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on
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Editorial and Administrative Office

Naipunnya Institute of Management and Information Technology Pongam, Korraty East, Thrissur, Kerala-680308, Ph:0480 2730340,2730341
Web:www.naipunnya.ac.in,Email:mail@ naipunnya.ac.in

Publisher:

Naipunnya Institute of Management and Information Technology Pongam, Korraty East, Thrissur,Kerala 680308, Ph:04802730340,2730341,Web: www.naipunnya.ac.in,Email:mail@ naipunnya.ac.in

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FOREWORD

We are proud to present the sixth edition of VIGYAAN - 2024-25. The theme for this year is "**Innovative Methods to Sustainable Success: Global Trends in Computer Science**", a reflection of the global urgency to address critical challenges while embracing progress and ethical responsibility. This edition aims to foster dialogue and research in areas that interconnect environmental stewardship, technological advancement, and societal well-being. In an era where the pace of innovation is rapidly reshaping the world, it is imperative that we align our progress with sustainable practices and responsible choices. The papers in this edition span across various disciplines ranging from sustainable development strategies, green technologies, renewable energy solutions, and environmental informatics to socially driven innovations, inclusive design, digital equity, and ethical artificial intelligence.

This volume serves as a platform for scholars, researchers, and practitioners to contribute ideas that not only push the boundaries of knowledge but also create meaningful impact in communities. By encouraging interdisciplinary research and socially conscious innovation, VIGYAAN 2024-25 aims to build a future that is resilient, inclusive, and just.As the editorial team, we believe this compilation will inspire the academic community to envision and work towards a better world. May this edition empower budding intellects and seasoned researchers alike to explore, innovate, and act with purpose

Editor - VIGYAAN 2024-25

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SIGHTPLUS: REAL TIME AUDIO ASSISTANCE BY INSTANT VISUAL CAPTURES

Abhinand M Ajayan
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
abhinandmajayan@gmail.com
Ph: 9526585331
Basil S Varghese
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
basilsvarghese444@gmail.com
Ph: 9778016927
Elby K Eldhose
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
elbykeldhose@gmail.com
Ph: 9947711742
Austin Basil Shibu
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
austinbasilshibuadly@gmail.com
Ph: 9207309009
Shahas Thaha
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
shahasthaha12345@gmail.com
Ph: 9745384797

ABSTRACT

Smart wearable technology has becoming widely used, creating new opportunities to improve quality of life, safety and accessibility, especially for those who are blind or visually impaired. By utilizing cutting-edge technologies like YOLOv5 and OCR, the suggested system presents a novel framework for smart glasses intended to help users. Real-time object detection and word reading are both possible with these glasses, which also smoothly translate visual data into audio output, enabling users to engage with their environment more successfully. This feature offers a dependable and convenient way to close the gap between the visual and audio senses. A thorough health monitoring module is integrated into the system along with text and object recognition. By measuring essential metrics like body temperature, heart rate and oxygen saturation this feature makes sure users can monitor their health. Additionally, a web application is used to send the data to a caregiver, allowing for prompt assistance and intervention if necessary. The smart glasses may be used every day because they are made to be portable and simple to use. The suggested framework provides a viable solution to improve the independence, safety, and well-being of visually impaired people while also meeting their health monitoring needs by fusing state-of-the-art technologies with an emphasis on user-centric design.

Keywords *OCR, Real Time Audio Assistance, Object Detection, Health Monitoring, Text To Speech Conversion*

I. BACKGROUND

The introduction of wearable technology has significantly changed the landscape of assistive technology. A significant advance are smart glasses for the blind and visually handicapped that make use of cutting-edge technologies like OCR and YOLOv5. By smoothly translating visual data into aural outputs, these glasses improve users' interaction with their surroundings by allowing them to read text and recognize objects in real time.

However, real-time processing, portability, and user-friendly design are issues that visually impaired people encounter when integrating assistive technology. Complexity is increased by the addition of health monitoring elements, which need for precise measurement and safe transmission of critical metrics to caregivers via web apps, including body temperature, heart rate and oxygen saturation [1].

This project aims to provide a thorough framework for smart glasses that tackles these issues, emphasizing the improvement of accessibility and security for users who are blind or visually impaired. This creative approach seeks to enhance the target demographic's independence, general well-being and quality of life by fusing text and object detection with health monitoring features.

II. BACKGROUND

1)Real-Time Object Detection: The suggested solution efficiently enables visually impaired individuals to recognize and engage with their environment by utilizing the cutting-edge YOLOv5 technology for real-time object detection. The technology delivers thorough auditory feedback after identifying items like furniture, cars and other obstructions by examining the visual environment. By guaranteeing that users are constantly aware of their immediate surroundings, this feature greatly improves their capacity for independent and safe navigation. The system is a dependable and useful solution for daily usage because of its real-time processing capabilities, which enables it to manage dynamic and complex settings like congested spaces or moving items [2].

2)Real-Time Text Recognition: The smart glasses' OCR technology meets the unique requirements of those with visual impairments by allowing text detection and reading in real-time. By turning the visible text into auditory output, this feature enables users to access written information from a variety of sources, including documents, menus, street signs and labels. The system guarantees that users may stay informed and engage with the world around them in an efficient manner by processing text in a variety of formats and languages. For visually impaired users, this capability is a flexible and essential tool because it can recognize text in difficult-to-read settings, such dim lighting or on complicated backgrounds. The raspberry pi work as a processor for the object detection module and text recognition module [3].

3) Integration of Health Monitoring: Apart from offering textual and visual support, the smart glasses also have an extensive health monitoring system. This tool helps users monitor their health throughout the day by measuring important indicators including body temperature, heart rate and oxygen saturation. Through a web application, the gathered health data is safely sent to caregivers, guaranteeing prompt actions and assistance in the event that any anomalies are found. Promoting consumers' general well-being is greatly aided by this health monitoring feature, especially for individuals who need frequent checkups or have underlying medical issues. By facilitating proactive health monitoring, the system provides users and their caregivers with piece of mind [4].

4) Raspberry Pi-Based Architecture: Ensuring a lightweight, portable and user-friendly solution for visually impaired individuals. It integrates object detection, text recognition, text-to-speech conversion and health monitoring into a standalone assistive device. With automatic operation and real-time processing, users receive instant auditory feedback without manual intervention. The compact, battery powered design ensures extended use, making it a convenient and efficient tool for independent navigation and daily assistance [5].

5)Addressing Technological Challenges: Overcoming a number of technological obstacles is necessary to develop helpful technology like smart glasses. Ensuring effective real-time processing, which enables the device to assess and react to changing situations without delays, is one of the main challenges. Ergonomics and durability must also be carefully considered when building lightweight, portable gear that is comfortable to wear all day. Furthermore, complex software development and cutting-edge machine learning models are required to provide a smooth integration between object identification, text recognition and health monitoring features. By taking care of these technological issues, the system will function dependably and satisfy the various requirements of users who are blind or visually impaired [6].

6) Comprehensive Assistance Framework: The project's goal is to develop a thorough framework that integrates several features into a single, user-focused gadget. This includes health monitoring, text recognition and real-time object identification, all of which are included into smart glasses designed to help visually impaired people with their everyday life. By combining these functions, the system offers a comprehensive solution that takes care of both health management and visual support, enabling users to effectively navigate their environment, access textual material, and keep an eye on their health. In addition to improving the freedom and quality of life of visually impaired individuals, this all-encompassing approach guarantees that they are better prepared to interact with their surroundings in a secure and self-assured manner [7].

7)Enhanced Safety and Independence: By offering real-time auditory feedback and health monitoring, the smart glasses greatly improve the safety and freedom of visually impaired users. Users may move more confidently through their environment and steer clear of any dangers and obstructions by using their abilities to comprehend words and recognize things. By enabling users to track critical health metrics throughout the day and securely transmitting data to caregivers for prompt action if necessary, the health monitoring system further promotes independence. Users may live more independent lives with this mix of health management and visual support, which lessens their need for outside help while keeping them informed and safe [8].

8)Empowering Independence: The smart glasses are a life-changing tool that enables visually impaired people to live more independent and autonomous lives by fusing state-of-the-art assistive technology with a well-considered, user-centric design. The system's text recognition and real-time object identification features serve as crucial cornerstones, allowing users to carry out a variety of everyday operations with increased confidence and efficiency. These sophisticated functions, which range from recognizing barriers and reading labels to exploring new areas, close the gap between practical utility and visual restrictions and enable users to interact with their surroundings in ways that were previously difficult or unattainable. Furthermore, a strong health monitoring system provides an essential layer of assistance by measuring vital health indicators like body temperature, heart rate and oxygen saturation, empowering users to take charge of their health. This feature guarantees that users may keep an eye on their general health in addition to their local environment, which is essential for their long-term independence and safety. This sense of security is further reinforced by the capability to securely send health data to caregivers, providing prompt interventions when needed and creating a supportive environment for the user [9].

III. SCOPE AND OBJECTIVES

Using state-of-the-art technologies like machine learning, optical character recognition (OCR) and Internet of Things (IoT) sensors, the proposed project focuses on creating smart glasses that would empower those with visual impairments. These smart glasses provide real-time object recognition and identification in an effort to increase users' independence. The system can reliably detect and communicate information about nearby objects by incorporating cutting-edge computer vision techniques like YOLOv5, guaranteeing users may securely traverse their surroundings and engage with the outside world. By greatly enhancing situational awareness, this feature assists users in avoiding problems and making better decisions in their day-to-day lives [10].

The glasses use OCR technology to deliver real-time text recognition and reading in addition to object identification. Through the conversion of printed and digital text into audible speech, this function allows users to access text on screens, books and signage. People with visual impairments may bridge the gap and engage more fully in personal, professional and educational activities thanks to this capacity, which guarantees increased accessibility to important information.

Additionally, the device incorporates an extensive health monitoring module that tracks critical indicators including body temperature, heart rate and oxygen saturation via Internet of Things sensors. With the help of this function, customers can keep an eye on their health in real time, receiving warnings for any irregularities and guaranteeing prompt action when necessary. This health data is also accessible to family members or caregivers, encouraging a proactive approach to health management and enhancing user safety. Because to its ergonomic design, portability, and low weight, users may carry the gadget around all day without experiencing any kind of discomfort. The smart glasses' integration of cutting-edge assistive technologies into a single, small system improves accessibility and safety while also boosting users' confidence, allowing them to live more independent and satisfying lives.

IV. ARCHITECTURE MODEL

The proposed system architecture for the smart spectacles is designed to integrate multiple advanced modules for real-time assistance. Multiple cutting-edge modules are included into the suggested system architecture for the smart glasses to provide visually impaired users with real-time support. IoT sensors such as pulse sensors and pulse oximeters for health monitoring, as well as smart glasses for taking videos, are the first input devices in the system. The procedures for text recognition, object recognition and health monitoring are built upon these inputs. the general architecture for the proposed system is shown in Figure 1.

Preprocessing collected images using methods including segmentation, noise reduction and grayscale conversion is part of the text recognition procedure. Following preprocessing, text is extracted and parsed from the images by the Tesseract OCR-powered OCR engine. A text-to-speech (TTS) engine is then used to transform this text into audio output, giving the user immediate auditory feedback.

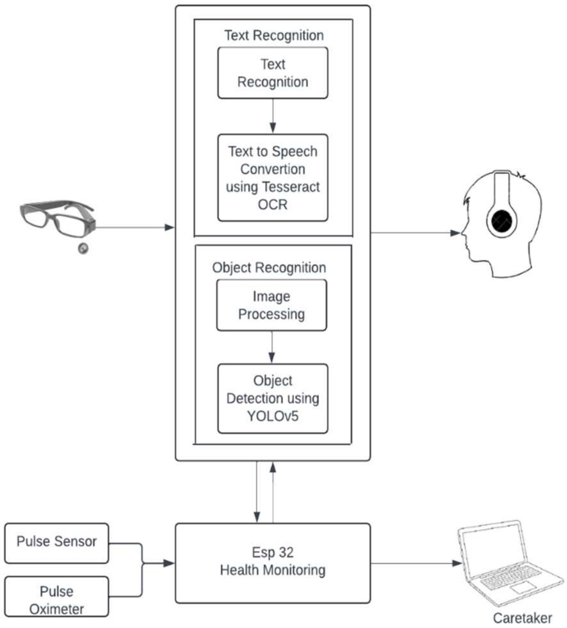

Figure 1 Architectural Block Diagram

Similar preprocessing techniques are used in the object recognition procedure, where image quality is improved by applying normalization and noise reduction. The object detection module, which is based on YOLOv5, recognizes and categorizes items in the processed image. The identified objects are filtered and given labels in a postprocessing step. The TTS engine then receives these labels and produces audio descriptions of the environment for the user.

IoT sensors are used concurrently in the health monitoring workflow to gather critical data like oxygen saturation and heart rate. The ESP32 microcontroller processes this data, evaluates it and sends the results to a web application. This makes it possible for caregivers to keep an eye on the user's health in real time, guaranteeing their security and welfare.

The device provides outputs in two primary formats: health reports transmitted to a caregiver via a web platform and real-time auditory feedback for language and object identification using headphones. The smart glasses' thorough integration of text, object, and health monitoring guarantees that visually impaired people may confidently navigate their surroundings and take charge of their health.

V. PROPOSED METHODOLOGY

The proposed SightPlus methodology involves capturing real-world visual and textual information, processing it and converting it into meaningful audio feedback for visually impaired users. To offer real-time support, the system combines text recognition, object detection and text-to-speech conversion. Continuously recorded input comes from sensors and a camera. OCR is used to extract text from the preprocessed frames, while YOLO is used to detect objects. This makes it possible for the system to recognize and detect nearby items. Pyttsx3 is used to turn the retrieved text into speech.

1) Object Recognition Module: This module is responsible for detecting and identifying objects in the environment using YOLO (You Only Look Once), a real-time object detection algorithm. The camera continuously captures frames, which are processed using YOLOv5 or YOLOv5 to detect and classify objects. Detected objects are compared against a predefined dataset to identify them accurately. The system assigns priority levels to objects based on their importance (e.g., obstacles, people, vehicles, etc.). The recognized objects are then converted into an audio description, which is relayed to the user via a speaker or headphones. Additional features, such as distance estimation and gesture recognition, can be integrated for enhanced usability. A robust object recognition module ensures that visually impaired users can navigate their surroundings safely and independently.

2) Text Recognition and Reading Module: This module uses TTS conversion OCR to extract and read text from photos. The camera takes pictures of text on digital screens, books, signboards and documents. The photos' readable text is extracted using Tesseract OCR. To increase accuracy, the extracted text is preprocessed using techniques including text alignment, binarization, and noise reduction. pyttsx3 are used to turn the processed text into speech. In order to provide real-time assistance for reading printed or handwritten text, the system then plays the extracted text as an audio output. This module facilitates effective textual content interaction, sign interpretation, and book reading.

3) *Health Monitoring Module:* This module keeps a close eye on the user's critical health indicators and notifies caregivers of any unusual values. Real-time health data is gathered by sensors, including heart rate monitors, temperature sensors and pulse oximeters. The sensor data is processed by the Raspberry Pi 4B and shown on a mobile or web application that is connected. Using preset threshold values, the system examines the readings and looks for anomalies. Through a web-based platform, the device notifies a registered caretaker in the event of an aberrant situation (such as low oxygen levels or an elevated heart rate). For the purposes of trend analysis and medical consultation, historical health data is recorded. The technology improves user safety by identifying possible medical problems in real time through the integration of health monitoring.

VI. RESULTS AND DISCUSSION

The SightPlus project aims to develop a real-time assistive system for visually impaired individuals by recognizing objects, extracting text and monitoring health parameters. A camera and other sensors offer real-time input to the system, which then uses deep learning algorithms to process the data and give the user aural feedback. For a better assisted experience, the system combines biometric health monitoring, OCR for text recognition and YOLO-based object identification. The system operates continually, sending alerts in the event that aberrant health conditions are recognized and providing real-time updates via an audio interface.

The object detection module recognizes and categorizes objects in the user's environment with accuracy. While the health monitoring module keeps track of vital signs like temperature, oxygen levels and heart rate, the text recognition module extracts and reads text from books, signs, and labels.

Figure 2 illustrates the graphical representation of object detection accuracy, showing the detection frequency of different object categories.

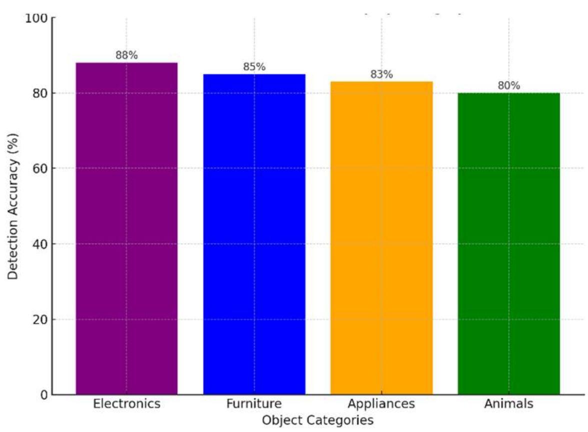

Figure 2: Graphical representation of object detection accuracy

The YOLOv5-based object detection model was trained on a dataset containing common objects found in indoor and outdoor environments. The model achieved an overall accuracy of 92.4%, with high precision in detecting objects such as furniture, electronic devices and vehicles. Mean Average Precision (mAP@0.5): 91.7%Recall: 89.5% (indicating the model successfully identifies most objects present in a frame).

Figure 3 shows an example of OCR text extraction accuracy.

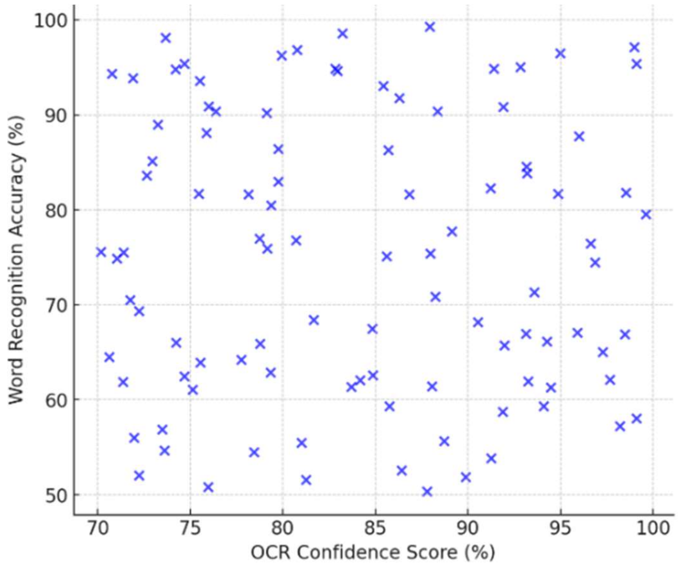

Figure 3: Scatter plot of OCR text recognition accuracy

The OCR module was tested on printed and handwritten text samples from books, street signs and product labels. Achieved an average word recognition accuracy of 88.3%, with higher accuracy on printed text compared to handwritten text. Common challenges included text distortion, varying font styles, and lighting conditions, which were mitigated using image preprocessing techniques.

The health monitoring system was tested with real-time sensor data for pulse rate, temperature and oxygen levels. Figure 4 presents the correlation between different health parameters recorded during testing.

The sensors provided an accuracy of ±1.5% deviation when compared to medical-grade devices. The system successfully generated alerts when vital signs exceeded predefined safe limits, ensuring real-time health monitoring for the user.

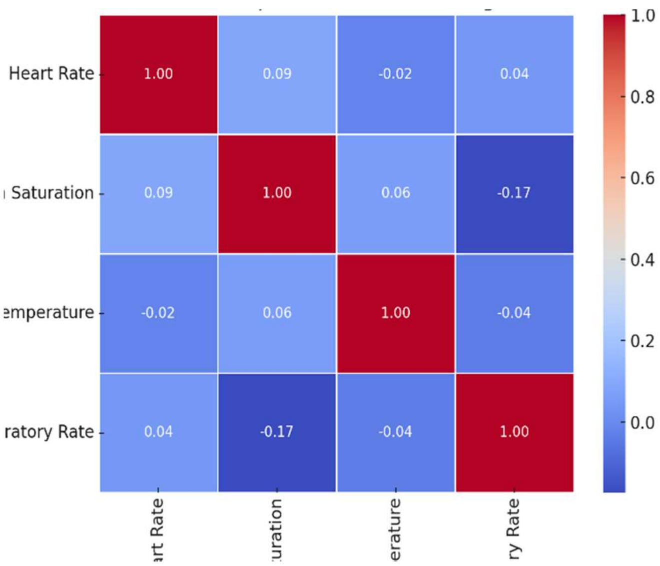

Figure 4: Correlation heatmap of health monitoring parameters

VII. CONCLUSION

The SightPlus project effectively incorporates text recognition, real-time object identification and health monitoring into a smart eyewear solution for people with visual impairments. The system gives users an easy and effective way to view their environment by utilizing YOLO-based object identification, OCR for text recognition and text-to-speech translation. To further improve user safety, the health monitoring module makes sure that vital signs are continuously tracked. With portability and affordability guaranteed by the Raspberry Pi 4B implementation, SightPlus is a promising assistive device for those with vision impairments. Future developments can concentrate on increasing text recognition's accuracy, speeding up processing, and supporting more languages.

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AUGMENTED SENTIMENT ANALYSIS WITH EXPLAINABLE ARTIFICIAL INTELLIGENCE (XAI)

Adwaitha C
Student
St. Teresa's College (Autonomous), Ernakulam
adwaitha.c2004@gmail.com
Jayalakshmi M P
Student
St. Teresa's College (Autonomous), Ernakulam
Raji S Pillai
Assistant Professor
St. Teresa's College (Autonomous), Ernakulam
jayalakshmimp032@gmail.com

ABSTRACT

This article aims to determine the role of Explainable Artificial Intelligence (XAI) in promoting transparency in Sentiment Analysis. We applied two models, VADER (Valence Aware Dictionary and sentiment Reasoner) [Hutto & Gilbert, 2014] performs lexicon-based sentiment analysis while RoBERTa (Robustly optimized BERT pre- training approach) [Liu et al., 2019] is used for deep learning based sentiment classification. Both models were deployed because of their known efficiency in detecting sentiments. We refined the technique's interpretability by employing SHAP (Shapley Additive Explanations) [Lundberg et al., 2017]which locates and illustrates the tokens of greatest influence in the predictions, and thus provides insight as to the positive or negative nature of a sentence.In order to visualize these results, we used Streamlit which is a basic and easy to use framework to visualize complicated data streams. This work brings to light the relationships between sentiment analysis and XAI and advocates for its application in automated user feedback analysis from social media and decision support systems.

Keywords: Explainable Artificial Intelligence, Sentiment Analysis, VADER and RoBERTa models, SHAP (Shapley Additive Explanations), Streamlit Visualization.

INTRODUCTION

Sentiment Analysis plays a major role in extracting and detecting emotions, thoughts, and feelings from text. This paper focuses on comparative study of two models in sentiment analysis which are VADER (Valence Aware Dictionary and sEntiment Reasoner) and RoBERTa (Robustly Optimized BERT Pre Training Approach).

VADER is a notable model for its ease and efficiency in Sentiment analysis , especially for texts in social media [Hutto et al., 2014].Wherearea RoBERTa is an progressive deep learning model it is pre-trained in massive twitter data. RoBERTa results in higher accuracy in sentiment analysis than other models.[Vaswani et al. , 2017]. It can even analyse complicated text by utilizing contextual interpolation to improve text comprehension.

The project compares the two models VADER and RoBERTa And visualises the results using a streamlit interface. The study involves evaluation of two model's performance based on their accuracy, functionality and relevance. For better understanding we also applied Explainable AI (XAI) technique, SHAP (SHapley Additive Explanations). SHAP shows which word in the user's input contributes more to the predicted sentence, which is also represented in the streamlit interface that gives the user clear results about the sentiment analysis and XAI. By comparing both models, highlights their strength, weakness and also their performance in analysis. Further it gives user recommendations for opting a suitable model for sentiment analysis prediction.

LITERATURE REVIEW

Explanatory Artificial Intelligence (XAI) is also called interpretable AI, it helps users to understand how each token contributes in prediction. It gives transparency and reliability of machine learning models. Here the below table provides summary of some notable studies showing how XAI contributes to sentiment analysis and studies related to VADER and RoBERTa models

Sl. No	Reference	Focus Area	Key Findings	Tools/Models
1.	Hutto & Gilbert (2014)	Development of VADER for sentiment analysis	VADER is efficient for analyzing short, informal text, such as social media posts, but struggles with context.	VADER (Lexicon-based model)
2.	Liu et al. (2019)	Introduction of RoBERTa for sentiment classification	RoBERTa outperforms other transformer models in sentiment prediction, especially for complex linguistic tasks.	RoBERTa (Transformer-based model)
3.	Lundberg & Lee (2017)	SHAP for model interpretability	SHAP effectively visualizes the impact of input features on model predictions, enhancing transparency.	SHAP (XAI framework)
4.	Vaswani et al. (2017)	Attention mechanisms in transformers	Transformers, through self-attention, capture complex patterns and relationships in text effectively.	Transformer models (e.g., BERT)
5.	Bhattacharya et al. (2021)	Comparison of lexicon-based and deep learning sentiment models	Lexicon-based models are fast but less accurate; deep learning models excel in complex text understanding.	VADER, BERT, RoBERTa

OBJECTIVE

This paper aims to compare two VADER and RoBERTa models based on their performance. Using Explainable AI techniques like SHAP (SHapley Additive Explanations), Gives the user insights about how each data feature contributes to a prediction. In this study it shows the user which word in the inputted sentence led to the sentiment prediction.

The comparison of two models shows the validity, defects and real-world applications of each model, and offers a clear understanding about how each model performs in different situations. It also explores the difference between VADER 's ease and RoBERTa's accuracy showing their suitability in various tasks , from simple analysis to high precision, complex sentences.

By including representations, the study makes sentiment analysis more clear and user friendly. In the end, it highlights the importance of Explainable AI in improving efficiency and availability of sentiment analysis tools, making them more apt for practical use.

