement. First, the proposed classification approach can be evaluated on larger and more diverse datasets to assess its robustness and generalizability. This would help validate its effectiveness across different patient populations and healthcare settings.

Additionally, the integration of other machine learning techniques and algorithms could be explored to enhance the classification accuracy even further. Deep learning models, ensemble methods, or hybrid approaches could be investigated to improve the predictive capabilities of the heart disease diagnosis system.

Furthermore, incorporating additional features or data sources, such as genetic information, patient demographics, or medical imaging data, may contribute to a more comprehensive and accurate prediction model. Feature selection and engineering techniques can be applied to identify the most relevant and informative features for heart disease classification.

Lastly, the real-time implementation and deployment of the proposed classification approach in clinical settings should be investigated, considering factors such as data privacy, scalability, and integration with existing healthcare systems. Conducting rigorous clinical trials and evaluating the impact of the classification system on patient outcomes and healthcare costs would be valuable for validating its effectiveness and practicality.

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Design and Implementation of a Sustainable FPGA-Based UART with HyperTerminal and External Input Device Integration for Enhanced Communication

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Abstract. In this work, a Logical synthesis of FPGA-based UART using a hyper terminal has been implemented. To enable real-time communication and user interaction UART with PISO baud rate generator, and FSM are integrated. It has been observed that the UART transceiver prints the ASCII value of the pressed key on an external keyboard using the FPGA board's LEDs and displays it on the screen via Hyper Terminal. Numerical values are also printed on the FPGA's Seven-Segment Display. Further, design synthesis using "Cadance Genus" and Xilinx Vivado 2016.4 versions was also implemented. The input devices and UART are integrated on Nexys Basys 3 considering the frame with one start bit and one stop bit and eight data bits. The baud rate of UART is observed as 115200 bps. The significant difference of reduced data path delay by a factor of 1942 ps as well as the setup time with a difference of 424 ps has been reported.

Keywords: UART · Baud rate Generator · FPGA · Design Synthesis · logical synthesis

1 Introduction

In the world of digital electronics, communication, and display are essential components of any system. UART is a widely used interface that enables communication and various applications. UART, which stands for Universal Asynchronous Receiver and Transmitter, is a communication protocol designed to facilitate the exchange of information between two devices reliably and effectively. Its primary focus is on achieving high reliability and the ability to transmit data over long distances [1]. UART consists of two fundamental components: a transmitter and a receiver. The transmitter takes parallel data from a computer and converts it into serial data for transmission. On the other hand, the receiver receives serial data from a device and converts it back into parallel data for the computer [2]. A high-level specification of a digital system may involve variables represented by an enumeration type. Additionally, new variables are created during the high-level

synthesis process to represent state variable conditions and control signals, which may have multiple possible values. Throughout the synthesis process, all symbolic values are encoded using binary patterns, and logic functions are optimized and broken down to identify the most efficient implementation of the system [3].

This paper aims to design and implement the UART interfaces with FPGA (LED) and computer systems using Verilog and an FPGA. This demonstrates the versatility and power of Verilog as a hardware description language and highlights the capabilities of FPGAs in implementing complex digital systems. After that, the design is synthesized using the industrial tool “Cadance Genus” which helps convert RTL (Register Transfer Level) descriptions written in hardware. The tool optimizes the design by applying various transformations, such as technology mapping, logic restructuring, and area/power optimizations. It also performs tasks like scan insertion and constraint verification. In the context of digital systems, complex logical functions are typically described using a network of simpler functions.

1.1 System Description

When data is transferred from the data bus to the transmitting UART, it is sent in parallel form. This means that multiple data bits are transmitted simultaneously, each occupying a separate wire or connection. Upon receiving the parallel data, the transmitting UART performs a series of operations to prepare it for serial transmission. First, the transmitting UART adds a start bit, which is typically a logic level of 0. This start bit serves as an indicator to the receiving UART that a new data packet is about to begin. Following the start bit, the transmitting UART appends a parity bit, which is an extra bit used for error checking. The parity bit is calculated based on the data bits and can be set to even parity or odd parity, depending on the specific UART configuration. Finally, a stop bit, usually a logic level of 1, is added to mark the end of the data packet [4].

2 Proposed Architecture

The proposed Verilog code represents a UART (Universal Asynchronous Receiver-Transmitter) implementation. It consists of multiple modules that work together to facilitate serial communication between a transmitter and a receiver. The top-level module, named “UART,” connects the transmitter and receiver modules to create a complete UART system. It includes input and output ports for data, clock, transmit, reset, and signals related to the receiver’s functionality.

2.1 Proposed Hardware Architecture

In this paper, implement a UART in between FPGA and keyboard using Verilog HDL and interface it with the hyper terminal. When the key strobe on the keyboard (from the computer) is pressed, the 8 bits are transmitted from the keyboard to FPGA through the USB-UART port based on 3 boards. 8 LEDs [7:0] on base 3 will be used to show the binary value of the ASCII character. All receiving is triggered when a key is pressed on the keyboard. There is a button to reset the output led as well. After implementation of UART performs logical synthesis using an industry tool “Candace Genus” with the use of TCL commands like “Elaborate”, “Syn_gen” and “Syn_map”.

2.2 Implantation of Proposed System

The receiver module, “Receiver,” is responsible for receiving data sent over the communication line (RxD) and extracting the received bytes. It utilizes a state machine to control the reception process. Internal variables, such as shift, state, bit_counter, sample_counter, baudrate_counter, and rxshift_reg, are used to manage the different stages of the reception process. The received data is stored in the RxData output port.

The transmitter module, “Transmitter,” handles the transmission of data. It also employs a state machine and internal variables like bit_counter, baudrate_counter, shiftright_register, state, shift, load, and clear. The transmitter takes input data and converts it into a serial stream of bits that are transmitted via the TxD output port.

The “Top_Module” module acts as a bridge between the transmitter and the top-level module. It incorporates a debounce_signal module, which debounces the transmit input signal, ensuring a stable input signal for the transmitter. The debounced output is then connected to the transmit_out input of the transmitter module.

The “debounce_signal” module utilizes a clock_enable module, which divides the main clock (clk) to generate a slower clock (slow_clk_en). The debouncing process involves using two D flip-flops (my_dff_en modules) to synchronize the input signal (pb_1) and create an output (pb_out) that represents a stable, debounced version of the input signal. Lastly, the “clock_enable” module acts as a clock divider, generating a slower clock signal (slow_clk_en) from the original clock signal (Clk_100M).

This Verilog code implements a basic UART system, including a transmitter, receiver, debouncing logic, and clock division components. It provides the necessary functionality for asynchronous serial communication (Fig. 1).

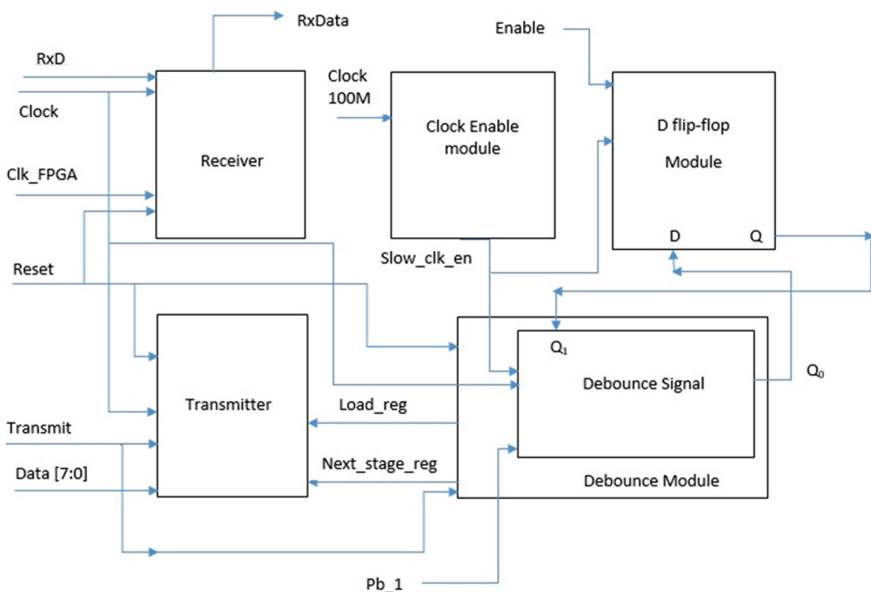


Fig. 1: Block Diagram of Proposed Architecture of UART

2.2.1 Implementation Steps:

Step 1:

The elaboration stage of synthesis is a crucial step in the digital design process, specifically in the context of hardware description languages (HDLs) like VHDL or Verilog. The HDL code is transformed and expanded during this stage to create a more detailed and refined representation of the digital circuit. Elaboration involves resolving all the hierarchical references, connections, and dependencies within the design. It ensures that all modules and components are correctly instantiated and interconnected, forming a complete circuit representation. The HDL code is parsed in the initial step to check its syntax and structure.

Step 2:

Syn_gen, short for “synthesis generation,” refers to the stage in the synthesis process where the high-level design description is transformed into a gate-level netlist or a register-transfer level (RTL) description. It involves a series of transformations and optimizations to convert the abstract representation of the design into a form that can be realized in hardware. The syn_gen stage focuses on mapping the design elements, such as logic gates, flip-flops, and interconnections, to the targeted technology library, taking into account constraints and optimization goals.

Step 3:

Syn_map is a stage in the synthesis process that involves mapping the high-level design description onto a target technology-specific library of components. During syn_map, the synthesis tool selects appropriate library elements, such as gates, flip-flops, and other primitives, to implement the functionality specified in the design. It considers factors like area, power, timing constraints, and technology-specific limitations to optimize the mapping.

3 Results and Discussion

In this section, logical synthesis is performed on the Transmitter and receiver of UART as shown in Fig. 3 which gives Top_module with a Receiver, the Top_module consists of submodules of transmitter & Debounce signal (Fig. 2).

HDL code is transformed and expanded to create a more detailed and refined representation of the digital circuit. The Cadence Genus tool resolves all the hierarchical references, connections, and dependencies within the design.

Figure 4 shows the syn_generic stage of the synthesis, here the high-level design description is transformed into a gate-level netlist or a register-transfer level (RTL) description. A series of transformations and optimizations is done to convert the abstract representation of the design into a form that can be realized in hardware.

As for the last stage run syn_map for the design of UART. In the syn_map stage, mapping the high-level design description is implemented onto a target technology-specific library of components. It considers factors like area, power, timing constraints, and technology-specific limitations to optimize the mapping. Figure 5 shows the timing

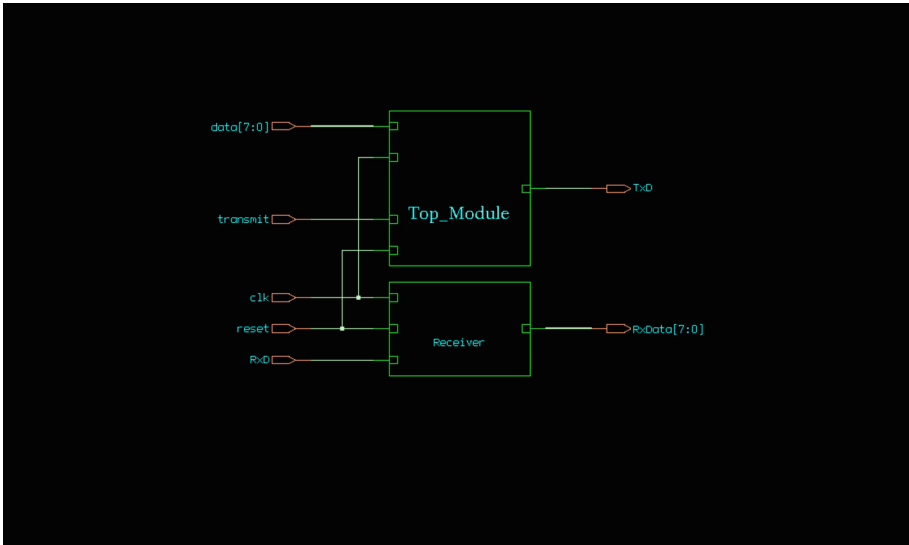


Fig. 2: Elaborate stage of UART synthesis

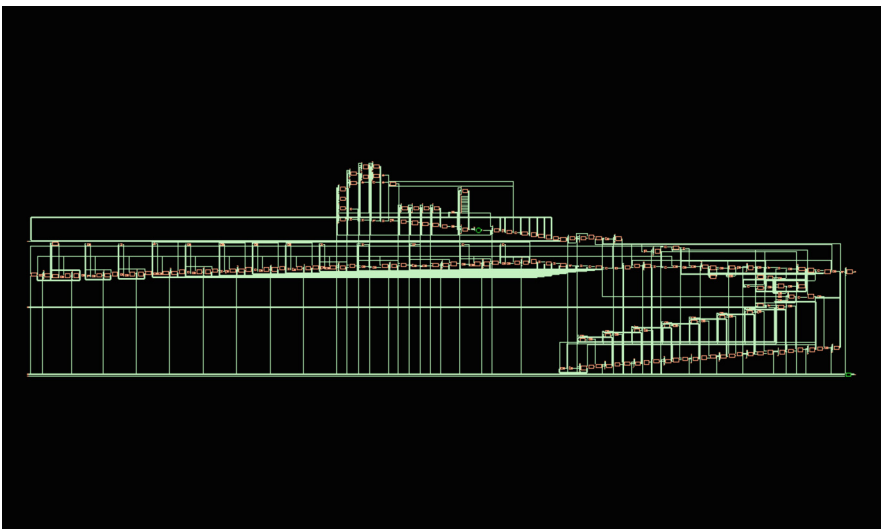


Fig. 3: : syn_gen stage of UART synthesis

report before the implementation of the syn_map stage which describes the unmapped cells & flops of the design.

The timing report in Fig. 5 which is a pre-mapped stage, shows a data path delay of 4761ps and a setup time delay of 1352ps due to this there is a slack of -4113ps which shows the setup time is violated by 4113ps. After the syn_map stage time report

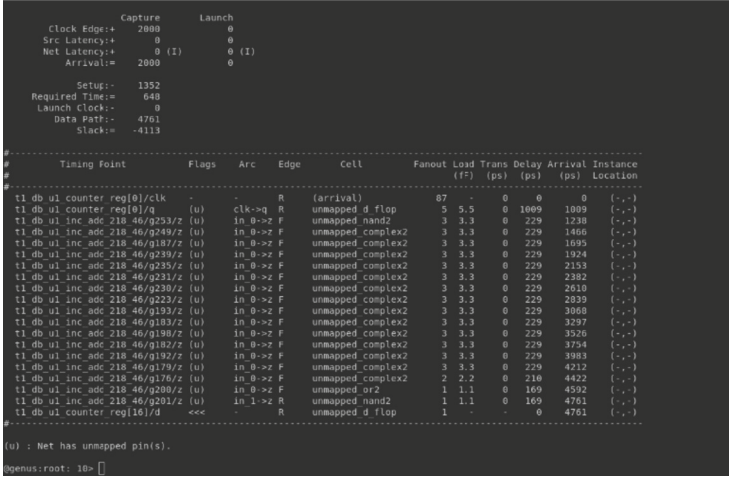


Fig. 4: Timing Report of UART pre-mapping

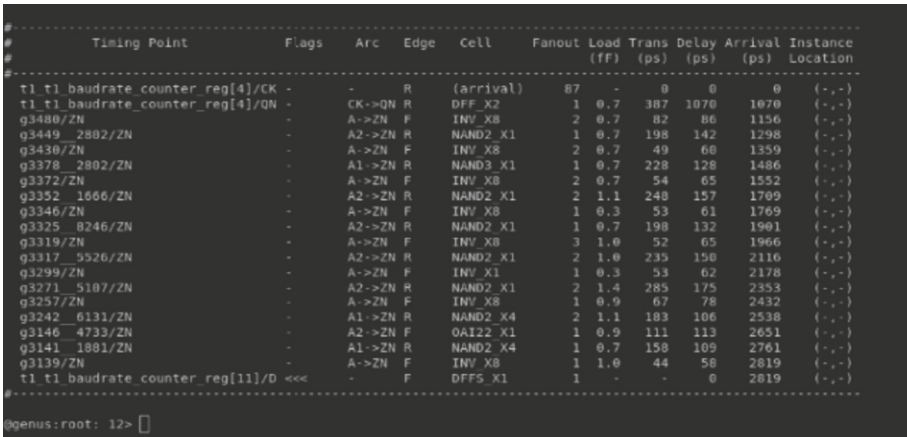


Fig. 5: Timing Report of UART post-mapping

in Fig. (6) has a data path delay of 2819ps and the setup time delay is 1594ps which makes the slack -2412ps, this also shows the setup time violated by 2412ps.

It has been observed that after the syn_map stage, the timing report as shown in Fig. 6, shows the cells are mapped and WNS (worst negative slack) is also improved by 1701 ps from the pre-mapped stage timing report. The difference in the WNS is also because of the change in data path delay as the data path delay was reduced by a factor of 1942 ps and the setup time of the capture flop also became more accurate by a difference of 242 ps.

4 Conclusion



In this work, the design, simulation, and synthesis of a high-speed Universal Asynchronous Receiver and Transmitter (UART) are successfully implemented Nexys Basys 3 FPGA board on and verified using Verilog hardware descriptive language (HDL language) on Xilinx Vivado 2016.4 version. The synthesis results are verified using Cadence Genus Tool. The high-speed serial data transfer at 115200 bps rate with a clock frequency of 100 MHz UART is used for serial data transfer and the speed of UART is depending upon the transmission media of transmitter and receiver. The baud rate of the UART transmitter and receiver is found to be comparable.

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Development of Third Eye for Enabling Sustainable Mobility for the Visually Impaired

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Abstract. Vision impairment affects at least 2.2 billion individuals worldwide. Blindness is the condition of total blackness of vision when the person is unable to see anything other than darkness with either eye. People who suffer from vision anomalies or even complete blindness can utilize this prototype in order to ensure their mobility without the assistance of other people. The pedestrians are alerted with a buzz sound along with a vibration whenever a hindrance is identified within a certain range along the path.

Keywords: Arduino NANO · Ultrasonic sensor HC- SR04 · Vibration motor

1 Introduction

Blindness, as we define it, is the inability of a person to see. Mobility is one of the most significant issues that visually impaired persons face. Various devices and techniques have been proposed over the last few years to assist the blind pedestrians in movement. Dogs are trained in a way for providing assistance to the blind persons in locomotion. However, this method has some major drawbacks since it requires much maintenance and sometimes it becomes difficult to understand the complicated directions implied by the dogs. Even though the white cane used by the blind individuals is light and portable, it is not helpful most of the time since it is not wearable and less appropriate for long range detection of hindrances coming in the path. The blind individuals need to carry it with themselves whenever they move which makes it unmanageable for them. It is a technological advancement that allows visually impaired persons to travel quickly across various locations safely by detecting all the obstacles in the path utilizing the assistance of the wearable glasses delivering ultrasonic waves by the two low-cost ultrasonic sensors fitted on both the glasses on either side. The proposed system is a wearable, effective yet economical innovation that attempts to minimize the drawbacks persisting in the existing models to some extent. It can be easily worn as sunglasses requiring fewer efforts. With high utilization and demand of the device, making some more improvements in the prototype will serve as a boon to the visually impaired community hence making their lives much simpler.

2 Literature Review

In the recent years, a good amount of research has been conducted and many new technologies have been developed for blind people helping them attain the ability to move without the support of other individuals. However, there are few restrictions and limitations revolving around the innovations.

D. Yuan et al. [1] proposed a virtual white cane sensing device but had few disadvantages that it identifies the object at a restricted rate and encounters various surface imperfections. B. Rathore et al. [2] introduced a laser cane capable of sensing obstacles from three distinct angles but was lacking system for deciding the position and location. S. Shovel et al. [3] introduced a NavBelt, with which it is hard to separate the sounds and it couldn't determine the moving position of the blind person. M. A. Espinosa et al. [4] proposed effective yet costly methods for the blind pedestrians which can only be afforded by people in the urban cities. According to P. Sharma et al. [5] the obstructions can be spotted, but only within a specific range and angle.

A. Pereira [6] proposed Blind Guide, an ultrasound sensor-based body area network for guiding blind people. S. Innet et al. [7] developed a distance measurement stick with distinct vibration waveforms at different ranges, making it difficult for blind individuals to distinguish. Furthermore, it is a difficult and time-consuming process. A device was introduced by E. Milios et al. [8] that enables for three-dimensional (3-D) spatial perception by sonifying range information acquired from a point laser range sensor. S. Sabarish [9] demonstrated an obstacle detection system that identifies obstacles using a stereoscopic sonar system and gives vibro-tactile feedback to the blind in order to notify them of their location. M. Bousbia et al. [10] discussed an approach containing a footswitch. When the footswitch is depressed, the acceleration and velocity are known to be zero, which can be used to make a correction. Out of all the technologies present nowadays for the visually impaired pedestrians, our proposed system is cost friendly, wearable and an optimized version with more effectiveness overcoming the above limitations to a greater extent.

3 Proposed System

The proposed system is designed in keeping view of the drawbacks of the existing systems and attempts to make them more productive and easier to use. It contains a pair of HC-SR04 ultrasonic sensors interfaced with Arduino Nano and firmly attached on a pair of glasses. If the obstacles are detected by the sensors, then a buzz sound along with a vibration is produced which can be heard by the users hence making them aware about the obstacles in the path.

3.1 Hardware and Software Components

The developed system includes the following components:

- Arduino Nano V3.0
- Ultrasonic sensors
- Micro coin vibration motor

- 12V Lithium battery
- 2 pin SPST Switch
- Jumper wire
- Buzzer
- Dark Sunglass
- 7805 Voltage Controller
- Puff Board

The above components are discussed below.

Arduino Nano and Spst Switch

The Arduino Nano as shown in Fig. 1(a) is a small, complete, and breadboard-friendly board based on the ATmega328 released in 2008.

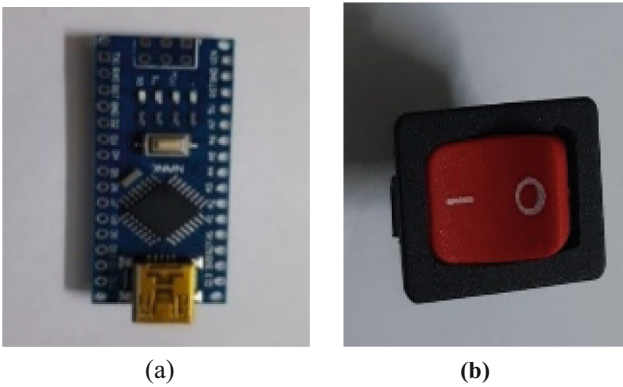


Fig. 1. (a) Arduino Nano, and (b) SPST Switch

The Arduino Nano is equipped with 30 male I/O headers, in a DIP-30-like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and running both online and offline. The board can be powered through a type-B mini-USB cable or from a 9 V battery. An SPST switch stands for “single pole single throw” which includes a single input and a single output. An SPST switch embraces a basic “ON/OFF” control of a single circuit and consists of two terminals that serve as electrical connection points as shown in Fig. 1(b). Power the switch “ON” to establish a connection between the two terminals.

Ultrasonic Sensors

The HC-SR04 Ultrasonic Distance Sensors indicated in Fig. 2, consists of two ultrasonic transmitters, a receiver, and a control circuit, employs non-contact ultrasound sonar to measure the distance to an object.

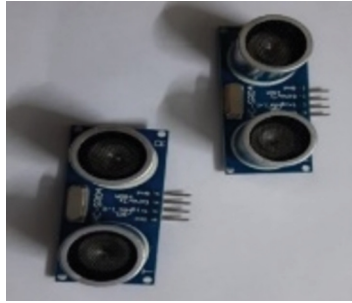


Fig. 2. Ultrasonic Sensors

Wires and Vibration Motor

The connecting components of a circuit are wires. Jumper wires are tiny wire ducts that can be used to join parts on bread boards or in other places, shown in Fig. 3(a). Vibration motor is a small sized DC motor, used to educate consumers by vibrating in response to signals. These Vibration motors as shown in Fig. 3(b) are widely used in various applications like Pagers, Handsets, and Cellphones and so on.