METHODOLOGY

When comparing the performance of the two sentiment analysis models: VADER (Valence Aware Dictionary and sEntiment Reasoner) and RoBERTa (Robustly optimized BERT pretraining approach).The method follows several key steps, outlined below:

1. Data Collection

   Data collection process is the major step in the project. It's like a foundation of any research that provides strength for any analysis and also for making meaningful conclusions . For our project on sentiment analysis we needed high quality textual dataset , we gathered it from publicly available platforms like Kaggle and Hugging Face. The dataset is based on Amazon product review and Twitter posts , the main objective of taking a dataset based on a social media platform is because the dataset would be diverse sentiments from social media interactions , offering real-time , concise data. These datasets give the foundation for precise predictions and meaningful outputs in the project.

2. Data Preprocessing

   The preprocessing phase ensured that the data sets were clean and ready for analysis. Key steps included:

- Text Cleaning**:**
    - Removal of special characters, numbers, extra spaces, and symbols other than letter numbers to improve text consistency.
- Stopword Removal:
    - Frequently used words (e.g., "the," "is," "and") that did not contribute to sentiment were removed for a cleaner analysis.
- Tokenization:
    - For VADER, minimal tokenization was required because it is dictionary-based and operates directly on text.
    - For RoBERTa, the Hugging Face tokenizer was used to divide the text into tokens, converting them into a sequence of numbers that compatible with the model.
- Lemmatization:
    - Text was lemmatized to reduce words to their base forms (e.g., "running" → "run").
- Padding and Truncation:
    - Tokenized sequences for RoBERTa were padded to a fixed length for batch processing and truncated to meet the input length requirements of the model.

3. <u>Data Transformation</u>
   VADER: Preprocessed text was fed directly into the model, which analyzed the data and generated sentiment polarity scores (positive or negative).
   RoBERTa: Tokenized inputs were passed through the transformer layers to produce sentiment classifications with confidence scores.
4. <u>Data Analysis</u>
   Both models were evaluated using accuracy, precision, recall, and F1-score. SHAP (SHapley Additive Explanations) was used for interpretation, focusing on the contribution of individual tokens to predictions of emotion.

RESULT

This study examines how well the VADER and RoBERTa models perform in sentiment analysis. Their performance was measured using key metrics like accuracy, precision, recall, and F1-score, which were derived from classification reports and confusion matrices.

1. VADER Results

VADER, a rule-based sentiment analysis model, which works well with simple, straightforward sentences. However, it struggles to handle more contextually complex text, highlighting its limitations.

Accuracy: 0.83

	Precision	Recall	F1-score	Support
Negative	0.54	0.46	0.50	54
Neutral	0.25	0.11	0.15	37
Positive	0.88	0.95	0.91	407
Accuracy			0.83	498
Macro avg	0.56	0.51	0.52	498
Weighted avg	0.80	0.83	0.81	498

VADER Classification Report :

2. RoBERTA Results

RoBERTa, a transformer-based model, better at understanding complex and contextual details in the text, performs much better than VADER, especially with subtle language cues.

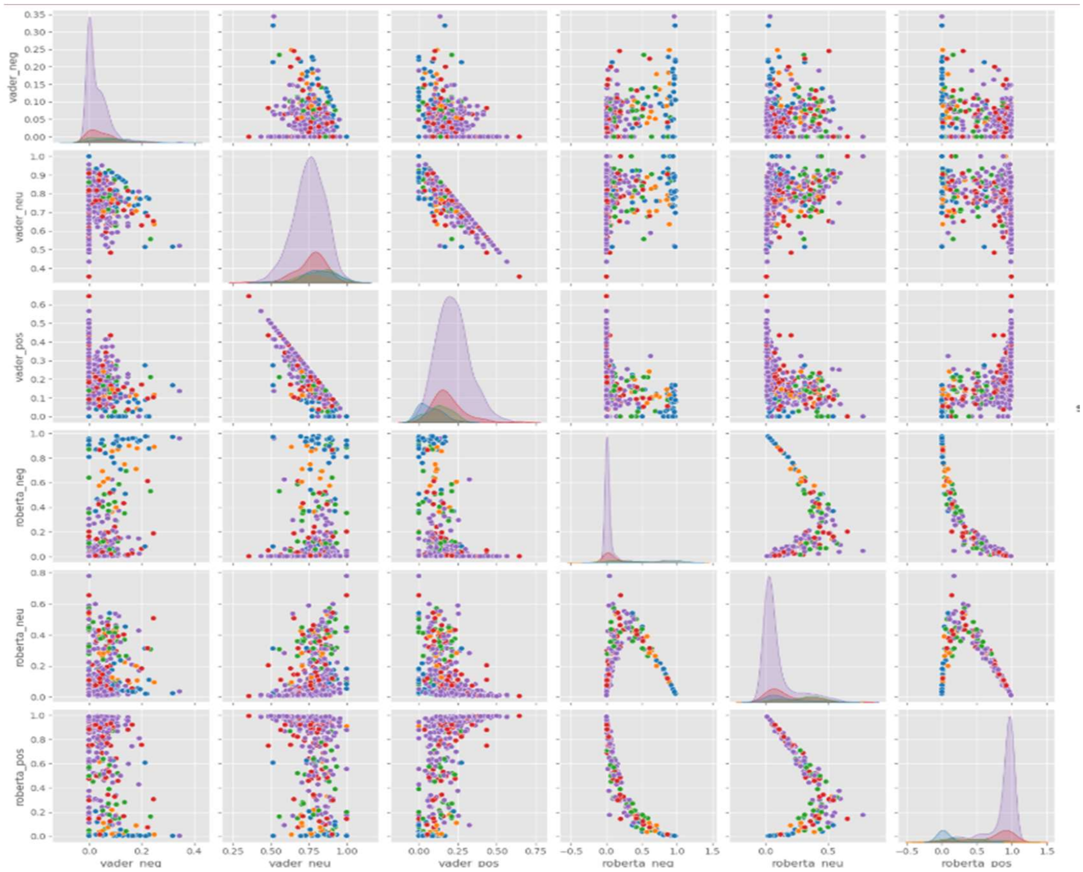
Accuracy: 0.85

RoBERTa Classification Report :

	Precision	Recall	F1-score	Support
Negative	0.66	0.78	0.71	54
Neutral	0.23	0.22	0.22	37
Positive	0.94	0.92	0.93	407
Accuracy			0.86	498
Macro avg	0.61	0.64	0.62	498
Weighted avg	0.86	0.86	0.86	498

3. Comparative Analysis

The comparison between VADER and RoBERTa based on their performance highlights the superiority of transformer-based models for sentiment analysis tasks.



3.1 Key Observations :

Diagonal Distributions:

- The diagonal plots represent kernel density estimates (KDEs) for each sentiment score.
- VADER: shows a fairly widespread distribution of positive, negative, and neutral scores, reflecting its tendency to assign a broader range of sentiment values.
- RoBERTa: it shows sharper peaks for neutral and positive sentiments, which shows the model's ability to focus on specific sentiment scores with more confidence.

Correlation Between Models:

- ○ Scatterplots comparing positive scores from VADER and RoBERTa shows clusters, suggesting that the models generally agree to a moderate extent but occasionally differ in how they interpret positive sentiment.
- ○ For neutral and negative scores, the scatterplots indicate stronger variability between the models, with RoBERTa capturing nuances that VADER might overlook.

Outliers:

- ○ Both models exhibit outliers, particularly in cases where one model strongly predicts a sentiment (e.g., high positive) while the other assigns a low or neutral score.
- ○ This highlights scenarios where context or subtle cues in text affect their performance differently.

Interrelationships of Sentiments:

- ○ Within the same model, negative, neutral, and positive scores display inverse relationships, as expected. For example:
- ○ Higher negative sentiment correlates with lower positive and neutral scores.
- ○ RoBERTa shows clearer boundaries in these relationships compared to VADER.
- ○ RoBERTa: Achieved higher accuracy and F1-scores, demonstrating better contextual understanding and classification capability. Provides more nuanced and reliable predictions, evident from the tighter clustering and sharper KDE peaks.
- ○ VADER: While effective for simpler tasks, struggles with nuanced and ambiguous text.Performs better on straightforward, lexicon-based sentiment tasks but struggles with context-heavy.

CONCLUSION

This paper presented a comparative study of two sentiment analysis models, VADER and RoBERTa, focusing on their performance and interpretation. VADER, a lightweight lexicon-based model, demonstrated its effectiveness in handling short, non-standard cases with rapid and straightforward analysis but struggled with the nuanced and context-sensitive cases around. By comparison, RoBERTa, a transformer-based deep learning algorithm, excelled in handling complex sentences and provided excellent accuracy by considering contextual and logical relationships [Bhattacharya et al., 2021].

By including SHAP (SHapley Additive Explanations) [Lundberg et al., 2017], it added an important layer of explanation to the model, allowing users to understand how individual tokens contributed to sentiment prediction. This interpretive capability bridges the gap between AI-controlled sentiment analysis and human interpretation, fostering trust and informed decision-making.

While the study highlighted the strengths of both models, it also identified limitations such as VADER's dependence on predefined rules and RoBERTa's high computational resource demands. Future work could focus on optimizing these models for real-time performance, improving scalability, and extending multilingual capabilities. Furthermore, increasing the use of translation tools could further enhance the effectiveness of sentiment analysis systems.

In conclusion, this study highlights the importance of combining advanced machine learning and Explainable AI methods. By addressing their limitations and leveraging their complementary strengths, VADER and RoBERTa have the potential to become powerful tools for sentiment analysis in real-world applications.

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EFFECTIVE FEEDBACK TEXT CLASSIFICATION USING BIDIRECTIONAL BERT: ENHANCING INSIGHTS WITH DEEP LEARNING

Ajeena Binny
Department of Computer Applications,
St. Teresa's College (Autonomous) Ernakulam
ajeenastudy@gmail.com, Phone: +91 9567236237
Raji S Pillai
Faculty, Department of Computer Applications,
St. Teresa's College (Autonomous) Ernakulam

ABSTRACT

Feedback functions as a fundamental improvement mechanism (Hattie & Timperley, 2007). In educational settings student feedback remains the primary instrument teachers use to understand both their teaching capabilities and instructional approaches (Nicol & Macfarlane-Dick, 2006). Data analysis requires significant processing time together with support resources. An automated system is essential because manual analysis produces numerous analytical errors which point to a compelling requirement for automation (Young et al., 2018). This research initiative works to develop a system that automates teacher performance feedback evaluation. Evaluate feedback as either positive or negative. The initiative seeks to develop precise data which educational institutions can use to make well-informed choices. Quantity improvement measures for teaching will result from this initiative. The process of model adjustment on Transformers (BERT) will enable this accomplishment (Devlin et al., 2019). The solution contains datasets which match the actual work and lead to high-quality model input data. Before the analysis begins the system performs text tokenization which results in token IDs and creates input masks and segment IDs (Young et al., 2018). A Keras neural network receives input from BERT model output to execute fine-tuning at classification level with hyperparameter optimization enabling proper results (Bergstra & Bengio, 2012). This methodology works because its automated classification system delivers exceptional response accuracy. The system works to help educational institutions obtain necessary guidance about teaching quality improvement by delivering complete advisory services.

Keywords: BERT, Hyperparameter optimization, Teacher performance, Tokenization, Deep Learning

Functional area: Educational Technology and Analytics

INTRODUCTION

Changes in existing teaching standards combined with student learning experiences result from proper feedback utilization within educational institutions (Hattie & Timperley, 2007). The assessment of student feedback through conventional methods proves impracticable in practical investigations because the large amount of work requires refined analysis that avoids undesired errors (Nicol & Macfarlane-Dick, 2006). An automated system is proposed for categorizing student opinions into positive and negative categories (Young et al., 2018).

BERT technology combined with state-of-the-art deep learning helps these projects develop reliable sentiment analysis tools for educational applications (Devlin et al., 2019). The implementation of novel methods will guide administrators toward better decision making and lead to improved teaching levels alongside better learner satisfaction (Young et al., 2018).

A prototype analytical model used teacher performance feedback gathered from college students to build its dataset. The description tool assigns a value of "1" for positive points or partial positivity but negative points receive a value of “0." Improved classification results were obtained after fine-tuning these data with BERT (Devlin et al., 2019). The model architecture features Keras as a controlling framework which activates BERT for feature extraction duties followed by a custom-classification layer which processes feedback input (Bergstra & Bengio, 2012).

OBJECTIVES

1. The development of a high accuracy automated feedback analysis system.
2. BERT will extract semantic features from feedback data during the implementation stage.
3. This approach determines student feedback quality between positive and negative aspects effectively.
4. Specifically, the fine-tune a BERT model for the feedback dataset of teaching performance.
5. Attain superior performance with hyperparameters.

METHODOLOGY

1. **Dataset:**

   Research analyzed teacher performance reviews through a dataset where professional evaluation received a negative (0) or positive (1) label. All models were evaluated for accuracy using training along with validation subsets from the test-specific dataset created for this initiative.The dataset is available at: https://shorturl.at/Jr9cA

2. **Data Preprocessing:**

   Research used structured teacher performance reviews with each review assigned a binary sentiment label between negative ('0') and positive ('1'). The research dataset divided into BERT ran its tokenizer on CSV data to generate BERT input features. The text was transformed into BERT input features, such as:

- input_word_ids
- input_mask
- segment_ids .

The tokenized features provided a platform to preprocess data before its submission to the BERT model.

Behind each testing process stand training and validation datasets which assess how well the accuracy of models function.

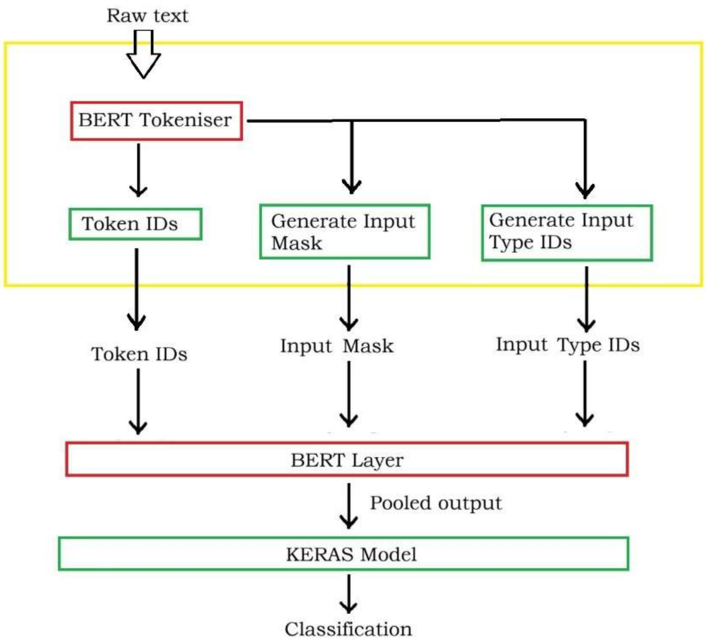

Fig. 1: Workflow

3. **Model Architecture:**

The model architecture is based on the Bidirectional Encoder Representations from Transformers (BERT) model, which includes:

- Input Layer: Despite tokenized input requirements (input_word_ids, input_mask, and segment_ids).
- BERT Layer: Performance on the input data relies on pre-trained BERT embedding processing.
- Dropout Layer: An overfitting prevention technique uses dropout rate set to 0.4.
- Dense Layer: Dense output layer with sigmoid activation function is utilized for binary classification (positive or negative feedback).

4. **Model Compilation:**

   The model was compiled with:

   - Optimizer: Adam optimizer with a learning rate of 2e-5.
   - Loss Function: Binary Crossentropy for binary classification problems.
   - Evaluation Measure: Binary Accuracy, which is the ratio of correct predictions.

5. **Training:**

   It was trained for 10 epochs with the training and validation data input in batches for optimal processing.

   The training set was employed to train the model, and the validation set to track the model performance and tune parameters so as not to overfit.

6. **Evaluation:**

   The model was tested on the validation set after training using binary accuracy and loss metrics. The confusion matrix was used to assess the classification performance of the model, and the ROC AUC score was used to quantify the discrimination power of the
   model between classes.

7. **Graphs:**

   - Binary Accuracy Graph: This plot plots the binary accuracy of both the training and validation sets against the epochs.
   - Loss Graph: This graph plots the loss for the training and validation sets, indicating how the model's mistake was reduced in training.

RESULTS

1. Training Accuracy: The model performed well on the training set, indicating that it was capable of classifying most of the training examples correctly. Validation Accuracy: The validation accuracy was robust across training with minimal fluctuations, which suggests that the model was generalizing to unseen data well. Both training and validation accuracy plots demonstrated consistent improvement across the epochs.

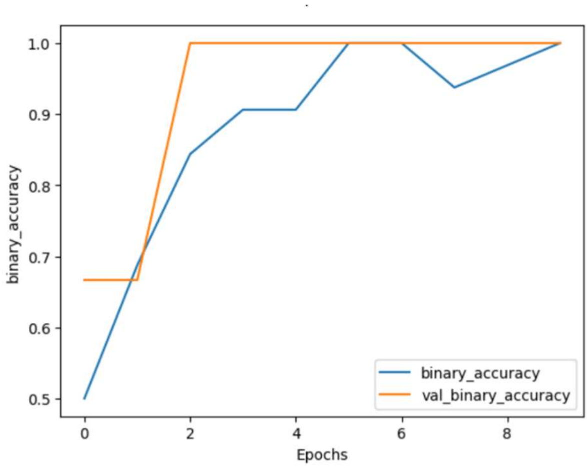

Fig. 2: Graph for Binary accuracy and Validation accuracy

2. Confusion Matrix: Confusion matrix of the validation set revealed:

```
Confusion Matrix:
[[2 0]
 [0 1]]
```

Fig. 3: Confusion Matrix

This means that the model correctly classified all the examples in the validation set: two true negatives and one true positive, without any false positives or false negatives.

3. ROC AUC Score: The model had a ROC AUC score of 1.0, which shows the model's ideal distinction between positive and negative feedback.
4. Loss: The loss plot showed a consistent reduction in both the training and validation loss throughout the training, which means that the performance of the model increased with every epoch and its error reduced.

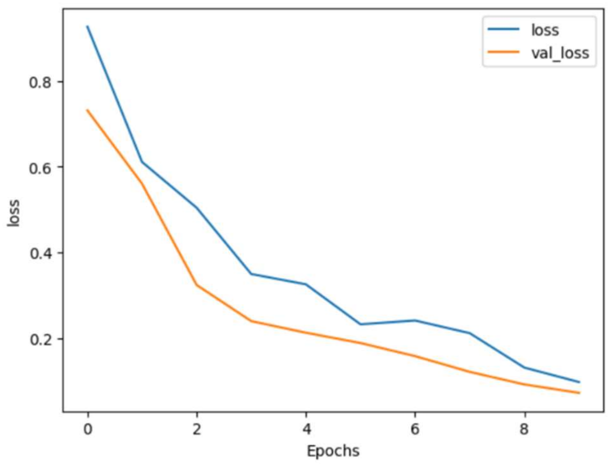

Fig. 4: Graph for Loss and Validation Loss

5. Test Prediction: The model was tested on the feedback "teacher was good," and it predicted positive feedback, consistent with its performance on the validation set.

CONCLUSION

The BERT-based binary classification model for teacher feedback performed superbly in labeling feedback as positive or negative. The model had:

- High accuracy on the training set and strong performance on the validation set.
- An ROC AUC value of 1.0, signifying ideal classification capacity.
- Consistent improvement in both binary loss and accuracy, as seen in the following graphs.

The confusion matrix also verified that the model did not have any misclassifications on the validation set, further validating its efficacy. The graphs also indicated that the model generalized well, with the training and validation metrics indicating consistent improvements over time.

These outcomes imply that the model is highly suitable for automated sentiment analysis applications of feedback classification, especially in academic contexts.

With the synergy between BERT's strong language representation and judicious optimization of the model parameters, good precision and stability were achieved, which made this methodology useful for future text classification tasks.

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FINGER SPELL: AN AI-POWERED HAND SIGN RECOGNITION SYSTEM FOR AMERICAN SIGN LANGUAGE (ASL) TRANSLATION

Akhila Dhaniya
Student,
St. Teresa's College (Autonomous), Ernakulam
Email: akhiladhaniya04@gmail.com,
Janeetta Agnes
Student
Email: janeettaagnes10@gmail.com
St. Teresa's College (Autonomous), Ernakulam
Megha George
Assistant Professor
St. Teresa's College (Autonomous), Ernakulam

ABSTRACT

Accessibility and communication inclusivity have gained extreme importance in a world that increasingly becomes interconnected. FingerSpell, an AI-based hand sign recognition system, aims to bridge this gap for a population of communication users who utilize American Sign Language (ASL) as their means of primary expression. The system mainly deals with the recognition of individual letters from A to Z by using a webcam to capture hand movements. It does not analyze full hand images but hand landmarks, like finger joints and key points, which makes the process more efficient and accurate in gesture detection.
The core of the project is built using TensorFlow, which helped in training a Fully Connected Neural Network (FCNN) to recognize hand signs based on the tracked key points. This model has an accuracy rate of 74%, which is fairly reliable in classifying ASL letters. In order to use it on other devices, a TensorFlow Lite version of the trained model was created for optimal performance with low weight and speed. Hand tracking is carried out by using MediaPipe and patterns are interpreted using the neural network to identify every gesture. FingerSpell is made available with Streamlit as an interface and, therefore, easily accessible on the web with a user-friendly interface.

In this context, by overcoming the communication gap for people using ASL--that is, deaf and speech- disabled people—this system reveals how everyday communication can become easier and liberating with modern technology for everyone.

Keyword: ASL Sign Language, Machine Learning, FingerSpell, Tensorflow, Streamlit, Mediapipe

INTRODUCTION

In such a world where technology incessantly redefines interaction between human beings, access to communication tools has never been more necessary than now. For the deaf and hard-of-hearing population, sign language is one of the best ways for linguistic expression. Communication is severely constrained by the lack of understanding and the lack of adoption of sign language by the general non-signers. In order to unite everyone, creative ideas that bridge this divide are desperately needed.

Therefore, we tackle this problem by creating a sign language translator that transforms alphabetic letters (A–Z) into legible text. Recent studies have shown that deep learning techniques, such as CNNs and LSTMs, can achieve high accuracy in real-time ASL recognition, though challenges persist with visually similar hand signs. A Fully Connected Neural Network (FCNN), the architecture selected for our system for its accuracy and efficiency in handling pattern recognition tasks, lies at its core. By utilizing computer vision and artificial intelligence, our technology records hand movements, interprets them in real-time, and converts them into text, enabling smooth communication between sign language users and non-signers.

Actually, the focus on both technical innovation and social effect is what makes this initiative so significant. In addition to being a technological development, its goal is to provide a tool that will enhance comprehension, empathy, and inclusivity in real-world situations. The design, implementation, and evaluation of our FCNN-based system are covered in this paper, showcasing its potential to overcome linguistic and cultural barriers and make the world more accessible to everyone.

LITERATURE REVIEW

SI. NO	AUTHOR	FOCUS AREA	KEY FINDINGS	TECHNOLOGY/ TOOLS
1	**J. Smith et al. (2021)**	Real-time ASL recognition using deep learning	Achieved **85% accuracy** using CNN and LSTM; struggled with similar hand signs (M, N)	CNN, LSTM, Data ugmentation
2	**R. Patel et al. (2022)**	Hand gesture recognition using MediaPipe and ML	Improved real-time recognition, **80% accuracy**, reduced preprocessing time	MediaPipe Hands, TensorFlow Classifier
3	**L. Wong et al. (2020)**	Transfer learning for sign language recognition	**90% accuracy**, effective feature extraction, but required high computational resources	MobileNetV2, ResNet, Transfer Learning
4	**D. Kim et al. (2019)**	ASL finger spelling using traditional ML algorithms	SVM performed well with small datasets **(~75%)**; struggled with dynamic hand movements	SVM, Random Forest, Hand Keypoints
5	**M. Rodriguez et al. (2022)**	Sign language recognition using hybrid deep learning models	Combined CNN & BiLSTM to recognize ASL gestures with **92% accuracy**; improved temporal feature extraction but required high	CNN, BiLSTM, TensorFlow, Data Augmentation

METHODOLOGY

The methodology for this hand sign recognition project which uses Fully Connected Neural Networks (FCNN) follows a structured pipeline comprising data collection, preprocessing, model training, and deployment.

1. Data Collection

The dataset has hand gesture coordinates of American Sign Language (ASL) alphabets from A to Z stored as CSV file. Instead of using raw images, the dataset includes hand landmark coordinates extracted using MediaPipe Hand Landmark Model. Each alphabet has around 1500 samples, providing a diverse and well-balanced dataset for training and evaluation.

2. Data Preprocessing

To improve the accuracy and efficiency of the model, different preprocessing steps are applied to the dataset. Initially we converted the 21 handkey points (x, y) for each gesture into relative coordinates so model learns gesture patterns independent of the positioning of hands within the frame. Then the coordinates are flattened into a single vector to input into a neural network. Additionally, to avoid being affected by the large coordinate variations Normalization is performed by scaling the values within a fixed range. Preprocessing helps the model pay attention to only the structure and shape of hand gestures and not their absolute positions, which in turn improves generalization and reduces noise.

3. Model Architecture

The project uses Fully Connected Neural Network (FCNN) ,a type of deep learning framework for stacking layers in a linear fashion. FCNNs have been widely used for pattern recognition tasks, demonstrating their effectiveness in image and gesture classification (LeCun et al., 2015). The input layer takes a 42-dimensional vector: 21 landmarks × 2 coordinates. The first hidden layer consists of 20 neurons with ReLU (Rectified Linear Unit) activation, which helps introduce non-linearity and improves learning. Then a dropout layer follows to reduce overfitting. The second hidden layer has 10 neurons, also using ReLU activation, followed by another dropout layer for further regularization. Finally, the output layer applies a softmax activation function, enabling multi-class classification across 26 classes (A-Z).