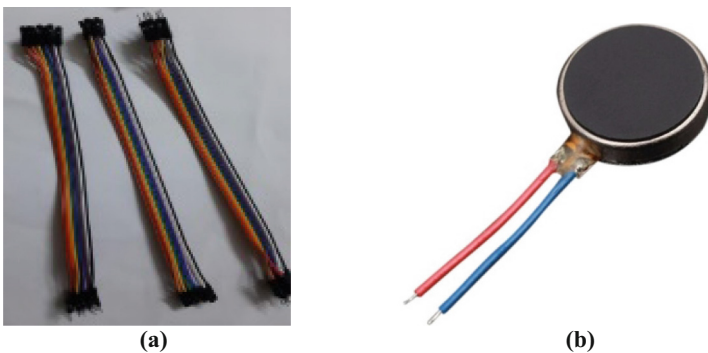


Fig. 3. (a) Jumper wires, and (b) Vibration motor

Buzzer and Battery

A buzzer made by Arduino Nano is similar to a beeper. A battery (12 V) is an apparatus that stores chemical energy and transforms it into electrical energy. Buzzer and Battery are indicated in Fig. 4(a) and (b), respectively.

Voltage Controller and Puff Board

The 7805 Voltage Controller, shown in Fig. 5(a), is generally a three-terminal linear voltage regulator integrated circuit with a set output value of 5V. A Puff Board as shown in Fig. 5(b) is a controlled medium used in electrical and electronic engineering to link electronic components.

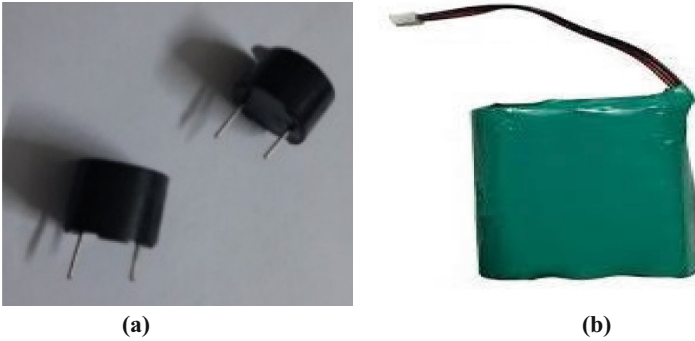


Fig. 4. (a) Buzzers, and (b) Battery

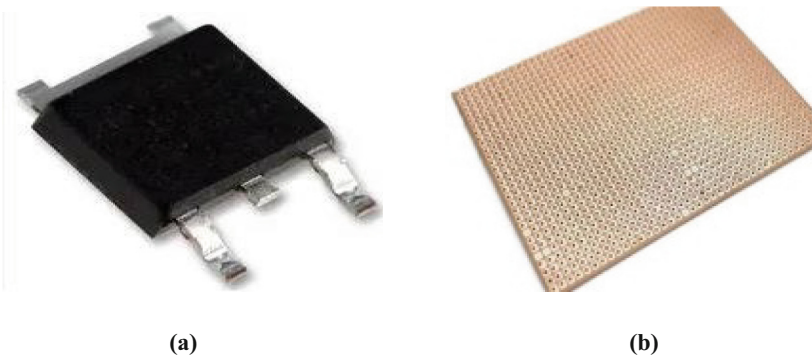


Fig. 5. (a) 7805 VC, and (b) Puff Board

3.2 Flow Chart of the Proposed System

This prototype is equipped with 2 ultrasonic sensors and modules. So, whenever any obstacle is detected by the device in the field of vision, within the range of about 1 m then, Module 1 which consists of Vibration motors & that are placed on the each of the sides of the glasses would respond with vibrations which is quite helpful in alerting the blind person about the presence of an obstacle in a crowded environment.

Similarly, other Module consists of Buzzers that are also placed on the each of the sides of the glasses would respond with Beep sound after sensing the obstacle also such a placement of modules will give a better idea of the direction of the obstacle that will help the visually impaired people traverse independently. In case, when no obstacle is detected then, the transmitted ultrasonic waves will not be reflected or received back by the sensors and therefore modules would not respond also (Fig. 6).

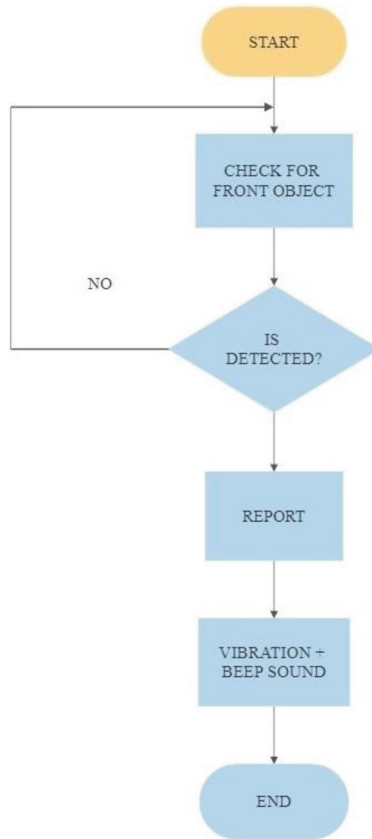


Fig. 6. Flow Chart

3.3 Circuit Diagram

Figure 7 shows the circuit diagram of the proposed prototype explaining all the connections of the components with Arduino Nano. This diagram helps in understanding the pin connections of all modules with the micro controller.

3.4 Block Diagram

Figure 8 displays the block diagram of the proposed system. It shows the communication between inputs and outputs. Whenever any obstacle is encountered within the range of about 1 m then, left and right Ultrasonic sensors sends signals to the microcontroller. Module 1 would respond with vibrations which are quite helpful in alerting the blind person about the presence of an obstacle in a crowded environment. Similarly, other Module 2 will respond with beep sound after sensing the obstacle. This mechanism will give a better idea of the direction of the obstacle that will help the visually impaired people traverse independently.

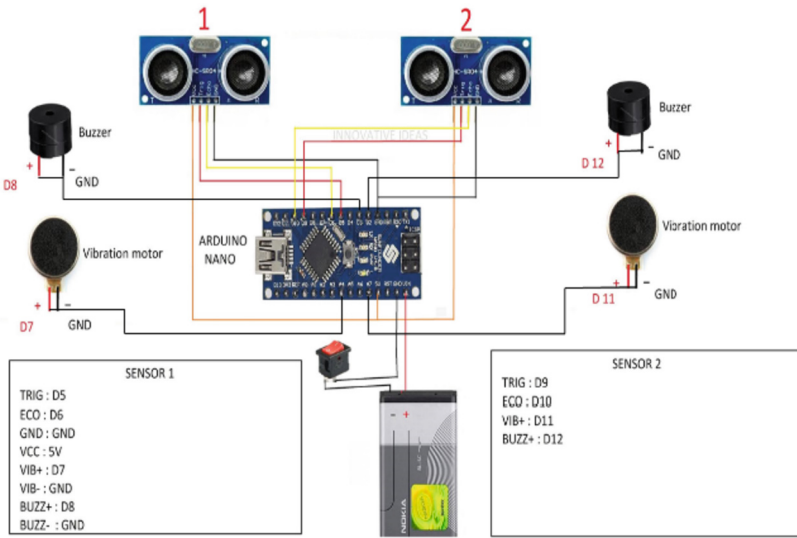


Fig. 7. Circuit Diagram

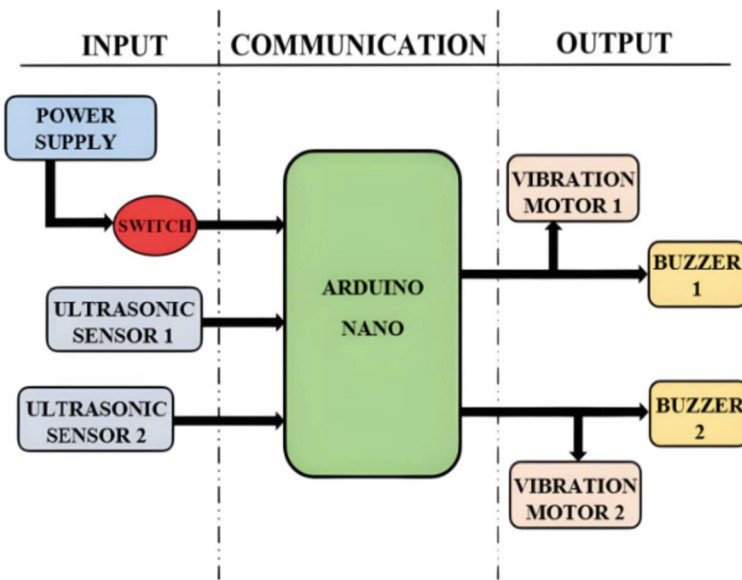
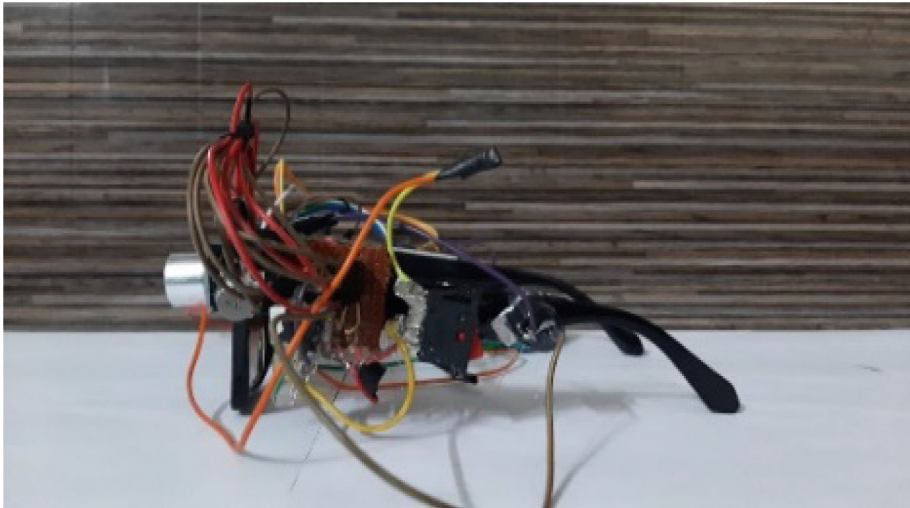


Fig. 8. Block Diagram

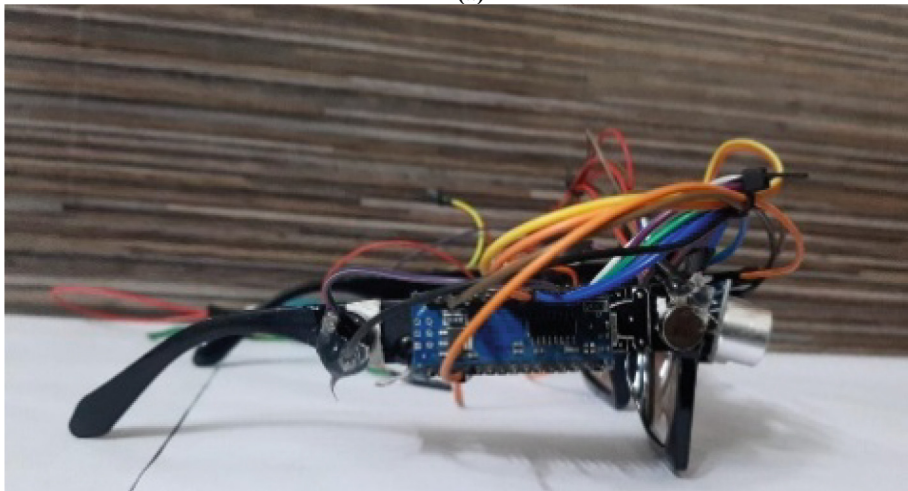
3.5 Final Prototype

The final working prototype is shown in Fig. 9 and Fig. 10 with side view and front view. The prototype consists of a framework of glasses consisting of a pair of ultrasonic sensors embedded on it. When ultrasonic waves travel, these sensors measure the distance

between the individual and the obstacle. They gather real time data and information and further send it to the Arduino Nano having a program uploaded into it for processing. Afterwards, a buzzing sound is invoked along with a vibration as a warning indicating the presence of a nearby obstacle in the path. The sensors used here can sense the distance up to 1 m and detect the obstacles within 120 Degree field of vision accordingly. The whole system is powered by a lithium type battery. Whenever the SPST switch is turned on, the system starts its working and generates sound warnings to alert the blind pedestrians.



(a)



(b)

Fig. 9. Side View of the prototype (a) Left View, and (b) Right View

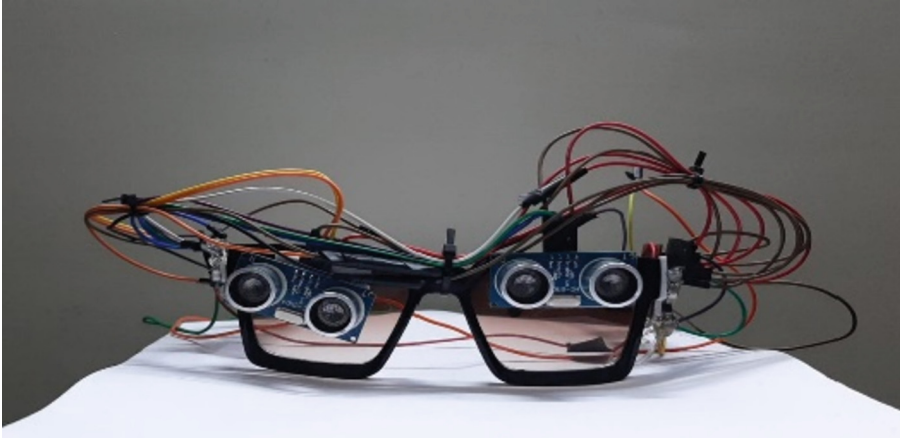


Fig. 10. Front View of the prototype

4 Results and Discussion

The final prototype so developed is tested blindfolded and necessary results are observed properly and noted down. In this proposed system, obstacles coming under the range of 1 m are sensed by the pair of ultrasonic sensors. Afterwards, a buzz sound along with a vibration is produced. The active vibration is helpful whenever the blind pedestrian is in a crowded region.

Similarly, other Module consists of Buzzers that are also placed on the each of the sides of the glasses would respond with Beep sound after sensing the obstacle also such a placement of modules will give a better idea of the direction of the obstacle that will help the visually impaired people traverse independently. In case, when no obstacle is detected then, the transmitted ultrasonic waves will not be reflected or received back by the sensors and therefore modules would not respond also.

5 Conclusion

Third eye for blind serves as an assistant device that simplifies the day-to-day life of the blind pedestrians. It requires less maintenance and detects the obstacles in the path coming under the range of the ultrasonic sensor but still there exists scope for improvement such as replacing Ultrasonic sensors with flex sensors which will result in the overall better performance and reduced weight of the device. After that, sound instructions are invoked alerting the blind person about the presence of a hindrance in the path. It is an effortless and an affordable device & this prototype can be commercialized after a few improvisations.

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Effectiveness of Agile Sustainable Project Management Approach in Software Industries

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Abstract. The primary objective of the research study is to examine and analyze the various challenges and limitations encountered during the implementation of agile project management in small and medium enterprises (SMEs) operating within the Indian market. This study identified an important limitation as there was no management involvement and employees were aware of the company's policies and culture. These limitations were identified through a literature review, specific case studies, and case study analysis. As the popularity of agile methods continues to grow, more and more software companies are abandoning the traditional approach to agile development because of its flexible and human approach that enables small teams to work together. This article aims to explore the importance, benefits, and limitations of implementing an agile project management approach in SMEs in the Indian market. The study seeks to gain a deeper understanding of the Indian SME marketplace.

Keywords: Agile Methodology · Small and Medium Enterprises · Software Development · Project Management

1 Introduction

In the last ten years, project management systems have undergone significant changes in design and operation. It is essential to note that conventional project management methods used by organizations are insufficient to keep up with the current work environment. Project management concepts and methodologies evolve as the technological landscape changes. In the 1990s, traditional project management methods were inflexible, and new methods had to be developed and embraced. The “application development crisis” or “application delivery delay” was widely regarded as a significant crisis in the 1990s. After three years of examination, there was a significant difference between confirmed business development and actual application development, indicating the inadequacy of traditional project management methods. This resulted in projects being canceled midway, or content requirements were not met adequately. It's important to use methodologies that meet business requirements and helps in delivering the project without any delay. Due to the ability to deliver the project on time and meet the business requirements, agile project management methodologies have gained significant popularity in the software development field.

1.1 Agile Methodologies in SMEs

Please A Small and Medium Enterprise (SME) is a business with few employees and income. The definition of SMEs varies by country and sector. For example, in Europe, an SME is generally defined as a company with fewer than 250 employees, while in the United States, an SME can have a maximum of 1,200 employees. SMEs play an important role in driving growth, fostering innovation, and promoting diversity. According to the Small Business Administration (SBA), SMEs constitute the majority of businesses in many countries, including the US, where they account for about 99.9% of all businesses. 2014 US SMEs contributed around 44% of the country's total GDP.

1.2 SMEs in India

Small and medium enterprises (SMEs) drive India's economic growth and revenue generation in the tech market. The low rate of technology adoption among SMEs in India is a major hurdle to their success. According to estimates, India has about 42.50 million SMEs, and the lack of registration impedes their success. In addition to driving the country's economic development, SMEs in India employ around 106 million people, which is about 40% of the country's total workforce. The Indian market presents a bright future for SMEs, which is why there is a need to build the digital capabilities of the Indian media market. This offers an opportunity to implement the agile methodology in the market. India's growth is expected to reach a CAGR of 7% between 2016 and 2021, which highlights the strong growth and profit potential for entrepreneurs and owners.

An agile-based project management approach involves implementing and implementing the agile cycle. Initially, the product is used for workplace review by customers and stakeholders to check its delivery and performance, after a review of the people used, products are released in a work environment where Agile methodology focuses on: Clients want a way that uses resources efficiently and avoids additional or different risks to the project (Fig. 1).

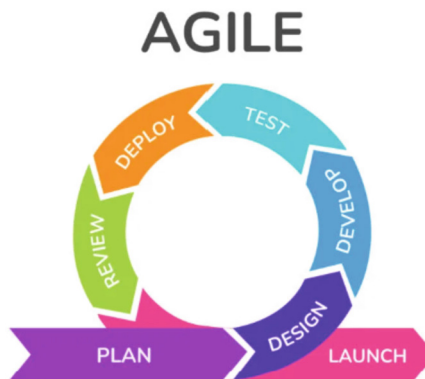


Fig. 1. Life Cycle of Agile Development

1.3 Agile vs. Traditional Methodologies

Project management is an ever-evolving field, and many companies in the marketing sector have shifted towards using agile procedures over traditional ones to offer efficient and appealing services to their customers. While traditional and flexible methods differ in terms of delivery time and customer satisfaction, their basic approaches are also very dissimilar. Traditional project management methods follow established guidelines, which require a project to complete its cycle in a specific order, prioritizing the linear process. Future planning, project prioritization, budget, and delivery schedules are all fixed and cannot be altered, leading to budget constraints and unmanageable delays during the project. The five phases of traditional project management are Initiation, Planning, Execution, Testing, and Completion.

One of the oldest and most popular methods in project management and software development, the waterfall model uses stages where the results of one stage are fed into the next. Each of these stages is suitable for the others. To avoid stage overlap, each stage has a set of outputs that form the basis for the next stage. This waterfall is riskier than the quick one because the change requires iteratively doing the whole process to update the product (Fig. 2).



Fig. 2. Traditional Methodology; Waterfall model.

On the other hand, the agile approach is a more modern and holistic method of project management that divides projects into series or sprints, each lasting approximately 2–4 weeks, resulting in higher productivity and creativity among employees. This approach consists of several stages, such as project planning, product roadmap creation, design release, sprint planning, daily preparation, and sprint reviews and retrospectives, resulting in innovative final project delivery (Table 1).

Table 1. Difference Between Traditional and Agile Methodologies

Traditional	Agile
Design up front	Continuous design
Fixed Scope	Flexible Scope
Deliverables	Features/requirements
Freeze design as early as possible	Freeze design as late as possible
Low uncertainly	High uncertainly
Avoid change	Embrace change
Low customer interaction	High customer interaction
Conventional project teams	Self-organized project teams

1.4 Benefits of Agile Project Methodologies

Agile methodologies are well-suited for small and medium-sized businesses that prioritize innovation. These methods emphasize communication between development teams and end users, with a focus on achieving business outcomes rather than simply following a project plan (Sheedy and Sankaran, 2013). For SMEs, adopting an agile approach to project management can offer many benefits and opportunities for growth and improved performance. Some of these benefits include:

Better product quality: Improved quality of the final product is the key advantage of agile project management. Regular testing is involved in the development cycle of the agile methodology and this process continuously monitors bugs and compatibility issues. Regular review of the development process at various stages allows the team to quickly identify weaknesses and develop effective solutions, ensuring that high-quality products are delivered to end-users within the proposed budget (Sheedy and Sankaran, 2013).

Improved customer retention and satisfaction: Improved customer retention and satisfaction is another significant benefit of adopting an agile project management approach. Agile project management focuses on building relationships and Communication between the development team and end users. This keeps both parties engaged throughout the project that matters to the client. Additionally, the flexibility and communication offered to the client allow them to effectively communicate their ideas, expectations, and vision, helping the team better understand customer perspectives and develop products accordingly. By addressing customer needs and expectations, agile methodology leads to greater customer loyalty and satisfaction, resulting in improved customer retention and satisfaction.

Better control of projects: Adopting an agile project management approach involves breaking projects into batches or phases, which can make communication and distribution of work between teams more efficient. By dividing the project into different sections like design, development, and testing, multiple teams can work together more easily. Smaller teams help create effective communication between team members and team meetings are done for discussing the progress, feedback, and the progress of the

project. In Addition, project management tools like Jira provide insight into every step of the development phase, ensuring clarity and transparency for all parties involved. As a result, agile project management approaches give development teams more control over projects and are known for improving collaboration and productivity (Apiumhub, 2020).

Low Risk: Agile methodology approach is considered highly effective in risk mitigation as it reduces the likelihood of project failure. Traditional project management methods have a higher risk of failure due to a lack of clarity about time and budget requirements. However, with agile, budgets and timelines are flexible and can be adjusted at any point during the development process. The agile approach provides teams with the freedom to adapt to changes and pivot as necessary, which helps reduce the risk of project failure (Fig. 3).

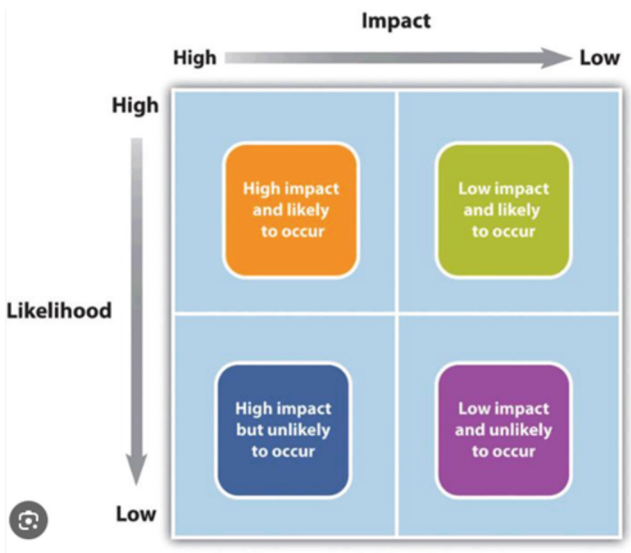


Fig. 3. Early-stage Mitigation and Risk Detection

Faster ROI: Agile project management approach helps companies to analyze their return on investment (ROI) at an early stage, providing a better plan for growth and profitability. Since the approach involves repeating the fast process, it enables the organization to forecast revenue and budget for each stage. Multiple teams can work collaboratively, focusing on different project units or sprints, which can lead to the quick delivery of functional products. This provides a higher chance of better ROI, as companies can bring their products to market earlier and generate revenue faster. Therefore, adopting an agile approach to project management can help companies analyze their ROI at an early stage and achieve faster returns on their investments (Apiumhub, 2020).