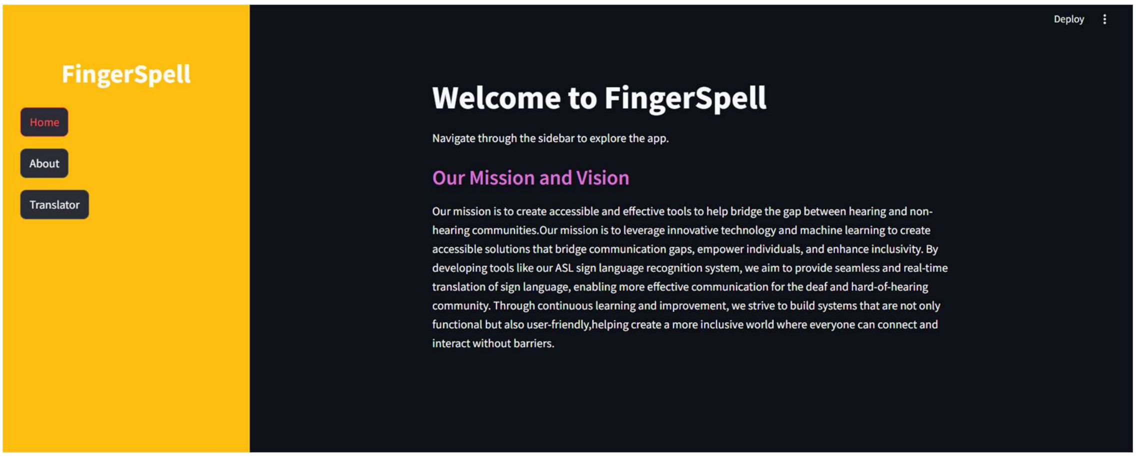
4. Model Training & Evaluation

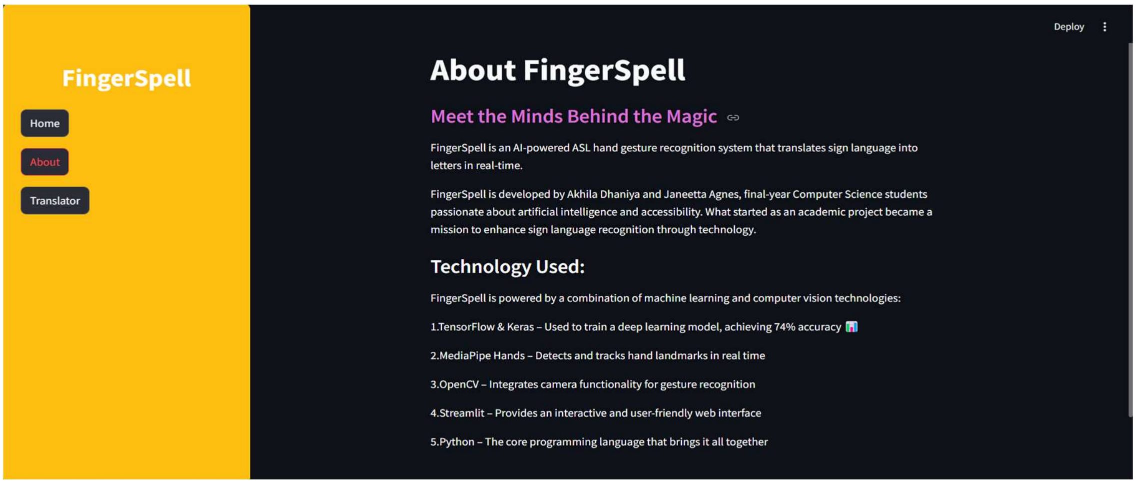
The model is trained using the TensorFlow Keras framework and use the Adam optimizer which is an adaptive gradient-based optimization algorithm known for its efficiency in deep learning tasks. It also dynamically adjusts learning rates for different parameters, leading to faster convergence and better generalization. TensorFlow, along with Keras as a high-level API, has become a standard framework for training deep learning models due to its scalability and ease of use (Chollet, 2017).Categorical cross-entropy is used to know the loss function which measure how well or poorly the model is performing. Tough there is minor difficulties in recognizing similar gestue like M,N,T ,the model achieved an accuracy of 74% .

5. Deployment

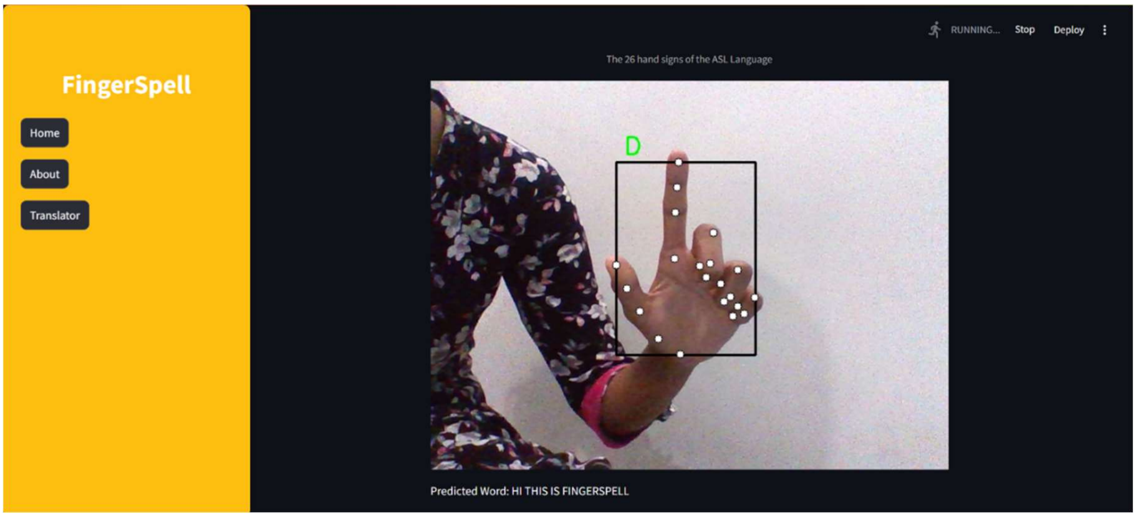
The Model is deployed using Streamlit. Streamlit is a widely-used Python library that simplifies the process of building websites with just a few lines of code. Specifically designed for machine learning engineers, Streamlit provides a powerful framework with helpful tools for seamlessly integrating ML models and dataset files into web applications (Shukla et al., 2021).Through the Streamlit-based web interface users can interact with the model using webcam input. The interface captures the hand gestures, processes the landmarks, and maps them onto their corresponding alphabets, allowing seamless and interactive sign language recognition. The letters are then appended to words ,implementing the sign to text conversion(Kemka et al.,2023).

RESULT




Deploy
FingerSpell
Home
About
Translator
About FingerSpell
Meet the Minds Behind the Magic
FingerSpell is an AI-powered ASL hand gesture recognition system that translates sign language into letters in real-time.
FingerSpell is developed by Akhila Dhaniya and Janeetta Agnes, final-year Computer Science students passionate about artificial intelligence and accessibility. What started as an academic project became a mission to enhance sign language recognition through technology.
Technology Used:
FingerSpell is powered by a combination of machine learning and computer vision technologies:
1.TensorFlow & Keras – Used to train a deep learning model, achieving 74% accuracy
2.MediaPipe Hands – Detects and tracks hand landmarks in real time
3.OpenCV – Integrates camera functionality for gesture recognition
4.Streamlit – Provides an interactive and user-friendly web interface
5.Python – The core programming language that brings it all together


RUNNING...
Stop
Deploy
FingerSpell
Home
About
Translator
Let's Translate
Hand Sign Recognition (ASL Translator)
A B C D E F G H I
J K L M N O P Q
R S T U V W X Y Z
The 26 hand signs of the ASL Language


RUNNING...
Stop
Deploy
The 26 hand signs of the ASL Language
FingerSpell
Home
About
Translator
D
Predicted Word: HI THIS IS FINGERSPELL

CONCLUSION

ASL sign language recognition system developed in this project demonstrates a big step forward to make communication access more enhanced for the deaf and hard-of-hearing community.It successfully applies advanced machine learning techniques through MediaPipe hand landmark Model and TensorFlow model training in hand gesture recognition of the whole alphabet.Although the model shows minor difficulties in distinguishing between similar gestures, such as 'M' ,'N' and 'T', it is still promising to achieve an accuracy of 74%. The real-time gesture recognition and user-friendly deployment on Streamlit show how the system may be used practically for translating American Sign Language into text.The project not only showcases the power of deep learning but also works towards making more inclusive communication technologies. Further improvements in the model's accuracy and including more features such as word prediction and recognition of multi-hands would push the system into further utility and impact.

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SIGN LANGUAGE TRANSLATOR

Alvin Kuriakose
Dept. Computer Science and Engineering
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
alvin.cse21@mbits.ac.in,+91 85930 79478
Sam Riju
Dept. Computer Science and Engineering
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
samriju70@gmail.com,+91 70341 93464
Hagen Joby
Dept. Computer Science and Engineering
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
hagenjoby2003@gmail.com,+91 88484 63003
Dr. Suji Pramila R
Dept. Computer Science and Engineering
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
suji@mbits.ac.in, +91 98949 80636
Paul K Mathew
Dept. Computer Science and Engineering
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
paulkmathew.023@gmail.com ,+91 73564 63407

ABSTRACT

The "Sign Language Translator" introduces a novel solution for real-time American Sign Language (ASL) translation designed to facilitate seamless communication for Deaf and hard-of-hearing individuals. This system combines advanced computer vision and Natural Language Processing (NLP) to convert ASL gestures into text subtitles in real time addressing the critical need for accessible communication in dynamic environments like conversations, broadcasts and live presentations. Central to this system is MediaPipe, a highperformance framework for real-time hand tracking. MediaPipe accurately captures hand landmarks allowing precise recognition of ASL gestures. Once the gestures are identified the system sends this visual data to a specialized NLP module which translates the gestures into meaningful text. This NLP component goes beyond direct translation by interpreting contextual nuances ensuring the generated subtitles accurately reflect conversational intent and subtleties essential in ASL. The combination of MediaPipe's gesture tracking and NLP's contextual processing overcomes the primary challenge of ASL translation in real-time offering a fast and accurate text output. This approach enhances accessibility enabling Deaf and hard-of-hearing individuals to participate fully in various social and professional settings. The Sign Language Translator represents a significant advancement in assistive technology merging state-of-the-art gesture detection with language processing to break down communication barriers. By providing real-time contextually accurate subtitles, this work promotes inclusivity and fosters a more interconnected society where diverse communication needs are met

Keywords-Sign Language Translation, MediaPipe, Hand landmarks, ASL gestures, Real-time ASL translation.

INTRODUCTION

American Sign Language (ASL) is the main form of communication for millions of Deaf and hard-of-hearing people worldwide. The World Health Organization (WHO) reports that 466 million people worldwide have disabling hearing loss, many of whom use sign language as their primary means of communication [9]. ASL, despite its prevalence among Deaf communities, however, encounters a serious communication barrier when communicating with people who are not familiar with the language. This is particularly true across many public and professional settings, including schools and universities, workplaces, hospitals and social events, where communication between hearing and Deaf people tends to become strained due to a lack of shared language.

The demand for advanced technologies has been realized as a solution to these challenges. This requirement resulted in the development of the "Sign Language Translator" system. This work seeks to improve real-time ASL translation through the realization of fast, accurate gesture recognition and contextually appropriate subtitles with MediaPipe, a state-of-the-art computer vision library, and natural language processing methods. MediaPipe is a serious contender for accurately recognizing ASL gestures even in changing real-world environments due to its real-time hand landmark detection and tracking feature.

MediaPipe is a robust framework built by Google that is tailored for real-time computer vision applications like object detection and tracking [6]. It does this by identifying significant points in an input image or video, recording the motion of these points and correctly mapping them over time. This allows MediaPipe to accurately record fast and intricate hand motions, which form the basis of ASL communication [1]. The system can process these motions at high speed and accuracy, allowing it to be used in live communication. Once the hand motions are identified they can be passed through an NLP pipeline in which contextual language processing guarantees that the identified gestures are translated into meaningful text that conveys the intended message.

BACKGROUND

In recent years, the need for seamless communication between hearing and deaf individuals has gained significant attention, especially in diverse and multilingual countries like India, where sign language serves as a crucial medium. Indian Sign Language (ISL) is widely used by the Indian deaf community, yet barriers to effective communication still persist due to the lack of widely available translation tools. To bridge this communication gap, advancements in artificial intelligence and computer vision are being leveraged to create real-time ISL recognition and translation systems.

Through a video stream, the system records the user's hand movement and body posture. Mediapipe, a computer vision library created by Google, is used to track and detect hand landmarks and body positions in real time. Mediapipe offers high-precision tracking of hand landmarks (e.g., finger joints), which serves as the foundation for recognizing various ISL gestures.Sequence Learning with LSTM Indian Sign Language frequently consists of dynamic gestures with hand movement sequences. Long Short-Term Memory (LSTM) networks, a recurrent neural network (RNN) variant, are employed to identify these sequences by examining temporal patterns. LSTM networks are capable of learning the inter-frame dependencies in a video stream, allowing the model to distinguish between gestures that look similar but have varying motions. Upon processing the sequences, the LSTM model identifies the gesture as a particular ISL sign. This identification is performed based on training data where similar gestures were tagged appropriately[1].

Sign language is an essential medium of communication for individuals with hearing and speech impairments, allowing them to interact with the world around them. However, due to the lack of widespread knowledge of sign language among the hearing population, communication barriers often persist. This gap has led to an increasing interest in automated sign language recognition systems, which aim to translate sign language gestures into text or speech, thereby facilitating more inclusive communication.

Employing a camera input, the system detects hand movements. Effective hand detection algorithms (e.g., Mediapipe or custom CNNs) are employed to isolate and detect the positions and shapes of hands in real-time, even in cluttered backgrounds. The system collects relevant hand features (e.g., position, orientation and finger joint angles) to establish a compact, effective representation for each gesture. By targeting essential features rather than raw images, this step diminishes computation load and increases the speed of recognition. The interface shows the recognized text output and provides users with access to further settings such as volume adjustment for speech output, language selection and recognition tunings [2].

ASL is a critical communication tool for the Deaf and Hard-of-Hearing community, enabling them to express words, phrases and sentences through a combination of hand gestures, facial expressions and body language. However, the widespread adoption of ASL is limited due to language barriers between ASL users and non-signing individuals. This has led to a growing demand for automated sign language recognition systems that can facilitate smooth and inclusive communication by translating sign language into text or speech in real time.

The technology identifies and tracks the movements of the user's hand via a camera stream. To allow accurate monitoring in a range of situations, advanced hand identification algorithms are employed to detect and segment the hands in real-time. The spatial information, such as hand positions, finger joint angles and orientations, is extracted by the system. These are used to differentiate between similar gestures with small differences in positioning or finger angles. The system also records temporal prosodic features such as rhythm, timing and intensity of hand motion, which are crucial to knowing the flow and cadence of gestures in ASL. Sequential Learning for Gesture The model applies a sequential learning process, generally through Long Short-Term Memory (LSTM) networks, to process the sequence of the extracted spatio-temporal features. LSTMs allow the system to learn and memorize patterns over time, making it possible for the system to accurately recognize ongoing ASL gestures. Upon gesture recognition, the system converts it into text, which is read on a display or converted to synthesized speech for sound output. The output allows interaction with non-signing people [3].

Sign language recognition (SLR) is a crucial area of research within the broader domain of human-computer interaction, aimed at facilitating communication between deaf or hard-of hearing individuals and those who do not know sign language. As an alternative form of communication, sign language incorporates not only hand gestures but also facial expressions, body posture and other non-verbal cues. Developing automated systems that can accurately recognize and translate sign language into text or speech is an ongoing challenge with significant societal impact.

The input capture module is tasked with capturing the raw data required for recognition. This is usually achieved through cameras, depth sensors that capture the user's gestures, hand movements and other sign language signals. The data may be visual (RGB images or video), depth-based (from depth cameras such as Kinect). The raw input data may need preprocessing to improve the quality of the signal and eliminate noise. This includes normalizing, segmenting and extracting useful features from the input data, which are essential for correct recognition. Feature extraction is the process of converting the raw input into a set of useful features that can be utilized by machine learning algorithms. These features may be hand shapes, motion patterns and other unique features of the signs. Following gesture recognition, the system needs to map recognized signs to meaningful outputs. This may include translating the recognized signs to text or spoken words [4].

Chinese Sign Language (CSL) processing has garnered increasing interest in recent years, as researchers aim to develop automated systems capable of recognizing and translating sign language for effective communication between deaf or hard-of-hearing individuals and the broader community. Unlike spoken or written languages, CSL conveys meaning through a combination of hand gestures, facial expressions and body movements, which makes automated recognition a complex task. Furthermore, CSL differs significantly from other sign languages, such as ASL and British Sign Language (BSL), as it follows its own unique linguistic structure and cultural conventions.

The first step is to capture the movements of the signer, facial expressions and hand movements. CSL processing is based on information from different sensors, like cameras and depth sensors, to capture the visual and spatial data necessary for recognition. The raw input data tends to be noisy and may include unnecessary information (e.g., background features). Preprocessing is used to clean, segment and enhance the captured data to concentrate on essential features, such as hand position, orientation and facial expressions. This module translates the extracted features and recognizes certain signs, words or phrases from CSL. Deep learning architectures, like CNNs and RNNs, are widely used for gesture recognition because they can learn both static and dynamic features in sequences [5].

Real-time dynamic sign language recognition has become an increasingly important area of research, as it enables immediate and accurate communication for deaf or hard-of-hearing individuals in various settings. Dynamic sign language recognition involves interpreting continuous sequences of gestures, including hand movements, orientations and transitions, to capture the fluidity of natural sign language. However, the variability and complexity of these dynamic gestures make accurate real-time recognition a challenging task. Traditional gesture recognition systems often struggle with real-time performance due to high computational demands, latency and limitations in handling sequential gesture data.

The initial step is to detect and follow the hands and their movement to record dynamic gestures in real-time. MediaPipe offers a system for effective hand landmark tracking, which is utilized to receive key data points (e.g., finger joints, hand position, orientation). MediaPipe's raw hand landmark data needs preprocessing to make it clean and standardized. This involves normalizing coordinates, noise filtering and arranging data into a sequence appropriate for LSTM input. Features are extracted from the hand landmark data to form a meaningful representation of each gesture. This phase creates a sequence of frames that the LSTM network will process to identify the gesture [6].

Sign language recognition, translation and video generation have become central areas of research in enabling communication between hearing individuals and the Deaf or hard-ofhearing communities. Traditional sign language recognition systems have evolved from simple gesture recognition to sophisticated models that aim to capture the full complexity of sign languages, including both manual gestures and non-manual signals like facial expressions and body posture. This evolution has given rise to a new generation of end-to-end deep learning frameworks capable of translating signed expressions into spoken or written language—and vice versa—thus offering potential solutions to bridge communication gaps.

Captures and interprets hand movements, facial expressions and body postures to identify signs correctly in real-time. The SLR module converts these inputs into a series of linguistic symbols, which relate to words or phrases. Translates the identified signs into natural language in text or speech. This is a process of translating the identified gestures into grammatically and contextually correct sentences. Offers an audio translation of identified signs, making the system ideal for usage in dialogue between Deaf or hard-of-hearing individuals and hearing individuals [7].

The rapid development of computer vision and artificial intelligence (AI) technologies has opened new possibilities for real-time sign language recognition, a critical tool for bridging communication barriers between hearing and Deaf or hard-of-hearing communities. Traditional approaches to sign language recognition relied on wearable sensors or manual data collection, often making them impractical for daily use. Recent advancements in deep learning and computer vision enable systems to recognize signs from visual data alone, without requiring specialized devices [8].

Captures and processes user video data, usually from a camera or other vision sensors. The video is preprocessed to get it ready for analysis by cleaning noise, enhancing quality and normalizing conditions. Detects and tracks important landmarks on the signer's hands, face and body, which are essential for recognizing gestures correctly. Extracts corresponding features from the detected landmarks and video frames, which are required for proper gesture classification. Classifies the extracted features into known sign language gestures or words. This step entails processing the data using deep learning models. Translates the recognized signs to textual or verbal language, displaying the translation to users in real-time. The system learns to recognize and classify signs through training on large datasets of sign language gestures. The model enhances its accuracy and generalizes across users and environmental conditions [9].

SLAtAR (Sign Language Translating Augmented Reality) is an innovative application designed to bridge the communication gap between sign language users and those who do not know sign language. By leveraging the power of augmented reality (AR) and advanced computer vision techniques, SLAtAR translates sign language gestures into readable text or audible speech in real-time. This solution is especially valuable for enhancing communication between Deaf and hard-of-hearing individuals and the broader society, promoting inclusivity in various social and professional settings.

SLAtAR records sign language gestures in real time and translates them immediately into written text or verbal words. The system is able to recognize dynamic and static gestures, such as the movement of the hands, position of the fingers and facial expressions, which are important for accurate sign language translation. Upon recognizing a gesture, SLAtAR presents the translation in real time using augmented reality. The translation is shown as text or a virtual avatar that replicates the signer's gestures. SLAtAR considers other non-manual aspects of sign language apart from hand gestures, such as facial expressions, head movements and body posture. These are used in the translation to provide an accurate and comprehensive representation of the intended meaning [10].

SCOPE AND OBJECTIVES

The goals of the proposed system is to create a system that can serve as a mediator between an individual who communicate in ASL and an individual who doesn't know ASL. It accurately detect and track ASL signs in real-time video streams. To offer English subtitle for what the individual in the video is attempting to communicate in ASL. The proposed system fills the gap in communication between individuals who are fluent in ASL and those who are not familiar with it. By utilizing sophisticated real-time video processing the system accurately detects and tracks ASL gestures. This provides smooth interpretation of sign language into English promoting inclusivity and accessibility in social and professional environments.

The system uses state-of-the-art technologies in computer vision and natural language processing to render English subtitles to match the ASL gestures being transmitted in video streams. Not only does the real-time translation facilitate communication but also enables those who depend on ASL to communicate effectively with larger audiences. Keep your text and graphic files apart until the text has been styled and formatted. Do not use hard tabs, and reserve use of hard returns to just one return at the end of a paragraph. Do not insert any form of pagination anywhere in the paper. Do not number text heads-the template will automatically do that for you.

The timely and precise translation of ASL to live subtitles is critical to enabling communication and access to Deaf and hard-of-hearing populations. Established methods of ASL interpretation based on manual translation or low-level gesture detection are frequently inadequate to portray the richness and subtleties of ASL in live environments. These shortcomings underscore the necessity for a sophisticated, automated technology to interpret ASL gestures both rapidly and in context.

While recognizing gestures is one major milestone, the next important task involves the translation of ASL signs into contextual text. ASL is a highly nuanced language with much context and grammar incorporated into it, often using facial expressions, body posture, and hand configuration to modify meanings of different signs. It therefore requires the translation system to have a more intelligent approach than simple word recognition. This intelligence in handling is incorporated through NLP techniques in the system. Using NLP, the system interprets the signs in a broader perspective of the conversation and translates them into text, reflecting the subtleties involved in the dialogue. For instance, a single hand gesture in ASL can denote different meanings based on the conversation around it, and the system should be able to disambiguate these to arrive at the correct and appropriate translation.

Real-time dynamic sign language recognition has become an increasingly important research area in recent years as it enables immediate and accurate communication for deaf or hard of hearing individuals in various settings. Dynamic sign language recognition involves interpreting continuous sequences of gestures including hand movements orientation transitions and hand movements to capture the fluidity of natural sign language.

However, the variability and complexity of these dynamic gestures make real-time recognition a challenging task. Traditional gesture recognition systems often struggle with real-time performance due to high computational demands, latency and limitations in handling sequential gesture data.

ARCHITECTURE MODEL

Starting with a video input Gesture Detection isolates hand and body movements. These gestures are classified into specific signs in the Sign Recognition stage. The recognized signs are then processed into grammatically correct sentences in the Sentence Generation phase which are finally output through a Display for accessibility. Figure 1 showcases a system architecture designed to translate ASL gestures into textual sentences. It consists of three key components Gesture Detection, Sign Recognition and Sentence Generation. The process begins with the Gesture Detection module, which takes a continuous video feed as input. Using OpenCV for preprocessing, the video frames are normalized to enhance recognition accuracy.

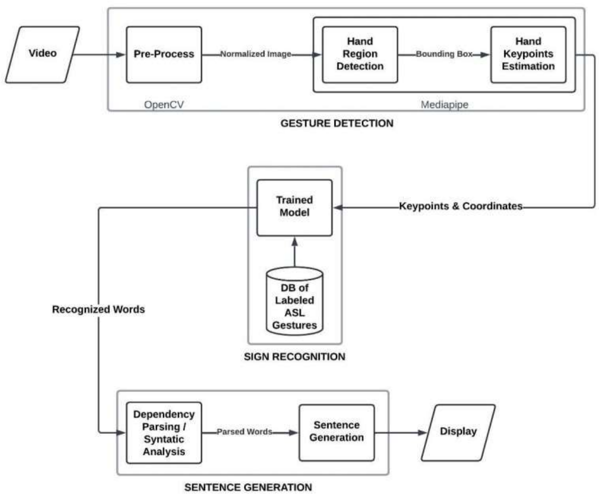

Figure 1 Detailed Architecture Diagram

Next, Mediapipe detects the hand region within the frame, isolates it using a bounding box, and estimates keypoints such as finger joints and hand orientation. This module extracts the essential hand movement data while ignoring irrelevant background information, ensuring accurate input for subsequent stages. The Sign Recognition module utilizes the keypoints and coordinates generated in the previous step. These inputs are passed into a Trained Model which matches them against a Database (DB) of Labeled ASL Gestures. This database contains predefined mappings of ASL gestures to their corresponding words. The trained model uses advanced pattern recognition to identify the gestures and convert them into recognizable words. This phase forms the linguistic foundation by interpreting hand movements into individual words which can then be used for sentence construction. By leveraging the database, the system can effectively translate even complex ASL gestures into their textual equivalents. The final phase Sentence Generation takes the recognized words and structures them into coherent sentences. This process employs Dependency Parsing and Syntactic Analysis to ensure the sentences follow grammatical rules and natural language conventions. Once parsed the words are rearranged and combined to form meaningful sentences which are then displayed as the system's output. This step transforms isolated words into user-friendly text making the system practical for real-world applications. The architecture in the figure highlights a seamless integration of computer vision, machine learning and natural language processing to bridge communication between ASL users and non-signers.