2 Literature Review

In recent years, agile software development methodologies have become popular due to their flexibility, adaptability, and faster delivery of quality software products. Several research works have been done on agile methodologies, their trends, and their impact on software development. Al-S. Saqqa, S. Sawalha, & AbdelNabi, H. (2020) provide an overview of different agile methodologies such as Scrum, Kanban, and Extreme Programming (XP) and highlight their advantages and limitations. The role of people factors in agile software development and project management, such as communication, collaboration, and trust, is discussed by Lalsing, Kishnah, & Pudaruth. (2012). Fernandez, & Fernandez, J. D. (2008) compare agile project management to traditional approaches and show that agile methodologies are more efficient in terms of time-to-market, quality, and customer satisfaction. Sliger (2011) provides a comprehensive guide to agile project management with Scrum. Moser, Abrahamsson, Pedrycz, Sil-litti, & Succi, G. (2008). Scrum is the most popular methodology, followed by XP and Lean. Manole, & Avramescu, (2017) compare different agile project management tools such as Jira, Trello, and Asana and show that Jira is the most widely used tool. Malhotra, R., & Chug, A. (2016) compare agile methods and iterative enhancement models in assessing software maintenance and show that agile methods are more effective in maintaining software quality. Dingsøyr, Nerur, Balijepally, & Moe, (2012) provide an overview of agile methodologies and explain the underlying principles and values of the Agile Manifesto. Nuottila, Aaltonen, & Kujala. (2016) discuss the challenges of adopting agile methods in a public organization and highlights the importance of cultural change and leadership support. Abrahamsson, Salo, Ronkainen, & Warsta. (2017) Review and analyze agile software development methods, including Scrum, XP, and Lean, and highlight their strengths and weaknesses. Van Casteren. (2017) compares the Waterfall model and agile methodologies and shows that the choice of methodology depends on project characteristics, such as size, complexity, and customer involvement. Jadoon, Ud Din, Almogren, & Almajed. (2020) propose a smart and agile manufacturing framework for the automotive industry, highlighting the benefits of agile methodologies in improving production efficiency and reducing waste. The literature review suggests that agile software development methodologies are effective in improving software quality, customer satisfaction, and time-to-market. However, their adoption also poses challenges related to cultural change, leadership support, and project characteristics.

R. Singh, Kumar, and Sagar (2017) utilized Interpretive Structural Modelling (ISM) to evaluate the impact of Agile methodology on software development and its suitability for specific projects. They concluded that ISM is a useful tool for assessing the appropriateness of Agile methodology for projects. In 2018, they proposed a two-way assessment approach to develop an Agile software methodology using Analytical Hierarchical Process (AHP) to evaluate feasibility. Singh, Kumar, and Sagar (2019) investigated the utility of process prioritization in Agile software testing using AHP and concluded that process prioritization is effective for Agile testing. They also conducted an analytical study of Agile methodology in the information technology sector and found that it enhances the performance of software development teams. In 2020, they proposed the use of Entropy and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to select the best software methodology and concluded that it

can help organizations choose the most appropriate software methodology based on their needs. In 2021, they used Way ANOVA to evaluate the significant difference between various Agile methods and found that different Agile methods have a significant impact on software development performance.

Hashmi, R. Simon, and Khatri (2018) proposed an improved model for enhancing the quality of user experience through usability testing, which they found to be that it can improve the accuracy and efficiency of intrusion detection. Adil, Simon, and Khatri (2019) proposed an automated invigilation system for the detection of suspicious activities during examinations in the same conference (AICAI), which they concluded can significantly reduce cheating during exams.

Mahajan, R. Simon, and Khatri (2017) proposed the use of Fuzzy AHP for the selection of a framework for Agile methodology implementation in the software industry and found it to be an effective technique for selecting the most appropriate framework. Singh, Kumar, and Sagar (2021) provided a practical approach to selecting an appropriate Agile methodology for software development projects and assessing the effectiveness of Agile testing to improve project outcomes and customer satisfaction. They also proposed a new framework for assessing the suitability of Agile methodologies in the public sector context, which can help public sector organizations make informed decisions regarding the selection of appropriate Agile methodologies for their projects. Overall, these studies offer a comprehensive understanding of software development methodologies and their assessment techniques.

3 Methodology for Analyzing Agile Project Management Techniques

a. Approach

An inductive research method is used for this specific research, which determines the qualitative research method of the study. This approach allows conclusions to be drawn based on feedback from project managers and software engineers. This approach is considered more appropriate for an interpretative research philosophy and is recognized as a research facilitator. This approach makes it possible to formulate a hypothesis after data collection and analysis. This is compared to the literature review on agile methods presented in this study.

b. Strategy

This study aims to identify attitudes, facts, situations and impacts that influence the development and implementation of effective Agile solutions in managed organizations in the Indian market for research. The main purpose of the research is to understand the thoughts and ideas of business people. Recognized as having primary responsibility for implementing an effective approach. It is important to emphasize qualitative strategies in researching to facilitate the application of research methods. Surveys of business representatives will provide insight into the status of the implementation of agile methods in Indian SMEs. Qualitative strategies can provide valuable information with clearer conclusions than quantitative research strategies. This may limit the scope of the search.

c. Time Frame Horizon

Given the appropriateness of the timeframe for examining the efficacy of agile project management methods in small and medium enterprises (SMEs) in India, a cross-sectional study appears to be the most suitable option. A proposed study is a scientific endeavor that must be accomplished within a specific timeframe. This approach is currently considered the most appropriate for quantitative or exploratory research, as well as for qualitative research. The study will concentrate on gathering data through employee surveys of SMEs in the Indian market, making this approach optimal.

d. Sampling

The proposed research study aims to gain valuable insights from individuals engaged in small and medium enterprises (SMEs) within the Indian market regarding the implementation and effectiveness of agile project management within their respective enterprises. They can provide valuable insights from their management experience. The event consists of getting in touch with the participants if necessary. Third-party sources were contacted as they were not directly related to the researcher. Therefore, the proposed study will use snowballing as an alternative sampling technique.

e. Survey Questions

A review has been conducted in this paper to understand the fundamental concepts of the agile methodology of project management and the difference between the traditional and agile methodology of project management. Furthermore, the literature review can be a potential foundation for comprehending the efficacy and necessity of the proactive approach in small and medium-sized project management companies, which may not be appropriate for large corporations. This review provides a foundation for further investigation into the guidelines. Formulation of research questions for the proposed study can be done as follows:

Q1: What are the benefits of adopting agile methodology in large organizations?

Q2: How the Indian SMEs implementing the agile methodology for managing projects without the support of any technology?

Q3: How the agile methodology helps Indian SMEs companies in growing and increasing their profits?

f. How the data is collected?

To conduct the proposed study, a primary research methodology will be utilized to collect data. The survey will be administered to project managers and software engineers from approximately three small and medium enterprises. The survey questionnaire will be used to analyze the project management techniques employed by these organizations and their effects on business success and growth. The data collected will be used to develop two hypothetical models. The one will be based on the responses from the project managers and the other one will be based on the responses of software engineers.

4 Data Analysis and Findings

The strongest pillars of the companies i.e., the project managers and the software engineers made the requests that the data which has to be collected based on two main assumptions based on the responses received from each one of them. The responses need to be thoroughly analyzed to understand the effectiveness of Indian SMEs' agile approach.

The SME representatives survey was conducted in two parts. The first part of the survey focused on the feedback and experience of the managers and the other part focused on the feedback from the engineers. Ethical values were kept in mind while making the research and no personal information of the participants was omitted during the survey. The survey questions are mainly based on the points mentioned below. Based on additional research studies that can be clearly explained.

- (a) Advantages of Introducing agile methodology for managing projects in the organizations.
- (b) Challenges of using effective agile methodology techniques.
- (c) Adopt Agile technology over traditional methodology techniques.
- (d) Are agile project methodologies effective for large projects?

5 Key Findings

a. Advantages of Implementing Agile Methodology for Implementing Projects

Based on the feedback provided by project managers working, it can be hypothesized that defining and managing tasks in several teams for a project is viewed as an exciting task. Nearly 85% of the respondents have reported using project management techniques effectively in their organizations. Agile technology is seen as a key feature in identifying problems and adapting to necessary intermediate changes. This approach helps plan and solve problems efficiently. One of the benefits of using Agile is that it allows teams to start troubleshooting immediately, regardless of the methods used, to ensure the highest quality of delivery. The second hypothesis can be drawn from the responses of community software developers, where nearly 70% have found project management helpful in creating effective communication among themselves and across teams, resulting in faster work and more satisfactory delivery of client projects. Agile methodology is considered to be a good approach by software engineers as it enables quick customer feedback, allowing teams to react and change plans without much effort. This approach provides greater visibility as all the team's stories and blueprints can be viewed at any time. It is important to note that the success of agile project management also depends on the employee's experience and familiarity with the concept, which can impact the overall growth and profitability of the business.

b. Obstacles to implementing the effective Agile Methodology for Project Management.

According to a proposed study, employee resistance to change is one of the major leadership challenges, especially when adopting agile project management techniques for on-site projects. Change management has been identified as a significant challenge for project managers, as employees often resist deviating from traditional work practices.

The lack of commitment from management is another limitation of agility, and effective implementation of agile project management strategies requires a commitment to agility. Failure to embrace agility can result in agile technologies being less effective than waterfall. Nevertheless, professionals working in the software engineering field often encounter challenges when attempting to implement agile techniques within project management processes, particularly in terms of role clarity and planning. Ambiguity in areas of responsibility and inconsistencies in planning can lead to overlap and chaos between teams at different levels, particularly, in scenarios where multiple teams or collaborators are simultaneously engaged in working on the same backlog. Additionally, the survey notes a lack of experience among employees, which could jeopardize the organization's success and overall growth and profitability.

c. Implementation of Agile vs traditional methodologies for managing projects.

The fundamental distinction between agile and traditional project management methodologies lies in the former's ability to quickly identify potential changes or issues and adapt to them while keeping the project's budget and delivery time intact. Achieving this is facilitated by incorporating a dedicated testing phase alongside the development phase, enabling the early detection of issues. However, the limited availability of employees within small and medium enterprises in India poses a significant challenge to the successful implementation of Agile methodologies. While most companies are familiar with the concept, it has yet to be fully adopted by the Indian SME market. According to the second hypothesis of the proposed research, implementing agile project management techniques can make employees' work easier. Real-time project testing during the development phase facilitates concrete and effective problem analysis and enables developers to quickly roll back, find vulnerabilities, and work efficiently.

d. Does the technique in Agile Project Management prove effective for large-scale projects?

According to the survey conducted, almost half (45%) of the project managers interviewed had previous experience working with Agile in large organizations before joining SMEs. This experience provided them with valuable insights into the successful adoption of Agile methodologies for large-scale projects. Respondents highlighted the importance of effectively adapting each step of the Agile technique to ensure success. Poor communication or lack of communication between team members was identified as a common cause of failure in some large projects that attempted to use Agile. This was attributed to the improper application of Agile concepts. In contrast, software engineers view Agile project management as an effective solution for large-scale projects, believing that it can facilitate the growth of great teams that can handle multiple projects simultaneously. As a result, they recommend the effective application of Agile project management techniques for large projects. It can work well for large projects if the hard work is done well, the team is efficient, the stakeholders are involved, and the organization supports agile principles.

5.1 Analysis of Agile Metrics

To understand the involvement of entropy metrics in the agile software development process, as mentioned by Munson, if all unit components of the software project are completed and executed properly, having the same probability, the point of highest entropy will occur, in this scenario this is the maximum entropy is generalized using Shannon. General entropy as mentioned in Eq. 1, describes the quantitative measurement of processes and layouts the relationship between information and uncertainty.

$$\text{Entropy} = - \sum_{i=1}^n p_i \log_2 p_i \tag{1}$$

where n equals the total number of changes or cases. I represent the categories of events that are being considered, it is a discrete variable with possible values {i1, in} and pi probabilities. There is also involved the threshold, the point of lowest entropy, which is 0. The software entropy of a developmental project is directly proportional to its complexity, which is known as the degree of disorder.

This section describes the practical applicability of entropy as mentioned in Eq. 1, concerning the metric factors which have been determined. The criteria selected for our approach study are- Probability, loss, and uncertainty. The significance of these criteria and their weightage have been used in calculation and observation. The weightage is based on criteria and metric factors. If the number of risks and uncertainty is m, in any software development process, the risks in the software process are represented and the resultant matrix is

$$R' = (r'_{ij})_{m \times n} \begin{bmatrix} r'_{11} & r'_{11} & \cdots & r'_{11} \\ r'_{11} & r'_{11} & \cdots & r'_{11} \\ \dots & \dots & \dots & \dots \\ r'_{11} & r'_{11} & \cdots & r'_{11} \end{bmatrix} \tag{2}$$

The standardization of it is

$$r_{ij} = \frac{r'_{ij} - \min_j \{r'_{ij}\}}{\min_j \{r'_{ij}\} - \min_j \{r'_{ij}\}}, R = (r_{ij})_{m \times n} \tag{3}$$

Entropy for i is

$$H_i = - \frac{1}{\ln n} \sum_{j=1}^n f_{ij} \ln f_{ij} \tag{4}$$

6 Results and Findings

The results are mentioned in the table using the above-mentioned equations and collected data.

MF Id			
(Criteria)	Loss	Probability	Uncertainty
MF_01	0.35	0.49	0.015
MF_02	0.55	0.85	0.010
MF_03	0.33	0.44	0.025
MF_04	0.37	0.48	0.023
MF_05	0.4	0.52	0.021
MF_06	0.42	0.50	0.033
MF_07	0.35	0.4	0.025
MF_08	0.28	0.36	0.032

6.1 Conclusion

Examining the implementation and effectiveness of agile methodologies for managing projects in SMEs is the main aim of this proposed study. To accomplish this, a sample of project managers and software engineers with practical experience in employing diverse project management methodologies was interviewed across approximately three small and medium-sized businesses. Statistics show that agile project management not only helps to build a solid foundation for the development and profitability of the organization but also gives the business habits such as visibility, performance, and employee satisfaction. Survey respondents cited customer satisfaction and the ability to adapt to times of change as important aspects of the agile management process. Agile project management techniques involve dividing tasks into multiple tasks, called sprints, managed by different teams. This saves the organization time and money and enables the organization to identify potential security vulnerabilities.

Testing and development are done at the same time, so employees can integrate testing into the development phase, identify problems promptly, reduce the risk of omissions, help companies create effective and efficient plans, and increase customer satisfaction. Another important benefit of using agile project management techniques is employee satisfaction, which is important for business growth and profitability. A good project management process reduces employee friction by breaking the entire project into cycles.

7 Future Scope

This study identified an important limitation as there was no management involvement and employees were aware of the company's policies and culture. These limitations were identified through a literature review, specific case studies, and case study analysis. This study also addressed various aspects such as strengths, limitations, and differences of traditional project management methods. Agile project management is very good for small and medium businesses as it provides high delivery and reduces the risk of not meeting the customer on time and within budget. However, the success of projects designed using agile project management techniques depends on the support of the management. The

study also states that agile project management was not initially considered suitable for large projects but based on the discussion and analysis of the study, it can be concluded that agile project management reduces the risk of failure in large projects. Overall, this study provides a good insight into the implementation of agile project management in SMEs in the Indian market and highlights the need for management support and knowledge of those doing it. Works with company policies and culture. It also highlights the importance of considering various aspects such as the strengths and limitations of agile project management and the difference between agile and traditional project management to ensure that projects are run using agile project management techniques.

8 Case Study of Ericsson AB: Shift from Waterfall Methodology to Agile

The Waterfall model is a sequential approach to software development, which has been used by many software testing companies since its inception in the early 1970s. This model involves a linear process of requirements engineering, design and implementation, testing, release, and maintenance, with the final product being delivered in a 'one-time bang'. However, over the years, several problems have been identified with this approach, including lengthy project cycles before implementation, difficulty in getting change requests authorized, and non-user-friendly systems deployed. Ericsson AB is a global provider of telecommunications and multimedia solutions in Europe. For several years, the company used the Waterfall model for large-scale industrial software development. However, the highly dynamic market in which Ericsson operates, characterized by high innovation in products and solutions, made it challenging to accurately predict project outcomes. Time was Ericsson's toughest challenge, and the pressure to meet urgent market needs often resulted in the testing stage of the Waterfall model being cut short to meet deadlines. This led to defective products that were not properly processed. To address these challenges, Ericsson AB adopted Agile Project Management in 2008. The company completes the product quickly and continues to develop it. Adoption of agile project management processes will recruit other professional trainers to train all team members within the framework of Scrum agile project management processes.

The Agile Project Management training transformed Ericsson AB from a linear Waterfall organization to a Scrum-like organization with respective Product Owners and multiple Scrum teams, as well as Scrum masters to lead each group. Existing project managers were transformed into Scrum masters, coaches, or team members. This transformation allowed Ericsson AB to improve its lead time and feedback loops, deliver faster and continuously improved products, and respond to changing market needs more effectively. In conclusion, the case study of Ericsson AB illustrates the challenges faced by companies that rely solely on the Waterfall model for software development. The adoption of Agile Project Management enabled Ericsson AB to overcome these challenges and become a Scrum-like organization with faster product development and continuous improvement.

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Enhancing Global Optimization for Sustainable Development Using Modified Differential Evolution

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Abstract. Among popular evolutionary algorithms (EAs), Differential Evolution (DE) is secondhand for comprehensive optimization. However, it has numerous restrictions like slow convergence, stagnation etc. Moreover, in DE choice of its mutation and control factor is also challenging for better optimization. To enhance search capability of DE, a modified differential evolution (mDE) is suggested in this article. It adopted the novel mutation strategy, using concept of PSO (particle swarm optimization) mechanism. On the other hand, to avoid stagnation at local minima, new control operator integrated with the proposed mutation strategy based on the time-varying scheme. By using the memory information and dynamically changed control factors the exploration and exploitation capability of mDE are well balanced. Six unconstrained complex benchmark functions (unimodal and multimodal) are solved to certify the presentation of the mDE method. The simulation result shows that the mDE has good global search ability and stronger proficiency. Its search precision and the convergence speed much better against the other optimization EAs.

Keywords: Global optimization · differential Evolution · mutation · crossover

1 Introduction

Nowadays, an enormous volume of EAs (evolutionary algorithms) are proposed to solve design optimization issues [1]. Differential Evolution (DE) has developed as utmost widespread population based optimizers since its inception in 1995 [2]. It has efficiency in dealing with complex optimization problems, due to its simple structure. Also, it has achieved noticeable progress during the last two decades, because of its robustness and effective search ability [3]. At the same time, DE has also been effectively applied in many areas, like power engineering [4], neural network [5], image processing [6], chemical engineering [7] and so on. However, DE faces some difficulties like to jump out from local optima at the time of solving complex optimization issues [3]. Additionally, DE doesn't guarantee for finding the best optimization result to all optimization problems efficiently.

Hence, numerous advanced DE variants have been proposed for achieving impressively enhanced performance compared to the classic DE algorithm. More parts of effective DE modifications can be found in recent reviews papers [8–13]. However, when DE was applied to complex optimization problems, performance of most of the existing variants was found to be unsatisfactory due to stagnation [14]. It happens because of choice of its mutation strategies and related control parameters. Hence, to improve DE efficiency various mutation, crossover, selection and control parameter schemes proposed by researchers for instance SADE [15], FiADE [16], rank-DE [17], IDE [18], MPEDE [19], ADE [20] and NBOLDE [21]. Also, hybridizing DE with other techniques like particle swarm optimization (PSO) [22] can compensate for its deficiency in local exploitation capability, and finally achieve effective and efficient DE variants like DPD [23], MBDE [24], *ihPSODE* [25] and *haDEPSO* [26]. Till date many DE variations and its hybrids solved numerous complex real-life problems. But they are incompetent to deliver reasonable result and falls into the local optima; as DE has no property to remember the best previous outcomes [24].

Motivated by memorized mechanism of PSO, a modified DE (mDE) is offered in this article. It adopted the novel mutation strategy which is integrated the new dynamically changed control parameters, to avoid stagnation at local optima. By using the memory information and dynamically changed control factors the exploration and exploitation capability of mDE are well balanced and provide good global solution. Six unconstrained benchmark functions (unimodal and multimodal) are solved to certify the presentation of mDE. The result of experiments shows that the mDE has good global search ability and stronger proficiency. Also, its search precision and the convergence speed much better against the other optimization EAs.

The rest paper is ordered as- basic DE overviewed in Sect. 2. Projected modified DE (mDE) presents in Sect. 3. Result with discussion shows in Sect. 4. Conclusion with future plans presented in Sect. 5.

2 Basic DE Outline

DE is a simple yet powerful and population-centered stochastic optimizer. It shares the same steps with other EAs. Details of main DE operation are described in the follow.

Step I- Initialization

The target vectors $x_i^j(t) = (x_i^1(t), x_i^2(t), \dots, x_i^D(t))$; $i = 1, 2, \dots, np$ (np is population size) is randomly created in given limits, at ' t^{th} ' generation, for any D -dimensional optimization problem.

Step II- Mutation

A mutant vector $v_i^j(t) = (v_i^1(t), v_i^2(t), \dots, v_i^D(t))$ is produced as follows.

$$v_i^j(t) = F \times (x_{r_2}(t) - x_{r_3}(t)) + x_{r_1}(t) \quad (1)$$

where F (*mutationfactor*) $\in [0, 1]$ $x_{r_1}, x_{r_2}, x_{r_3} \in [1, np]$, $r_1 \neq r_2 \neq r_3 \neq i$.

Step III- Crossover

A new trial vector $u_i^j(t) = (u_i^1(t), u_i^2(t), \dots, u_i^D(t))$ created as follows.

$$u_i^j(t) = \{v_i^j(t); \text{ifrand}(0, 1) \leq C_r, x_i^j(t); \text{ifrand}(0, 1) > C_r \quad (2)$$

where C_r (crossover constant) $\in [0, 1]$, $rand(0, 1)$ is uniformly distributed random no between 0 and 1.

Step IV- Selection

$$x_i^j(t+1) = \{u_i^j; \text{iff}(u_i^j) \leq f(x_i^j)x_i^j; \text{iff}(x_i^j) > f(u_i^j)\} \quad (3)$$

Step V- Termination

Stop as per ending criteria otherwise repeat II-V.

3 Proposed Modified DE (mDE)

Usually, balance among the convergence and population diversity of EAs algorithms relates better exploration and exploitation abilities. Also, from the above literature survey following are the observation.

- (i). $v_i^j(t+1) = x_{r_1} + F(x_{r_2} - x_{r_3})$ is the basic DE successful and widely used mutation strategy [2, 27]. It maintains population diversity with better search ability. But, by using it the DE convergence speed is slow [27].
- (ii). $v_i^j(t+1) = x_{r_1} + F(x_{r_2} - x_{r_3}) + F(x_{r_4} - x_{r_5})$ May lead to better perturbation than $v_i^j(t+1) = x_{r_1} + F(x_{r_2} - x_{r_3})$ [28]. It can provide more exploration ability of the search space.
- (iii). $v_i^j(t+1) = x_{best} + F(x_{r_1} - x_{r_2})$, $v_i^j(t+1) = x_{best} + F(x_{r_1} - x_{r_2}) + F(x_{r_3} - x_{r_4})$, $v_i^j(t+1) = x_i + F(x_{r_1} - x_{r_2})$, $v_i^j(t+1) = x_{best} + F(x_{r_1} - x_{r_2})$ and $v_i^j(t+1) = x_i + F(x_{best} - x_{i,j}) + F(x_{r_1} - x_{r_2})$ i.e. greedy mutation like have great exploitation performance, but in case of multimodal test functions they have low exploration and provide poor solutions [28].
- (iv). So as to overcome the shortcomings of DE, many mutation strategies introduced by researchers [29, 30]. These mutations strategies may considerably improve the performance of DE, but still need the improvisation in terms of the search capability.
- (v). Also, DE used the inclusive info of the search space instead of commit about the memory process. Thus, it leads to excess of time and untimely convergence [31].

Inspired by the literature survey and the above mentioned fact, a modified differential evolution (namely, mDE) offered in this article to overcome the limitations of different kinds of mutation operations. The steps of suggested mDE are mentioned as below.

Step I- Initialization

mDE starts with random formation of np (population size) individuals using the following formula.

$$x_i^j(t) = x_{i,min} + rand(0, 1)(x_{i,max} - x_{i,min}) \quad (4)$$

where t denotes the iteration number, $i = 1, \dots, np$, $j = 1, \dots, D$ (D - problem dimension), and $x_{i,max}$ & $x_{i,min}$ - maximum and minimum value of the i^{th} design variable separately.