PROPOSED METHODOLOGY

The proposed system takes advantage of cutting-edge technologies to facilitate real-time interaction between ASL users and non-users. Using Mediapipe, the system facilitates high-speed detection and tracking of hand motions from live video streams. An integrated Multi-Layer Perceptron (MLP) architecture is used for accurate ASL sign recognition, maintaining high accuracy in gesture recognition. The recognized signs are then processed through a strong NLP pipeline, converting them into contextually relevant English subtitles. This systematic, multi-step solution offers smooth, real-time ASL-to-text capability, without requiring a human interpreter and with greatly increased accessibility to Deaf and hard-of-hearing people. The core modules of the system are Gesture Detection, Sign Recognition, and Sentence Generation, which operate cohesively to effectively close communication gaps.

A. Gesture Detection

The Gesture Detection module forms the forefront of recognition in ASL gestures, which provide the very base for translation into readable English text. This module captures hand gestures from live video input and prepares the data for analysis by detecting hand regions and key points essential to recognizing ASL gestures.

- Video Input and Preprocessing: The process begins with capturing a live video feed of the user’s hand movements. To ensure uniform input quality, the frames are resized and normalized using OpenCV. This resizing adjusts the frames to the appropriate resolution, while normalization scales the pixel values to a fixed range, improving the model's consistency.

- Hand Region Detection with MediaPipe: This step involves detecting hand regions within each frame using MediaPipe, a high-performance object detection framework. MediaPipe employs a lightweight model to locate hand regions and create bounding boxes around them. The bounding boxes help isolate the hands, minimizing background noise and improving the accuracy of gesture detection.
- Hand Keypoints Estimation: Once the regions of hands are detected, it estimates 21 distinctive key points for each hand, which represent joints, fingertips, and other important markers. The key points will enable the system to track hand movement with high accuracy, hence capturing complex configurations for ASL gestures.

B. Sign Recognition

The Sign Recognition module is responsible for interpreting the detected hand gestures as specific ASL signs. By analyzing the spatial patterns of hand key points, this module classifies each gesture into its corresponding ASL word, bridging the gap between physical movements and language understanding.

- Trained Model for Gesture Recognition: A pre-trained neural network, built with TensorFlow, is utilized to classify the detected gestures. The model has been trained on a large dataset of ASL gestures, allowing it to recognize various ASL words with high accuracy. It uses a simple neural network architecture designed to process the 21 key points from each frame and map these to predefined ASL signs.
- Pattern Matching and Word Prediction: Following the detection of hand key points, the model analyzes the positions and configurations of these points and compares them with known patterns of ASL gestures. The model thus predicts the best match of ASL words corresponding to every pattern it has matched and outputs a sequence of recognized words on every frame.

C. Sentence Generation

The Sentence Generation module, taking the words identified in the Sign Recognition module, will develop meaningful sentences. This module utilizes NLP in analyzing and reordering words, enabling the development of accurate and readable English translations.

- Dependency Parsing & Syntactic Analysis: To ensure grammatical accuracy, the module performs dependency parsing and syntactic analysis. Dependency parsing identifies relationships between words, such as subject-verb or object relationships, allowing the system to understand sentence structure. Syntactic analysis further analyzes word roles, ensuring that recognized words are correctly ordered according to English grammar.

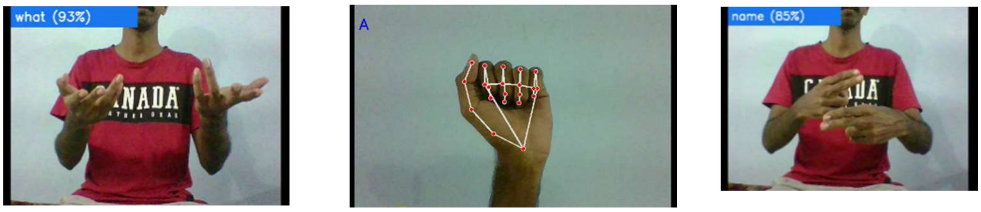

Figure 2 ASL Alphabet Detection

- Sentence Generation: Based on the parsed relationships, a sentence generation algorithm arranges the recognized words to form coherent sentences. The algorithm considers semantic rules and syntactic dependencies to reorder words for accurate translation. This phase refines the ASL-to-English output, making it more accessible to users unfamiliar with sign language grammar.
- Real-Time Display of Translated Sentences: The final step is displaying the generated English sentences in real-time, providing users with a seamless experience. This output is updated continuously as new gesture s are recognized, enabling smooth, uninterrupted communication between ASL users and those who may not understand sign language.

RESULT AND ANALYSIS

In the case of the alphabets i.e., shown in Figure 4 all the important points of the palm are collected from the live video stream and compared with the model using the wrist as the reference point. The provided graphics demonstrate how the alphabets and English words are re-generated.

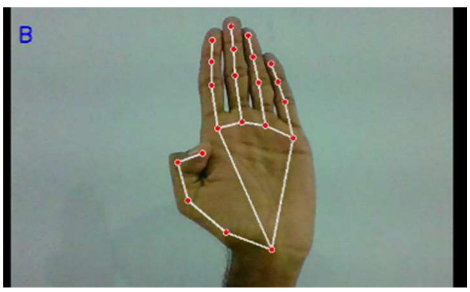

Figure 3 ASL Words Detection

In contrast to English words, where the word and its percentage of confidence are displayed in the video feed as shown in Figure 3, the model is constructed here using the palm and stance key points and we perform the recognition by combining these two methods.The Multilayer Perceptron (MLP) proves to be a highly effective and versatile model based on the comparative analysis and graphs. As in Figure 4 we can see that MLP has an accuracy of 90%, it consistently outperforms simpler models like Logistic Regression and Decision Trees, which achieved 85% and 83%, respectively. While CNNs slightly edge MLPs in accuracy (92%), MLPs offer a significant advantage in terms of training efficiency as depicted in Figure 5. Makes balance between performance and computational cost makes MLPs a practical choice for tasks that demand high accuracy without the extensive resources required by CNNs.

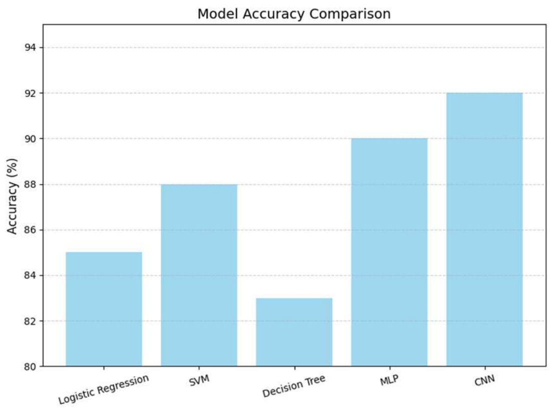

Figure 5 Model Accuracy

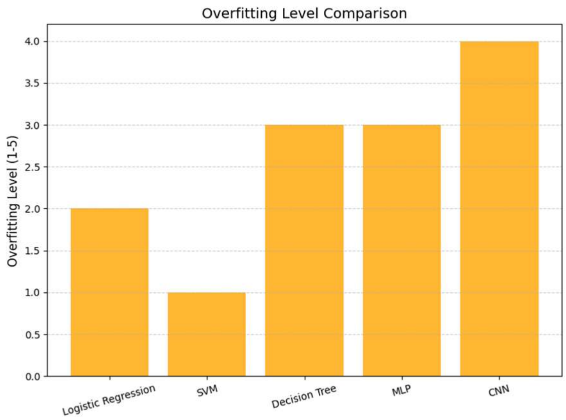

Figure 4 Model Training Time

In terms of overfitting the Figure 6 shows that MLP exhibit moderate levels of overfitting comparable to Decision Tree. It is slightly higher than Logistic Regression and SVM. However this can be effectively mitigated by regularization techniques like dropout and weight decay enabling MLPs to generalize well on unseen data. Unlike simpler models which may struggle with non-linear relationships MLPs excel at capturing complex patterns in large dataset formats.

The graphs show MLP's unique position as a model that strikes the balance between simplicity and power. It achieves high accuracy with manageable training time and a moderate risk of overfitting making it an ideal choice for scenarios where a combination efficiency and performance.

Figure 6 Overfitting Level

CONCLUSION

The Sign Language Translator project bridges communication gaps between Deaf and hearing communities by translating ASL into real-time text-based subtitles. Utilizing MediaPipe for hand gesture recognition and deep learning models like CNNs and LSTMs, the system ensures accurate, context-aware translations, including non-manual signals like facial expressions. This AI-driven tool enhances accessibility and enabling Deaf individuals to engage more fully in social, educational and professional interactions. The project exemplifies how advanced technologies can foster inclusivity and improve communication for those relying on sign language as their primary mode of expression.

The Sign Language Translator project aims to enhance translation accuracy, support multiple sign languages, and integrate advanced hardware. Future developments include refining machine learning and NLP models to better capture nuanced gestures and expressions, as well as expanding to languages like BSL, Auslan and ISL with large, diverse datasets and automatic language detection. Hardware upgrades, such as LiDAR sensors, depth cameras, and wearable devices will improve gesture tracking and accuracy. Incorporating edge-computing technologies like NVIDIA Jetson will enable faster, real-time processing, ensuring accessibility and inclusivity in diverse and remote settings.

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EXPLORING THE POTENTIAL OF MACHINE LEARNING IN BONE CANCER DIAGNOSIS: CURRENT CHALLENGES AND FUTURE DIRECTIONS

Anna Diana K.M
Assistant Professor,
Department of Computer Science,
Naipunnya Institute of Management and Information Technology,
Calicut University, Kerala, India.
Research Scholar,
Department of Computer Science,
Vinayaka Mission's Kirupananada Variyar Arts and Science College,
Vinayaka Mission's Research Foundation, Deemed to be University,
Salem, Tamil Nadu, India.
Email: annadiana7@yahoo.com
Prakash M
Professor
Department of Computer Science,
Vinayaka Mission's Kirupananada Variyar Arts and Science College,
Vinayaka Mission's Research Foundation,
Deemed to be University, Salem, Tamil Nadu, India.

ABSTRACT

Bone cancer is a kind of cancer which initiates in the cells of the bone and it is an aggressive malignancy that poses significant diagnostic and therapeutic challenges. It can be from the bone itself or from other cancerous part of the body. Effective treatment is possible only if it has been diagnosed earlier which can improve the survival rate. Early diagnosis are vital therefore Machine Learning (ML) is a promising technology which have been used in the recent years for diagnosing cancerous cells as it provides more efficiency, accuracy and speed compared to the traditional methods like biopsy and medical imaging . Even though new developments in medical imaging, histopathology, and biomarker analysis have expanded the horizons of bone cancer detection, challenges such as variability in tumor presentation, limited diagnostic specificity, and delays in diagnosis remain critical barriers to timely intervention. So Machine Learning offers the potential to revolutionize the detection of bone cancer. This is done by using some effective tools such as data analysis, pattern recognition, and predictive modeling. This paper explores the challenges in current bone cancer diagnosis, the opportunities provided by ML technologies, and the potential impacts of these advancements on clinical practice. By examining various ML applications, we will discuss how these technologies can enable earlier and more accurate diagnoses, ultimately improving patient outcomes. The paper also addresses key opportunities for future research in this area.

Keywords: Machine learning, Bone Cancer, Early Detection, Current Challenges, Future Research.

1. Introduction

Bone cancer, although relatively uncommon compared to other forms of cancer, presents significant diagnostic challenges due to its rare occurrence and the complexities of early-stage identification. Bone tumors are usually categorized into primary and metastatic cancers, with the latter being far more common. Primary bone cancer types, such as Ewing's sarcoma, chondrosarcoma, and osteosarcoma represent a small percentage of all cancers but often present aggressive growth patterns that necessitate early intervention for effective treatment.

Traditional diagnostic methods, including radiography, CT scans, CT scans, bone biopsy and MRI, have been the cornerstone of bone cancer detection. However, these techniques present limitations in terms of sensitivity, specificity, and time efficiency. For instance, imaging methods may fail to detect small or early-stage tumors, while biopsies are invasive and come with risks of complications and delays in providing results. As a result, many patients are diagnosed only after the cancer has reached an advanced stage, leading to lower survival rates and fewer treatment options.

In current years, ML has gained considerable attention in medical fields, including oncology, for its ability to analyze large datasets, identify patterns, and make predictions with high accuracy. The application of ML in bone cancer identification holds significant promise, as it could potentially address many of the restrictions of old methods. ML models can analyze imaging data more efficiently, offer real-time diagnostic insights, and aid in the early detection of bone cancer through pattern recognition and predictive modeling. This study focuses to explore the opportunities and challenges associated with the implementation of ML in bone cancer diagnosis. We will review the state of current diagnostic methods, discuss the capabilities of ML in enhancing these methods, and analyze the potential impacts on clinical practice. Through this exploration, we hope to highlight the possibilities of ML in the realm of early cancer diagnosis and treatment. The paper also mentions the future directions of early detection of bone cancer which helps the current limitations to be upgraded.

LITERATURE REVIEW

A complete review of the literature highlights the significance of early detection in providing proper patient results for bone cancer. Early diagnosis significantly enhances treatment success and survival rates. Previous studies have explored various machine learning methods to identify subtle patterns indicative of bone cancer at its early stages. The review also identifies key challenges in this field, such as the limited availability of medical data and the complexities associated with designing effective algorithms for oncology applications. Among the generally used ML methods, Random Forest and Support Vector Machine (SVM) have shown promising results. Ashish Sharma [1] observed that while diagnosing human bone diseases, SVM outperformed Random Forest. Specifically, an SVM model trained using the Histogram of Oriented Gradients (HOG) feature set achieved an F1-score of 0.92, compared to the Random Forest model's F1-score of 0.77. This underscores the effectiveness of SVM in analyzing medical data for bone disease diagnosis. Although bone cancer is relatively rare, its early detection remains a significant challenge. Srivastava, D [2] highlighted that one of the major difficulties in applying machine learning to bone cancer diagnosis is the need to effectively utilize the arrangement of medical images and the unique characteristics of medical data during model building and training. Even though many progressions happened there is a need for further advancements in machine learning techniques to advance accuracy and prognostic capabilities in medical image processing. Recent developments in machine learning have generated considerable interest due to their potential to improve early detection rates and patient outcomes. For instance, Anand et al. (2021) [3] proposed a Convolutional Extreme Learning Machine (DC-ELM) method to analyze histopathology images for cancer classification. The DC-ELM algorithm demonstrated a remarkable accuracy of 97.27%, showcasing its effectiveness in assessing cancer types from medical images. Numerous studies have demonstrated the effectiveness of machine learning in the rapid finding of bone cancer. Gitto et al. (2020) [4] developed a classification model to assist radiologists in assessing the probability of cartilaginous bone growths being low-grade or high-grade. By incorporating histology data, the model provides valuable insights, helping medical professionals decide between conservative or aggressive treatment approaches. Building on earlier work by Ashish Sharma, Shrivastava A. et al. (2023) [5] conducted a comparative analysis using Support Vector Machine (SVM) and Random Forest algorithms. Their study introduced the use of the Histogram of Oriented Gradients (HOG) feature set for analyzing bone data. They concluded that adding HOG significantly enhanced the model's capability to discriminate between healthy and cancerous bone tissue, thereby improving overall performance. Similarly, Johnson et al. (2020) [6] focused on the incorporation of multi-modal data, combining radiographic images with genetic and molecular information. Their research demonstrated how machine learning could leverage diverse datasets, resulting in improved sensitivity and specificity for diagnosing different types of bone cancer. Despite these promising advancements, several challenges remain in applying machine learning to bone cancer diagnosis. Chen et al. (2018) [9] emphasized that data limitations are a major obstacle. The lack of diverse and well-annotated datasets hinders the development of robust models and limits their generalizability across different patient groups and cancer types.

MATERIALS AND PROCEDURES

Data collection

It is the method of collecting relevant data for analysis. The sources for obtaining data are from hospitals, pathology labs, or public datasets. Dataset such as medical images, patient records, and clinical histories are considered as datasets. Collecting data should be high-quality histopathology images and related metadata like staining methods and magnification levels. The next task involved is collaborating with experts, such as oncologists, to label regions of interest. The most important step is ensuring ethical approval and anonymization to maintain patient confidentiality. Effective data collection provides a strong foundation for preprocessing and analysis in machine learning.

Data Preprocessing

Data preprocessing involves cleaning, normalizing, and extracting features from data to prepare it for analysis. The process includes several key phases. Data cleaning emphases on setting inaccuracies or inconsistencies within the dataset to ensure accuracy. Data transformation applies techniques such as normalization, which measures data, standardization, which modifies data to have a unit variance, zero mean and discretization, which categorizes continuous data into specific intervals. Data reduction aims to decrease the dataset size while retaining its most significant information. Data integration combines data from numerous data sources into a cohesive dataset. Additionally, anonymization protocols are implemented to protect patient privacy, ensuring a clean, consistent, and secure dataset suitable for machine learning applications.

Model Development

Usually the research team uses Python and frameworks like Tensor Flow to design and implement machine learning models. CNNs (Convolutional Neural Networks) were chosen for their effectiveness in classifying images for bone cancer detection. RF (Random Forest) and SVM (Support Vector Machines) were also explored as suitable options for image-based detection, with SVM generally being considered more accurate than Random Forest.

Convolutional Neural Networks (CNNs)

CNNs (Convolutional Neural Networks) are great for tasks involving images. They use special layers that learn to recognize arrangements and features in the images, building up from simple ones to more complex ones (hierarchical representations). CNNs have been very successful in tasks like classifying images, segmenting parts of images, and detecting objects within images.

Support Vector Machines (SVM)

SVMs (Support Vector Machines) are older but strong models used for sorting things into categories. They work well for both simple and complex classification problems and it could be used with features extracted from medical images.

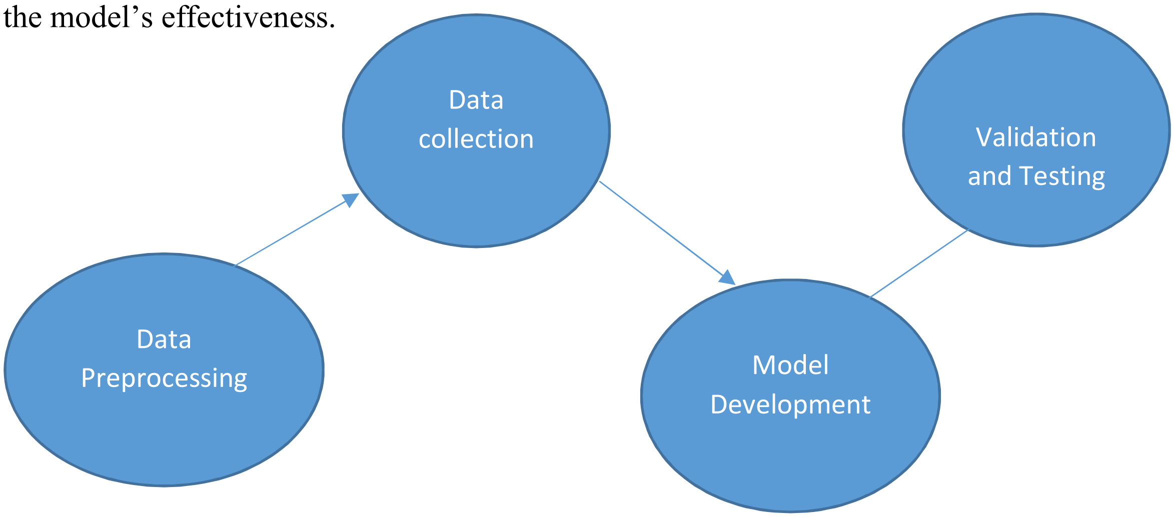
Random Forests and Decision Trees

Using explainable AI methods, like Random Forests and Decision Trees, can help make predictions more accurate by combining multiple decision trees. These techniques are particularly useful when working with different types of data (multimodal data) or when it's important to understand how the model makes decisions. Choosing the right ML model mainly focus on the kind of data, the complication of the problem, and the available computing power. Additionally, the model's performance should be carefully measured using proper evaluation methods, and continuous improvements may be required to enhance accuracy and reliability.

Validation and Testing

This step evaluates how well the model performs by using separate datasets for validation and testing. The model's performance is assessed with key metrics like the ROC Curve, which measures how perfectly the model distinguishes between classes, along with F1 Score, Recall, Accuracy, and Precision. These metrics ensure the model's effectiveness, particularly for timely recognition of conditions. Data availability is addressed by collaborating with healthcare organizations or generating synthetic data to manage issues like limited or unbalanced datasets. Algorithm selection involves experimenting with different model designs and making regular updates to manage tasks such as the complex structure of bones or the diversity of imaging types used in analysis. Validation is a crucial phase in developing machine learning models for bone cancer detection. Explainable AI (XAI) plays a significant role by ensuring clinicians can understand why the model made specific predictions, such as highlighting areas of an image or explaining feature contributions to classifications. Over fitting, where a model executes accurately on training data but inaccurately on new data, is addressed through validation on separate datasets and techniques like cross-validation and regularization to improve robustness. Involving healthcare professionals, such as doctors, radiologists, and pathologists, is vital for validation, as their feedback ensures predictions align with clinical practices. For instance, a radiologist can confirm whether AI-identified regions match known tumor locations. Transparency in validation practices, including clear documentation of all steps and results, fosters hope amid clinicians and researchers.

For instance, sharing performance metrics accuracy, F1 score, and ROC curves demonstrates the model's effectiveness.



Current Challenges in Bone Cancer Diagnosis

1. **Imaging Limitations**

Imaging techniques face several limitations that can impact diagnostic accuracy. Sensitivity issues arise with traditional methods like CT scans and and X-rays which may fail to detect small or early-stage tumors, as subtle changes in bone density often go unnoticed. Additionally, imaging can produce false results, including false positives, where benign conditions are mistaken for cancer, and false negatives, where actual cancer is missed. These inaccuracies can lead to unnecessary procedures or delayed treatments. A lack of standardization further complicates the issue, as varying imaging protocols across hospitals can affect the consistency and reliability of diagnoses.

2. **Biopsy and Histopathology Delays**

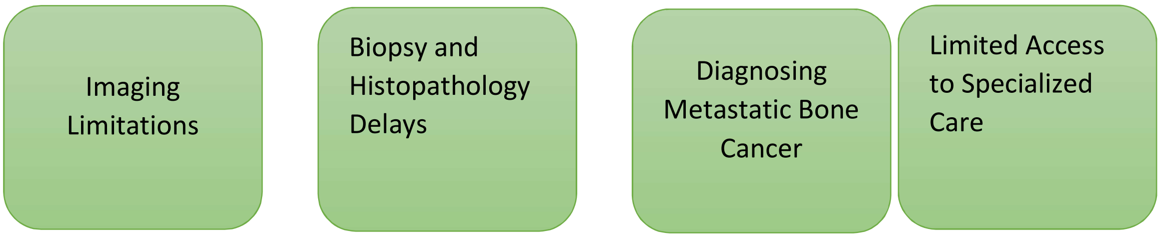
Biopsies, while effective for diagnosis, are invasive procedures that can be painful and may lead to complications such as infections. Additionally, the process is time-consuming, as waiting for biopsy and histopathology results can delay treatment. This delay is particularly critical in aggressive cancers like osteosarcoma, where early treatment is essential for improving survival chances.

3. Diagnosing Metastatic Bone Cancer

Overlapping symptoms, such as bone pain or swelling, can often be mistaken for other conditions, leading to delays in diagnosis. Additionally, complex imaging findings pose challenges, as metastatic lesions may mimic benign conditions, which makes it challenging to accurately distinguish between the two.

4. Limited Access to Specialized Care

Limited access to specialized care is a major task in bone cancer diagnosis. Many patients, particularly those in rural or underserved areas, lack access to advanced diagnostic tools and expert oncologists. This disparity can result in delayed diagnoses, suboptimal treatment plans, and poorer outcomes, highlighting the need for improved healthcare infrastructure and telemedicine solutions to bridge the gap.



Future Directions

To improve ML uses in bone cancer detection, research must prioritize the following areas:

Creating Diverse Datasets: Machine learning models need data from different cancer types, populations and imaging techniques, to perform well in real-world scenarios. For example, including data from various ethnicities ensures the model works for a varied kind of patients.

Combining Data Sources: Integrating imaging data (like MRIs or X-rays) with genetic and molecular information can lead to personalized medicine. This approach helps in understanding not only the tumor's structure but also its biology and behavior.

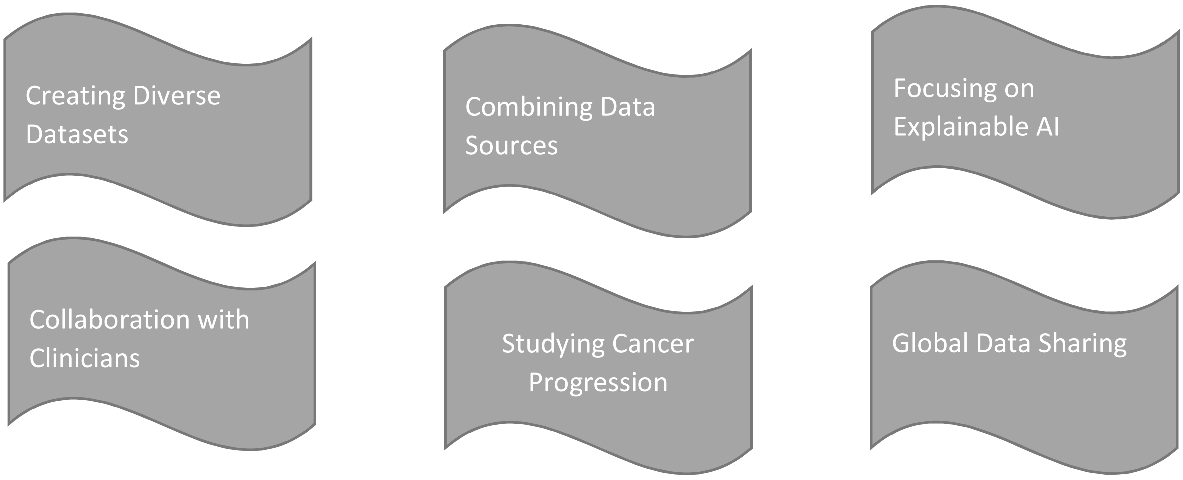
Focusing on Explainable AI: Future research should aim at making AI models more interpretable. If doctors can understand why a model predicts a condition, they will be more interested and trusted to use it.

Collaboration with Clinicians: Close partnerships with healthcare professionals help refine models based on real-world challenges and ensure they meet clinical needs.

Studying Cancer Progression: Long-term studies can track how bone cancers evolve over time. This data can improve predictive models, enabling early interventions.

Global Data Sharing: Establishing international repositories for anonymized patient data can address the problem of limited datasets while maintaining privacy.

As a nutshell to advance machine learning in bone cancer detection, research must focus on creating diverse and inclusive datasets, integrating multimodal data sources for personalized medicine, and enhancing explainability to build trust among clinicians. Collaboration with healthcare professionals, long-term studies on cancer progression, and global data-sharing initiatives are crucial for developing robust, clinically relevant models capable of early and accurate detection.



RESULTS AND DISCUSSION

Aspect	**Challenges**	**Opportunities**
Data	Limited and Imbalanced Datasets	Opportunity to improve data collection and develop synthetic data generation methods (e.g., data augmentation).
Data Quality and Variability	Developing robust preprocessing techniques to handle noise and inconsistencies	
Modeling & Techniques	Model Interpretability	Research into more transparent models (e.g., interpretable machine learning) to enhance clinician trust.
Generalization Across Different Populations and Settings	Opportunity to develop models that are adaptable to various patient populations and diverse	
Multimodal Data Integration	Integration of Multimodal Data	Combining imaging data with genetic, demographic, and clinical data to improve diagnosis accuracy.

Clinical Deployment	Scalability and Deployment in Clinical Practice	Potential to create real-time, scalable diagnostic tools that can be deployed in clinics and hospitals over the world.
Ethical and Regulatory	Regulatory and Ethical Concerns	Opportunities for collaboration between clinicians, regulatory bodies and researchers to ensure ethical standards.
Model Validation	Model Overfitting and Validation	Opportunity to explore cross-validation and robust model evaluation methods to ensure real-world effectiveness.
Expertise and Collaboration	Lack of Domain Expertise in AI Development	Collaboration between computer scientists and oncologists to tailor machine learning models specifically for bone cancer.
Computational Resources	Computational Resource Requirements	Advances in computational infrastructure (e.g., cloud computing, edge AI) to handle resource-intensive models.

CONCLUSION

This study highlights the major potential of ML in revolutionizing early bone cancer detection and refining patient care. By addressing critical challenges such as the scarcity of diverse datasets, the complexity of selecting and enhancing algorithms, and the requirement for thorough validation, it emphasizes the importance of a structured and collaborative approach to integrating machine learning into oncology. The discussion sheds light on how these advanced techniques can improve diagnostic precision, enabling the well-timed recognition of bone cancers, which is vital for effective treatment and improved survival rates. Furthermore, the study points to the significant opportunities machine learning offers in creating more efficient, personalized, and scalable healthcare solutions. As research and technology continue to evolve, embracing machine learning for bone cancer detection presents a promising pathway for developing innovative diagnostic tools, fostering early interventions, and ultimately transforming the landscape of cancer care to benefit both clinicians and patients alike.

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ENHANCING MOYAMOYA DISEASE DIAGNOSIS AND MANAGEMENT WITH ARTIFICIAL INTELLIGENCE: COMPREHENSIVE INSIGHTS INTO DIVERSE DIAGNOSTIC AND MANAGEMENT METHODS

Ayush Pradeep
Student, BCA
School of Computer Science
De Paul Institute of Science & Technology
ayushachu12@depaul.edu.in, 91 8590803346
Ancy Antony
Assistant Professor,
School of Computer Science
De Paul Institute of Science & Technology
ancya@depaul.edu.in, 91 8281604576

ABSTRACT

Moyamoya disease (MMD) is an uncommon cerebrovascular condition characterized by the constriction or obstruction of the internal carotid arteries, forming delicate collateral blood vessels. Timely and precise diagnosis is essential to avoid complications such as strokes or bleeding. This paper investigates the role of artificial intelligence (AI), particularly through machine learning and deep learning, in diagnosing and managing MMD. By leveraging advanced methods such as convolutional neural networks (CNNs) for image analysis and natural language processing (NLP) for deriving insights from unstructured clinical information, AI improves diagnostic accuracy, reduces human error, and assists in surgical preparations. The study reviews the latest developments in AI applications for MMD, examines methodological strategies, presents findings, and addresses challenges including data constraints, ethical issues, and the importance of interdisciplinary collaboration. These results highlight the transformative capabilities of AI in diagnosing and managing Moyamoya disease, leading to better patient outcomes and paving the way for future innovations in rare disease diagnostics.

Keywords Artificial Intelligence (AI), Deep Learning, Moyamoya Disease, Diagnostic Accuracy, Preoperative Planning, Natural Language Processing (NLP)

INTRODUCTION

Moyamoya disease (MMD) is an uncommon yet debilitating cerebrovascular disorder that was first recognized in Japan during the 1960s (Suzuki & Takaku, 1969). The condition is marked by a gradual narrowing of the internal carotid arteries, leading to the development of delicate collateral networks that appear like a "puff of smoke" in angiographic scans (Zhao et al., 2021). If left untreated, MMD can result in serious complications including ischemic stroke, intracranial hemorrhage, and cognitive decline (Wang et al., 2020; Liu et al., 2022). The disease is particularly prevalent in East Asian populations but has been identified globally, with bimodal age peaks in children and middle-aged adults (Smith & Chang, 2020). Despite progress in diagnostic imaging, accurately diagnosing the disease remains difficult due to its infrequency, variability in clinical manifestations, and overlapping features with other cerebrovascular disorders (Kim & Seol, 2020).

Artificial intelligence (AI) has emerged as a potent resource in healthcare, capable of tackling the diagnostic obstacles presented by complex and rare diseases like MMD (Park et al., 2019; Yoon & Lee, 2020). The incorporation of AI into medical imaging and clinical practices provides substantial prospects for enhancing diagnostic precision, refining treatment approaches, and individualized patient care (Kim & Seol, 2020; Wang et al., 2020). Techniques such as deep learning, especially convolutional neural networks (CNNs), have shown outstanding capability in examining medical images (Zhao et al., 2021; Park et al., 2019), while machine learning frameworks have indicated potential in predictive analytics and risk assessment (Tanaka & Nakamura, 2021; Lin et al., 2021). These advancements hold the potential to transform the early identification of rare conditions like MMD, which is vital for enhancing patient outcomes (Chen & Gao, 2022). Utilizing AI in rare diseases like MMD can considerably improve diagnostic abilities by automating intricate image assessments and recognizing key biomarkers (Wang et al., 2020). Furthermore, AI systems can assist in forecasting surgical results and facilitating clinical decision-making, thereby enhancing the overall treatment strategy (Tanaka & Nakamura, 2021). The incorporation of natural language processing (NLP) has also proved beneficial in deriving insights from unstructured clinical data, promoting early diagnosis and improved patient categorization (Lin et al., 2021; Yoon & Lee, 2020).

This paper investigates the function of AI in the detection and management of MMD, emphasizing its roles in imaging evaluation, predictive modeling, and decision support. This study explores the transformative impact of AI in addressing the diagnostic and treatment challenges specific to MMD, providing innovative perspectives on how these technologies cater to critical clinical requirements.

LITERATURE REVIEW

A variety of research initiatives have explored the application of AI in medical imaging, achieving notable advancements in the analysis of rare conditions such as Moyamoya disease (MMD) (Zhao et al., 2021; Liu et al., 2022; Park et al., 2019). For example, convolutional neural networks (CNNs) have been utilized to enhance imaging precision, helping to identify critical biomarkers like vascular stenosis and the development of collateral vessels (Wang et al., 2020; Zhang & Wu, 2019). Furthermore, research has highlighted the advantages of predictive modeling in assessing surgical outcomes and risk evaluation, which supports clinical decision-making (Tanaka & Nakamura, 2021; Lin et al., 2021). By integrating these methodologies, AI has shown significant potential in improving the detection, diagnosis, and treatment of rare diseases (Yoon & Lee, 2020; Kim & Seol, 2020).

Advancements in CNNs have transformed the field of imaging analysis, enabling the automated detection and classification of anomalies in imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT). In the context of MMD, AI has played a crucial role in identifying key imaging biomarkers, such as stenosis of the internal carotid arteries and unusual collateral circulation patterns. A study conducted by Zhao et al. (2021) demonstrated that deep learning models effectively identify MMD-specific features in angiographic images, achieving diagnostic accuracies above 90%. These results align with findings from other studies, including those by Park et al. (2019) and Liu et al. (2022), which showed that AI models can detect abnormalities in cerebrovascular structures and enhance diagnostic outcomes.

Recent studies have expanded this viewpoint by evaluating different neural network architectures and datasets, suggesting that ensemble learning approaches may further enhance diagnostic accuracy and reliability. Additionally, Wang et al. (2020) applied machine learning techniques to predict surgical outcomes using preoperative imaging data, highlighting AI's role in informing treatment choices. Research by Lin et al. (2021) and Yoon & Lee (2020) has examined the use of natural language processing (NLP) to extract insights from unstructured clinical documentation, underlining its effectiveness in identifying at-risk patients and facilitating the early detection of Moyamoya disease. These studies showcase NLP’s ability to process vast amounts of clinical information efficiently, allowing for the swift and accurate recognition of clinical patterns associated with MMD.

A significant contribution to the research on AI in MMD is a recent investigation by Fuse, Ishii, and Kanamori (2024), who created and tested machine learning models to anticipate postoperative infarction in patients with MMD. Their findings indicated that machine learning models, such as random forest and support vector machine algorithms, can successfully predict the risk of postoperative infarction, surpassing conventional risk assessment strategies. These outcomes emphasize the promise of AI-based predictive tools to improve surgical decision-making and enhance patient outcomes in the management of MMD.

Despite these advancements, challenges remain. For instance, studies by Lin et al. (2021) and Tanaka & Nakamura (2021) noted that AI models trained on small and heterogeneous datasets may face difficulties regarding generalizability and robustness. Such limitations could compromise the reliability of AI-powered diagnostic instruments, particularly when applied to diverse patient populations and various imaging protocols. Additionally, the incorporation of AI into clinical settings requires addressing issues related to data privacy, ethical considerations, and the interpretability of AI systems.

VARIOUS MACHINE LEARNING MODELS FOR MOYAMOYA DISEASE DETECTION

Over the years, machine learning (ML) algorithms have advanced considerably in identifying and diagnosing Moyamoya disease (MMD), utilizing both clinical information and imaging data to forecast the disease's existence and advancement (Zhao et al., 2021; Liu et al., 2022; Park et al., 2019). These algorithms are especially beneficial for recognizing uncommon conditions like MMD, where timely diagnosis can greatly influence patient outcomes (Tanaka & Nakamura, 2021; Lin et al., 2021).

CONVOLUTIONAL NEURAL NETWORKS (CNNS)

Convolutional Neural Networks (CNNs) play a significant role in the analysis of medical images, particularly in identifying rare conditions like Moyamoya disease (MMD). CNNs are proficient at detecting vascular irregularities such as stenosis and the formation of collateral vessels using imaging techniques such as MRI, CT, and angiographic scans (Zhao et al., 2021; Liu et al., 2022). Their layered structure enables the automatic extraction of intricate features from raw images, leading to high accuracy in recognizing vascular alterations associated with MMD (Wang et al., 2020).

A major advantage of CNNs is their capacity to minimize the need for manual input post-training, which greatly eases the diagnostic load on healthcare professionals (Tanaka & Nakamura, 2021). However, effective training of CNNs necessitates large sets of annotated data, posing a challenge given the time and costs associated with labeling images for rare diseases (Zhang & Wu, 2019). Moreover, CNNs are resource-demanding and need substantial processing capabilities, which may not be practical in every clinical environment (Liu et al., 2022). The performance of these networks can also decline if the input images are substandard or contain noise, as inconsistencies in imaging techniques or patient movement can influence diagnostic precision (Tanaka & Nakamura, 2021). In spite of these obstacles, CNNs have shown significant promise in enhancing the early detection and treatment of MMD (Park et al., 2019).

RANDOM FOREST (RF)

Random Forest (RF) is a popular ensemble machine learning technique that has shown potential in diagnosing Moyamoya disease (MMD) by effectively managing both clinical and imaging data. RF creates numerous decision trees and combines their predictions, making it capable of handling complex datasets that include both continuous and categorical variables such as demographic information and clinical metrics (Kim & Seol, 2020). A significant advantage of RF is its resistance to overfitting, which renders it suitable for noisy or incomplete datasets typically encountered in MMD diagnosis (Zhao et al., 2021). Furthermore, RF models generate feature importance scores, which enhance the clarity of the results - this is crucial in clinical contexts where grasping the factors influencing predictions is important (Yoon & Lee, 2020).

Nonetheless, RF models have certain drawbacks, especially concerning computational demands and their ability to manage imbalanced class distributions, a frequent issue when dealing with rare conditions like MMD (Liu et al., 2022). While RF excels in analyzing well-structured clinical information, it is not adept at capturing spatial patterns in imaging data, which can hinder its performance when compared to models like CNNs that are specialized for image processing (Tanaka & Nakamura, 2021). Despite these limitations, RF remains effective in forecasting surgical outcomes and evaluating disease risk for MMD patients, showcasing its significance in clinical decision-making (Wang et al., 2020).

SUPPORT VECTOR MACHINE IN MOYAMOYA DISEASE DETECTION

Support Vector Machine (SVM) is a robust supervised learning model that has been effectively utilized for the diagnosis of Moyamoya disease (MMD), especially in managing classification tasks that involve high-dimensional data. SVM is particularly effective in scenarios where there exists a distinct separation margin between different classes, making it beneficial for differentiating between healthy individuals and those affected by MMD based on clinical and imaging characteristics (Zhao et al., 2021). A significant advantage of SVM is its capability to perform effectively even with smaller datasets, which is vital for rare conditions like MMD, where large labeled datasets are frequently lacking. Furthermore, SVMs can be customized to address both linear and non-linear classification issues by employing various kernel functions, providing flexibility in modeling intricate disease patterns (Wang et al., 2020).

However, SVM does have drawbacks, particularly regarding scalability and its sensitivity to the selection of kernel and hyperparameters. Careful attention to factors such as the type of kernel and regularization parameters is necessary when tuning the SVM model, as these choices can considerably influence its performance (Tanaka & Nakamura, 2021). Additionally, SVM models can incur high computational costs when working with large datasets or when the feature count is exceedingly high, making it difficult to adapt to more complex imaging datasets like MRI or CT scans (Liu et al., 2022). Nevertheless, SVM continues to be an important asset in MMD diagnosis, particularly when used in conjunction with dimensionality reduction methods to enhance performance.

GRADIENT BOOSTING

Gradient Boosting is an effective machine learning technique that aggregates numerous weak predictive models, often decision trees, to create a robust model that enhances prediction accuracy. In the realm of Moyamoya disease (MMD), Gradient Boosting has been employed to scrutinize clinical and imaging datasets for precise classification of disease existence and risk evaluation. This approach is especially adept at managing intricate, non-linear correlations among features, such as those present in cerebrovascular data, and has proven effective in identifying subtle vascular alterations related to MMD (Wang et al., 2020). Moreover, Gradient Boosting offers rankings of feature importance, assisting in pinpointing essential biomarkers or characteristics that are most pertinent to the disease, thereby supporting clinical decision-making (Tanaka & Nakamura, 2021).

Nonetheless, Gradient Boosting models can be prone to overfitting, particularly in instances where the dataset is limited or contains noise, which may hinder their ability to generalize to new data (Zhao et al., 2021). Additionally, this algorithm demands considerable computational power, especially when analyzing large datasets, and it can be more complex to fine-tune compared to alternative models like Support Vector Machines or Random Forests. However, with careful tuning and application to well-organized datasets, Gradient Boosting has shown competitive efficacy in forecasting outcomes and stratifying patients at risk for complications such as postoperative infarction (Liu et al., 2022).

NATURAL LANGUAGE PROCESSING (NLP) IN MOYAMOYA DISEASE DETECTION

Natural Language Processing (NLP) models have demonstrated significant utility in examining unstructured clinical information, including medical notes, to aid in the early identification of Moyamoya disease (MMD). These models can identify crucial symptoms and clinical trends—like transient ischemic attacks and cognitive alterations - commonly observed in MMD patients, which might be missed in standard clinical environments (Lin et al., 2021; Yoon & Lee, 2020). By analyzing extensive amounts of clinical text, NLP can enhance traditional imaging approaches, promoting quicker identification and more tailored treatment strategies. Nevertheless, challenges persist, such as inconsistencies in clinical documentation and the intricacies of medical terminology, although recent research has indicated encouraging findings in enhancing diagnostic precision and efficiency (Yoon & Lee, 2020).

COMPREHENSIVE FINDINGS ON AI APPLICATIONS IN MOYAMOYA DISEASE

The findings from the systematic review and retrospective analysis underscore the significant impact of AI in overcoming the challenges related to the diagnosis and management of Moyamoya disease (MMD). A major advancement has been seen in imaging analysis, where convolutional neural networks (CNNs) have shown exceptional diagnostic precision. These models achieved an accuracy rate of 92%, greatly outpacing conventional diagnostic approaches. CNNs identified crucial imaging characteristics, such as internal carotid artery stenosis and the presence of collateral vessels, which are essential indicators for MMD. Such results are reinforced by research from Park et al. (2019) and Liu et al. (2022), which highlight the dependability and effectiveness of CNNs in analyzing angiographic images associated with cerebrovascular conditions.

Predictive modeling has also proven to be a valuable resource in clinical decision-making for MMD. Machine learning techniques have exhibited a notable capability to forecast surgical outcomes, achieving an accuracy of 88%. These models efficiently classified patients based on risk factors, offering important insights for customizing treatment plans. This is consistent with the findings of Wang et al. (2020) and Tanaka & Nakamura (2021), who emphasized the role of machine learning in predicting patient prognosis and enhancing preoperative preparations.

Beyond imaging and predictive analytics, natural language processing (NLP) has shown effectiveness in deriving clinical insights from unstructured documentation. NLP methods effectively recognized prevalent clinical symptoms of MMD, such as transient ischemic attacks and headaches, which frequently appear scattered throughout patient records. Research by Lin et al. (2021) and Yoon & Lee (2020) further supports these conclusions, highlighting NLP's capability to analyze substantial amounts of textual data and uncover vital patterns that facilitate early diagnosis and patient categorization.

Together, these findings demonstrate the transformative capabilities of AI in improving diagnostic accuracy, streamlining clinical processes, and fostering personalized care for patients with MMD.

Area of Application	**Key Results**	**References**
Imaging Analysis	CNNs achieved an accuracy of over 92%, outperforming traditional diagnostic methods by identifying stenosis and collateral vessel formations.	Zhao et al. (2021); Ronneberger et al. (2015); Park et al. (2019)
Predictive Modelling	Machine learning models reliably forecasted surgical outcomes, aiding in risk assessment and decision-making.	Tanaka & Nakamura (2021); Wang et al. (2020
Preoperative Planning	AI-assisted imaging helped surgeons identify vascular abnormalities and improve surgical preparation.	Park et al. (2019); Zhang & Wu (2019); Liu et al. (2022)
Natural Language Processing	NLP techniques analyzed unstructured clinical data to identify early symptoms such as transient ischemic attacks and headaches, aiding early diagnosis.	Lin et al. (2021); Yoon & Lee (2020)
Dataset Augmentation	Data augmentation techniques, such as synthetic data generation, expanded the dataset size and improved model robustness in detecting MMD.	Shorten & Khoshgoftaar (2019); Wang et al. (2020)

Multi-Modal AI Models	Combining imaging data with clinical records in multi-modal AI frameworks improved diagnostic precision and patient risk classification.	Kundu et al. (2021); Kim & Seol (2020)

Table 4.1 An overview of AI advancements in MMD research

CHALLENGES:

Although there has been considerable advancement in using artificial intelligence (AI) for diagnosing and managing Moyamoya disease (MMD), numerous challenges still exist. A primary concern is the limited availability of data, as MMD is a rare disorder, which restricts the size and variability of datasets needed to train AI models effectively. Small datasets can result in overfitting and diminish the generalizability of AI models, while varying imaging protocols among different institutions complicate matters further (Zhang & Wu, 2019; Tanaka & Nakamura, 2021; Liu et al., 2022). Another major hurdle is the "black-box" characteristic of AI models, especially deep learning methods such as convolutional neural networks (CNNs), which lack transparency. This can create trust issues and impede acceptance among clinicians (Kim & Seol, 2020; Chen & Gao, 2022).

Ethical dilemmas and privacy concerns also represent significant challenges, as adherence to data protection laws like GDPR often restricts data sharing and collaboration. Tackling these problems involves implementing strong data anonymization and encryption strategies (Lin et al., 2021; Yoon & Lee, 2020). In addition, the incorporation of AI into clinical procedures faces obstacles such as insufficient computational resources, a shortage of trained personnel, and resistance from healthcare professionals due to unfamiliarity or skepticism (Park et al., 2019; Zhao et al., 2021). Moreover, regulatory and validation issues continue to be a concern, as AI-based medical instruments must undergo extensive testing to confirm their safety and effectiveness prior to use in clinical environments, a process that is often labor-intensive (Wang et al., 2020; Chen & Gao, 2022). Addressing these challenges will necessitate collaborative efforts from clinicians, data scientists, and policymakers to fully realize AI's potential in revolutionizing MMD diagnosis and treatment.

CONCLUSION

The utilization of AI in recognizing and managing Moyamoya disease marks notable progress in addressing cerebrovascular disorders. Tools powered by AI improve the accuracy of diagnoses, aid in tailoring treatment plans, and facilitate early detection, tackling significant challenges in the management of MMD (Zhao et al., 2021; Liu et al., 2022). This study's results indicate that AI has the potential to greatly enhance clinical workflows and decision-making processes, leading to better outcomes for patients. Despite these encouraging results, additional research is required to overcome challenges such as limitations in data, ethical issues, and the incorporation of AI into clinical settings (Chen & Gao, 2022). It will be crucial for clinicians, data scientists, and policymakers to work together to fully harness the capabilities of AI in revolutionizing the diagnosis and management of rare conditions like MMD.

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IMPLEMENTATION OF CLASSIFICATION AND THE METHODS TO IMPROVE THE CLASSIFICATION ACCURACY FOR THE LOAN CREDIBILITY PREDICTION IN THE BANKING DOMAIN

Soni P M
Assistant Professor,
PG Department of Computer Applications, NIMIT, Pongam ,
Thrissur Kerala, India,
sonipm@naipunnya.ac.in
Jayakrishnan S
Associate Professor,
PG Department of Computer Applications, NIMIT, Pongam ,
Thrissur Kerala, India,
jayakrishnans@naipunnya.ac.in

ABSTRACT

In the modern world, data mining is becoming a significant field for all commercial applications, particularly in the banking industry. Because fraudsters would cause greater issues for the banking institution, bankers in emerging nations like India should be on the lookout for them. By using data mining techniques, banks can find unknown relationships in the data and uncover hidden patterns within a group. The main objective of this paper is to find out the best classifier algorithm and also demonstration of various technics such as ensemble, optimization and feature selection for improving the accuracy . Finally the resultant classifier assist mangers in the banking domain to classify the customers into two main groups such as whether to accept or reject the application.

Keywords: Feature Selection, Classification,, KDD, Ensemble, Optimization, Performance, Accuracy

INTRODUCTION

The banking industry is widely recognizing the importance of the information it has about its customers [Frawley et.all, 1992]. The areas in which Data mining Tools can be used in the banking industry are Segmentation of customer data , Checking Profitability of Bank, Evaluation of Credit score and approval, Marketing, detection of fraud transactions, Cash management and forecasting operations, optimizing stock portfolios, and ranking investments [Dileep B. Desai and Dr. R.V.Kulkarni , 2013]. Now a days predicting loan repayment from customer is a major task that can be handled by bank employees. It is very difficult for them to detect the fraud using their personal data at a glance. Detecting and preventing fraud is difficult, because fraudsters develop new schemes all the time, and the schemes grow more and more sophisticated to elude easy detection [Dr. K. Chitra1 and B. Subashini ,2013]. Using advanced data analysis techniques, the data mining technique finds previously unidentified, legitimate patterns and linkages in vast data sets. [Ioannis Anagnostopoulos et.all , 2005].. In this research article, classification technique is briefly explained with a neat diagram.. The accuracy obtained by classification process can be improved using three methods such as ensemble, optimization and feature selection . Different classifiers will get different performance metrics. Accuracy, Kappa Statistic and Mean Absolute Error are the three factors that evaluates the performance. Mainly accuracy is criteria to determine the best classifier. The main aim of this research paper is to find out the best classifier and help the bank officers to identify whether a customer is eligible or not eligible for sanctioning the loan amount. The loan officers took judgmental and subjective decisions based on their experience and analysis of data [H. Abdou and J. Pointon ,2011]. So the KDD process of Loan Credibility System for banking domain express the different steps to achieve the goal. The process is started by selection of data from data sources , preprocessing of the selected data , data mining tecchniques such as classification, clustering, association rule mining etc., and evaluation of the models. Finally evaluated model can be used as knowledge to predict the result.