Step II- Mutation

To increase the population diversity, using the idea of PSO [31] it creates mutation vector $v_i^j(t)$ with respect to the target vector $x_i^j(t)$ as follows.

$$v_i^j(t) = x_i^j(t) + F_1(xbest_{i,j}(t) - x_i^j(t)) + F_2(xbetter_j(t) - x_i^j(t)) + F_3(xworst_j(t) - x_i^j(t)) \tag{5}$$

where- $xbest_{i,j}(t)$ - best individuals, $xbetter_j(t)$ - better individual and $xworst_j(t)$ - worst individuals. These individuals are updated as follows.

$$xbest_{i,j}(t) = \{x_i^j(t); \text{iff}(x_i^j(t)) < f(xbest_{i,j}(t-1))\}xbest_{i,j}(t-1);$$

$$\text{iff}(x_i^j(t)) \geq f(xbest_{i,j}(t-1)) \quad xbetter_j(t) = \{xbest_i^j(t)\} \quad \& \quad xbworst_j(t) = \{xbest_i^j(t)\}$$

$i = 1, 2, \dots np$

Also, F_1, F_2 and F_3 are the control factors designed as below.

$$F_1 = F_1^{initial} - (F_1^{final} - F_1^{initial}) \times \left(\frac{t-1}{t_{max}-1}\right)$$

$$F_2 = F_2^{initial} - (F_2^{final} - F_2^{initial}) \times \left(\frac{t-1}{t_{max}-1}\right) \text{ and } F_3 = F_1 \times (1 - e^{(F_2 \times t)})$$

where t & t_{max} - current & maximum number of iteration.

During the search process, F_1, F_2 and F_3 control factors has the following properties.

- (i). F_1 Starts by a big and gradually falls to a lesser value, whereas F_2 starts by lesser and gradually upturns to a big value. At the start stages, big F_1 and lesser F_2 , are permitted individuals to freely travel over the search space, rather than disturbing to the population’s best. Conversely, in the latter stages lesser F_1 and big F_2 are permitted individuals to converge at global best.
- (ii). At the early iterations F_3 increase quickly then decreases gradually. It helps the individuals to find proper direction and guide for movement to better position at the initial and latter iterations individually.

After an extensive analysis, in the entire experiments $F_1^{initial} = F_2^{final} = 2.5, F_1^{final} = F_2^{initial} = 0.5$ are fixed for mDE. During the search process of mDE, F_1, F_2 , and F_3 are described in Fig. 1.

Step III- Crossover

It generate $u_i^j(t)$ (trail vector) by recombines the $v_i^j(t)$ (mutant vector) and $x_i^j(t)$ (target vector), as-

$$u_i^j(t) = \{v_i^j(t); \text{ifrand}(j) \leq C_r\}x_i^j(t); \text{ifrand}(j) > C_r \tag{6}$$

where $j = 1, \dots, D; C_r$ = Crossover Rate which is generally selected between [0, 1] and $\text{rand}(j)$ is the random number between 0 & 1.

Step IV- Selection

To select a vector for the next iteration, a greedy strategy applies in mDE as-

$$x_i^j(t+1) = \{u_i^j(t); \text{iff}(u_i^j(t)) \leq f(x_i^j(t))\}x_i^j(t); \text{iff}(u_i^j(t)) > f(x_i^j(t)) \tag{7}$$

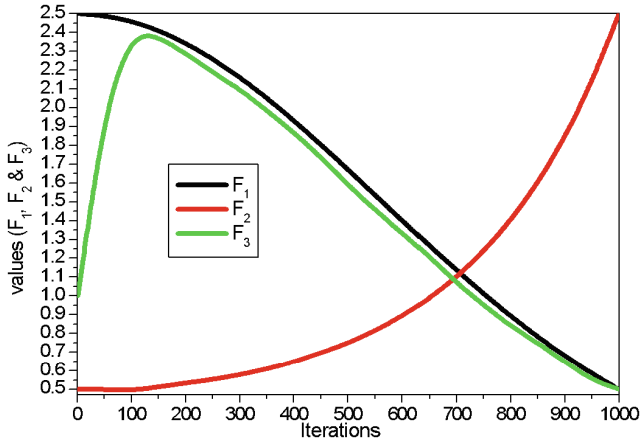


Fig. 1. Variation of F_1 , F_2 , and F_3 according to iteration number

Step V- Termination

Stop, as per specified criteria like maximum iterations (t_{max}). Else, repeat Step II to V.

4 Result and Discussion

Proposed mDE used to solve six complicated unconstrained benchmark function, to check efficiency. In Table 1, the mathematical formulation and properties of these complicated unconstrained benchmark function are presented.

Following parameters have been used for all unconstrained benchmark functions- $np = 30$, $t_{max} = 10000$, $D = 30$ and $trails/run = 30$. The Core i7, 32 GB RAM and Intel(R) Win10 OS used for all simulation experiments. The achieved results of presented mDE equated with DE/rand/1 [2], DE/best/1 [32], DE/target-to-best/1 [33], GDE [34] and PSODE [35]. Note that independent run, np and t_{max} used same as equated methods for presented mDE. In each tables, best results presented with bold letters.

In Table 2, listed the mean function value (MN) and standard deviation (SD) over 30 runs. It is noticed that from Table 2, the projected mDE has effective performance. Also, results of Table 2 demonstrated that the capability to find the global optimum of mDE is higher with others. Less standard deviation of mDE on each unconstrained benchmark function shows its stability. Further, to measure the significance of experimental results of mDE with others SR% (success rate %) and MFEs (number of mean function evaluations) on considered benchmark functions are reported in Table 3. Where, $success\ Rate = \frac{\text{number of successful run}}{\text{total runs}}$ (if $f(x) - f(x^*) \leq 0.0001$ than a run is stated as a successful run, where $f(x^*)$ and $f(x)$ is the known and obtained optima respectively). This table shows that proposed mDE has highest success rate percentage and fewer no of average function evaluations on each benchmark function compared to others. It illustrates that mDE displays better convergence capability and exhibits the highest reliability in comparison with others.

Table 1. Unconstrained benchmark function

Function name	Properties		
	Trait	Search range	f_{min}
Sphere $f_1(x) = \sum_{i=1}^d x_i^2$	Unimodal	[-100, 100]	0
Schwefel $f_2(x) = \sum_{i=1}^D x + \prod_{i=1}^D x_i $	Unimodal	[-10, 10]	0
Rosenbrock $f_3(x) = \sum_{i=1}^{D-1} \left((x_i - 1)^2 + 100(x_{i+1} - x_i^2)^2 \right)$	Unimodal	[-30, 30]	0
Rastrigin $f_4(x) = \sum_i^D [x_i^2 - 10\cos(2\pi x_i) + 10]$	Multimodal	[-5.12, 5.12]	0
Ackley $f_5(x) = 20 + e - 20e^{-\left(\frac{1}{5}\sqrt{\frac{1}{D}}\sum_{i=1}^D x_i^2\right)} - e^{-\left(\frac{1}{D}\sum_{i=1}^D \cos(2\pi x_i)\right)}$	Multimodal	[-32, 32]	0
Griewank $f_6(x) = \frac{1}{4000} \sum_i^D x_i^2 - \prod_i^D \cos\left(\frac{x_i}{\sqrt{i}}\right) + 1$	Multimodal	[-600, 600]	0

Table 2. Numerical Comparison results on 6 unconstrained benchmark function

f	Criteria	DE/rand/1 [2]	DE/best/1 [32]	DE/target-to-best/1 [33]	GDE [34]	PSO-DE [35]	mDE
f_1	MN	1.35E-03	4.96E-04	1.09E-04	6.07E-24	1.44E-150	0
	SD	5.30E-04	3.32E-04	4.72E-05	8.53E-24	5.72E-150	0
f_2	MN	2.13E-01	2.88E-02	2.04E-02	1.75E-07	5.14E-84	0
	SD	7.31E-02	7.52E-03	8.34E-03	4.18E-07	1.43E-83	0
f_3	MN	2.48E-02	2.75E-02	2.02E-02	1.89E-02	2.83E-54	0
	SD	6.14E-03	6.85E-03	5.10E-03	6.10E-03	3.26E-60	0
f_4	MN	1.96E+02	1.10E+02	2.01E+02	4.74E+01	5.71E-15	0
	SD	7.62E+01	1.89E 01	6.94E+00	1.20E+01	1.00E-14	0
f_5	MN	1.79E-02	8.16E-03	3.60E-03	2.12E-10	1.08E-14	1.01E-15
	SD	3.40E-03	2.81E-03	9.84E-04	1.12E-10	3.06E-15	2.51E-16
f_6	MN	7.26E-03	5.78E-03	4.03E-03	8.12E-03	1.59E-02	0
	SD	2.93E-03	5.30E-03	3.99E-03	9.78E-03	2.39E-02	0

Moreover, the performance chart [25] and convergence curves of mDE with others are separately depicted in Fig. 2 and Fig. 3 (a-f) on considered unconstrained benchmark

Table 3. Statistical comparison on 6 unconstrained benchmark function

f	Criteria	DE/rand/1 [2]	DE/best/1 [32]	DE/target-to-best/1 [33]	GDE [34]	PSO-DE [35]	mDE
f_1	MFES	118197	112408	91496	72081	18204	8519
	SR	100%	100%	100%	100%	100%	100%
f_2	MFES	115441	109849	91354	66525	15067	7867
	SR%	100%	100%	100%	100%	100%	100%
f_3	MFES	102259	103643	87518	74815	16115	10182
	SR%	100%	100%	100%	100%	100%	100%
f_4	MFES	99074	98742	127423	53416	7701	5627
	SR%	96.70%	100%	100%	100%	100%	100%
f_5	MFES	125543	118926	100000	76646	29757	17551
	SR%	100%	100%	100%	100%	100%	100%
f_6	MFES	125777	117946	97213	81422	18394	9014
	SR%	60.00%	46.70%	56.70%	100%	100%	100%

functions. As per the defined performance criteria, the maximum percentage occupied area by any algorithms performs better. Also, in convergence curves objective function/error values gained from each method on same population/seed are used in y-axis and number of iterations is applied in x-axis. It is determined that from Fig. 2 and Fig. 3(a-f), the developed mDE presentation is the greatest and converges quickly than other methods. Accordingly, projected mDE method is a flawlessly optimizer for unconstrained optimization problems.

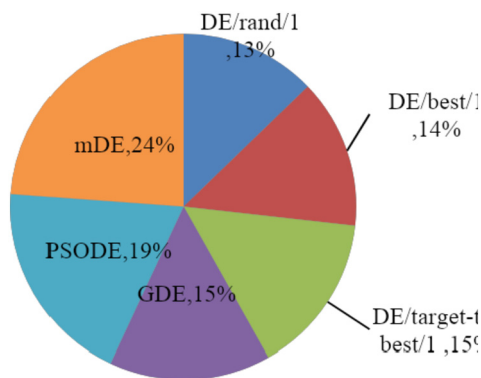
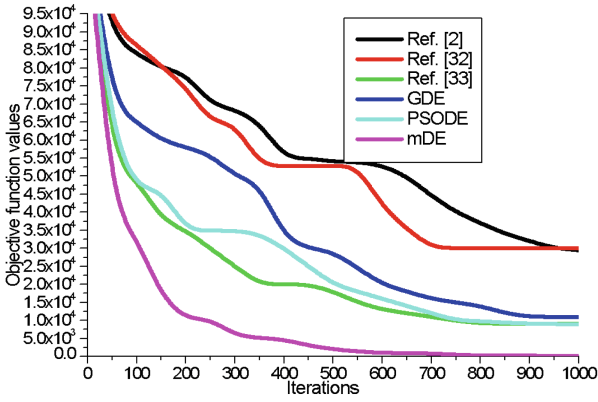
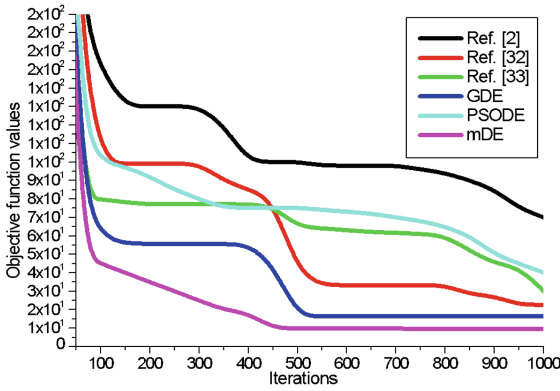


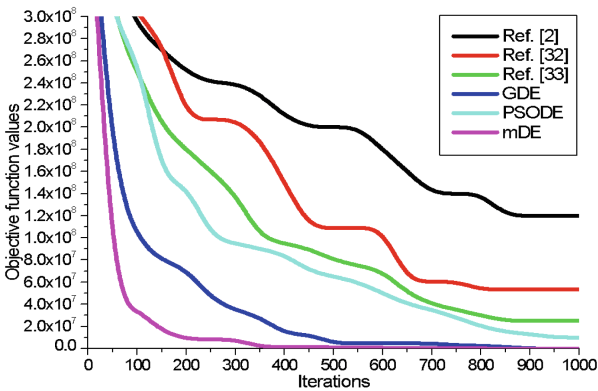
Fig. 2. Performance of mDE with other methods



(a) f_1 : Sphere

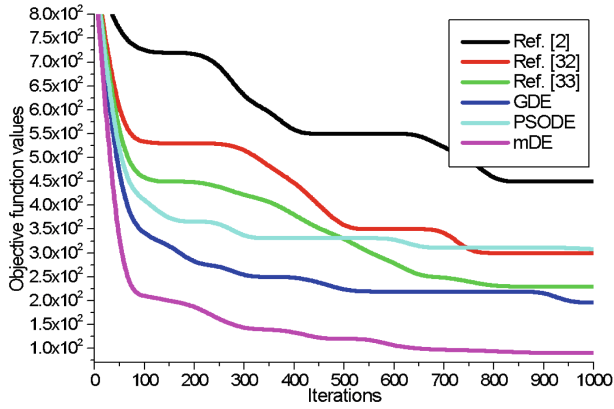


(b) f_2 : Schwefel

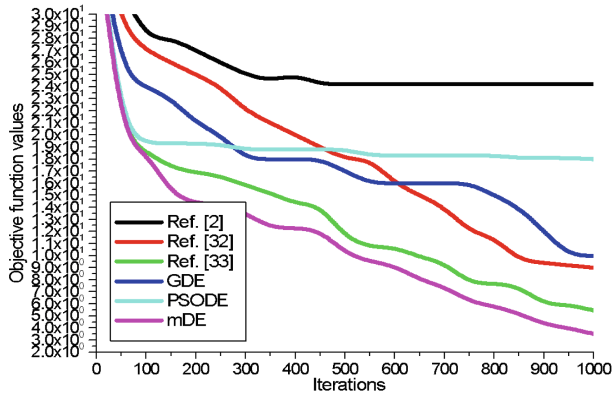


(c) f_3 : Rosenbrock

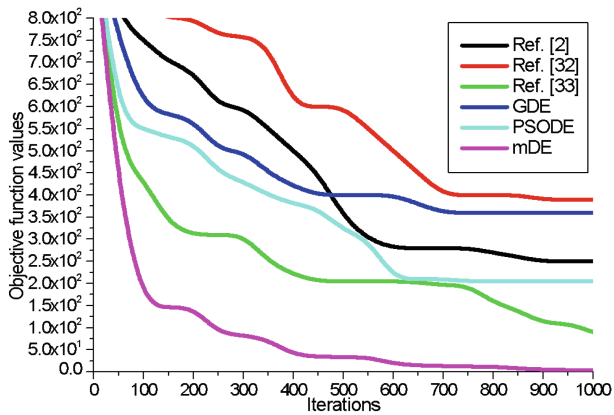
Fig. 3. (a-f). Convergence curves of mDE with other methods



(d) f_4 : Rastrigin



(e) f_5 : Ackley



(f) f_6 : Griewank

Fig. 3. (continued)

5 Conclusion and Future Works

This section contained conclusion and future scope of the proposed mDE.

5.1 Conclusion

A modified differential evolution (viz. mDE) presented in this article for solving global optimization problems. It adopted the novel mutation strategy (based on particle swarm optimization (PSO) mechanism), which enhance search capability of DE. On the other hand, new control operator integrated with the proposed mutation strategy (based on the time-varying scheme), which avoid to be trapped in local minima. By using the memory information and dynamically changed control factors the diversity of mDE is balanced significantly.

The presentation of mDE has been validated on six widely used unconstrained benchmark functions namely Sphere, Schwefel, Rosenbrock, Rastrigin, Ackley and Griewank. In terms of searching and convergence ability, the outcomes achieved by mDE equated with DE, GDE with one hybrid version of DE and PSO (PSODE). For all unconstrained benchmark functions, mDE find the global optimum very efficiently with lesser time, due to its novel mutation scheme and scaling factors (F_1 , F_2 and F_3).

5.2 Future Scope

In conclusion, suggested mDE is an effective variant of DE for solving global optimization issues. Besides advantages, it is observed that in a few test functions and at higher dimensions, the efficiency of mDE approach drops. Hence, some effective scheme will be employed for further strengthen of mDE, as a future works. Also, another promising research area is the development of multi-objective variants of mDE to solve real-world issues.

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Enhancing Sustainable Development Through Electrooculography Based Computer Control System for Individuals with Mobility Limitations

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Abstract. Electrooculogram (EOG), the bio-potential produced around eyes due to eyeball motion can be used to track eye movements. This system is especially helpful for individuals with motor disabilities like ALS (Amyotrophic Lateral Sclerosis) and paralysis. The research describes a method of controlling the mouse cursor on a computer screen using a technique called Electrooculography (EOG). EOG could detect the electric potentials generated by eye movements and blink features. The recorded EOG signal is then analyzed to identify and classify the relevant eye movement features. These features are then used to generate control signals that allow for cursor movement. The results show that the cursor control application is highly accurate when tested offline.

Keywords: Electrooculogram (EOG) · bio-signal processing · EOG calibration · eye-tracking

1 Introduction

Electrooculography (EOG) is a method of measuring the potential difference between the front (positive pole formed by cornea) and back (negative pole formed by retina) of the eye ball and thus can be used for detection of eye movements and blinks. When the eyes are fixated straight ahead, a steady baseline potential is measured by electrodes placed around the eyes. This EOG (electro-oculogram) is a reliable and cost-effective bio-signal that measures the standing potential between the cornea and the retina. The eye is considered a dipole, with the anterior side being positive and the posterior side being negative. The iris of the eye induces a voltage drop, creating an EOG signal that can be detected through electrodes. EOG has vast number of applications such as to control the devices, navigate the wheelchairs, activity recognition, analysing human cognition, etc. Typically, EOG signals have lower amplitudes between 0.05 and 3.5 mV and a frequency range of 0.1–20 Hz. The human eye is involved in almost everything we do in our daily lives, making it a potential component for interfacing in HCI applications that involve eye tracking and eye movement detection. There are several methods available

for tracking the eye movements such as the Scleral search coil magnet method Electrooculography (EOG), Videoculography (VOG) and Infrared oculography (IROG). However, EOG-based tracking of eye movements is preferred for its accuracy, simplicity, and affordability.

This paper describes an offline EOG-based eye movement feature detection method and its application to control a mouse cursor. It captures eye movements through electrodes, processes them with a microcontroller, and translates them into cursor movements on a computer screen. It enables paralyzed individuals to interact with software applications, browse the internet, type, and perform various tasks independently. By providing accessible computer usage, the system promotes greater independence and access to digital resources, enhancing communication, education, employment, and entertainment for paralyzed individuals.

2 Literature Review

Despite the growing interest in EOG-based eye cursors, a comprehensive literature survey encompassing the methodologies, techniques, challenges, and potential applications is lacking. This paper aims to fill this gap by providing a comprehensive overview of the existing research in this domain. Through a systematic review of relevant literature, we aim to shed light on the advancements made, highlight the limitations and challenges faced, and identify potential avenues for future exploration. In this literature survey, we will analyse and synthesize studies that investigate the development and implementation of EOG-based eye cursors. The survey will cover various aspects, including signal acquisition and processing techniques, cursor control algorithms, user interface designs, usability evaluations, and potential applications across different domains. By consolidating the existing knowledge, this survey will serve as a valuable resource for researchers, practitioners, and developers interested in leveraging EOG-based eye cursors for enhanced human-computer interaction.

Delaney Donnelly et al. [1] developed a device using an electrooculogram (EOG) and Arduino, the researchers successfully constructed a basic eye gaze communication device capable of capturing horizontal, vertical, and diagonal eye movements and translating them into a 3×3 grid. However, this model can benefit from further enhancements in certain areas. For instance, the current implementation employs wet electrodes, which might lead to discomfort or drying out during extended usage. Therefore, investigating the integration of dry or non-contact electrodes in this model could improve user comfort and wearability. Ahsan-Ul Kabir Shawon et al. [2] developed a module that is being designed to facilitate computer mouse control, enabling individuals, particularly patients with limited hand or finger mobility, to interact with a computer fully. The project has been implemented by integrating the module with an Arduino pro mini to interface with a computer mouse program. However, there is a need to enhance its robustness, affordability, compactness, and user-friendliness. Konica Kuntal et al. [3] presents the development of an automated wheelchair prototype that utilizes EOG signal detection, targeting individuals with quadriplegia or paralysis for whom mobility is a critical factor. The EOG-based circuit implemented in this prototype demonstrates a cost-effective and efficient solution, displaying a linear relationship between the detected

signals and real-time eye movements. The current prototype focuses on enabling forward and backward wheel activation. However, there is potential for expanding its capabilities by implementing the system on a standing wheelchair using RF transmitter and receiver technology, allowing operation in larger areas. Samina Abdullah et al. [4] constructed a cursor controlled by EOG signals, utilizing both hardware and software components. The system employed vertical and horizontal potential differences to determine the cursor's location. However, an accuracy error was observed, with the cursor often landing in the general vicinity of the desired location but not precisely on target. This error likely resulted from fluctuating offsets that required frequent updates. K. M. Mamatha et al. [5] developed an EOG-based Human-Machine Interface (HMI) which was designed and implemented, utilizing eye movements and eye blinking signals as intermediate outputs. These signals were further processed into commands at the UART interface. The generated commands were then transmitted to the application section, which interpreted them to move the cursor accordingly and initiate button clicks by toggling the corresponding relay, thus controlling the connected appliance. The system's performance is influenced by several factors, including drift in eye movements. Implementing a more efficient algorithm, utilizing high-end circuitry, and optimizing the embedded system software can help mitigate such drift.

Dr. Punyaban Patel et al. [6] used Human Computer Interface and imouse built with OpenCV python library and C++ module software, its meant to just retrieve spatial attention data or to tweak interface showing eye movements and where the user spent a lot of time looking, if required the spatial view of history can drawn on world process, for future applications like driving cars with eye movements, its technique is that Microsoft LifeCam HD-6000 detects user face and eyes by Hough Transform Algorithm and Haar Cascade Algorithm for eye-tracking, imouse is based on Voila Jones Algorithm which is a less-cost solution. Samar Jyoti Saikia et al. [7] has developed a Human Computer Interface that has Retina Based Mouse Control based on MATLAB and LabView software, it increases the response time of the disabled person and at the same time helps with increment in rate of information flow which provides customer satisfaction, its technique uses a pair of electrodes for positive side of retina and the negative side of retina, due to which it bears higher cost.

3 Proposed System

The proposed system is designed in keeping view of the drawbacks of the existing systems and attempts to make them more productive and easier to use. An EOG based cursor control device has been designed using which an ordinary pc mouse can be controlled with the help of eyes movement. The system makes use of a BioAmp Exg Pill which is a pill size sensor with ESP32 WROOM 32 microcontroller based circuitry to achieve this functionality.

A. Hardware and Software Components

The developed system includes the following components:

1. Bio Amp EXG Pill

Bio Amp EXG Pill is a small ($2.54 \times 1.00 \text{ cm}^2$) and elegant Analog Front End (AFE) board for Bio Potential signal acquisition that is used with any 5 V Micro Controller Unit (MCU) with an ADC as shown in Fig. 1.