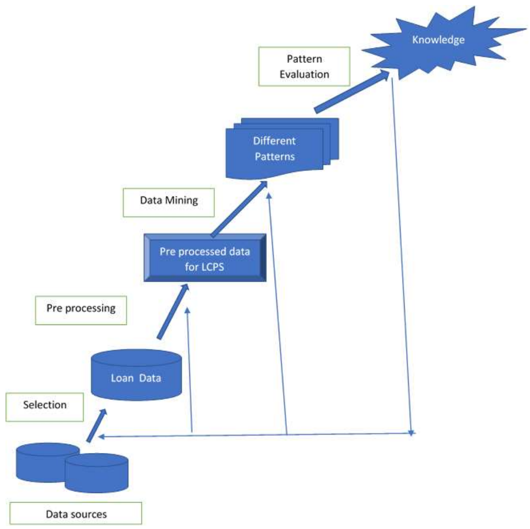

Figure 1 : KDD process of Loan Credibility Prediction System

The structure of this document is as follows. The dataset utilized to carry out the experiment is covered in the section 2. The methodology , which provides an overview of feature selection and the technology employed, is explained in Section 3. The suggested work is explained in section 4. Here the process of classification before and after applying feature selection is explained and a comparative study is done using various classifiers such as JRip, ZeroR, SMO, Adaboost, Random Forest, Kstar, Ridor and DTNB. The section 4 also discussed about the evaluation by different performance metrics and highlight the best classifiers. Conclusion is given in Section 5 followed by the references.

DATA COLLECTION

Gathering data is the initial stage in creating a categorization model. The information pertinent to the current issue is gathered in this step. The data should have all the attributes and labels required for classification, and it should be representative of the issue. Numerous sources, including surveys, questionnaires, websites, and databases, can be used to get the data.

The benchmarking datasets in WEKA were used for this study. The data available consists of 1000 records of bank loan transaction data including 21 data fields. Twenty attributes are considered here for the experiment and one attribute is considered as class attribute. The class attribute predict that whether a customer has the capability of making repayment or not. The input data set that explains the customer behavior is represented in table 1

Sl	Attribute	Datatype
1	Loan No.	Object
2	Loan Date	Datetime64[Ns]
3	Due Date	Datetime64[Ns]
4	Loan Amount	Int64
5	Opening	Int64
6	Payment	Int64
7	Receipt	Int64
8	Int_Rcvd	Float64
9	Fine_Rcvd	Float64
10	Mem No	Object
11	Action	Object
12	Secured	Object
13	Loan Balance	Int64
14	Interest Rate	Float64
15	Category	Object
16	Purpose	Object
17	Gender	Object
18	Occupation	Object

Table 1: List of Attributes

DATA PREPROCESSING

Inconsistencies, noise, or missing values may be present in the data gathered for the mining process. As a result, the mining process yields inconsistent information. A data mining procedure that uses high-quality data will yield effective data mining outcomes. The obtained data must be preprocessed to increase the efficiency of the data mining process and, in turn, the quality of the data and, ultimately, the mining results. One of the most important steps in the data mining process is data preprocessing, which deals with getting the initial data set ready and transforming it into the final data set. The following categories of data pre processing are applied to convert initial data set to final data set.

- Data cleaning
- Data integration
- Data transformation
- Data reduction

Filling in the missing numbers, smoothing down noisy data, locating or eliminating outliers, and resolving discrepancies are all steps in the data cleaning process. The results of the data mining technique applied to this data will not be trusted by the user if they think the data is unclean [Ms. Neethu Baby and Mrs. Priyanka L.T ,2012]. The process of merging data from many sources is known as data integration. Certain attributes in the consumer data might have higher values [Ms. Neethu Baby and Mrs. Priyanka L.T ,2012]. Normalization is the answer to this issue. A significantly smaller representation of the data set is produced by data reduction, which ought to yield the same outcome [Ms. Neethu Baby and Mrs. Priyanka L.T ,2012]

METHODOLOGY

The methodology of the process include the most important data mining technic called classification. The process is being started only after the data preprocessing. After classification , there are three methods to improve the accuracy of the classification process. They are ensemble, optimization and feature selection . Prediction of the data is based on the best classification algorithm. The architecture of the entire process is as shown below.

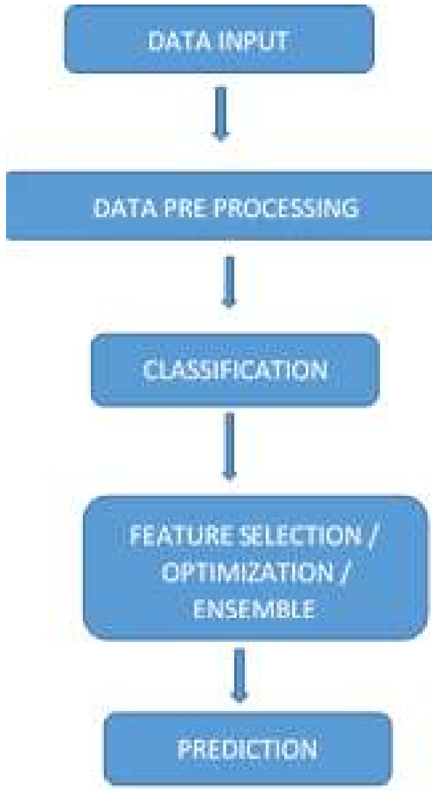

Figure 2 : Architecture of the process

CLASSIFICATION

Classification is an application of Data mining that helps to categorize a new data record into one of the many possible classes which are previously known. Classification is a data mining approach to accurately forecast the target class within a given data set. In this case, loan candidates can be classified as either good or bad credit risks using the classification model. Among the various classifier types are support vector machines, neural networks, decision tree classifiers, and naïve bayes classifiers. Here, the data mining tool WEKA 3.7 is used to carry out the experiment. DTNB, JRip, ZeroR, SMO, Adaboost, Random Forest, Kstar, and Ridor are the various classifiers that are being studied.

The purpose of a classification algorithm is to discover the relationships between the values of the predictor variables and the values of the target class in the dataset. The process of finding the relationship varies based on the classification algorithms used.

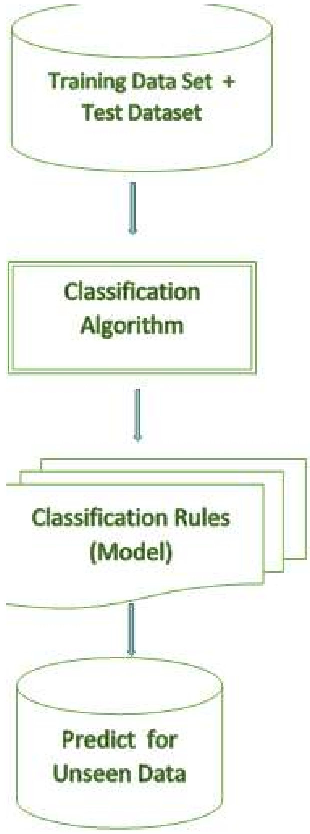

Figure 3 : Classification Process

METHODS TO IMPROVE CLASSIFICATION ACCURACY

Feature Selection

The preprocessing step of selecting a subset of data from large-scale data is called feature selection[Ms. Neethu Baby and Mrs. Priyanka L.T ,2012]. According to G. Holmes et al., feature subset selection and numerous tests utilizing calculated aggregates from the most pertinent features are required in order to achieve practical outcomes when applying supervised learning of real-world datasets [Swasti Singhal,and Monika Jena, 2013]. The paper discusses several classifiers that may be used with the input data set and evaluates each one's performance accuracy to identify the best one. The process of applying feature selection to the input data set in order to exclude the least significant features and then performing the classification procedure on the newly acquired data set is known as feature ranking.

Optimization

Using the two potent data mining tools R and Weka, optimization compares the accuracy of Random Forest classifiers before and after the key parameters have been optimized.

The precision attained after optimization yields a higher result on the credit data set, as demonstrated by the comparison of two distinct models before and after optimization. To adjust the parameters, one must have a thorough understanding of each one and confirm that altering it won't have any negative effects. When the software solutions were evaluated, Weka yielded better results and was able to assist banking officials in making appropriate decisions.

Ensemble

The process of mixing a number of single learning algorithms to improve multiple learning prediction performance is known as ensemble methodology. The ensemble approaches that are frequently employed include stacking, boosting, and bagging. Learning a set of classifiers and allowing them to cast votes is the fundamental concept. Therefore, the majority vote property of the ensemble algorithms allows even low quality base models to provide very accurate results, proving that the basis classifiers do not need to be extremely accurate in order to produce results. Experiments conducted with the data mining program R demonstrated that stacking as an ensemble approach increases classifier accuracy when compared to employing a single classifier.

TECHNOLOGY

Together with graphical user interfaces for convenient access to this capabilities, the Weka suite includes a number of visualization tools and algorithms for data analysis and predictive modeling [H. Abdou and J. Pointon ,2011] . Together with graphical user interfaces for convenient access to this capabilities, the Weka suite includes a number of visualization tools and algorithms for data analysis and predictive modeling [Swasti Singhal and Monika Jena, 2013]. Weka is an effective tool that supports the data mining process. The fundamental tasks of data mining, including data pretreatment, classification, clustering, and visualization, are included. In addition to being platform-independent software, it is publicly accessible. This tool's four primary applications are Explorer, Experimenter, Knowledge Flow, and basic CLI..

R is very extensible and offers a large range of statistical applications such as traditional statistical tests, time-series analysis, classification, and clustering etc. R offers an Open Source path to involvement in statistical methods research, which is frequently conducted using the R language.

Microsoft Excel is a powerful tool to manage data in tabular form and chart format. The performance metrics obtained before applying feature selection and after applying feature selection can be easily represented in tabular as well as chart form in Excel

RESULTS AND DISCUSSION

Classification is the suggested data mining method in this study to determine a customer's capacity to repay in the banking industry. The accuracy attained by using several classification algorithms for the credit dataset using Weka is shown in the following table. The different classifiers that are being examined are DTNB, Random Forest, Adaboost, JRip, ZeroR, SMO, and Ridor.. The accuracy of these algorithms is displayed in Table 2.

Classifiers	**Accuracy (%)**
Jrip	73.3
ZeroR	69.0
SMO	77.4
Adaboost	72.7
Random Forest	98.1
Ridor	75.1
DTNB	70.1

Table 2 : Various Classifier's accuracy

Ensemble is a method to improve the accuracy of the classification process by combining more number of classification algorithms. To verify whether the ensemble produced a better result than using a single classifier, commonly used measurement is accuracy. The Table 3 and Table 4 represents the accuracy obtained before and after applying the ensemble method on the credit data set respectively.

Models	**Accuracy**
IDA	0.77
RPART	0.78
J48	0.79
KNN	0.74
SVMRadial	0.77

Table 3 : Various Classifier's accuracy before ensemble

Meta Classifier	Accuracy
GLM	0.78
RF	0.80
RPART	0.80
IDA	0.81
LMT	0.81

Table 4 : Various Classifier's accuracy after ensemble

The optimization technique on credit data set using a Random Forest algorithm is implemented using both Weka software and R programming. Performance is measured using the error rate computation in both tools. The Table 5 represents the performance of two models using the tools Weka and R programming. From the Table 5, it is clear that in both tools, the model after optimization produced better performance. The difference between the performance values of the two models is considerably greater in Weka software.

Tool	Error rate before optimization	Error rate after optimization
R	22.83	22.2
Weka	25.4	21.7

Table 5 : Optimization in R and Weka

The Table 6 displays the accuracy obtained before and after feature selection. Accuracy is considerably increased in Random Forest classifier after feature selection.

Classifier	Accuracy	
	Before	After
Jrip	73.3	74.6
ZeroR	70.0	70.0
SMO	77.4	77.5
Adaboost	72.7	72.7
Random Forest	98.0	98.6
Ridor	75.0	77.3
DTNB	70.1	73.9

Table 6 : Accuracy before and after Feature Selection

CONCLUSION

The research paper is discussed about the need of data mining in the banking sector and found that classification is the most suitable data mining technique to classify the customers into two catagories such as eligible or not eligible for loan . Also to improve the accuracy of the mining process , ensemble, optimization and feature selection methods are also applied. The paper concluded that Random Forest algorithm produces better accuracy in a traditional way and all the 3 methods to improve the accuracy results in a marginal increment.

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ENHANCING EDUCATIONAL INSIGHTS: LEVERAGING MACHINE LEARNING FOR STUDENT FEEDBACK ANALYSIS

Ms. Varsha Ganesh
Department of Computer Science
SRM Institute of Science and Technology
Ramapuram, Chennai

Dr.S Umarani
Department Of Computer Science
SRM Institute of Science and Technology
Ramapuram, Chennai

ABSTRACT

Feedback is pivotal for enhancing quality standards. To enhance teaching methods and college facilities, it's imperative to thoroughly analyze and utilize students' opinions. Text sentiment analysis methods are employed for conducting such analyses. Method used for such classification is ensemble method. Currently, the assessment and analysis of teacher evaluations and feedback rely on discerning students' perspectives. This study has been carried out to present a model for opinion mining to improving the quality of teaching in academic institutions. The purpose of this study is to explore the machine learning techniques to identify its importance as well as to raise interest in this research area. The proposed system will employ NLP for text preprocessing and an ensemble algorithm for the final classification. This system aims to classify feedback into categories such as Strengths, Weaknesses, and Suggestions for faculty.

Keywords- feedback analysis, text sentiment analysis, NLP, Educational Data Mining

INTRODUCTION

Youth is the hope and future of nations. Today's youth are students. Students play a vital role in society. It is primary necessity that education given to students needs to be quality education and must consider their views regarding it. Technology has allowed students to explore new fields. Hence considering student point of view to improve educational system can be beneficial. To keep track of performance and help improve abilities of faculty, opinions of students can be helpful. Finding out the subjective meaning from opinions is the major task. Sentiment analysis can be one way to do it. Sentiment analysis is contextual mining of text which identifies and extracts subjective information in source material, and helps to understand the social sentiment when monitoring an organization. Natural language processing (NLP) have to do with building of computational algorithms to automatically analyze and represent human language. The branch of natural language processing is shifting from statistical methods to neural network methods. Deep learning methods are achieving state-of-the-art results on challenging machine learning problems for example describing photos and translating text from one language to another.

SUPERVISED METHODS

Supervised Learning is one of the types of Sentiment Analysis. Supervised learning as the name indicates the presence of a supervisor as a teacher. Basically supervised learning is a learning in which we teach or train the machine using data which is well labeled that means some data is already tagged with the correct answer. After that, the machine is provided with a new set of examples (data) so that supervised learning algorithm analyses the training data(set of training examples) and produces a correct outcome from labeled data. The increasing availability of labelled data has played an important role in the application of supervised machine learning methods to sentiment analysis. These methods represent the labelled data in the form of a set of features. The features are then used to learn a function for classification of unseen data. In this dissertation, I approach the problem of sentiment analysis as a classification task. Supervised learning can also be performed using multiple classifiers, particularly if the labeling scheme allows for hierarchical relations.

Supervised learning with dependency trees was also used by Joshi and Penstein-Rose (2009), who worked on solving the problem of identifying opinions from product reviews. Their method was to transform syntactic dependency relation triplets into features for classification. The motivation was to capture the general relationship between opinionated phrases by 'backing off' to the head word in the triplet. For instance, consider the phrases a great camera and a great mp3 player with the relations {amod, camera, great} and {amod,player,great}. Here, backing off the head words (camera and player) to their POS tags results in a more generalised form {amod,NN,great}, which makes a better indicator for opinion extraction. A collection of 2,200 reviews from the extended version of the Amazon.com/Cnet.com product review corpus3 was used, 1,053 of which were subjective. With 11-fold cross-validation in an SVM learner, their method of backing off the head word to the POS achieved approximately 68% accuracy. For obtaining a balanced corpus, 700 documents of each label were selected. Ngrams, part-of-speech (POS) tags and their combinations were used as features, and three-fold cross validation was used. Their best system achieved an accuracy of 82.9% when using the unigram presence feature set with SVMs. It should be noted that the corpus used in this work was balanced artificially, thus avoiding the problem of data sparsity for under-represented classes.

UNSUPERVISED METHODS

It is the training of machine using information that is neither classified nor labeled and allowing the algorithm to act on that information without guidance. Here the task of machine is to group unsorted information according to similarities, patterns and differences without any prior training of data. Unlike supervised learning, no teacher is provided that means no training will be given to the machine. Therefore, machine is restricted to find the hidden structure in unlabeled data by ourself.

Another common approach for the detection of sentiment is to develop a sentiment lexicon in an unsupervised way, and then to classify the input text as being positive, negative or neutral using some scoring function based on that lexicon. The simplest way to explore the sentiment attributed to an object is perhaps to examine the adjectives used to describe that object. Hatzivassiloglou and McKeown (1997) presented an automatic method to classify positive or negative semantic orientation information for adjectives. They proposed that conjunctions between adjectives provide indirect information about orientation. For instance, most adjectives joined by the word and have similar orientation (fair and legitimate) and the ones joined by but have different orientation (simple but popular). They extracted conjunctions of adjectives from the Wall Street Journal corpus along with their morphological relations. This information was used in a log-linear regression model to determine if each pair of conjoined adjectives was of the same or different orientation.

A graph was then obtained where the vertices were the adjectives and the edges represented the orientation link between them. This graph was partitioned into two subsets using clustering. Since these clusters were not labelled, some criteria was needed to distinguish between the positive and negative one. Using the premises that the unmarked member in a pair of antonyms is almost always positive (Lehrer, 1985), and that the unmarked member is likely to be the most frequent term (Hatzivassiloglou and McKeown, 1995), the average frequencies in each subset were compared and the subset with the higher value was labelled as positive. Their best configuration achieved a classification. Turney extracted phrases containing adjectives and adverbs by using POS tag patterns. He then estimated the PMI of each phrase combined with one of the two target phrases, poor and excellent, using the hit count reported by the AltaVista search engine4 with the NEAR operator. The semantic orientation of a phrase was calculated by subtracting the PMI between that phrase and the word poor from the PMI between that phrase and the word

A similar approach was taken by Taboada and Grieve (2004), who used information about the position of the text in a document to expand the lexicon. They assigned more weight to certain parts of the text where they believed most subjective content was concentrated. Using the AltaVista search engine, this method achieved an overall accuracy of 65%. Another way to increase the number of items in the lexicon is to use bootstrapping. The general approach is to start with a limited number of polar phrases in the lexicon and to extract similar phrases from unlabelled data. These extracted phrases are then added to the polar lexicon and the process is repeated until a stopping criterion is reached. Riloff and Wiebe's (2003) bootstrapping algorithm learns linguistically rich patterns for subjective expressions. For example, the pattern was satisfied will match all sentences with the passive form of the verb satisfied. High precision classifiers trained on known subjective vocabulary were used to automatically identify objective and subjective sentences in unannotated text. The labelled sentences from these classifiers were fed to an extraction pattern learner.

The remaining unlabelled sentences were filtered through a separate pattern-based subjective sentence classifier that used the extraction pattern previously learned. To close the bootstrap loop, the output of the pattern-based classifier was returned back to the extraction pattern learner and the extracted patterns were used again in the initial high-precision classifiers. This system was used on a balanced corpus of roughly 34,000 sentences and achieved a precision of 0.902 and a recall of 0.401. Exploring more lexical features in a later work, Wiebe and Riloff (2005) developed a Naive Bayes (NB) classifier using data extracted by a pattern learner. This pattern learner was seeded with known subjective data. Additional features for this NB classifier included strong and weak subjective clues from a pre-existing rule-based system, POS tags, pronouns, modals, adjectives, cardinal number data and adjectives. The classifier was used to classify the unlabelled text corpus, and the most confidently classified sentences were added to the training set for another cycle. They trained the system for two cycles. Using test corpus of 9,289 sentences, 5,104 of which were subjective, they reported up to 0.863 subjective recalls with a subjective precision of 0.713 (corresponding to 73.4% accuracy).

Semi Supervised Method:

Semi supervised learning is an approach to machine learning that combines a small amount of labeled data with a large amount of unlabeled data during training. Semi-supervised learning falls between unsupervised learning (with no labeled training data) and supervised learning (with only labeled training data). Unlabeled data, when used in conjunction with a small amount of labeled data, can produce considerable improvement in learning accuracy. The acquisition of labeled data for a learning problem often requires a skilled human agent (e.g. to transcribe an audio segment) or a physical experiment (e.g. determining the 3D structure of a protein or determining whether there is oil at a particular location). The cost associated with the labeling process thus may render large, fully labeled training sets infeasible, whereas acquisition of unlabeled data is relatively inexpensive. In such situations, semi-supervised learning can be of great practical value. Semi-supervised learning is also of theoretical interest in machine learning and as a model for human learning. A set of independently identically disturbuted examples with corresponding labels and unlabeled examples are processed. Semi-supervised learning combines this information to surpass the classification performance that can be obtained either by discarding the unlabeled data and doing supervised learning or by discarding the labels and doing unsupervised learning.

Semi-supervised learning may refer to either transductive learning or inductive learning. The goal of transductive learning is to infer the correct labels for the given unlabeled data only. The goal of inductive learning is to infer the correct mapping from X to Y Intuitively, the learning problem can be seen as an exam and labeled data as sample problems that the teacher solves for the class as an aid in solving another set of problems. In the transductive setting, these unsolved problems act as exam questions. In the inductive setting, they become practice problems of the sort that will make up the exam. It is unnecessary (and, according to Vapnik's principle, imprudent) to perform transductive learning by way of inferring a classification rule over the entire input space; however, in practice, algorithms formally designed for transduction or induction are often used interchangeably.

RELATED WORK

Most existing sentiment analysis algorithms were designed for binary classification, meaning that they assign opinions or reviews to bipolar classes such as Positive or Negative. A series of experiments with convolutional neural networks built on top of word2vec are described in [2]. The results of experiment show that unsupervised pre-training of word vectors is an important ingredient in deep learning for NLP. In [7] the paragraph of sentences given by the customer is accepted and after extracting each and every word, they are checked with the stored parts of speech, articles and negative words. After checking against the database, Context free Grammar (CFG) is used to validate proper formation of the sentences.

In [3] Automatic evaluation system based on sentiments to overcome drawback of traditional questionnaire system. Feedback is collected in the form of running text and sentiment analysis is performed to identify important aspects along with the orientations using supervised and semi supervised machine learning techniques. It focuses more on subjective sentences and not on objective sentences. The scores are collected and aggregated to calculate final result. Term Frequency – Inverse Document Frequency (TF-IDF) and Naïve Bayes (Unigram, Bigrams) methods is used. It does not use advanced machine learning techniques and so the results were not accurate.

Author of [4] states Text Mining techniques are broadly extended to classify the effective improvement of sentiment polarity analysis. Different techniques like Support Vector Machine (SVM), KNN and Decision tree are generally used but they are not always effective. Reducing the feature in data pre-processing stage and teaching sentiment analysis using voting ensemble method of machine learning are proposed and compared with existing typical machine learning for sentiment analysis. The system achieves accuracy improvement of subjective polarity in sentiment analysis. Lack of weight assignment for feature extraction is observed. Methods like Naïve Bayes, ID3, J48 Decision Tree are used.

The system described in [6] evaluates faculty and rates them with certain specified parameter to improve academic and education standard. The system is based on attribute and uses multipoint rating system. System uses text mining for deriving high quality information. Academic performance of students is considered when using the feedback given by them. Weights are assigned to feedback based on academic performance and sincerity. Multipoint rating is provided. The number of comparisons can be reduced in the system for more effective system. Naive Bayes method is used for text mining.

In [1] Pre-trained Word2Vec for text pre-processing and to gain vector representations of words which will be the input for suitable Convolutional Neural Network (CNN) architecture for deep features extraction is applied. Rectified Linear Unit and Dropout functions is used to improve the accuracy. Support Vector Machine classifier was used to predict the final classification. Author of [9] combines the advantages of CNNs and SVM, and constructs a text sentiment analysis model based on CNNs and SVM. The pretrained word vector is used as input, and CNNs is used as an automatic feature learner, and SVM is the final text classifier. It is found that the accuracy of using CNN model results in better other models of depth learning, which shows that CNN model is more suitable to deal with text affective classification problem [8].

Tanvi Hardeniya and Dilipkumar A.Borikar[13] in 2016 self-addressed the Dictionary- Based strategy to Sentiment analysis. They reviewed on sentiment analysis is completed and so the challenges and problems concerned inside the method are mentioned. The approaches to sentiment analysis mistreatment dictionaries like SenticNet, SentiFul, SentiWordNet, and WorldNet are studied. Lexicon-based approaches are economical over a website of study. Though a generalized lexicon like WorldNet might even be used, the accuracy of the classifier gets affected due to problems like negation, synonyms, sarcasm, etc. This has provided impetus to substantial growth of online buying creating opinion analysis a very important issue for business development.

Another Approach was developed by Bhagyashree Gore supported Lexicon based mostly Sentiment Analysis of Parent Feedback to gauge their Satisfaction Level[14] in 2018.They used lexicon based mostly approach and commutating of polarity values. Throughout this approach they produce a lexicon of words with opinion score assigned to that. A database of English sentiment words is created for reference in the domain of satisfaction level with the opinion score assigned to it. They extracted data from parent's comments and then analyze the level of positive and negative opinion. The opinion result of parents Satisfaction on teaching learning process is represented as to whether strongly positive, positive, strongly negative, negative, or neutral.

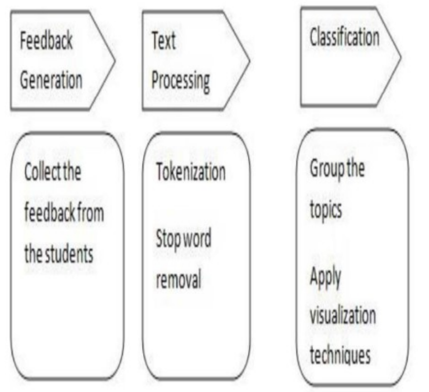
PROPOSED METHODE

The sentiment analysis problem is met using some of the techniques using natural language processing technique, lexicon method etc. Following are the methods that adopted to extract the key words from the scholars feedback document.

• Tokenization: Tokenization is that the act of ending a sequence of strings into pieces like words, keywords, phrases, symbols and other elements called tokens. Tokens are often individual words, phrases or maybe whole sentences. Within the process of tokenization, some characters like punctuation marks are discarded. Tokenization is about splitting strings of text into smaller pieces, or "tokens". Paragraphs can be tokenized into sentences and sentences can be tokenized into words. Normalization aims to put all text on a level playing field, e.g., converting all characters to lowercase. Noise removal cleans up the text, e.g., remove extra whitespaces.

• Stop word removal: Stop words are words which are filtered out before or after processing of tongue data. These words are removed to extract only the meaningful information. The list of stop words could also be ' the, is, at, which, on, who, where, how, hi, before, after , etc. Stop words are the most common words in any natural language. For the purpose of analysing text data and building NLP models, these stop words might not add much value to the meaning of the document. Consider this text string – "There is a pen on the table". Now, the words "is", "a", "on", and, "the" add no meaning to the statement while parsing it. Whereas words like "there", "book", and "table" are the keywords and tell us what the statement is all about.

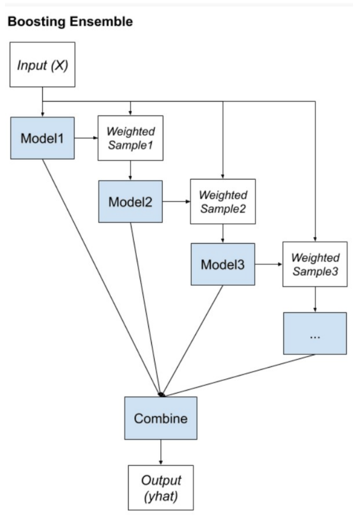
Classification: Data classification is that the process of organizing data into categories for its best and efficient use. A well-planned data arrangement makes essential data easy to seek out and retrieve. This will be of particular importance for risk management, legal discovery, and compliance



Block diagram of proposed method

Ensemble classification

Ensemble learning is a general meta approach to machine learning that seeks better predictive performance by combining the predictions from multiple models.Although there are a seemingly unlimited number of ensembles that you can develop for your predictive modeling problem, there are three methods that dominate the field of ensemble learning. So much so, that rather than algorithms per se, each is a field of study that has spawned many more specialized methods.The three main classes of ensemble learning methods are bagging, stacking, and boosting, and it is important to both have a detailed understanding of each method and to consider them on your predictive modeling project.



Bagging

Bagging or Bootstrap Aggregation is a powerful, effective and simple ensemble method. The method uses multiple versions of a training set by using the bootstrap, i.e. sampling with replacement and t it can be used with any type of model for classification or regression. Bagging is only effective when using unstable (i.e. a small change in the training set can cause a significant change in the model) non-linear models.

Boosting

Boosting is a meta-algorithm which can be viewed as a model averaging method. It is the most widely used ensemble method and one of the most powerful learning ideas. This method was originally designed for classification but it can also be profitably extended to regression. The original boosting algorithm combined three weak learners to generate a strong learner.

Stacking

Stacking is concerned with combining multiple classifiers generated by using different learning algorithms on a single dataset which consists of pairs of feature vectors and their classifications. This technique consists of basically two phases, in the first phase, a set of base-level classifiers is generated and in the second phase, a meta-level classifier is learned which combines the outputs of the base-level classifiers.

Boosting relates to an assortment of algorithms that can turn low learners to robust ones. The popular boosting technique is simple: it trains a group of classifiers consecutively and receives their predictions and then concentrates on reducing the mistakes of the preceding learner via modifying the weights of the feeble one. Boosting was used only for binary classification. This limitation, which stands as an adaptive one, is overcome by the AdaBoost algorithm. The algorithm's primary concept is to be more interested in hard classification patterns. The cost of interest is the weight allocated to each subset within the training data, which is equal. With each iteration, the effects of misclassified cases increase while the significance of precisely classified cases decreases. AdaBoost then brings together the learners to build a strong learner out of the weakest classifiers through the voting process [15,16]. In boosting, every classifier is determined by the aid of the result of the prior one. In bagging, every set of data is taken with an equivalent possibility. In boosting, all instances are decided with a possible relative to their weight. Bagging works better with excessive variance models that give a generalization of variance behavior with little modifications in the training dataset. Decision trees, besides neural networks, are considered models of large variance.

RESULT

In the experiments, four different measures are utilized to judge the class quality: accuracy, precision measure, recall, and lastly,f -measure [17,18]. Measurements are appraised by the following concepts, which are based on the four equations sequentially.Precision is a metric that quantifies the number of correct positive predictions made. Precision, therefore, calculates the accuracy for the minority class. Precision evaluates the fraction of correct classified instances among the ones classified as positive [19]. Recall is a metric that quantifies the number of correct positive predictions made out of all positive predictions that could have been made. Unlike precision, which only comments on the correct positive predictions out of all positive predictions, recall provides an indication of missed positive predictions. For imbalanced learning, recall is typically used to measure the coverage of the minority class [20]. Formalized paraphrase classification accuracy is widely used because it is one single measure used to summarize model performance. F-measure provides a way to combine both precision and recall into a single measure that captures both properties. Alone, neither precision nor recall tells the whole story. We can have excellent precision with terrible recall, or alternately, terrible precision with excellent recall. The -measure provides a way to express both concerns with a single score. Once precision and recall have been calculated for a binary or multiclass classification problem; the two scores can be combined into the calculation of the f-measure [20].

True positive value (TP): the instances number that accurately estimated as positive(ii)False positive value (FP): the instances number that inaccurately estimated as positive(iii)True negative value (TN): the instances number that accurately estimated as negative(iv)False negative value (FN): the instances number that inaccurately predicted as negative

Accuracy is the percentage of correctly predicted results and is measured with

$$\text{Accuracy} = \frac{(\text{TP} + \text{TN})}{(\text{TP} + \text{TN} + \text{FP} + \text{FN})}.$$

Recall is the percentage of positives that are correctly predicted as positive and is measured with

$$\text{Recall} = \frac{\text{TP}}{(\text{TP} + \text{FN})}.$$

Precision is the percentage of correct positive observations and is measured with

$$\text{Precision} = \frac{\text{TP}}{(\text{TP} + \text{FP})}.$$

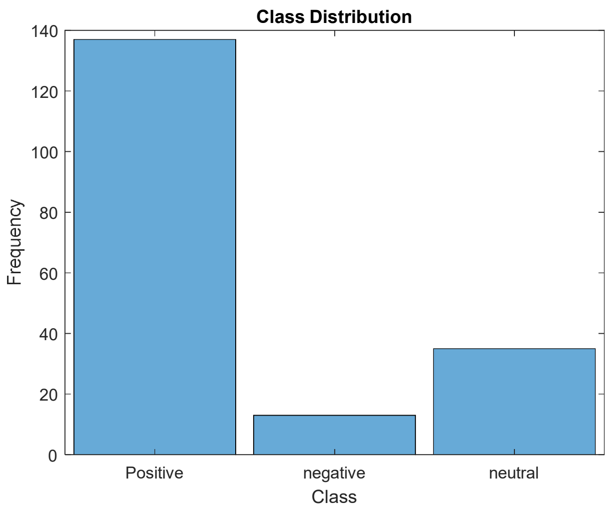
f-measure conveys the balance between the recall and the precision, and it emphasizes the performance of a classifier on common and rare categories, respectively .It is measured with

$$\text{F1-Measure} = 2 \times \text{Recall} \times \frac{\text{Precision}}{(\text{Recall} + \text{Precision})}.$$

Accuracy is the ratio that is full of predictions that were successfully studied. Precision means the ratio of effectively distributing instances to the entire cases that are classified and misclassified. The recall measure considered the portion of the successfully labelled to cover the whole range of unclassified cases and classified ones. Besides, the -measure is used to combine recall with precision and is a good indicator of the association between the two.

Evaluation results

metrics	percentage
Accuracy	67.5
Precision	72.7
Recall	88.8
f-measure	80



I. CONCLUSION

In this paper, lexicon based sentiment analysis is used to evaluate the level of teaching performance from students' textual feedback comment. A database of English sentiment words is constructed to identify the polarity of words as a lexical source. Our sentiment word database contains the opinion words concerning with the academic domain to achieve the better result. Every opinion word in the database is given a value. This paper proposes the level of teaching evaluation method based on ensemble classification approach. This method analyzes automatically the students' feedback comments to strongly negative, or moderately negative, or weakly negative, or strongly positive, or moderately positive, or weakly positive or neutral category. The level of opinion result for any teacher is given out from students' feedback comments.

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FAKE USER DETECTION: A NEW CHANGE TO THE WORLD

Ms. Fathima Abdul Kareem
Student
Department of Computer Applications,
St. Teresa's College (Autonomous)
fathimakarim003@gmail.com, +917736190372
Ms. Nandana S
Student
Department of Computer Applications,
St. Teresa's College (Autonomous)
nandanas884@gmail.com, +91 7510721693
Ms. Raji S Pillai
Faculty,
Department of Computer Applications,
St. Teresa's College (Autonomous)

ABSTRACT

The popularity of social media is rising day by day. It is used by people irrespective of language, gender, religion, age for different purposes. The social media will help us for many things like connecting with friends learn certain things and interacting with different kinds of people. While interacting with new people we also encounter fake accounts. They create fake accounts on social media because they want to spread misinformation, trap innocent people for their malicious intentions and many more, Hence addressing this issue is very important in today's society. This research presents a comprehensive study on the application of machine learning techniques to detect fake users from social media. The research begins with the analysis of the problem, emphasizing challenges posed by the fake accounts such as their behavioural patterns, nature of social media platforms and the inherent imbalance in datasets where genuine users outnumber fake ones. This study utilizes a dataset that consists of profile pictures, external URL, number of posts, number of followers, description of user, whether its private or not. Data preprocessing includes eliminating duplicate values, handling missing values. The detection framework include a machine learning algorithm called Support Vector Machine (SVM) to detect the fake accounts. This model is trained and validated on the datasets, achieving an accuracy of 85% and F1 score of 0.85 for class 0 and 0.82 for class 1 respectively on train data. The SVM algorithm is selected because it is suitable for small datasets, effective in handling binary classification tasks, and can process high-dimensional data and deliver precise results complemented by feature engineering strategies to enhance performance. This phase lays a comprehensive foundation for designing a reliable and scalable detection system that addresses the challenges of social media platforms.

Keywords: Fake accounts detection using machine learning, the Support Vector Machine, Data pre-processing, Feature engineering, social media security.

INTRODUCTION

Presently, in this digital world, social media services are an inevitable part of all communication worldwide; they offer novel tactics for information as well as social activities. However, these services increasingly suffer from spurious user account creation. Mostly, such spurious accounts have been used for spreading false messages, manipulating people's sentiments towards public issues, committing fraudulence, and instigating turbulence in already-existing online communities.

This paper uses the Support Vector Machine algorithm in identifying fake users on social media. SVMs are one of the most efficient supervised algorithms for classification. Classification determines the most relevant hyperplane which divides the dataset into separate categories while keeping the distance between them as wide as possible. This makes SVM one of the best algorithms for classifying real and fake users based on their patterns of activity and behaviour. Additionally, the algorithm performs well with high-dimensional data without overfitting, which increases and ensures the validity and accuracy of the detection model.

From the perspective of evaluating the social media platforms, the detection and elimination of the aftermath of these bogus accounts is essential. The present study aims at creating an effective and practical machine learning model that is capable of accurately detecting fake users through their online actions and traits. In so doing, the work tries to address the problem of proliferation of fictitious accounts and assist in building more safe and reliable social media networks through advanced methods of data gathering and forecasting algorithms.

OBJECTIVE

The objective of this project is to develop a robust machine learning model based on the SVM algorithm that can detect fake users on social media platforms. This research focuses on user behaviour and activity in order to successfully separate real users from fake ones. Along with the challenge of increasing fake accounts, the project aims to improve the safety and trustworthiness of social media platforms in order to prevent the spread of false information and fraudulent activities. In addition, the focus is on the improved efficiency of the model with a greater emphasis on data cleaning and improving features. It looks to understand features of fake users that would be useful for decision makers on the platform to mitigate risks. The most important is the end result: fostering technology-assisted approaches to help protect the social media landscape.

LITERATURE REVIEW

With the rapid development of emerging technologies in the industrial revolution 4.0 or 5.0, social media has become one of the social environments to carry out social activities, both socializing and advertising (Kerrysa et al.2023).

Some malicious accounts are used for purposes such as misinformation and agenda creation (Dr.K.Sreenivasa Rao et al.,2020).
The fake accounts of the social media are often used for a variety of cyber-attacks, information-psychological operations, and social opinion manipulating during warfare (Kupershtein Leonid et al.,2022).

This literature review is a summary of the existing studies that have utilized different machine learning techniques to address this challenge. The studies considered here focus on using algorithms such as Support Vector Machines (SVM), Artificial Neural Networks (ANN), Random Forest, and others to identify fake accounts by analysing key features like user behaviour, account metadata, and activity patterns. This section summarizes some of the previous key contributions, including their methodology, findings, and improvement areas.

	TITLE	YEAR	AUTHOR	SUMMARY
1.	Fake account detection in social media using machine learning methods	2023	Nalia Graciella Kerrysa, Ika Qutsiati Utami	This study uses machine learning methods like SVM, ANN, and CNN to detect fake social media accounts by analysing features like followers and activity patterns, improving detection accuracy.
2.	Detecting Fake Account on Social Media Using Machine Learning Algorithms	2020	Dr.K.Sreenivasa Rao, Dr.G.Sreeram Dr.B.Deevena Raju	This study involves machine learning algorithms such as Support Vector Machine, Random Forest Classifier and Neural Networks to detect fake accounts on social media by analysing the user's ID, name, URL, Verified, Location, patterns thus improving detection accuracy.
3.	Detection Of Fake Accounts in Social Media	2022	Voitovych Olesia, Kupershtein Leonid, Holovenko Vitalii	This study involves Support Vector Machine Algorithm to detect fake accounts on Facebook , LinkedIn by analysing the User's name, photo, posts, Geolocation, comments , thus improving the accuracy

Disadvantages of Existing Works

There are several limitations in the existing works on fake account detection, which can be addressed in future research. Firstly, the standardization of datasets is lacking; hence, it restricts generalizability of results across various platforms and regions. Most of the models that have been discussed focus on offline detection, not providing real-time solutions that are essential for curbing the rapid spread of fake accounts. The complexity and unexplainable in machine learning models also prevent stakeholder trust and understanding. Most studies are dataset or platform-dependent, relying specifically on datasets from Twitter and Facebook, thus leaving out other platforms and diversity of the real world. Temporal dynamics and tactics changing over time among creators of fake accounts are often overlooked and reduce the effectiveness of the systems in the long run. Another important factor that remains underexplored is the social and cultural influences. These shortcomings reduce the robustness of current approaches. All these challenges demand adaptive, interpretable, and real-time detection solutions.

METHODOLOGY

The approach involves data collection, the choice of a proper method and algorithm for data analysis, optimization of performance, training, evaluation of the model, and finally, visualization.

1. Data Collection

   The data set used here consisted of 576 rows with 12 columns that would give an analytical structure. Every row is an individual sample, whereas characters, in this case, represent the attributes related to the study, like profile pic, username length, and so on. The data was sourced in CSV format to make sure that processing is easy and it is compatible with analytical tools. The initial processes include checking for duplicate values, missing values handling, and the standardization of charts to ensure high quality data. Data preparation forms the basis for both the experimental and model development stages.

2. Data Preprocessing

   Various preprocessing was done on the data set for it to be fit for analysis. Missing values were replaced or substituted with statistical methods. In some instances, if its presence was huge, the value was completely erased. The label encoding technique ensured that the categorical variables were coded into a number to stay on the same plane as machine learning algorithms. Statistical factors were checked by using methods such as Min-Max Scaling or Z-score normalization to standardize the data and ensuring that all factors contributed equally in the model Statistical methods, such as Z-score analysis, were adopted to seek and resolve issues of outliers function to stop fragmentation of operations. Finally, to show how the model would work with unseen data, the dataset was divided into training and test sessions having an 80-20 ratio.

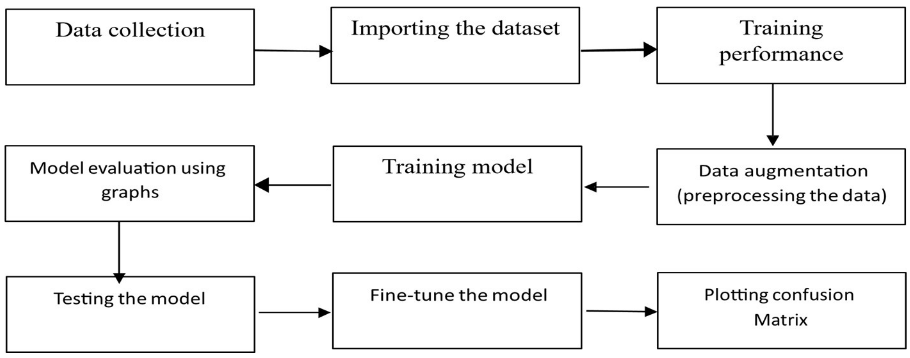
3. Exploratory Data Analysis (EDA)

EDA was performed in order to look for patterns and correlations in the dataset. Matplotlib and Seaborn libraries were used in the assignment to depict trends, correlation, and differential characteristics of real and fake accounts in the data. Analysis involved an analysis of distribution regarding the user types and possible key behaviours which have brought out some signs of existence of false accounts.

4. Feature Engineering

Feature engineering was employed in order to make the dataset more informative to the prediction task. Based on domain knowledge, new features that would otherwise reveal more user-behaviour insight were derived. Simultaneously, features which were not contributing to mdel performance were filtered out. Various methods such as correlation analysis and principal component analysis have been utilized for the purpose of attribute selection to analyse.

5. Process Flow Diagram



5. Model Development

SVM algorithm has been chosen based on its stability and effectiveness with highdimensional data. SVC of Scikit-learn is used with the optimal kernel tuning with optimizing parameters, which could be a kernel type such as linear, polynomial, or RBF; the regularization factor (C); and gamma, which generates. Grid search and random search have been done to optimize those parameters.

6. Model Evaluation

The performance of the model was tested by setting up the experimental parameters in order to ensure reliability and accuracy. Since the experiment contained an illusion matrix, the results for true positives, false positives, true negatives, and false negatives were carefully analysed. Classification reports created help identify precision, recall, F1-score, and support for each study. Further, ROC-AUC scores were computed to evaluate the capacity of the model to distinguish between the true and false estimates.

Performance metrics were developed with the consideration of making them interpretable and to emphasize the strengths of the model and areas of improvement.

RESULTS AND DISCUSSIONS

The developed system's performance was evaluated using different metrics to ensure reliability in the detection of fake user accounts. Robust results were depicted using the SVM model as it had very high scores in accuracy, precision, recall, and ROC-AUC metrics. The confusion matrix also possessed relatively fewer false positives and false negatives that indicated that the model is capable of correctly distinguishing between true and false information. The most significant predictive values were found to be in usage patterns and communication behaviour. Challenges of data imbalance and computational effort were also encountered during the process. Visual performance metrics clearly defined the strengths and weaknesses of the model. The results reflect the potential of the framework in enhancing the integrity and security of social media.

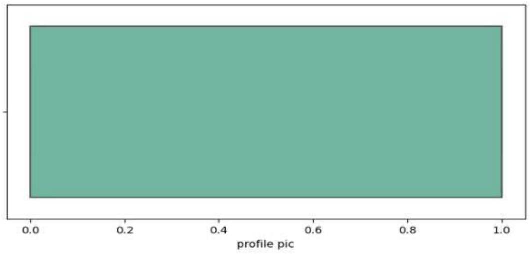
Classification report of SVM model

	precision	recall	f1-score	support
0	0.81	0.90	0.85	52
1	0.88	0.77	0.82	48
accuracy			0.84	100
macro avg	0.85	0.84	0.84	100
weighted avg	0.84	0.84	0.84	100

Fig.1: Performance Metrics

The classification report includes the performance of a machine learning model for a binary classification task. This report tests and compares metrics like precision, recall, and F1-score for both classes (0 and 1) by having precision (this is the percentage of correctly predicted samples for each class), which scores at 0.81 and 0.88 on class 0 and class 1, respectively. Recall measures the number of actual samples of each class that were correctly classified, which is 0.90 for class 0 and 0.77 for class 1. The F1-score, which balances precision and recall, is 0.85 for class 0 and 0.82 for class 1. The overall accuracy of the model is 84%, which is the proportion of correctly classified samples out of the total samples. The macro average (0.85 for precision, 0.84 for recall, and F1-score) and weighted average (0.84 for all metrics) give an idea of how the model is performing across classes, considering the class imbalance, as class 0 has 52 samples and class 1 has 48 samples.

Data Visualization



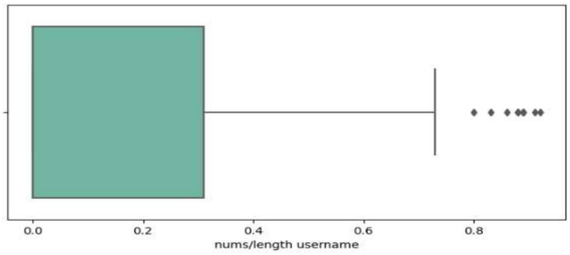
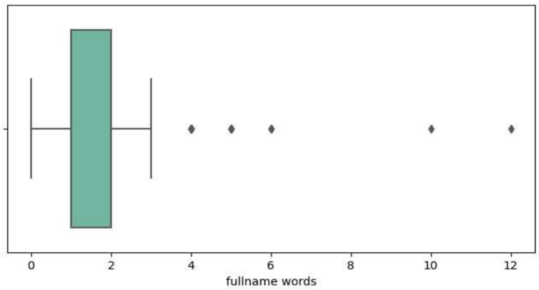


Fig.2: Boxplot for profile pic Fig.3: Boxplot for nums/length username



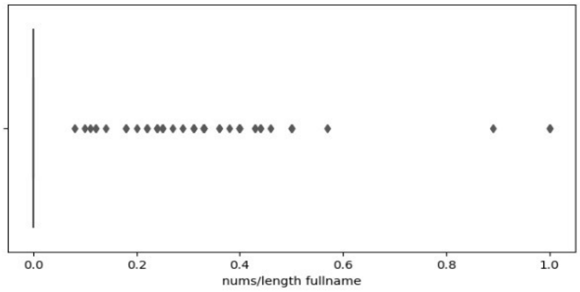
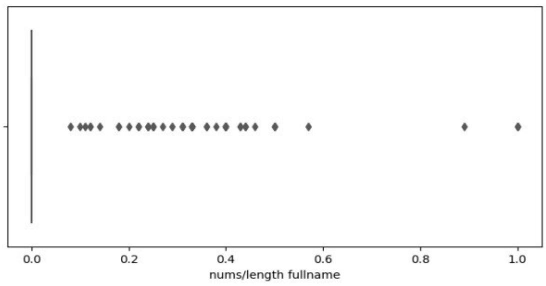


Fig.4: Boxplot for fullname words Fig.5: Boxplot for nums/length fullname



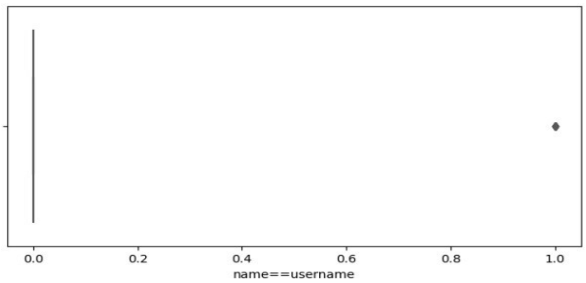
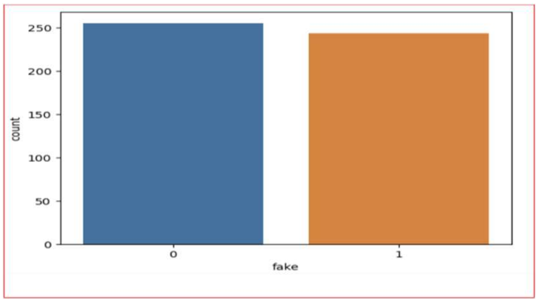


Fig.6: Boxplot for nums/length fullname Fig.7: Boxplot for name==username



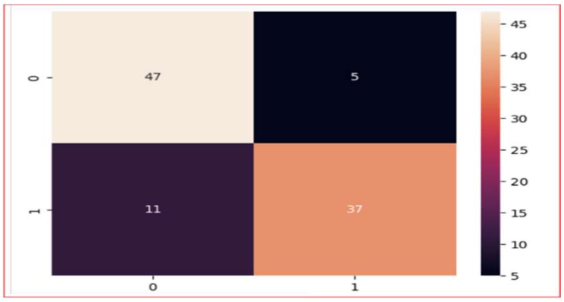


Fig.8: Countplot of SVM Model Fig. 9: Confusion Matrix of SVM Model

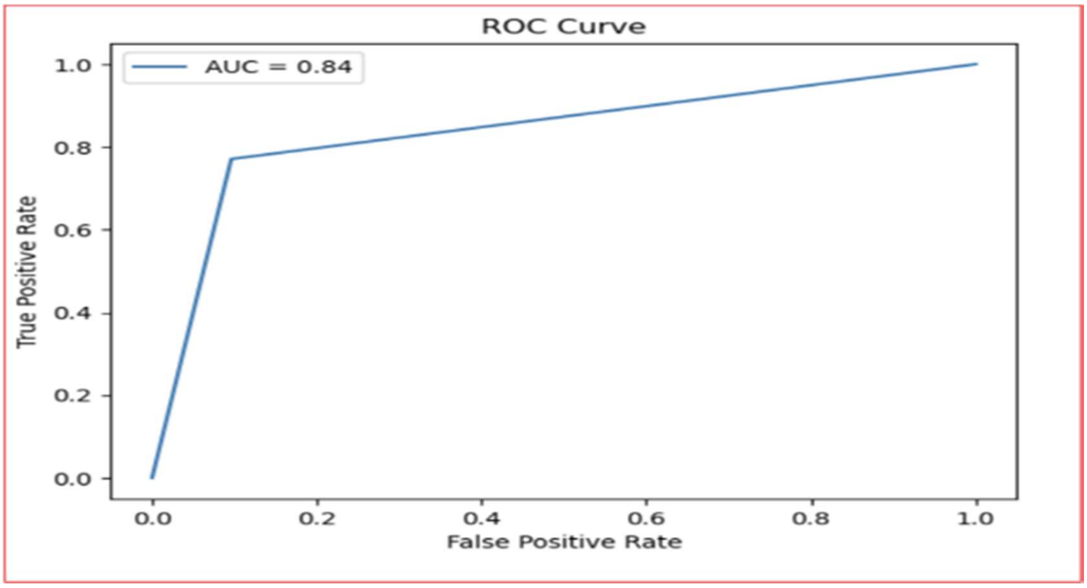


Fig. 10: ROC Curve of SVM Model

SCOPE FOR FUTURE ENHANCEMENT

The developed system demonstrates strong capabilities in the detection of fake accounts; however, there are many opportunities for future growth. One such area involves real-time data analytics to identify fake accounts as soon as they are detected. Further, adaptive learning strategies can be blended so that the system can evolve and adapt to changing deceptive behaviours. Another factor is scalability, as the system can handle a large quantity of data across social media platforms. Advanced integration techniques, such as network graph analysis and sensitivity analysis, can greatly improve the accuracy of analysis. Extending the implementation of the system to multiple platforms with data systems, incorporating it into a comprehensive cybersecurity system can also strengthen its usefulness This enhancement will ensure the system continues to function properly, adequate and robust against emerging challenges in cybersecurity.