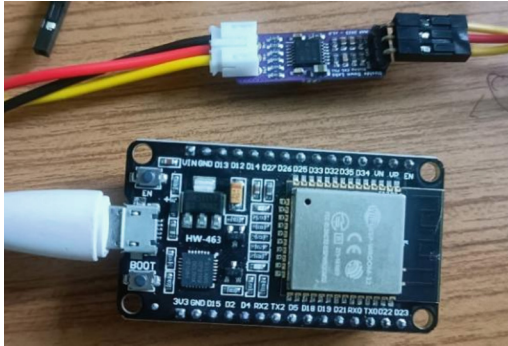


Fig. 1. Bio Amp EXG Pill with soldered wires

2. Connecting Wires

The connecting components of a circuit are wires. Jumper wires are tiny wire ducts that can be used to join parts on bread boards or in other places as shown in Fig. 2.

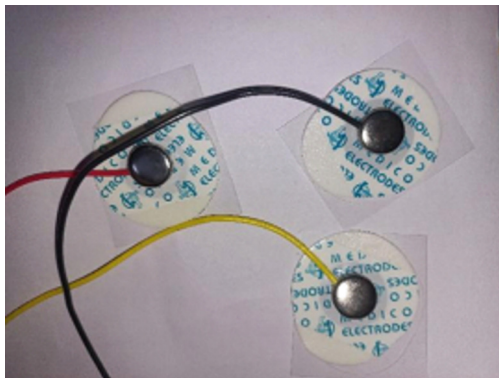


Fig. 2. Connecting wires and ECG

3. ESP32 WROOM 32 Microcontroller

The ESP32 is a collection of inexpensive, energy-efficient microcontrollers that combine Wi-Fi and dual-mode Bluetooth functionality. The ESP32-WROOM-32 module is a versatile and robust Microcontroller Unit (MCU) with integrated Wi-Fi, Bluetooth, and Bluetooth Low Energy capabilities. At the core of this module is the ESP32D0WDQ 6 chip as shown in Fig. 3.

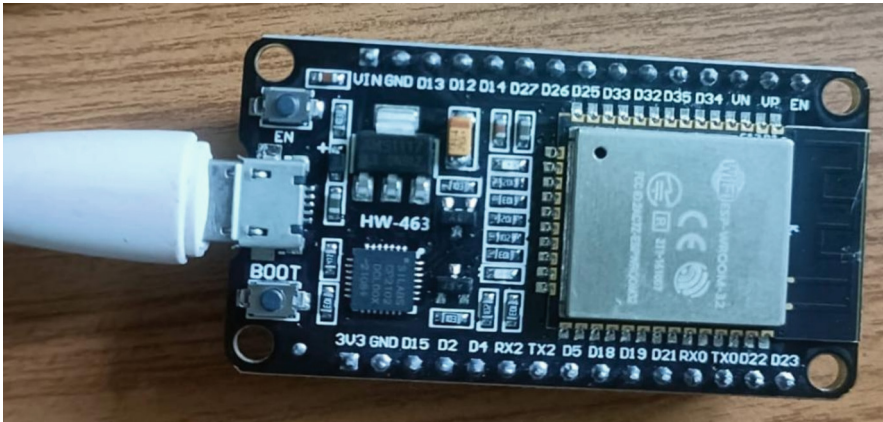


Fig. 3. ESP32 WROOM 32 Microcontroller

4. Electrooculography (EOG)

Electrooculography (EOG) is a method used to measure the cornea-retinal standing potential, which refers to the electrical potential between the front and back of the human eye. The signal that is obtained from this measurement is commonly referred to as the electrooculogram, as illustrated in Fig. 4.

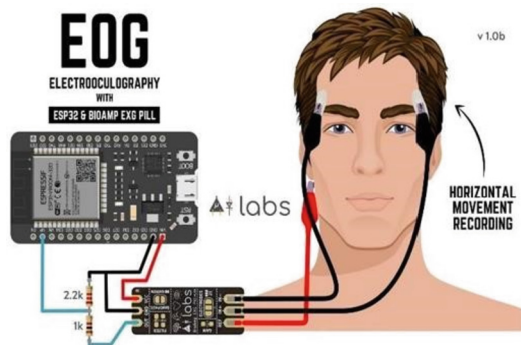


Fig. 4. Recording Corneo-retinal Potential through VioAmp Pill and ESP32 Wroom 32 microcontroller

5. Resistors (1 K or 2.2 K Ohm)

Typical axial-lead resistors, such as 1K ohm Carbon Film Resistors, offer improved temperature stability and lower noise levels.

1K Ω resistor has a value of 1,000 ohms and 2.2K Ω resistor has a value of 2,200 ohms respectively as shown in Fig. 5.

B. Flow Chart of the Proposed System

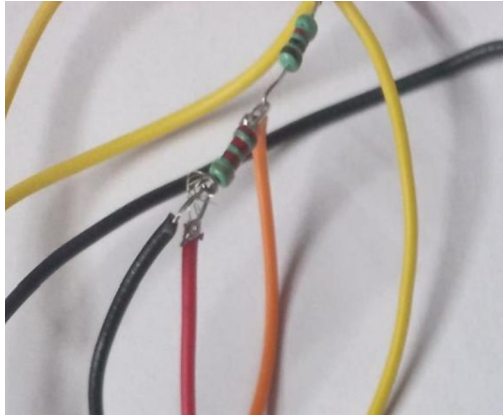


Fig. 5. Resistors 1 K Ohm and 2.2 K Ohm

Electrooculography (EOG) is a technique employed to gauge the cornea-retinal standing potential, which represents the electrical potential disparity between the anterior and posterior regions of the human eye. When the signal is detected by the eye, there will be two cases: eye tracing and blink detection. Through retinal movement the cursor movement will be seen, mouse scrolling up, down, left and right. The cursor is controlled with by the movement of retina. When the eye moves away from the center position towards one of the two electrodes, the positive side of the retina is observed by that particular electrode, while the opposite electrode detects the negative side of the retina. If the eye blinks the click event will take place. We can scroll, select, and can even work with virtual keyboard through click process. Fig. 6 as shown below may give the clear view of the process through a flow chart.

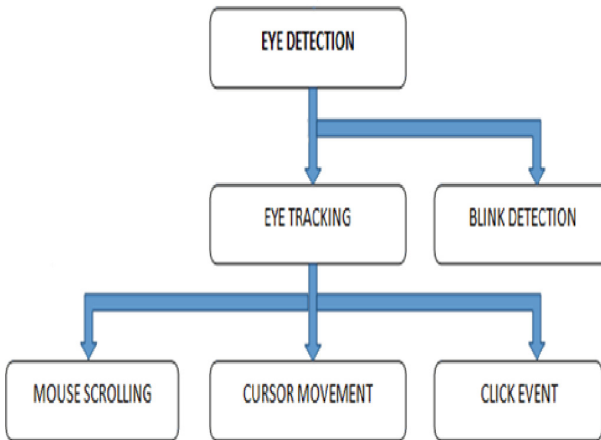


Fig. 6. Flow chart

Eye detection consists of 2 techniques eye tracking and blink detection Blemouse (Bluetooth low energy) devkit python library is used for mouse scrolling, cursor movement and click event by eye detection through eye tracking in Arduino IDE (integrated development environment) for eye tracking by bioamp pill converts bio signals into electrical signals which are amplified and fed to the Esp 32 Wroom32 Microcontroller which is interpreted by the Arduino IDE python library for Bluetooth low energy devkit called blemouse devkit and the code is uploaded by boot button and switched on to upload the code on Arduino IDE for mouse scrolling by tracking eye movements .

C. Block Diagram

(See Figs. 7, 8)

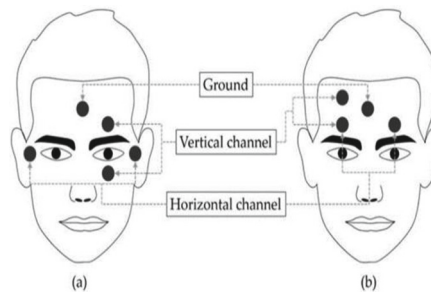


Fig. 7. (a) Sense by both upper and lower portion by EOG, and (b) Sense by upper portion of face by EOG

D. Circuit Diagram

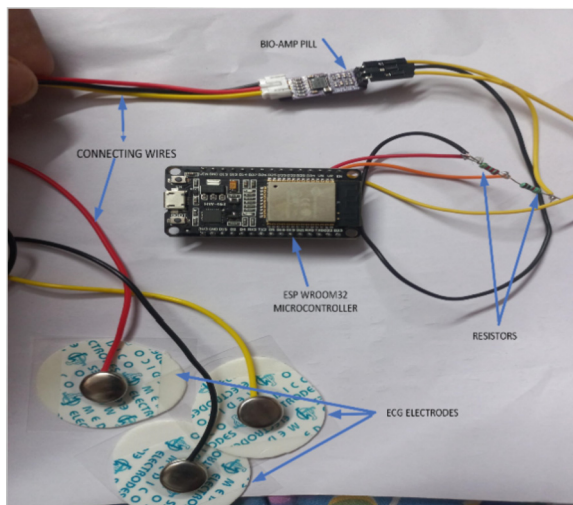


Fig. 8. Circuit diagram

E. Working of the Prototype

The EOG-based eye cursor is a technology designed to assist paralyzed individuals in using a computer independently. The EOG-based eye cursor system utilizes electrooculography (EOG) to monitor eye movements, which are subsequently translated into corresponding cursor movements on the computer screen. The functioning of the EOG-based eye cursor involves the following steps:

The Bio Amp EXG Pill captures the EOG signals generated by eye movements. The EOG signals pass through the voltage divider circuit created by the resistors, which adjusts the signal level. The processed EOG signals are then fed into the ESP32 WROOM 32 Microcontroller. The microcontroller analyses the EOG signals to determine the direction and speed of the cursor movement. Different algorithms can be used for this purpose, such as thresholding or machine learning-based approaches. Once the cursor movement is determined, the microcontroller communicates with the computer, either through a wired or wireless connection (e.g., Bluetooth or Wi-Fi), to control the cursor movements on the screen. By tracking the user's eye movements and translating them into cursor movements, the EOG-based eye cursor allows paralyzed individuals to interact with a computer and perform tasks such as browsing the internet, typing, or operating software, enabling them to use the computer independently. The overall working of the EOG-based eye cursor involves the following steps. The microcontroller processes the EOG signals and converts them into meaningful cursor movements. This involves mapping the range of EOG signal amplitudes to corresponding cursor speeds or distances. For example, larger EOG signal amplitudes may result in faster cursor movements. The microcontroller communicates with the computer by emulating mouse movements. It sends the appropriate signals to the computer's mouse interface, simulating the cursor's movement in the desired direction and speed. The computer receives the simulated mouse movements and updates the cursor position on the screen accordingly. In addition to cursor movements, the microcontroller can also be programmed to recognize certain eye movement patterns or gestures as specific commands or actions. For instance, a prolonged blink or a specific eye movement sequence may be interpreted as a mouse click or a keystroke. The microcontroller can communicate with the computer to perform additional functions beyond cursor movements, such as clicking, dragging, scrolling, or executing keyboard commands. This allows paralyzed users to interact with various software applications and perform a wide range of tasks.

Overall, the working of the EOG-based eye cursor system involves capturing EOG signals, processing them with the microcontroller, emulating mouse movements, and communicating with the computer to control the cursor and perform various actions. The system aims to provide paralyzed individuals with an accessible means of using a computer and interacting with software applications, enabling greater independence and access to digital resources. By tracking the user's eye movements and translating them into cursor movements, the EOG-based eye cursor allows paralyzed individuals to interact with a computer and perform tasks such as browsing the internet, typing, or operating software, enabling them to use the computer independently.

4 Equations

A. Transfer Function (Conversion Formula)

The bio signals acquired with bio signals plux devices are initially analog sensor signals, which are then converted into digital values ranging between 0 and $2^n - 1$ (where n represents the sampling resolution, typically 8-bit or 16-bit). These digital values are streamed in their raw digital format. In many applications, it is preferable or necessary to work with the original physical unit of the acquired EOG signal (Table 1). To achieve this, the raw digital sensor samples can be converted back into millivolts (mV) using the following formulas:

$$(V) = [(ADC/2^n - |1/2) * VCC]/G \tag{1}$$

$$E (mV) = E(V) * 1000 \tag{2}$$

Valid sensor range: $[-1.5 \text{ mV}, 1.5 \text{ mV}]$ with:

(V) : EOG signal measured in V

(mV) : EOG signal measured in mV

ADC : The value samples obtained from the sensor or channel, represented in the form of digital values.

n : The sampling resolution, typically defaults to 16-bit resolution ($n = 16$), although other resolutions such as 12-bit and 8-bit may also be found.

VCC : The operating voltage (3 V when used in conjunction with bio signals plux)

$GECC$: Sensor gain (2040)

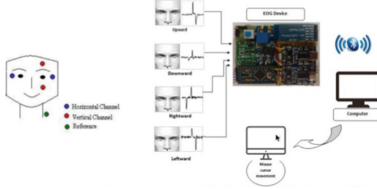
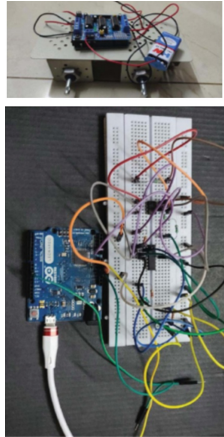
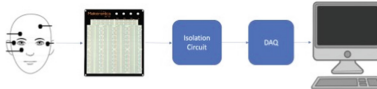
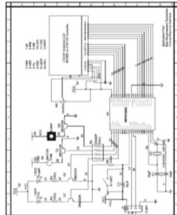
B. Comparison Table

Table 1. .

Paper	Purpose	Software	Hardware	Purpose	Cost
[1]	(EOG) Eye Gaze Communication Device	EOG signal created in MATLAB	Arduino Mega		Low cost around 2k-3k

(continued)

Table 1. (continued)

Paper	Purpose	Software	Hardware	Purpose	Cost
[2]	<i>EOG based Mouse Cursor Control For application in Human- Computer Interaction</i>	<i>Arduino IDE, Python GUI</i>	<i>Microcontroller ATmega 328, Arduino pro mini</i>		<i>Low costing around 3k-4k</i>
[3]	<i>Design of Wheelchair based on Electrooculography</i>	<i>Arduino IDE</i>	<i>Arduino UNO & Leonardo, electrodes</i>		<i>Low cost automated wheelchair prototype based on EOG around 9k-10k</i>
[4]	<i>Electrooculography controlled cursor</i>	<i>Lab View</i>	<i>Electrodes, signal conditioning circuit, OP amp, resistor, capacitor</i>		<i>Around 3k-4k</i>
[5]	<i>EOG based HMI for paralysed people to control electrical devices</i>	<i>KEIL, flash magic and hyper-terminal</i>	<i>Electrodes, amplifiers, active filter, ADC, RETX module, LCD, GLCD</i>		<i>Around 5k-6k</i>

(continued)

Table 1. (continued)

Paper	Purpose	Software	Hardware	Purpose	Cost
[6]	<i>Eye Gesture control system</i>	<i>Open CV, C ++ modules</i>			<i>Low cost around 3k-4k</i>
[7]	<i>A Review paper on a system design approach in control a computer mouse using EOG signal</i>	<i>MATLAB, Lab view</i>			<i>Higher costing</i>
This paper	<i>Electrooculography based computer control system for people with mobility limitations</i>	<i>Arduino IDE, python lang.</i>	<i>ESPWROOM32 Microcontroller, Bio amp pill, resistors, electrodes</i>		<i>Low cost approximately 3k</i>

5 Results and Discussions

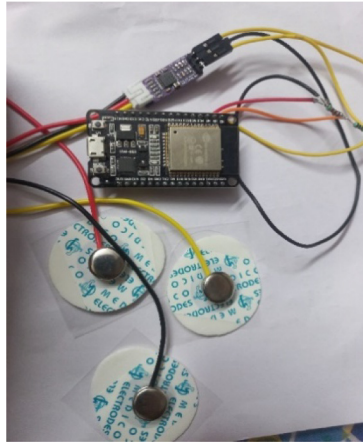
When comparing this study to previous literature, it exhibits several advantages including low cost, improved control stability, and ease of use. Similar studies in the literature have explored different signals, such as EEG, but they tend to be more costly and complex in terms of system requirements. Additionally, these alternative signals may introduce interferences, necessitating more complex software for computer or system control. Consequently, such software can strain the system’s processing capabilities. In contrast, this study focuses solely on EOG for cursor control, offering the advantage of reduced processing load compared to studies involving additional signal support.

6 Final Prototype

The final working prototype is shown below:
(See Fig. 9)



(a)



(b)

Fig. 9. (a) Electrooculography Equipment on Human, & (b) Prototype working model on breadboard with ESP WROOM 32 Microcontroller and the BioAmp EXG Pill

7 Conclusion

This study presents the development of a cost-effective, portable, and user-friendly microcontroller-based system utilizing EOG (electrooculography) for individuals with conditions such as ALS or stroke. The system enables easy computer usage in their daily lives by allowing them to control the computer through eye movements. This research primarily aims to analyze and classify eye movements and blinking patterns using the EOG signal. The ultimate goal is to generate control signals that can be utilized to manipulate a mouse cursor. This system offers significant advantages over previous methods that relied on image processing, as it is more affordable while providing better accuracy

with minimal effort. Consequently, users can adapt to daily life with less difficulty and independently use computers without relying on assistance from others. Person with disabilities or being paralyzed can easily communicate with the people around them. They will not feel much helpless, bored and alone around other people. They can watch movies, can order something for them, play games and make their miserable life better.

8 Scope of Work

Our future objective is to develop real-time systems that can be controlled through eye movements, offering potential applications in areas like rehabilitation and military use. We aim to enhance the durability, affordability, and compactness of these systems while improving their user-friendliness. There is room for improvement in the placement of electrodes around the eyes. Furthermore, we plan to introduce additional mouse functionalities such as erasing. These advancements will greatly enhance the quality of life for individuals who have limited hand or finger mobility, empowering them to actively participate in productive activities. We can add virtual keyboard so that the patient can type easily and watch movie, dramas and order something for them. It can be used in homes and hospitals by the patients.

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Enhancing Sustainable Returns: Unleashing the Potential of Automated Trading with Advanced Technologies

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Abstract. Algorithmic trading is the process of utilizing computer programs to search through massive amounts of data for actual signals that accurately represent the underlying market dynamics. Algorithms are used in algorithmic trading to define a set of trade instructions and observe trends. It is merely a means to reduce the price, market impact, and risk of order execution. Investment banks and hedge funds frequently use it. The algorithm has unnaturally high frequency and speed of revenue generation. The objective of this project is to create a trading algorithm from scratch that offers returns that beat the market. We have derived the different formulas for the Sharpe and Sortino ratios which are used to analyze the effectiveness and the returns of an algorithm and back-test the algorithm on historically available data, using Python and its various free to use libraires. The study aimed to analyze different algorithms used in automated trading to identify their benefits and drawbacks for refining and increasing profits with less risk. Back-testing various algorithms on similar datasets showed that Bollinger Bands was the optimal algorithm due to its low average loss and highest net profit. Further fine-tuning of the Bollinger Band technique can lead to more profit or similar profits with substantially reduced risks.

Keywords: Trading · Algorithm · Returns · Profit

1 Introduction

In the market, using algorithms to make trading choices has become a common practice. The practice of using automated algorithms to find real signals amid vast volumes of data that accurately reflect the underlying market dynamics is known as algorithmic trading. Algorithms that analyze trends are applied in algorithmic trading to provide a set of trade instructions. It is only a way to reduce price, effect on market, and risk of order-execution. You must comprehend how and why prices change (for instance, in response to global events), where profit possibilities are present, and how to realistically take advantage of these chances. Beginner traders and those with some trading expertise should get to know a few technical indicators. These provide insightful information on trade trends.

A trading strategy is a systematic methodology used for buying and selling in the securities markets. A trading strategy is based on predefined rules and criteria used when making trading decisions. Trading strategies are employed to avoid behavioral finance biases and ensure consistent results.

1.1 Automated Trading System

Algorithmic trading, automated trading, and system trading are other labels for automated trading systems. They help investors to specify specific criteria for trade entry and exits that, once programmed, may be carried out automatically by a computer. In fact, some platforms claim that automatic trading algorithms move more than 70% to 80% of the share prices on American equity markets.

As the trader, you'll combine thorough technical analysis with setting parameters for your positions, such as orders to open, trailing stops and guaranteed stops.

Automated trading must be operated under automated controls since manual interventions are too slow or late for real-time trading in the scale of micro- or milli-seconds.

1.2 Advantages of Automated Trading System

Minimizing Emotions Automated trading platforms keep emotions to a minimum while trading. Traders often have an easier time sticking to the strategy by controlling their emotions.

Trade orders are automatically executed when the deal requirements are satisfied, so traders cannot pause or second-guess the trade. In addition to helping individuals who are afraid to "hit the trigger," automated trading can control traders who have a propensity to overtrade, purchase and sale.

The advantages of algo trading are related to speed, accuracy, and reduced costs.

1.3 Backtesting

Backtesting evaluates the viability of a concept using historical market data and trading regulations. There should be no space for interpretation in any rules when creating an automated trading system. The computer is unable to hazard a guess; it requires explicit instructions. These sets of rules may be used by traders, who may back-test them on historical data points before putting their money at risk in the market trading. Through rigorous backtesting, traders may analyze and improve a trading idea as well as calculate the system's expectation, or the normal profit per unit of risk that a trader can expect to make (or lose).

A backtest is usually coded by a programmer running a simulation on the trading strategy. The simulation is run using historical data from stocks, bonds, and other financial instruments. The person facilitating the backtest will assess the returns on the model across several different datasets.

1.4 Preserving Discipline

Due to set trading rules and automatic transaction execution, discipline endures even under erratic market conditions. Emotional variables like the fear of losing or the willingness to make a little bit more money from a transaction are the main causes of discipline loss. Automated trading makes it easier to keep discipline since the trading strategy will be adhered to precisely. Furthermore, “pilot error” is reduced. For instance, if a mistake is made and a 100-share purchase order is placed as a 1,000 share sell order.

1.5 Increasing Order Entry Speed

Computers react instantly to fluctuating market conditions, enabling automated systems to execute orders whenever trading requirements are satisfied. A deal’s outcome can be greatly impacted by an entry or exit that has been a few seconds earlier. All extra orders, such as stop losses and profit goals for protection, are generated automatically whenever a position is registered. Markets move quickly, and it can be upsetting to see a trade reach its profit target or rocket over a stop-loss level before the orders can be executed. This is avoided by using an automated trading system.

1.6 Sharpe Ratio

The Sharpe Ratio, created by Theoretical physicist William Sharpe, is used to determine the uncertainty returns of a certain investment.

Investment resources are limited, while investment assets are not. As a result, choosing which investments to make is sometimes a challenge for investors. We may make a decision using the Sharpe Ratio.

The key is to increase returns while lowering volatility. If an asset had 0 volatility but only a 10% yearly return, its Sharpe Ratio would be infinite (or undefined).

When the risk-free rate of return is subtracted from the average investment return and divided by the investment’s standard deviation, the Sharpe ratio is obtained. If two funds offer similar returns, the one with higher standard deviation will have a lower Sharpe ratio. In order to compensate for the higher standard deviation, the fund needs to generate a higher return to maintain a higher Sharpe ratio.

$$\text{Sharpe Ratio} = (R_p - R_f) / \sigma_P \quad (1)$$

$$R_p = \text{return of portfolio} \quad (2)$$

$$R_f = \text{risk - free rate} \quad (3)$$

$$\sigma_P = \text{standard deviation of the portfolio return} \quad (4)$$

1.7 Sortino Ratio

Another indicator of risk-adjusted return is the Sortino ratio. Frank Sortino was the one who created it. The profit earned of an asset over the desired return is calculated using the Sortino ratio and is divided by the investment's return standard deviation. The investor's desired return is known as the target return. The standard deviation serves as a gauge for the returns on an investment's volatility.

There are several benefits to using the Sortino ratio. It first considers the goals or objectives of the investor. It also considers the investor's level of risk tolerance. Thirdly, it considers the investment's time horizon. Fourthly, it may be used to evaluate how well certain investments have performed. Fifth, it may be used to assess how well various investment managers have performed.

$$\text{Sortino Ratio} = (R_p - r_f) / \sigma_d \quad (5)$$

$$R_p = \text{Actual or expected portfolio return} \quad (6)$$

$$r_f = \text{Risk-free rate} \quad (7)$$

$$\sigma_d = \text{standard deviation of the downside} \quad (8)$$

1.8 Bollinger Bands

Bollinger Bands a fundamental and technical predictor that may be used to gauge volatility as well as if a commodity is overbought or overvalued in the financial markets. On a trading chart, Bollinger Bands are three lines. The instrument's price's simple moving average (SMA), which represents the average of the price over a specific period, is represented by the middle line of the indicator. Typically, this is set to 20 days. The SMA plus two variance makes up the top band. The bottom band is the SMA less the probable error.

1.9 VWAP

All traders may use the trading tools volume-weighted average price (VWAP) to make sure they are obtaining the best possible price. However, short-term traders and trading platforms that rely on algorithms are the ones that utilize these tools the most consistently.

VWAP is frequently used to gauge how well smart money is trading. Institutional traders match their prices to VWAP values. These are skilled traders who operate at financial companies or hedge funds and must trade huge volumes of shares each day. They are unable to join or leave the market by purchasing or selling a sizable stake in shares during the day (Fig. 1).

Rolling Statistics				
	Sharpe Ratio			
	1 Month	3 Months	6 Months	12 Months
01/31/2021	-0.7750	-0.7750	-0.7750	-0.7750
02/28/2021	1.0619	0.5444	0.5444	0.5444
03/31/2021	1.2733	1.3390	1.3390	1.3390
04/30/2021	6.3722	3.4818	2.3846	2.3846
05/31/2021	0.5652	2.3100	1.8787	1.8787
06/30/2021	2.9596	2.3886	1.9500	1.9500
07/31/2021	1.8948	1.7439	2.4819	2.0143
08/31/2021	4.3037	3.1199	2.5899	2.1767
09/30/2021	-2.5710	0.4406	1.4797	1.5375
10/31/2021	6.9953	1.6263	1.6790	1.8968
11/30/2021	1.0517	0.9783	1.8683	1.8390

Fig. 1. VWAP Analysis

1.10 MACD

Computers Trend trading frequently makes use of the MACD. However, MACD is not utilized to identify overbought or oversold conditions, unlike conventional oscillators. Instead, to generate trading signals, MACD assesses momentum or trend strength and compares it to the signal line. Like the 2-line moving average technique, the line oscillator generates trading signals. It displays the correlation between 2 moving averages of a security's price that were computed over various time-frames (Fig. 2).

Overview	Report	Orders	Insights	Logs	Code	Share
Download Results						
PSR		27.738%		Sharpe Ratio		0.487
Total Trades		21		Average Win		1.72%
Average Loss		-3.30%		Compounding Annual Return		5.756%
Drawdown		13.900%		Expectancy		0.141
Net Profit		5.751%		Loss Rate		25%
Win Rate		75%		Profit-Loss Ratio		0.52
Alpha		-0.005		Beta		0.363
Annual Standard Deviation		0.09		Annual Variance		0.008
Information Ratio		-0.668		Tracking Error		0.134
Treynor Ratio		0.12		Total Fees		\$14.00

Fig. 2. MACD Analysis

1.11 EMA

EMA (Exponential Moving Average) tries to measure directions of the trend over a period. It achieves this by determining an avg. of the values after assessing a variety of

historical data points. Thus, the EMA will track prices more closely than a matching SMA because of its special calculation.

EMA (Exponential Moving Average) tries to measure directions of the trend over a period. It achieves this by determining an avg. of the values after assessing a variety of historical data points. Thus, the EMA will track prices more closely than a matching SMA because of its special calculation (Fig. 3).

Overview	Report	Orders	Insights	Logs	Code	Share
Download Results						
PSR		2.494%		Sharpe Ratio		-0.221
Total Trades		28		Average Win		6.12%
Average Loss		-1.40%		Compounding Annual Return		-2.894%
Drawdown		12.800%		Expectancy		-0.233
Net Profit		-5.017%		Loss Rate		86%
Win Rate		14%		Profit-Loss Ratio		4.37
Alpha		-0.017		Beta		-0.011
Annual Standard Deviation		0.077		Annual Variance		0.006
Information Ratio		-0.119		Tracking Error		0.174
Treynor Ratio		1.525		Total Fees		\$0.00

Fig. 3. EMA Analysis

1.12 RSI

The Relative Strength Index (RSI), a skilled momentum-based oscillator, is employed to gauge both the magnitude and the speed of directional price moves. Essentially, when RSI is graphed, it offers a visual way to track a market's historical as well as present strength and weakness. A trustworthy metric for measuring changes in price and momentum is created by basing the strength or weakness on closing prices over the course of a certain trading period (Fig. 4).

1.13 Keltner Bands

This volatility-based indicator plots upper, lower, and middle lines using average prices. The three lines all follow the price's movement and resemble channels. The Keltner Channel is an Envelop-based indicator (others include Bollinger Bands, Donchian Channels, etc.). This means it has an upper and lower boundary to help you identify potential "overbought and oversold" levels. Prices typically fluctuate inside the channel, which is made up of upper and lower bands. The channel's or angle's direction aids in determining the trend's direction; for example, when the channel is up, the price is rising, and when it is down, the price is falling (Fig. 5).

Overview	Report	Orders	Insights	Logs	Code	Share
						Download Results
PSR		6.234%		Sharpe Ratio		-0.016
Total Trades		81		Average Win		3.08%
Average Loss		-4.18%		Compounding Annual Return		-3.986%
Drawdown		29.600%		Expectancy		0.000
Net Profit		-6.227%		Loss Rate		42%
Win Rate		58%		Profit-Loss Ratio		0.74
Alpha		0.048		Beta		0.707
Annual Standard Deviation		0.221		Annual Variance		0.049
Information Ratio		0.32		Tracking Error		0.218
Treynor Ratio		-0.005		Total Fees		\$0.00

Fig. 4. RSI Analysis

Overview	Report	Orders	Insights	Logs	Code	Share
						Download Results
PSR		22.966%		Sharpe Ratio		0.44
Total Trades		537		Average Win		0.56%
Average Loss		-0.51%		Compounding Annual Return		12.661%
Drawdown		45.500%		Expectancy		-0.002
Net Profit		12.661%		Loss Rate		53%
Win Rate		47%		Profit-Loss Ratio		1.11
Alpha		0.158		Beta		0.221
Annual Standard Deviation		0.458		Annual Variance		0.21
Information Ratio		0.008		Tracking Error		0.466
Treynor Ratio		0.913		Total Fees		\$586.02

Fig. 5. Keltner Analysis

1.14 Research Objective

To provide better returns without the need of human intervention and minimizing human-made errors made during trading by automating the strategy.

1.15 Research Scope

The scope of the project right now is to make an easy-to-use automated trading algorithm that beats the baseline market returns.

2 Methodology

This research article analyses various kinds of trading algorithms used in the market using a quantitative approach by backtesting all the algorithms on historical data on major cryptocurrencies and computing various indicators and ratios related to technical tradings which are then compared and analysed to find the optimal algorithm out of those compared. The tool we used for this analysis was quantconnect and the accurate historical data that was used for backtesting was also provided by the same platform.

2.1 QuantConnect

Define QuantConnect's LEAN engine manages your portfolio and data feeds letting you focus on your algorithm strategy and execution. QuantConnect is a web algorithmic trading tool that enables the creation, testing, and execution of strategies. With support for Equities, Futures, Options, Forex, CFD, and Cryptocurrencies, they provide terabytes of credit counselling data and enable live investing using information from a set of leading investment companies or their own statistics, back testing of procedures is conducted. The platform is meant to be a pretty simple, all-in-one destination to take you from having no tactics running online on their technology at all to having them fully verified and back-tested.

2.2 Language Support

Use QuantConnect supports both Python and C# within its IDE, despite the fact that the strategy implementation platform for the two languages has somewhat different sets of accessible modules for each.

2.3 Backtesting Strategies – SDF vs Classic

Method 1: Construct a basic algorithm from scratch. Your set purchase and sell logic determines how transactions are carried.

Method 2: Sometimes known as the SDF, is as follows: The SDF has ready to use modules that you may apply with little to no change, as was already indicated.

5 stages are covered in these modules:

- 1) Selecting assets to trade
- 2) Alpha production
- 3) Construction of portfolio
- 4) Execution
- 5) Managing risks

Some possible limitations present in the analysis done in this research is that the data used for backtesting was from 1st January 2021 to 1st January 2022 only spanning one year. Furthermore, the data was only from one asset class which are cryptocurrencies. These limitations were due to lack of access to varied data and processing power supplied by the platform for free.

3 Result

Among the strategies listed in the table, Bollinger Bands stand out as the best option in terms of net profit. With a total of 179 trades, the Bollinger Bands strategy yielded a net profit of 98.76%. This indicates that, overall, this strategy was highly successful in generating profits (Table 1).

Table 1. Backtesting results for Net profit, Win rate and avg. Win.

S. No	Strategy Name	Total Trades	Net Profit	Win Rate	Avg. Win
1	Bollinger Bands	179	98.76%	51%	5.48%
2	VWAP	1	3.07%	99%	3.07%
3	MACD	21	5.75%	75%	1.72%
4	EMA	28	-5.01%	14%	6.12%
5	RSI	81	-6.22%	58%	3.08%
6	Keltner Bands	537	12.66%	47%	0.56%

Although Bollinger Bands had a win rate of 51%, which may seem moderate, the average win of 5.48% suggests that when the strategy did generate profitable trades, the gains were significant. This demonstrates the effectiveness of Bollinger Bands in capturing favourable market movements and generating substantial profits. Therefore, based on the information provided, it can be concluded that the Bollinger Bands strategy was the most profitable among the listed options, delivering a substantial net profit of 98.76% (Table 2).

Table 2. Backtesting results for drawdown, loss rate, avg. Loss and Sharpe ratio.

S. No	Strategy Name	Drawdown	Loss Rate	Avg. Loss	Sharpe Ratio
1	Bollinger Bands	40.9%	49%	3.46%	1.55
2	VWAP	23%	0%	0%	0.158
3	MACD	13.9%	25%	3.30%	0.487
4	EMA	12.8%	86%	1.40%	-0.221
5	RSI	29.6%	42%	4.18%	-0.016
6	Keltner Bands	45.5%	53%	0.51%	0.44

When considering the performance metrics provided in the table, Bollinger Bands still emerge as a favorable strategy, despite its drawdown of 40.9%. While the drawdown represents the maximum peak-to-trough decline experienced by the strategy, it is important to note that the net profit of 98.76% outweighs this drawback. In terms of loss rate, Bollinger Bands had a 49% occurrence. Although this indicates that almost half of

the trades resulted in losses, the average loss of 3.46% suggests that the losses were relatively contained. Additionally, the Sharpe Ratio of 1.55 for Bollinger Bands indicates a favorable risk-adjusted return. A Sharpe Ratio above 1 is generally considered good, and in this case, the Bollinger Bands strategy demonstrates the ability to generate excess returns relative to its risk. Comparing Bollinger Bands with the other strategies listed in the table, it outperforms them in terms of net profit and the Sharpe Ratio. Despite its drawdown and loss rate, Bollinger Bands' ability to generate a substantial net profit and its favorable risk-adjusted return make it a better choice among the listed strategies (Fig. 6).

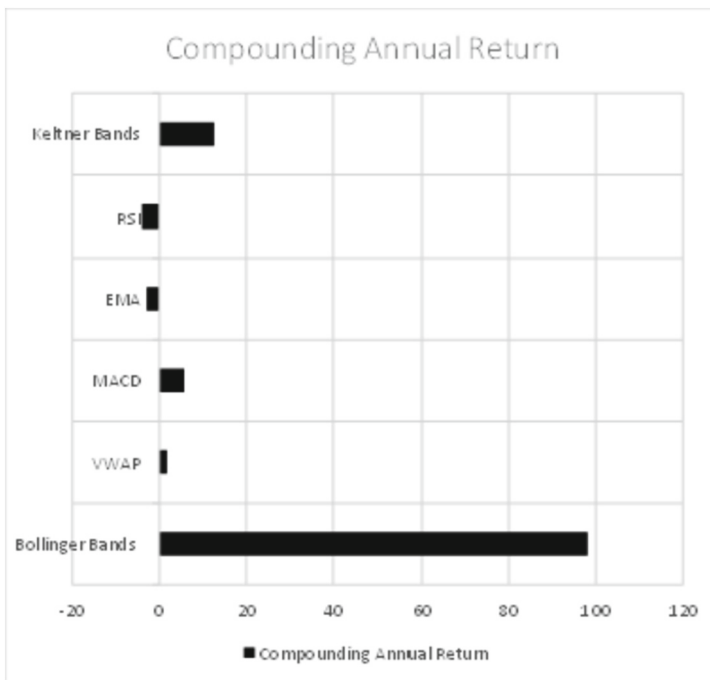


Fig. 6. Compounding Annual Returns

4 Future Scope

The future holds promising opportunities to expand the scope of research on the profitability of trading algorithms applied to Bitcoin over a one-year time frame. With advancements in technology and access to an ever-growing array of algorithms, researchers will be able to conduct more comprehensive comparisons and analysis.

One significant aspect of future research lies in the exploration of a wider range of algorithms. By testing and evaluating additional algorithms, researchers can better understand their performance in different market conditions. This expansion allows for

a more nuanced analysis of algorithmic trading strategies, considering various technical indicators, machine learning models, and quantitative methods.

Moreover, the future scope of research can involve an extension of the time period covered by the Bitcoin dataset. Expanding the analysis from one year to five years, or even more, provides a broader perspective on algorithm performance. A longer time frame enables researchers to capture different market cycles and evaluate the algorithms' adaptability over time.

In order to achieve more accurate and reliable results, it will be essential to conduct rigorous backtesting and simulation studies. By utilizing historical Bitcoin price data and simulating trades, researchers can assess the effectiveness of different strategies and refine their findings. Robust backtesting methodologies will help identify potential strengths and weaknesses of algorithms, ultimately contributing to more informed decision-making.

In conclusion, the future scope of research on the profitability of trading algorithms on Bitcoin for a one-year time frame is promising. By exploring a wider range of algorithms, extending the time period of analysis, conducting rigorous backtesting, examining real-world implementation, performing comparative analysis, and considering future trends, researchers can contribute to a deeper understanding of algorithmic trading strategies and their performance in the cryptocurrency market.

5 Conclusion

With the increased use of technologies like automated trading algorithms ran on software it is important to analyze the different kinds of algorithms available to find out their benefits and drawbacks to further refine them and earn more profit with less risk. By back-testing various algorithms on similar datasets this study interprets the results and analyzes various parameters to find that bollinger bands was the optimal algorithm mainly due to low average loss and highest net profit whereas all the other algorithms tested either had low net profitability or very high loss rates. Further analysis into the bollinger band technique should focus on fine tuning parameters to gain more profit or similar amount of profits but with substantially reduced risks. Furthermore, this study looked at algorithms in isolation but more studies are required to gain insight how the algorithms perform when used in conjunction with each other.

The algorithmic trading is the mixture of core statistical methods and information technology. In the absence of either core statistical methods or information technology, such program of trading is not possible and cannot be executed.

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Attaining Sustainable Development Goal of Quality Education through Data Analytics in Institutional Research: Insights and Applications

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Abstract. With the rise in various sources of educational courses in both online and offline mode, large volumes of educational data is generated. In a data driven era, it becomes quite necessary to analyze huge amount of exponentially growing data and obtain meaningful information out of it. Educational data, if analyzed well, can be quite useful in enhancing the quality of education, risk management of institutions and taking effective measures to provide better skills to the students. This paper is a review of various studies carried out to implement data analytics in institutional and education research and further proposes a model to analyze various factors that affect academic progression of students. The motive of the study is to identify the key factors enhancing or hindering a student's progress. The proposed model is a step towards a wider perspective where analytics can be applied at micro level to bridge the gap between a learner and educator and provide a sound operational and financial system for the institutions and attain the sustainable development goal of quality education.

Keywords: Institutional Research · Data Analytics · Educational Research

1 Introduction

We are currently living in a data driven era, where human beings and machines are generating tons of data at an exponential rate. With advent of technology [1] and increasing population, we are generating more and more data every day. Data may not have held much importance over past years when it was scarce, but as the volume of data is growing it is becoming critical to manage data. It was not until recent years, that scientists and researchers realized that each bit of data associated with human beings can be quite useful in obtaining insights about other aspects related to them. This theory forms the basis of data analysis and this is how data analytics came into inception. While this theory is largely applicable to industrial data, behavioral data and business related data [2], educational data is equally under its ambit as well. In the past few years, the zeal to learn has increased and there has been tremendous growth in learners and teachers which can be attributed to educational courses offered by institutions in both online and offline

mode. With ever increasing educators and learners, there is a proportional growth of educational data as well. All this educational data can be used to streamline the key aspects which hold prominence over other aspects and highlight the areas where improvement is needed. Applying analytics to the educational data will help learners understand their learning patterns and also help educators to understand what needs to be done to enhance the quality of education. The motivation behind carrying out research in this area was highly driven by zeal for improving the learner and academician's relation by bringing clarity about the factors that hinder or enhance a learner's academic growth. Choosing data analytics as the core technology to aid this research work was due to the fact that data analytics is a booming field which has helped in augmentation of various sectors such as health, education, finance and business etc. The immense amount of student data available with the institutions in their databases further made it possible for the research work to be carried out smoothly. This further lead to the exploration of various published work by eminent researchers in the field of education research. Education research and analysis of educational data has been a prominent concern for most of the scholars and researchers and a lot of studies have been carried out in this field over the past years. Some of the recent and relatable literature is been discussed in the next section.

2 Literature Survey

(Y.C. Chang et al., 2022) [3] questions the role of emotional intelligence in a student's academic performance. The idea came to the mind of authors owing to the fact that how educational institutions were closed during pandemic and there was a wide shift in teaching methodologies. Through their thorough research and analysis through expectancy model and correlational analysis, they came to a conclusion that emotional intelligence has no significant direct impact on the learning patterns of students, however it plays a significant role in motivating students to improve their skills. The study also examined how lack of face to face communication and peer interaction affect students. This study brought to light the importance of surveying what mode of learning learners' would prefer.

(M. Soncin et al., 2022) [4] authors have considered educational research as such an important area that they have proposed creation of new job role – Educational Data Scientists, ones in charge of applying their analytical skills and technical expertise to analyze educational data and detect patterns through large sets of data. The emphasis is on the role of data analytics in higher education and how much it helps in understanding which student is lagging behind or at risk so that more focus can be drawn at the factors that lead to this state.

(P. Vats et al., 2021) [5] thoroughly reviewed the previous literature enriched by various researchers who have worked in the field of education research with the aim of improving the student progression system using various educational data mining techniques. The crux of their study is to study the various factors that affect student progression. After collecting data of secondary schools, they have analyzed the data in a histogram representation and found a correlation between the types of meals taken by the students and their scores. There was no correlation to gender and parental level of education, although these were the attributes taken in consideration for their study.

(A. Nguyen et al., 2020) [6] presented a comprehensive study on role and application of data analytics in academics through its newly derived disciplines – learning analytics, academic analytics and educational data mining. The paper briefly describes each concept and how each and other are related in some way yet different from each other. The research study provides an integrated view of the three principles of data analytics in academics and emphasizes on the fact that all these disciplines play a key role in improving institutional research methods, thereby enhancing quality of education.

(R. Raju et al., 2020) [7] comprehensively studied the various supervised and unsupervised learning algorithms and applied them on student dataset. The main objective was to divide the dataset into ten parts and perform a ten-fold cross validation. Out of these ten parts, nine parts of datasets were examined against one part used as a training dataset. The models examined were – logistic regression model, support vector machine and neural network. The entire study was carried out to predict the final year score of students, taking in consideration the previous year scores of the given students.

(S.A. Salloum et al., 2019) [8] argues that developing countries have failed to realize the full potential of e-learning systems despite the fact that a lot has been invested in IT infrastructure for providing education. The survey studies the key factors behind such a failure, questioning whether it is failure at the learners' end or at the end of academic institutions and teachers. UTAUT (Unified Theory of Acceptance of Use of Technology) is implemented and a section of students are surveyed to understand their motivation behind acquiring skills through e-learning. The findings of the study reveal that the factors of motivation are social impact, desire to improve skills and have better credentials. The study sets an example to the education providers that analyzing educational data through learners' perspective can bring positive changes in education system.

(J. Gagliardi et al., 2018) [9] emphasize the role of institutional research in enhancing quality of education. They have identified the importance of analyzing enormous educational data through data analytics so that institutions can be benefited in having better insights through structuring the unstructured data. Access to the data and then using this data to bring about significant changes for an improved system is promoted in this survey.

(B.M. Drake et al., 2018) [2] brings forth an interesting connection between institutional research and business intelligence tools. Huge amount of educational data which is stored in administrative departments is not easy to access at any time, but when this data is warehoused, it can be mined and visualized as per the requirement. With help of business intelligence tools, this data can be quite handy in decision making. Not limiting the scope of business intelligence to only business enterprises, the authors bring forth the application of business intelligence to educational data, thereby enhancing institutional research. The authors propose two business intelligence maturity models – EDUCAUSE and HEDW for data warehousing of educational data.

The literature studied so far as referred above gave useful insights and some of the significant findings of these papers are tabulated in table below (See Table 1).

Table 1. Findings from the Literature.

S.no	Year	Reference	Reference Type	Findings
1	2022	(Y.C. Chang <i>et al.</i> , 2022) [3]	Research Paper	Impact of emotional intelligence under circumstances such as pandemic using correlation analysis, results show no correlation between EI and Academic Performance
2	2022	(M. Soncin <i>et al.</i> , 2022) [4]	Review Paper	Educational Data Scientists responsible for analyzing educational data
3	2021	(P. Vats <i>et al.</i> , 2021) [5]	Research Paper	Analysis of non-academic factors and their role on academic performance, results show no correlation to family background but significant correlation to type of meals taken by students
4	2020	(A. Nguyen <i>et al.</i> , 2020) [6]	Review Paper	Difference between Learning Analytics, Academic Analytics and Educational Data Mining and how they can be applied in an integrated manner
5	2020	(R. Raju <i>et al.</i> , 2020) [7]	Research Paper	Various learning algorithms for data analysis, applied logistic regression to study effect of previous grades on current grades, results show 68% accuracy, i.e., 68% significance of proposed factor
6	2019	(S.A. Salloum <i>et al.</i> , 2019) [8]	Research Paper	Analysis of e-learning motivation in developing nations through UTAUT model, results show keen interest of students in e-learning but lack of adequate implementation of resources
7	2018	(J. Gagliardi <i>et al.</i> , 2018) [9]	Review Paper	Role of Institutional Research, Structuring the unstructured data
8	2018	(B.M. Drake <i>et al.</i> , 2018) [2]	Review Paper	Inter-relating Business Intelligence and Institutional Research to work on the academic data. Proposed model for educational data ware housing (EDUCAUSE, HEDW)

3 Findings

From the insights gained and facts learned after reviewing the literature surveyed, it was found that there are various factors at play when it comes at assessing the student academic progress. Various academic and non-academic factors can be considered and their effects can be studied by applying data analytics upon related and unrelated student data

to deduce which factor largely affects upon a student's progress. Also from the literature reviewed so far, it becomes necessary to discuss some key aspects to be considered for the current study. The following sections are a brief overview of the base facts and bare essential for the study carried out.

4 Education Research

Education is the backbone of the nation's growth [10] as it not only impacts an individual's life with an everlasting effect [11] but also indirectly impacts the society that educated individuals become a part of. While the importance of education is unquestionable, this is also true that an educational institution or even a nation can claim itself as academically acclaimed if it produces well educated students who can show results of what they have gained from their institutions. Since partaking education without actually implementing it to produce productive results is not worth the effort. An individual can only apply the gained knowledge in right direction when they have been educated properly; hence, Education Researchers are constantly working on finding ways to improve the quality of education by analyzing various factors. However, academic growth and learning experience are not only dependent on academic factors alone, there are a certain non-academic factors that play a major role as well such as – study environment, teaching methods, family support, financial support, friend circle and interest of students in the chosen domain [12]. Education research is a field of study which analyzes the educational data to enhance quality of education, which not only helps the learners in acquiring better skills but also increases the credibility of the educational institutions.

In an effort to improve the research methods, education research has been relying largely on data analytics to analyze the educational data [9]. To understand how it is done, first we understand data analytics and its branched out concepts of data analytics in academics in the next section.

5 Data Analytics

Data analytics is quantitative and qualitative analysis of data which is derived from various sources of information. This data may be structured or unstructured. This leads to the foremost step in data analysis and that is – data preprocessing, where data is cleaned, processed and transformed. Once the data is transformed as per the requirement of the application, it is then loaded into the data marts where it is ready to be analyzed and visualized. The entire process of turning raw unstructured data into meaningful information is called data mining [13]. Data mining is also known as KDD (Knowledge Discovery in Database Process) [14] and the above steps of extracting raw data, preprocessing it and then finally loading it can be understood by the process called ETL (Extraction, Transformation and Loading) [15]. Figure 1 explains the ETL process implemented in data mining to turn raw data into useful information. (See Fig. 1).

Applying data analytics to academics, we further understand the branched out disciplines of data analytics in education. (See Fig. 2).

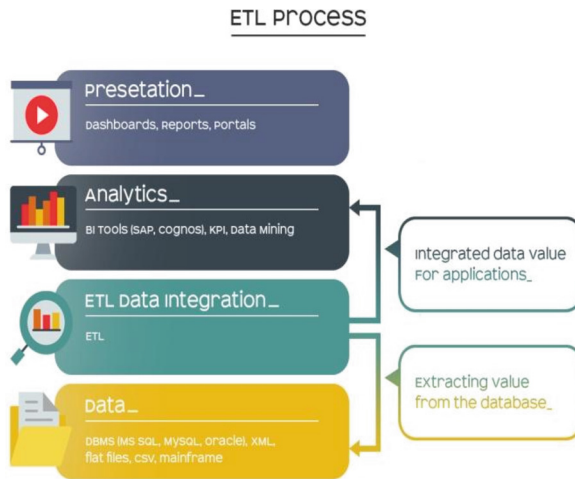


Fig. 1. Data to Insights (<https://galaktika-soft.com/>)

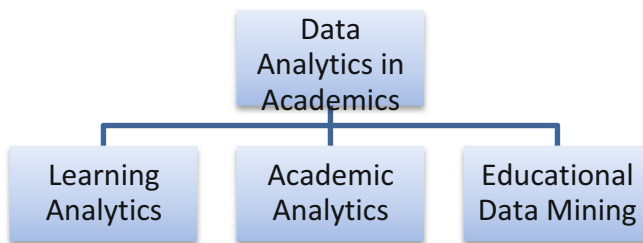


Fig. 2. .

5.1 Learning Analytics

Learning analytics is a specialized branch of descriptive data analytics which deals with understanding the learning outcomes through the learners themselves. According to the formal definition devised at the First International Conference on Learning Analytics and Knowledge (LAK 2011), learning analytics is the measurement, analysis and reporting the data about the learners, so as to improve or optimize the learning process and the environment in which this learning takes place. Learning analytics is also referred as educational data analytics [4]. Learning analytics are further applied on individual concepts such as – contextual learning analytics, dispositional learning analytics, discourse learning analytics and social learning analytics, each concerned with a specific area such as mode of learning, environment of learning or social interactions of the student [6]. Learning analytics are further developing into adaptive learning systems, which adapt themselves dynamically as per the insights gained from learners.

5.2 Academic Analytics

While learning analytics focuses on learning about learners, academic analytics is helpful for the institutions in learning about the ongoing courses and the outcomes of those

courses. With help of academic analytics, educational institutions can revamp their revenue model by assessing the courses offered, find out the lagging areas, drive down cost and work upon risk management. If a student is not performing well and is on the brink of poor performance, then efforts can be made to remove the factors which are hindering the growth and enhancing the factors which may aid in productivity. The idea behind academic analytics is to improve KPI (Key Performance Indicators) [6] and have a sound decision making system for operation and finances of the institution.

5.3 Educational Data Mining

IEDMS (International Educational Data Mining Society) explains EDM as an emerging discipline for the development of research methods that work upon huge amount of educational data and using those methods, understand the learners' learning pattern and bring about useful changes [16]. Immense data about the students, such as their particulars, their courses, their personal data, their participation or non-participation in various activities, their feedbacks and their social interactions - everything is made available through various sources. Useful knowledge is derived out of this data so as to arrive to a certain conclusive point, which is not only based on the teaching methodologies or the learning environment, but also takes in account the social and cognitive behaviour of the learner [17]. Educational Data Mining further applies various methods in education research such as – prediction, relationship, clustering, discovery etc. [6]. Prediction aims at predicting some value by using it as dependent variable and using other factors as independent variables. Relationship is useful in finding out possible relation between unrelated factors. Clustering is applied by grouping similar activities of students and then finding anomalies and density of clusters which help understand patterns. Discovery based educational data mining is helpful in understanding relation between a student's unobvious or unrelated factors that affect the academic progression.

After thoroughly studying the base concepts of data analytics in education, we highlight the unexplored aspects of this field in the next section.

6 Limitations and Future Research

From the literature surveyed so far it is well understood that data analytics has a significant role to play in analyzing educational data. However, most of the studies have been carried out at macro level, and at micro level it is quite important to get first-hand information from the learners and then analyze how the improvement can be brought about in the educational system. The learners' perspective plays an important role in decision making process and the decisions to bring about changes should not solely rely upon superficial perceptions. Also, the factors considered in most of the research works have been imposing upon the previous academic records or the learner's family or financial background. The current research work does not consider any such generalized biases and focuses at the factors at micro-level which studies the effect of current subjects and learning patterns also considers the learners' own abilities and choices. The current research work aims to bridge the gaps and produce effective results. We therefore, propose a methodology to collect primary data from the students through a

questionnaire having relevant questions regarding their current subjects, current learning environment, preferred mode of learning and future directions and motivation. This data is to be cleaned and pre-processed using RapidMiner tool and further to be analyzed using statistical regression model and later visualized on scatterplots and pie charts. The visualization part plays a key role in better understanding the factors and their dominance over the academic scores of the students. Collecting fresh data from students will be helpful in many ways, since these students are heading towards post-pandemic era after studying for most of their graduation years in unusual circumstances; they have a better understanding of what disrupted their learning track and what could be improved in teaching methods to get better outcome. The information gained from this study will help teachers and institutes to make changes at nascent stages, so that they can benefit in producing well-learned skilled academicians at the end of their courses. Figure 3 shows the outline of the proposed model using MS Excel and applying multivariate regression analysis on the data obtained from the students (See Fig. 3).

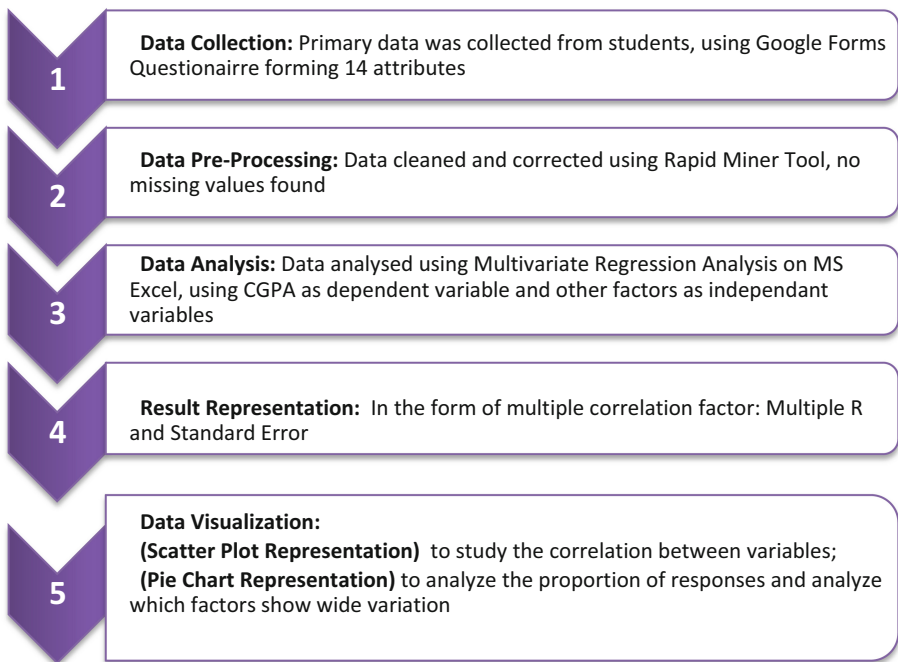


Fig. 3. Stepwise Process followed in Proposed Model

7 Conclusion

To conclude this paper, we must acknowledge the importance of analyzing educational data in institutions and other academic set ups to enhance the quality of education. Any type of data generated can be useful at some or the other stages to understand a

certain pattern among learners and these patterns can be a projection towards improved education system. If the educational data is effectively managed and analyzed, it can be helpful in understanding which courses are beneficial and which courses are becoming obsolete, it would help improve quality of teaching, optimize resource management and allow institutions to stay in touch with the demands of the learners. In this constantly growing field of study of education research, every step adds value to the education system.

Authors' Contribution. Ruchi Sehgal – Responsible for conceptualization, investigation, literature survey, methodology and writing of the paper.

Neetu Rani – Responsible for suggesting literature to be surveyed, revision of concepts, writing style of the paper and entire supervision of the research study.

Data Availability Statement. The datasets generated during the current study are available from the corresponding author on reasonable request.

Conflict Of Interest. The authors have no conflict of interest to declare. There is no financial interest to report. We certify that the submission is original work.






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The Contribution of Pilgrimage Tourism to Environmental Sustainability, Particularly in the Context of India

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Abstract. This paper deals contribution of pilgrimage tourism to sustainability. Despite the government's obvious investment in improving the nation's infrastructure, environmental impact from pilgrimage tourism has not been explicitly taken into account. Because of this, it became necessary to practice sustainable development in order to safeguard both the natural environment and man-made resources, such as sacred shrines and temples. The issues and challenges of pilgrimage tourism have been examined in the proposed study, and significant solutions have been provided to achieve sustainable negative impact mitigation measures in India. In order to collect qualitative data, the proposed study's research methodology utilized an inductive design and case study or journal analysis.

Keywords: Pilgrimage of Indian Tourism · Sustainability · Context of India

1 Introduction

In this literature survey on the other Outbound, inbound, and domestic tourism, on the other hand, are all types of tourism [1]. According to the process, a study of global tourism trends prompted the development of Indian tourism policy [2]. It has a lot of potential to provide needed employment opportunities, promote national integration, and earn money in foreign exchange. Pilgrimage tourism has grown significantly in importance over the past few years in India's various tourism categories [3].

Pilgrimage tourism refers to the journey undertaken by individuals to visit religious or spiritually significant sites such as temples or shrines [4]. It is closely associated with religious tourism. In India, pilgrimage tourism has proven to be a significant source

of foreign exchange earnings for the government. In the fiscal year 2017, the Indian government received approximately 51,587 INR in foreign exchange earnings from pilgrimage tourism. Furthermore, during the same year, the revenue generated by the tourism and hospitality sector experienced a growth of 5.1% [5].

However, in order to develop sustainable policies in India, immediate action is required due to a number of critical factors, such as the expansion of lodging facilities, the development of deforestation, and the disposal of waste in water bodies and landfills [6]. The research in the field of pilgrimage tourism and its connection to sustainable development has been relatively limited, particularly within this specific area of study. This research gap serves as the motivation behind the proposed study, as it aims to address this dearth of knowledge and contribute to the existing body of literature [7].

2 Proposed Work

The existing body of research on pilgrimage tourism in India has predominantly focused on infrastructure improvements, providing valuable insights into the topic [8]. However, an important aspect that has been overlooked in previous studies is the lack of examination of sustainable development policies and strategies implemented by the government. This gap raises concerns about the potential negative impact on the environment and the increasing pollution associated with pilgrimage tourism.

To address these concerns, it is crucial for India to develop well-crafted policies and strategies that prioritize sustainable measures for pilgrimage tourism [9]. The objective of this study is to conduct a comprehensive analysis of the issues related to pilgrimage tourism and highlight the need for sustainable development policies in India [10].

Furthermore, the study aims to provide significant solutions for the development of long-term strategies for pilgrimage tourism. Figure 1 illustrates the relationship between the physical environment and the modified environment, which will aid the Indian government and policymakers in understanding and implementing strategies that promote both growth and sustainability [11].

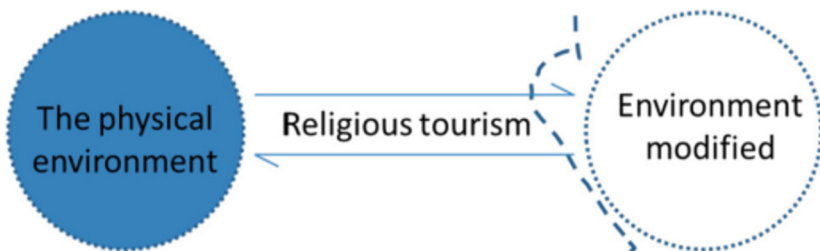


Fig. 1. Relation between physical and modified environment

The study’s objectives include [12]:

- examining the challenges posed by pilgrimage of Indian tourism for maintainable process;
- To investigate the requirements and advantages of maintainable process in India’s pilgrimage tourism industry;
- To provide significant solutions for the implementation of long-term strategies to boost India’s pilgrimage tourism and Fig. 2 defined the Major characteristic of religious tourism

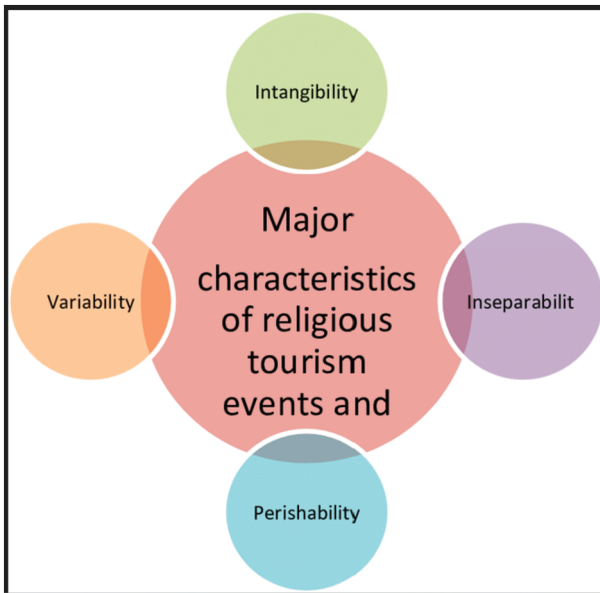


Fig. 2. Major characteristic of religious tourism

To enhance the quality of tourism services, it is crucial to devise strategies for planning and development [13]. Researchers have emphasized the significance of integrating various elements such as tourism organizations, transportation, the physical environment, services and information, and promotional activities for effective tourism planning and development in a particular region [14]. In contrast, argued that managing tourism-related environmental issues necessitates the implementation of a sustainable development plan. Due to the uniqueness of their heritage, it has also been agreed that cultural and historical sites must be protected, and efforts must be made to prevent physical destruction in order to facilitate efficient site maintenance [15]. As a result, protecting the environment and preserving cultural heritage are crucial.

Concerns about pilgrimage tourism in India, according to the article, India's air and water have become polluted as a result of a lack of attention paid to the environmental impacts of pilgrimage tourism [16]. In addition, it has been determined that the government's concern for the development of pilgrimage infrastructure and the physical environment is not well maintained in light of the rising number of foreign tourists, which has an impact on the sustainability and viability of tourist destinations [17–24]. According to the article that they proposed, other significant issues for the same.

3 Results and Discussions

Its findings make it abundantly clear that India's governance structures and policy framework for religious or pilgrimage tourism are inadequate. Additionally, significant tensions have resulted from the complexities brought about by the transition from traditional pilgrimage practices to a contemporary religious tourism economy. The researcher discovered that the tourism department's management at the local level is extremely conscious of its promotional and management practices, but they do not address the negative effects on the environment. In addition, the researcher has discovered a structural and systematic institutional gap in India's response to the direct and indirect effects of religious or pilgrimage tourism. Additionally, it has been determined that environmental-related issues are not being properly taken into account as a result of the proliferation of tourism government agencies. The religious actors do not take into account the significant pollution caused by challenges like congestion, large crowds, and high densities. In order to move beyond the traditional platform and achieve sustainable pilgrimage tourism in India, religious actors and government agencies must come together.

According to the research that was carried out, it is abundantly clear that one of the primary concerns that tourism regulators have is the preservation of the natural environment. The study clearly demonstrates that pilgrimage tourists and religious leaders are not particularly concerned about the environment. In addition, service quality is prioritized significantly more than environmental and infrastructure quality.

The researcher in the article presents a compelling argument highlighting the negative impacts of temple waste disposal on deforestation, pollution, and overall environmental degradation. To address these issues, the researcher advocates for investment from policymakers and the tourism industry to improve environmental quality through sustainable utilization of local and man-made resources.

The preservation of man-made infrastructure, such as temples, shrines, and other structures, also requires collaborative efforts from the government, nonprofit organizations, and the private sector. This alignment of responsibilities ensures the sustainable preservation of these sites, benefiting local communities and allowing future generations to enjoy them.

To achieve sustainability in pilgrimage tourism, it is crucial to focus on several primary components. These components include mitigating negative effects, maximizing benefits for local communities, and preserving sites for future generations to enjoy. Specifically, addressing environmental issues like waste disposal and air pollution is essential in minimizing the negative impacts of pilgrimage tourism on the environment.

By implementing sustainable measures, such as effective waste management systems and measures to reduce air pollution, pilgrimage tourism can become more sustainable, benefiting both the environment and the local communities involved.

The study highlights the negative effects of pilgrimage centers on the environment, emphasizing the need for more efficient and effective responses to accommodate the increasing number of pilgrims visiting India each year. The rising number of tourists puts significant pressure on natural resources in the region, particularly in terms of constructing infrastructure such as lodging facilities for pilgrims. This has implications for the physical environment and calls for measures to mitigate the environmental impact caused by the development of pilgrimage infrastructure.

Based on the findings of the study, it can be concluded that pilgrimage tourism has a significant negative impact on India's natural ecosystem and environment. The strain on essential services such as water supply, depletion of natural resources, pollution, and issues related to wastewater disposal and solid waste management are major concerns associated with pilgrimage tourism.

While pilgrimage tourism contributes to economic growth and generates revenue for the nation, it is crucial for stakeholders to acknowledge and address the environmental consequences. The study emphasizes the need for a thorough analysis of the impact of pilgrimage tourism by all relevant stakeholders.

Efforts should be made to implement sustainable practices and policies that minimize the negative effects on the environment. This may involve better management of water resources, waste disposal systems, and measures to reduce pollution. By addressing these issues, pilgrimage tourism can be more sustainable and contribute to the overall well-being of both the economy and the environment.

A significant threat to the environment is being posed by difficulties such as the expansion of lodging facilities, waste disposal in water bodies, and landfills. Government and religious leaders have given a lot of thought to the rise in urbanization brought on by the influx of tourists to pilgrimage sites, but not enough attention has been paid to the environmental threats. By achieving common goals and developing sustainable measures to mitigate the challenges and threats posed by pilgrimage tourism—particularly those pertaining to the environment—tourists, citizens, governmental entities, and others involved must take these issues into consideration. Religious tourism is defined as a type of tourism that reflects itself with socially responsible actions by respecting the sacred and thorough stewardship of sacred sites.

These policies and strategies should be followed by all members of the nation, including visitors from outside the country. For sustainable development to be possible and carried out, it is also necessary for government and local agencies to align their goals of protecting the environment and reducing pollution. On the other hand, visitors and local agencies need to be educated about the various issues associated with pilgrimage tourism. In addition, in order to eliminate the primary cause of pollution—plastics, waste disposal, water disposal, and air pollution caused by temple rituals—the government must prohibit certain materials or activities. The environment would be protected, sustainable development would result, and valuable and resource-rich man-made objects would be preserved. In Fig. 3 shows the economics environment of pilgrimages and Fig. 4 denoted the family affair of pilgrimages as it is Fig. 5 obtained as revenue growth in India.

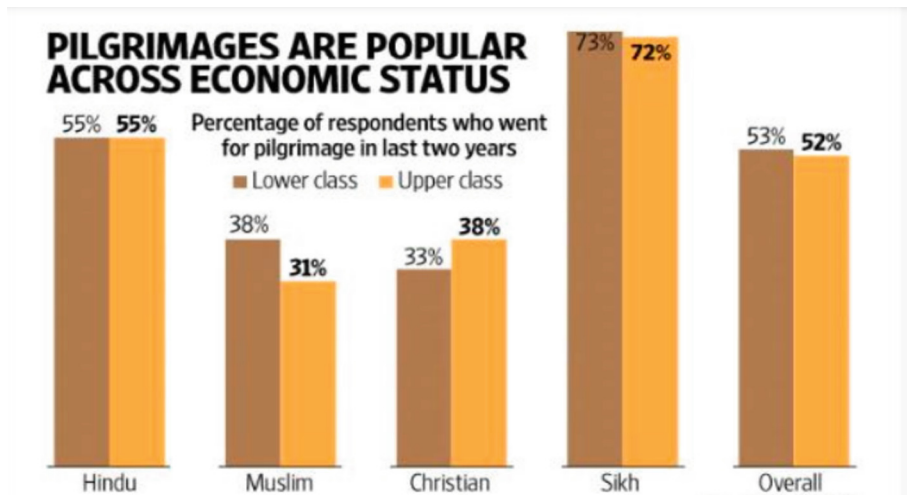


Fig. 3. The economics environment of pilgrimages

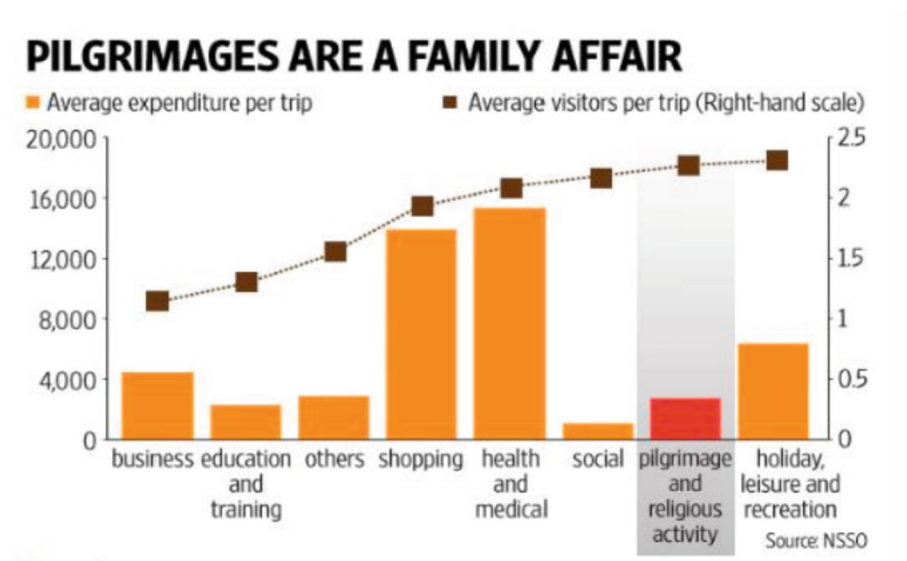


Fig. 4. The family affair of pilgrimages

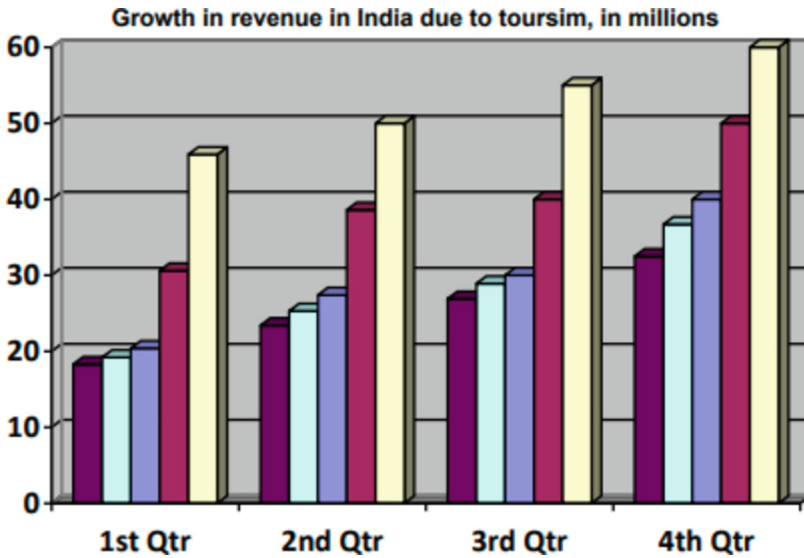


Fig. 5. The revenue growth in India

4 Conclusion

With the use of quantitative data and resources, this certainly opens up opportunities for future research. The fact that the entire study was conducted in India is the second limitation. As a result, its applicability to other nations and areas with pilgrimage tourism is limited. Additionally, this makes room for additional research. The study's limited time and resources were the final restriction. However, these limitations did not hinder the researchers' efforts to achieve the study's overall goals. In order to produce precise results based on the specific research area, demographic variables could also be integrated and accessed in the appropriate manner. Additionally, it provides a significant area of investigation for future studies.

5 Future Scope

The future scope of the study on the contribution of pilgrimage tourism to sustainability includes several potential areas of exploration and development. These areas can help to enhance the understanding and implementation of sustainable practices in pilgrimage tourism in India. Some possible future scopes:

1. Long-term impact assessment: Conducting a longitudinal study to assess the long-term environmental, social, and economic impacts of pilgrimage tourism. This could involve analyzing data over an extended period to understand the trends and patterns of pilgrimage tourism's effects on the natural environment and local communities.
2. Stakeholder engagement: Further investigate the role of various stakeholders, such as local communities, religious institutions, government bodies, and tourism operators, in promoting sustainability in pilgrimage tourism. Explore ways to foster collaboration and engage stakeholders in sustainable development initiatives.

3. Policy and governance: Analyze the existing policies and governance structures related to pilgrimage tourism and assess their effectiveness in addressing sustainability concerns. Propose policy recommendations and guidelines that can integrate sustainability principles into the planning and management of pilgrimage sites.
4. Technological advancements: Explore the potential of technological innovations, such as renewable energy systems, waste management solutions, and smart infrastructure, to minimize the environmental impact of pilgrimage tourism. Investigate the feasibility and implementation strategies of these technologies in the context of pilgrimage destinations.
5. Community-based initiatives: Investigate the role of community-based initiatives in promoting sustainable practices and empowering local communities. Examine successful case studies of community-led projects that have achieved positive environmental and socio-cultural outcomes in pilgrimage tourism.
6. Tourism education and awareness: Develop educational programs and campaigns targeting tourists, pilgrims, and local communities to raise awareness about sustainable tourism practices. Promote responsible behavior, cultural sensitivity, and environmental conservation among visitors to pilgrimage sites.
7. Comparative studies: Conduct comparative studies between different pilgrimage destinations in India or across different countries to identify best practices, success factors, and lessons learned in sustainable pilgrimage tourism. This could involve analyzing case studies, benchmarking sustainability indicators, and sharing knowledge and experiences.





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Towards Sustainable Development: Unveiling False Data with Machine Learning Techniques

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Abstract. FAKE data and news has increased rapidly to a large mass of people than ever before in this technology era, the main reasons coming from the direct messaging platform and rise of social media. Methods of false information subject matter introspection are innovative, varied, and exciting. With this study aims to apply machine and deep learning techniques for analytics of text and train different machine learning algorithms for discovering and examining fake data based on news heading or info. The study's solution is premediated to be used in actual social networking and media platforms and reduce the negative user experience of receiving false information from unreliable and untrustworthy resources. Using different algorithms, data cleaning and reprocessing such as data removal using PCA (principal component analysis), are used before vectorization them into sequence vectors using TF-IDFs (Terms frequency inverse document frequency) or dummy encoding for handling categorical data respectively. Output from the different algorithms are representing that model is trained with news data help in achieve maximum accuracy with different tools and different algorithms while model trained with news title need lower evaluation time to achieve a better efficiency.

Keywords: Machine Learning · TF IDF vectorizer · Random Forest Classifier · Logistic Regression · Support Vector Machine · K Nearest Neighbours · Passive Agressive Classifier

1 Introduction

This issue of false information is a major problem in this modern digital era, with “fake news” referring to news, information, or reports that are wholly or partially untrue. The circulation of false data can have wide-ranging and negative consequences, both for individuals and for society as a whole. It has the potential to quickly and easily propagate. Fake news also roles a significant threat to national security, the economy, and the well-being of individuals. Unfortunately, many people are unaware of the influence which false information and data can have on their lives and may inadvertently spread false information. With billions of articles being published daily, controlling the spread of false information is a difficult work. Therefore, it is essential to develop mechanisms to limit the exponentially increasing of false news stories.

WhatsApp, in particular, has been a major platform for the spread of false [1] information, with 2 million user accounts being closed-off monthly to prevent the circulation of false information. Fake data has not only affected personal relationships but also politics, with the Brazilian elections in 2018 being poisoned by fake news spread through WhatsApp. WhatsApp has tried to encounter the spread of fake news by developing an automated system to remove millions of fake news [2] messages, but it is difficult to determine how many accounts were misclassified as fake news in the process.

2 Problem Statement

Social networking sites has revolutionized the way masses connect and disclose with one another, making it easier and more accessible than ever before. However, this has come at a cost to the quality of interpersonal relationships, which is at risk due to the common use of social media in daily life. People have become depent on social media applications and have made them an crucial part of their lives. With the advancement of technology, social media usage continues to increase, creating a global community where individuals can connect with anyone, anywhere in the world. While this has provided opportunities for people to interact with strangers from diverse backgrounds, it has also created opportunities for hackers to access people's vital information, resulting in cybercrime.

The impact of social media can be far-reaching and can affect interpersonal relationships negatively when people enable network platforms to control their way of communication. One of the major issues associated with social media is the spread of false data and info and misleading content, which can cause mess, disorder and reports to circulate. This can have devastating consequences for individuals, such as committing suicide. Existing systems for detecting fake news and disinformation have been center on on-line checks and publicly posted content on social networks. However, it can challenge to find false information because it may exist in various paradigm, and there is have been significant advancements in natural language processing frameworks.

3 Proposed Solution

The proposed project aims to address the problem of misinformation and false information by developing different models to detect them. Each will be fed with various data vectors of news data, title and news subject-content for comparison on model performance. The models are as follows:

1. TF IDF vectorizer
2. Random Forest Classifier
3. Logistic Regression
4. Support Vector Machine
5. K Nearest Neighghours
6. Passive Agressive Classifier

The machine learning workflow suggested by Google developers will be used for developing the proposed solution, as it has been shown to work effectively in spam mail classification that also involves text analytics and classification. This model start with data collection, followed by news-dat-content explore, data preprocessing and data preparations, model training, evaluation of algorithm, and at last, model deployment as shown in Fig. 1 [3].

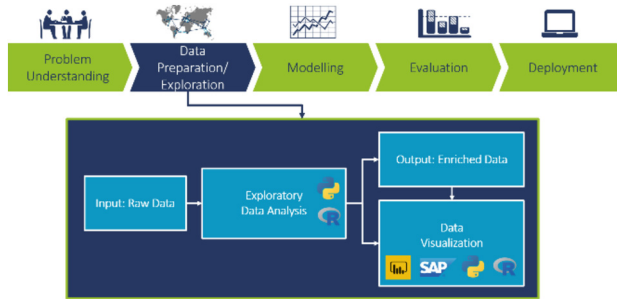


Fig. 1. WORKFLOW of MACHINE LEARNING

3.1 Data Collection, Integration and Clean-Up

The objective of this project is to build a model which can classify news as real or fake based solely on their titles or content, without being biased towards any particular news source. To achieve this, a dataset of news articles can be collected from various resources [9] like Google Dataset Search or Google Scholar or Kaggle. By removing dependency on news sources, the model can be more generalized and effective in its classification task.

The project focuses on using English language news because it has more open-source news datasets available online and more English-language text analytics and categorization research is being done. Additionally, English news is delivered everywhere which drives the motivation for the work. With respect to less time and the effort required to integrate data, the project collects a US English news dataset from two different various Kaggle sources. Both sources have similarity labels, including news title, news content, and news labels (“real” for real news and “fake” for false information). Other fields such as the URL source are not mentioned as being relevant to the project [4].

During the data cleaning process, it is standard practice to remove certain columns such as ID and URL that are not necessary for analysis. Additionally, any rows with missing, duplicate, or inconsistent values are typically removed. Moreover, some news titles or contents had special characters such as newlines or tabs, which caused the text to be split into multiple rows or columns within the CSV file. To prevent such issues, these problematic rows were also removed.

3.2 Data Exploration

After collecting the data, the process of data exploration is crucial for understanding the characteristics of the dataset and identifying any patterns that may exist [5]. Additionally, exploring the information helps to lower the chance of having highly un-balanced data, which impact a major influence on the evaluation of any models trained on the data in the later stages.

Once the dataset has been gathered, integrated then cleaned, exploration stage can be evaluated to visualize and analyze various aspects of the data, such as the apportionment or ratio of false data and genuine data, counts of word, or even plot them to display the highly common words. It is important to note that this process should be carried out with care and attention to detail, as inaccurate or biased data exploration can lead to incorrect conclusions and potentially harm the effectiveness of any downstream analyses or models.

3.3 Data Preparation

Data preparation is an essential stage in which data is transformed and structured in a way that a machine can comprehend and process [6]. A crucial tool in data science for pattern matching is regular expression, which involves specifying text search strings. It performs several basic activities, including word and sentence segmentation as well as stemming [7]. Tokenization of words is simply a series regular expression substitutions. Stop words refer to common words that are typically removed when creating an index, such as “the”, “a”, “on”, “are”, “around”, and many others that can be easily found online.

Data preparation involves preparing data by applying various data processing techniques, like as regular expressions to remove special symbol and punctuations, tokenization to split text into words, lemmatization to convert words to their base form, and limit word removal to eliminate words with no meaning. The next step is this to obtain keywords and convert them into numerical vectors using vectorization.

The N-gram model is a commonly used tool in natural language processing that involves breaking down a sample of text into contiguous sequences of n items. The model then estimates the proportion of words sequence by analyzing the frequency of the preceding words in a given the result to a sentence or any other vector of words. On the other hand, TF-IDF, is a statistic used in information retrieval to reflect the significance of a term in a article. It does so by increasing the weight of a word based on how often it appears in the document while taking into account the fact that some words may occur frequently in general. Finally, one-hot or dummy encoding is a setup to change words into numerical vectors, such as binary vectors with “0” and “1,” which are used to represent textual data as a series of numbers that a machine can process.

Using different uni-gram, bigram and trigrams vectorizations methods with encoding using TF-IDF to generate arithmetic vectors that provide result for each. TF IDF Vectorizer method is employed in Python to convert data title and information into N-grams which calculate their TF-IDF values. The resulting answer is a matrix of sparse of $n \times m$, n & m represents the of row number and m represents the length of vocabularies.

Sequence vectorisation is a technique used to convert a vector words in arithmetical vectors found on their indexes of token. In contrast to N-gram vectorization, the entire sequence is transformed into a vector. These vectors are then one-hot encoded to create matrices consisting of only 0s and 1s. The size of the vocabulary determines the number of dimensions in the matrices. The result is a numerical vector representation of the words in a news title or content.

3.4 Model Training

The graph in Fig. 2 suggests that commonly known machine learning algorithms such as Decision Tree and BayesNet, Support Vector Machine are not meeting the expectations and failing to achieve at least 90% accuracy and recall rate [8]. Research shows that to find fake news passive aggressive is best. As shown in graph, it can be seen Passive Aggressive Classifier is finding the highest accuracy of all after the K-fold cross validation. As a result, passive aggressive is identify fake news in best manner.

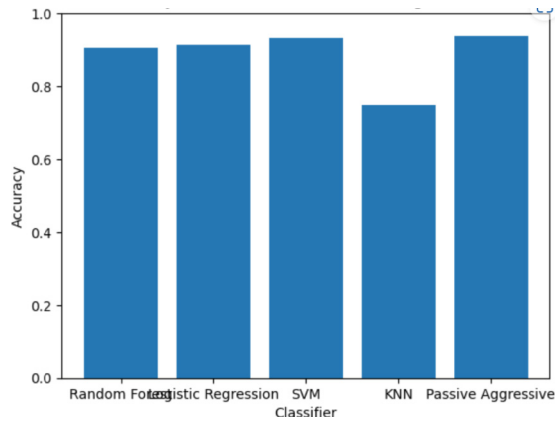


Fig. 2. Accuracy on different Machine Learning Algo

The jupyter notebook model's last layer, also called the output layer, is equipped with a function (sigmoid activation). This ensures that the model's result is in binary format, which is ideal for this project because there are only two possible outcomes: "0" denotes real news, and "1" denotes fake news. To minimize overfitting and improve generalization, the model implements early stopping. The training set comprises 80% of the news dataset, with the left-out 20% serving the testing set. To validate the model before evaluating it with unseen data, 20% of the training dataset would be employed as the data-validation dataset.

3.5 Evaluation

This model will undergo testing on a previously unseen test dataset to assess their performance using metrics such as computation calculated time, recall and accuracy.

With the main purpose of accuracy score matrix in the model is to gauge the models' ability to accurately classify genuine and false data. A greater accuracy score indicates that this project can highly probable to correctly differentiate in between real and false dataset.

This accuracy of a modal may not always be optimal, but it can be still useful if it can correctly predict false information, that is the main objective if this project. The recall matrix is employed in assess the modal's ability to identify fake news correctly. A higher recall indicates a greater likelihood that the model can accurately classify fake news. For the project, recall is crucial, when the recall rate is max and actual false news is identified, the spread of false information on social media could mitigated.

The notebook model's last layer, also called the output layer, is equipped with a function(not-default). This ensures that the model's output is in proper format, which is ideal for this project because there are only two possible outcomes: "real" denotes real data, and "fake" denotes false data. To minimize overfitting and improve generalization, the model implements early stopping. The training set comprises 80% of the news dataset, with the left-out 20% serving the test set. To validate the model before evaluating it with unseen data, 20 percent the training data-set will be employed as the valida dataset.

3.6 Deployment of Model

While thie model is not focused on deploying the model in real-world social media platforms, it could be beneficial to propose this ouput to such company as a means to prevent the spread of fake news and mitigate potential negative outcomes.

4 Results and Discussion

With the exception of deployment of model, which has not results to display because the model has not been deploy, each stage of the machine learning workflow's results is shown in this section. Additionally, the output performance of four different algorithms will be displayed.

4.1 Data Cleaning and Collection

The final dataset will have different colums namely title, label, and content which represent the news title, data label, and information respectively. This dataset will be created by collecting two datasets, merging them together, and removing any errors or inconsistencies.

4.2 Exploration Stage

During the exploration of data, it is important to examine the label ratio of the dataset to determine if it is not balanced, that can potentially impact the results of the training of model in next lator stages. This can be accomplished by obtaining the total range for each fake and real data label and creating a bar chart, as shown in Fig. 2. Based on this graph analysis, it can be seen that the dataset is balanced, with the proportion of real

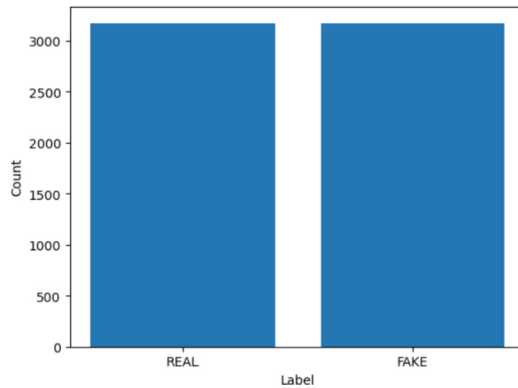


Fig. 3. REAL and FAKE data label

news to false news being approximately equal, or close to 50:50, you can see this in Fig. 3.

The article analyzes the occurrence of words in real and fake news by plotting their counts of word in x-axis. Two figures are presented, one depicting the for real news and the other showing the same for fake news. The analysis reveals that certain words such as “said,” “Trump,” and “one” appear common in both real and false data, suggesting that the word may not contribute significantly to distinguishing between the two categories and could be given less importance when train the dataset in the model.

4.3 Preprocessing of Data

Before feeding the dataset titles and dataset to the model, they undergo two pre-processing stages: text preprocessing and vectorization. In the text preprocessing stage, several techniques such as TF_IDF, PCA(Principal Component Analysis) and limit text removing are applied to each row in article heading and data in order to extract terms. This is done to obtain a cleaner and more meaningful representation of the text data. The resulting output of this stage is a processed version of the original text.

In other words, the first step is to clean and transform the text data of a news title using pre-processing techniques. Then, the processed text data is converted into numerical vectors. These numerical vectors are combined into a single matrix to represent the original news title and content in a numerical format. Finally, the resulting matrix is presented in the form of a figure.

We used several cross-validation strategies (k-fold cross-validation) which give a more accurate estimate of output and limit the danger of overfitting.

4.4 Training of Model

Python and its Sci-kit libraries were employed. There are many libraries and extensions for Python that can be used for machine learning.

Nearly all of the machine learning algorithms that are freely available for Python are included in the Sci-Kit Learn package, which contains the majority of machine learning algorithms. As a result, it is simple and quick to identify fraudulent items.

Now, move to Modeling part in which we will classify and train the model with different ML classification algorithms.

The initial stage in training an machine learning model is to provide data training to an machine learning algorithm (also known as the learning algorithm). An machine learning model is the byproduct of the training procedure that was created.

The training data must contain the proper response, often known target feature or target. The learning algorithm looks for similarities in the data training which link the properties of the input content to the result (the outcome you want to predict), and then creates machine learning model that incorporates the similarities.

The use of news content in training language models can improve their performance significantly. However, this also comes with the disadvantage of requiring more algebraic time dues to larger size of vocabulary.

Table 1. Accuracy and Confusion Matrix from all ML algos

S. No	Model	Accuracy	Confusion Matrix
1	Random Forest	90.61%	[[570 58] [61 578]]
2	Logistic Regression	91.4%	[[585 43] [66 573]]
3	Support Vector Machine	93.29%	[[598 30] [55 584]]
4	K Nearest Neighbours	74.82%	[[596 32] [287 352]]
5	Passive Aggressive Classifier	94.0%	[[587 41] [35 604]]

Training machine learning models using news titles requires less computational time compares to training models with entire dataset content. Although training models solely on data can provide maximum recall rates, and accuracy, using news titles is a practical approach due to the reduced computation time required. This is an important factor to consider when selecting the appropriate data for training machine learning models.

Table 1: Accracy of Different Models:

Of all the training models referred to Table 1, the highest accuracy has been given by Passive Aggressive Classifier model.

We have at last done the Ensemble using Voting classifier.

Accuracy: 93.21

Confusion Matrix:

[[599 29]

[57 582]]

Which has given the accuracy of 93.21 which is less than the accuracy of Passive Aggressive Classifier.

Social media platforms like WhatsApp and WeChat are commonly used for talking and social network. Users have a tendency to respond quickly to incoming call and messages, and as a result, false information can scatter rapidly if someone intends to do so. To address this problem, models which could quickly detect false data with high accuracy and recall rates are essential. One possible solution is to train models using news headlines, which could be used to detect false data. Although models trained using news content may take longer to compute, they could be useful for detecting false information on social media platforms like Instagram, Twitter, and Facebook, where false data often comes from posts/feeds. Detecting false information as it is published may not be necessary because users' feeds may not update immediately, but having a highly accurate and reliable model can quickly remove fake news from feeds once it is detected.

4.5 Model Interpretability

In machine learning, the PCA(principal component analysis) method is frequently employed. For reduction of dimensionality and data visualization. It can also be used for model interpretability, as it helps in identifying and understand the most important feature or components that contribute to the variance in the data.

In the provided code snippet, PCA is applied to the TF-IDF vectorized text data. It is frequently used in text classification tasks. The PCA class from the sklearn.decomposition module is used to perform PCA, and the n_components parameter is set to 2 to minimize the dimensionality of these data to two principal components.

Next, the PCA transformation is applied to the training dataset and test datasets using the fit_transform() and transform() methods, respectively, to obtain the reduced-dimensional representations of the text data. These transformed data points are then presented using a scatter plot graph with the principal components one and principal components two as the x & y axes, respectively.

The scatter plot is colored based on the labels (y_train) to visualize the spread of data points from different classes into reduced-dimensional spaces. This can provide insights into the separability of different classes and the potential presence of clusters or patterns in the dataset.

By visualizing the text data referred Fig. 4 in a lower-dimensional space using PCA, we can gain a better understanding of the inherent structure and patterns in the data, which can aid in model interpretability. For example, we can identify if the classes are well-separated or overlapping, if there are any outlier data points, or if there are any discernible patterns or trends among the data points. This information can help in interpreting the interpretation of the machine learning models, and making informed decisions in terms of model selection, feature engineering, and hyperparameter tuning to improve the model's precision and generalization performances.

**Below figure explained variance Proportion of Principal Components:
Principal Component 1: 0.03**

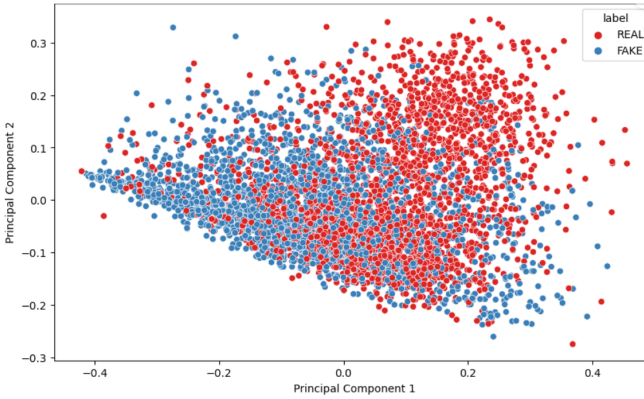


Fig. 4. PCA Visualization of Text Data

Principal Component 2: 0.01

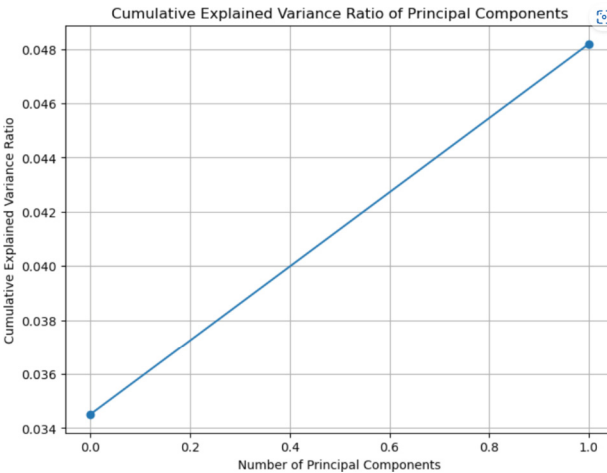


Fig. 5. Explained Variance Proportion of Principal Components

Explained Variance Proportion of Principal Components calculate and plotting of the explained variance proportion and cumulative explained variance proportion of principal components obtained from PCA in Fig. 5. The explained variance ratio shows the proportion of the variance total in the data that is explained by each principal component data that is explained by the first n principal components. These metrics can provide insights into how much information is retained by the reduced-dimensional representations obtained from PCA, and help in determining the optimum figure of principal component to hold for model interpretability.

Additionally, you can further customize the visualization, such as changing the color palette, adjusting the figure size, or adding additional annotations, to suit your specific requirements and preferences for interpreting the text data.

5 Conclusion

To summarize, the project work has found that the best performing model can achieve 93.6% accuracy for detecting fake news, with very few errors. They use TF-IDF to assign a weight score to most significant words. Model is trained with data label are adequate for social media applications with their fast computational time and higher recall rate. Such models can quickly detect and can control the spread of false information. However, for applications with constantly updated feeds, model training with data content would be a good choice as they have higher accuracy and recall. Overall, these findings suggest that machine learning models are effective in discovering false information and can be tailored to various application scenarios based on their strengths and limitations.

To enhance the accuracy and recall of models for discovering false information, future improvements could include parameter tuning and the use of others. Additionally, there is a potential for further research to improve the models by analyzing images, videos, and text within images. To adapt this solution for similar other techniques or algorithms may be used in model training on the dataset collected and integrated. Furthermore, experiments can be conducted on news to further develop and refine the models.

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