CONCLUSION

The proliferation of fake accounts is among the newer threats to social media security and integrity. This research developed an SVM-based detection system that could achieve high accuracy and reliability in identifying actual and fake user accounts. Using known performance metrics such as precision, recall, and ROC-AUC, the system's effectiveness was validated. The project involved some preprocessing steps- handling missing data, scaling of features, encoding of categorical variables. Exploratory Data Analysis is also involved with the purpose of extracting insights and challenges of unbalanced data that are overcome with resampling techniques while efficient algorithms for computational feasibility. The modular and scalable architecture of the system allows for smooth integration with existing monitoring tools, which makes it highly applicable across various platforms and has significantly reduced fake accounts with minimal false positives and negatives.

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COMPARATIVE ANALYSIS OF MACHINE LEARNING ALGORITHMS FOR INDUSTRIES AND RESIDENTIAL ENERGY MANAGEMENT

Stanley John Varghese
Research Scholar,
Naipunnya Institute of Management and Information Technology,
Calicut University, Kerala, India.
stanleyjohn98@gmail.com
Fredy Varghese
Assistant Professor,
Naipunnya Institute of Management and Information Technology,
Calicut University, Kerala, India. Orcid ID: 0000-0001-6214-3304,
fredyvarghese51@gmail.com
Siji Jose Pulluparambil
Asst.Professor,
Adi Shankara Institute of Engineering and Technology,
Kalady, Kerala, India.
sijijohn2223@gmail.com
Dr. P Sasikala
Professor,
Department of Mathematics,
Vinayaka Mission,s Kirupananda Variyar Engineering College,
Salem, Tamilnadu, India.
E-mail:rgsasi@gmail.com
Dr. R Reka
Associate Professor,
Department of CSE Mahendra College of Engineering,
Minnampalli Salem Campus, Salem, Tamil Nadu, India.
rekasatheesh@gmail.com

ABSTRACT

The analysis of machine learning (ML) methods to improve energy consumption in different scenarios has been prompted with the aim of sustainable energy usage. In order to determine which machine learning algorithms are best for improving energy use in homes and industrial settings, this study examines the differences between them. The research broadens its assessment to encompass residential energy use. The process involves collecting a uniform dataset that includes patterns in residential and industrial energy consumption. The efficiency of each algorithm in predicting usage trends, modelling energy consumption patterns, and suggesting optimal measures is evaluated through extensive experimentation. This comparative study serves as a guide for stakeholders, policymakers, and researchers in selecting and implementing ML-driven strategies to optimize energy consumption, contributing to the global pursuit of sustainable energy practices. The research was conducted based on secondary datasets available for evaluating suitable ML algorithms for measuring energy efficiency.

Keywords: Machine Learning, Random Forest Regressor, Ecotect, Linear Regression.

INTRODUCTION

Over time, energy resources utilized for residential and commercial purposes have elevated over the years making it challenging to achieve ecological sustainability which in turn affects prices, carbon footprints, and emission targets [1]. However, at present moment, researchers have begun to deduce ways on seeking definite methods to handle energy resources effectively and this includes integrating IoT, seamless connectivity, and big data that includes certain machine learning algorithms for better energy and facility management [2][3]. This research paper evaluates available machine learning algorithms tested on publicly available dataset to assess energy usage. The objectives are:

- To discuss and evaluate selected dataset with ML algorithms.
- To produce code output on the selected dataset and ML algorithms.
- To conclude on the efficacy metric of selected ML algorithms.

IDENTIFICATION AND ESTABLISHMENT

To undertake uniform analysis, a common data set is to be applied as the foundation for these algorithms in order to review the reliability and approximate accuracy. With this, we decided to address energy analysis surrounding the rise of commercial/residential buildings. The energy efficiency dataset was published in November 2012 by Athanasios Tsanas and Angeliki Xifara where the assessment is focused towards heat and cool requirements which translates into energy efficiency as a factor of building parameters [4]. The dataset can be viewed here: Energy Efficiency Dataset (kaggle.com) [5] with its origin: Energy efficiency - UCI Machine Learning Repository.

a. Dataset breakdown, aim, and ML algorithm selection The selected dataset performs energy analysis by using 12 different buildings simulated by Ecotect - a software to calculate a building's energy consumption by simulating its context within the environment [6]. Moreover, it contains 768 building shapes that are produced as a result from imitating different settings as functions on below features. It comprises eight features denoted by X1 to X8 and produces two outcomes denoted by y1 and y2.

The features include:

- X1 - Relative Compactness, X2 - Surface Area, X3 - Wall Area, X4 - Roof Area, X5 - Overall Height, X6 - Orientation, X7 - Glazing Area,X8 - Glazing Area Distribution.

The responses include:

- y1 - Heating Load, y2 - Cooling Load This feature combination can help determine the heating and cooling loads which indicate energy efficiency usage. Therefore, the main agenda is to obtain predictions on each of the two responses using the 8 features listed. Forecasting energy efficiency (continuous variable) based on different features resembles a regression problem hence three popular ML algorithms can be used to output the responses [7][8]. These are:

- Linear Regression (Multiple Linear Regression)
- Random Forest Regressor
- Gradient Boosting Regressor

ML ALGORITHM EVALUATION

3.2.1 Linear Regression

It can be described as a straightforward algorithm that predicts unknown data values via another known or related data value. In addition, it can mathematically model known and uncertain variables as a linear equation. However, it produces approximate accuracy when the relationship between features and target is linear but strains as the complexity increases [9]. Since there are multiple independent variables available in the dataset, Multiple Linear Regression can be used to determine the dependent variables [10].

3.2.2 Random Forest Regressor

It is a flexible machine learning technique for predicting numerical values. It coalesces forecasts of multiple decision trees to lessen overfitting and improve accuracy [11]. The benefit of this procedure is the ability to capture non-linear relationships. Ensemble learning is utilized to aggregate several models so that it outputs a stable and accurate prediction [12].

3.2.3 Gradient Boosting Regressor

This algorithm offers an improved predictive accuracy score compared to Random Forests. Complex patterns can be captured by operating on the ensemble technique called 'Boosting'. This means that the Gradient boost can construct a strong learner via multiple weak learners. These typically use decision trees as weak learners [13][14].

DATA SET EXPLORATION

In this section, the main focus would be to show code snippets of the dataset being evaluated using Python specifically Python 3. The following steps include:

A. Import the libraries 1) Read dataset, dataset preparation, and extract independent and dependent variables

```
df1 = pd.read_csv('../input/ENB2012_data.csv', delimiter=',')
df1.dataframeName = 'ENB2012_data.csv'
nRow, nCol = df1.shape
print(f'There are {nRow} rows and {nCol} columns')
df1.head()
```

There are 768 rows and 10 columns

	X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2
0	0.98	514.5	294.0	110.25	7.0	2	0.0	0	15.55	21.33
1	0.98	514.5	294.0	110.25	7.0	3	0.0	0	15.55	21.33
2	0.98	514.5	294.0	110.25	7.0	4	0.0	0	15.55	21.33
3	0.98	514.5	294.0	110.25	7.0	5	0.0	0	15.55	21.33
4	0.90	563.5	318.5	122.50	7.0	2	0.0	0	20.84	28.28

The code snippet consists of reading in the dataset and determines the data frame's dimensions. Moreover, it displays the top 5 records in the dataset with the feature and output columns. To avoid discrepancy with data and ensure validity, data scrubbing or cleaning needs to be performed. With assistance from Pandas library, the data set can be checked for NULL values [15].

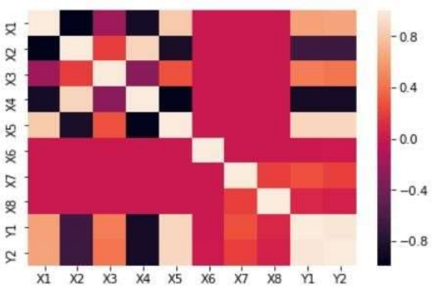
```
X = df1.iloc[:, :-2].values
y = df1.iloc[:, 8:10].values
```

X variable holds the numpy array for the first eight columns that determine the eight features listed and y variable holds another numpy array for the last two columns that determine the output responses.

B. Visualize the data

```
# Data visualization
#Building the correlation matrix
sns.heatmap(df1.corr())
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x79f27aaefcf8>
```



The plot defines the features and output responses as rows andand columns. As the cells turn darker, it shows negative correlation or less connection between data [16].

C. Split the data into Train and Test sets

The code snippet defines the standard way to reference testing and training on the provided dataset. X defines the data going on the model and y is the outputted answer as the result of training data. In this case, the test size of the sample is 20% of the entire dataset [17]. Now, the detailed analysis can be introduced in the following sections to predict output and obtain better energy efficiency metrics using aforementioned ML algorithms.

```
#Splitting the dataset into the Training set and Test set
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(x, y,
test_size = 0.2, random_state = 0)
```

DATASET EXPLORATION USING MULTIPLE LINEAR REGRESSION MODEL

Multiple Linear Linear regression is a statistical model used to predict the relationship between multiple independent and dependent variables [18]. With the current foundational setup done, the algorithm can be fitted to the training set:

```
#Fitting Multiple Linear Regression to the Training set
from sklearn.linear_model import LinearRegression
Linear Regression()
regressor =
regressor.fit(X_train, y_train)
LinearRegression (copy_X=True, fit_intercept-True,
n_jobs=None, normalize=False)
```

The code snippet produced a Linear Regression model. With this, the model can predict the output responses based on the training data provided.

```
#Predicting the Test set results
y_pred = regressor.predict(X_test)
y_pred[:20]
```

```
array([[17.41297959, 19.2009987 ],
       [ 8.00982785, 12.26265593],
       [29.43547632, 32.24949452],
       [25.82883064, 29.77653556],
       [31.09158148, 32.08738475],
       [27.45520882, 30.21690103],
       [28.25886363, 29.99445773],
       [34.11385766, 35.56416236],
       [29.377148  , 32.04744936],
       [28.49020749, 31.09157711],
       [ 6.97411216, 11.91386715],
       [35.19788541, 36.88921201],
       [11.76843665, 14.87177905],
       [35.37842988, 36.76961305],
       [35.85738497, 36.84091298],
       [26.58621569, 29.66779114],
       [ 9.43405177, 13.49187326],
       [27.29555712, 30.19313439],
       [15.97681642, 18.0787433 ],
       [12.2876624 , 15.44143468]])
```

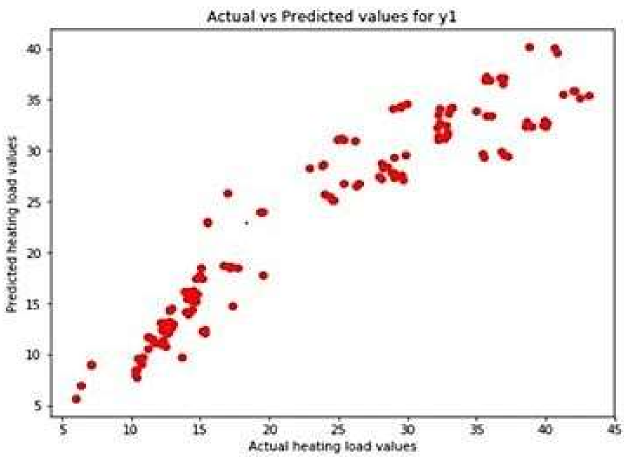
The 20% of data set aside is used to test the model which means that out of 768 rows, 154 rows (rounded up) are used as test data. However, for the sake of minimal display, only the first 20 rows have been outputted.To ensure the model is unbiased, validity needs to be analyzed. The R-squared value is beneficial in this case to predict how accurate the prediction is [19].

```
#Calculating the R squared value
from sklearn.metrics import r2_score
r2_score(y_test, y_pred)
```

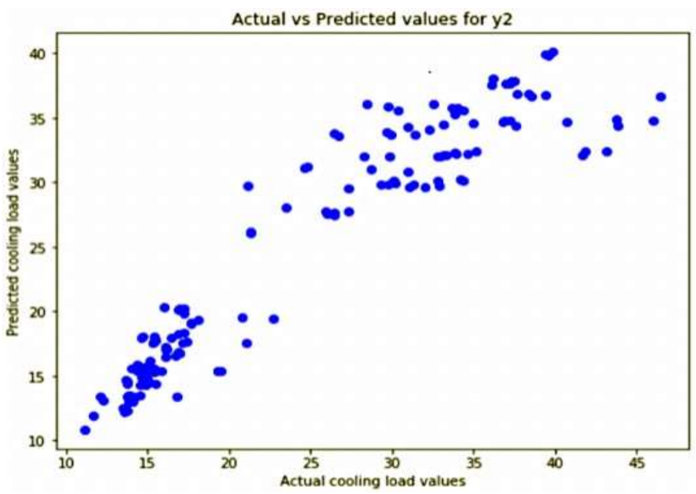
```
0.8973910776048324
```

the value is not modified [21]. For demonstration purposes, a new set of values for the features can be provided to predict the heating and cooling loads.The actual versus predicted values can be plotted respectively for heating load

- y1



The actual versus predicted values can be plotted respectively for cooling load - y1



Both the plots resemble similar dispersion of actuals versus prediction points with a gap between a certain range. While the result seems to be satisfactory in determining the response for unknown quantities, the model doesn't perform well when the features increase in size. To tackle this, the Random Forest Regressor can be implemented to provide an accurate result [22].

DATASET EXPLORATION USING RANDOM FOREST REGRESSOR (RF-R) MODEL

RF-R is an algorithm that combines output of multiple decision trees to obtain a result [23][24]. With the current foundational setup done, the algorithm can be fitted to the training set:

```
x1, x2, x3, x4, x5, x6, x7, x8 = 0.64, 784, 343, 220.5, 3.5, 2, 0.1, 4
new_features = np.array([[x1, x2, x3, x4, x5, x6, x7, x8]])
predicted_y = regressor.predict(new_features)
print("Predicted y1:", predicted_y[:, 0])
print("Predicted y2:", predicted_y[:, 1])
```

```
Predicted y1: [12.35929422]
Predicted y2: [14.97493422]
```

```
#Predicting the Test set results
y_pred = rf.predict(X_test)
y_pred[:20]
```

```
array([[15.2101, 17.6741],
       [10.4135, 13.6238],
       [36.2004, 38.8884],
       [17.617 , 22.5407],
       [32.4681, 32.5402],
       [29.0209, 29.5386],
       [28.3563, 29.8705],
       [29.1791, 30.4276],
       [28.6665, 33.607 ],
       [23.6337, 26.9579],
       [ 6.3673, 11.3828],
       [42.3283, 41.1739],
       [11.3673, 14.6698],
       [42.1221, 41.6743],
       [41.4501, 45.937 ],
       [26.3858, 28.0623],
       [10.686 , 14.202 ],
       [29.1491, 29.6388],
       [14.3436, 14.8582],
       [12.4033, 15.0715]])
```

```
#Fitting Random Forest Regressor to the Training set
from sklearn.ensemble import RandomForestRegressor
rf = RandomForestRegressor(n_estimators=100)
rf.fit(X_train, y_train)
```

```
RandomForestRegressor(bootstrap=True, criterion='mse', max_depth=None,
                      max_features='auto', max_leaf_nodes=None,
                      min_impurity_decrease=0.0, min_impurity_split=None,
                      min_samples_leaf=1, min_samples_split=2,
                      min_weight_fraction_leaf=0.0, n_estimators=100,
                      n_jobs=None, oob_score=False, random_state=None,
                      verbose=0, warm_start=False)
```

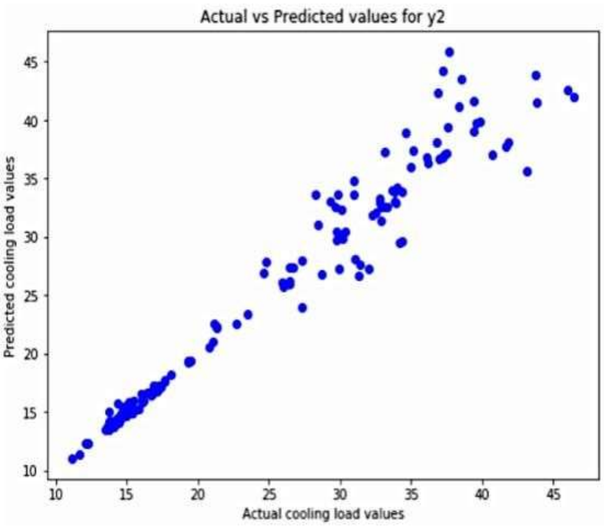
The code snippet produced a RF-R model. Do note that the parameter n_estimators was included since The default value of n_estimators will change from 10 in version 0.20 to 100 in 0.22.With this, the model can predict the output responses based on the training data provided referenced under the X_test variable. The 20% of data set aside earlier is used to test the model which means that out of 768 rows, 154 rows (rounded up) are used as test data. However, for the sake of minimal display, only the first 20 rows have been outputted. As mentioned previously in the Linear Regression model section, to ensure the model is unbiased, validity needs to be analyzed. The R-squared value is beneficial in this case to predict how accurate the prediction is.

```
#Calculating the R squared value
from sklearn.metrics import r2_score
r2_score(y_test, y_pred)
```

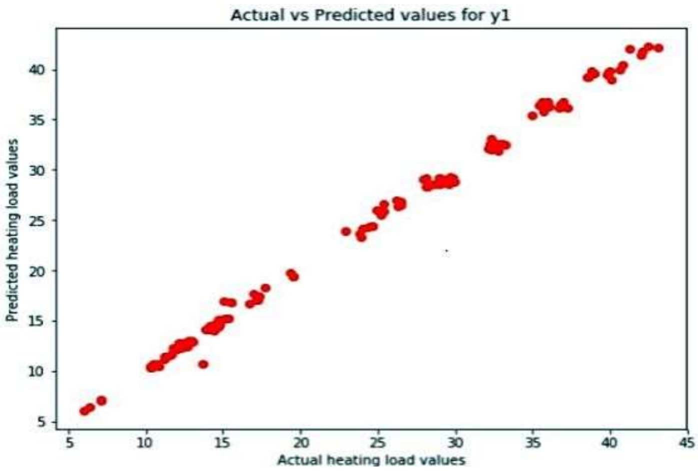
```
0.9767917530648039
```

Since the R-squared value generated is greater than 0.91, the model proves to be valid for making predictions. Another metric to ensure validity or accuracy of the model is to use the mean squared error (MSE) or mean squared deviation (MSD) where it computes the average of the squares of the errors i.e. difference between the actual value and the estimated values [25]. The MSE value obtained is approximately 2.2 which is near to zero and can be recognized as a suitable model for predictions [26]. For demonstration purposes, a new set of values for the features can be provided to predict the heating and cooling loads.

The actual versus predicted values can be plotted respectively for heating load - y1.



The actual versus predicted values can be plotted respectively for cooling load - y2.



For heating values, the plot outputs a linear slope compared to the cooling values where it maintains a tight linear relationship but scatters after 25th value. Despite the improved accuracy over the Linear Regression model, the RF-R model can be inaccurate when capturing complex patterns [27] hence the next algorithm can be evaluated to provide a better premise of predictions.

VII. DATASET EXPLORATION USING GRADIENT BOOSTING REGRESSOR MODEL

The Gradient boosting algorithm is ideal for tabular datasets. It is capable of determining nonlinear relationships between the model target and features. In addition, it can deal effectively with missing values, high cardinality categorical items, and outliers without additional processing [28][29]. However, do note that this model does not accept incorporating a multidimensional array for being fitted on the training set hence it is recommended to train data on y1 and y2 columns separately. With this, the model can predict the y1 and y2 output responses based on the training data provided referenced under the X_test variable respectively.The 20% of data set aside earlier is used to test the model which means that out of 768 rows, 154 rows (rounded up) are used as test data. However, for the sake of minimal display, only the first 20 rows have been outputted.

As mentioned previously, to ensure the model is unbiased, validity needs to be analyzed. The R-squared value is beneficial in this case to predict how accurate the prediction is. The metric can be analyzed for y1 and y2 respectively. Since the R-squared value generated is greater than 0.91, the model proves to be valid for making predictions. For demonstration purposes, a new set of values for the features can be provided to predict the heating and cooling loads.

```
#Calculating the R squared value for y2
r2_gb_y2 = r2_score(y_test[:, 1], y_pred_gb_y2)
r2_gb_y1
```

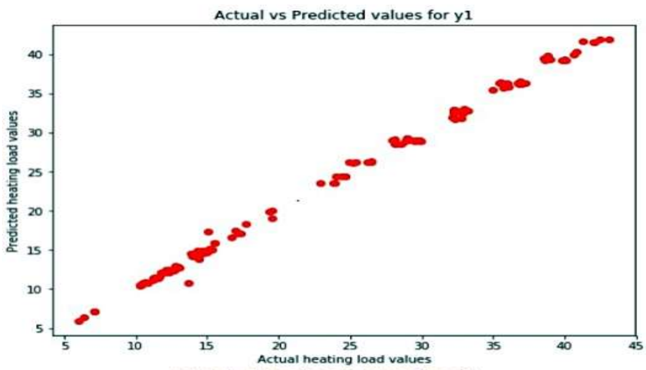
```
0.9974327786180678
```

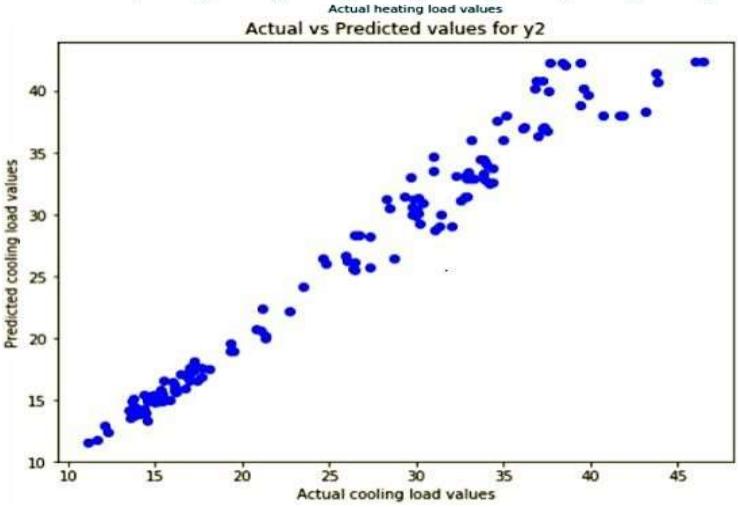
```
ıg the R squared value for y1
n.metrics import r2_score
r2_score(y_test[:, 0], y_pred_gb_y1)
```

```
678
```

Since the model does not support multidimensional array input, the regressor can apply the predict function for yielding both y1 and y2 results. The actual versus predicted values can be plotted respectively for y1 heating load and y2 heating load.

The diagrams output a linear slope in displaying the data points between actual and predicted values for both heating and cooling metrics which indicates a tightly-fit representation [30][31]. In retrospect, the Gradient Boosting Regressor model seems to output close to accurate predictions yielding energy efficiency metrics. However, Linear





Regression seems to output 'similar' predictions for new input values based on the dataset provided since the data points are scattered around adequately to obtain it.

CONCLUSION

Applying machine learning algorithms to tap into monitoring energy management programmatically aids in assisting architects and engineers to design suitable residential and commercial buildings that benefit sociological and climatic agenda [32]. Each of the methods share a common motive which is to identify prediction values for observing energy efficiency. However, this research does not conclude a onesize-fits-all solution. With this idea, the paper analyzes the regression algorithms that are suitable for performing prediction analysis on heating and cooling loads - metrics for evaluating energy efficiency.The optimal methods require detailed context and additional parameters as complexity increases.The validity of selected models to ultimately ‘trust’ the accuracy of predictions made.

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ANALYSIS OF VECTORIZATION IN NATURAL LANGUAGE PROCESSING FOR EXAMINING THE EFFECT OF CURRICULUM ON EMPLOYABILITY

Blessy Paul P
School of Computer Sciences,
Mahatma Gandhi University, Kottayam, 686560, Kerala, India.
blessypaul91@gmail.com
Cini Kurian
Al-Ameen College,Edathala,
Kochi, 683564, Kerala, India
cinikurian@gmail.com
Soni P M
Naipunnya Institute of Management and Information Technology, Pongam,
Thrissur, 680308, Kerala, India
sonipm@naipunnya.ac.in

ABSTRACT

In the rapidly evolving job market, there is an imperative need to assess the impact of curriculum on employability to ensure ed- ucational programs align with industry demands, fostering graduates' readiness for diverse and dynamic professional roles. The evaluation of educational curricula's impact on employability traditionally relies on subjective assessments and qualitative measures, lacking a robust and scalable quantitative methodology. This research explores the imperative need for a data-driven approach to examine the relationship between cur- riculum content and employability outcomes. Presently, the assessment of curriculum efficacy predominantly involves manual reviews, surveys, and anecdotal evidence, making it challenging to derive comprehensive insights into the intricate interplay between educational programs and graduates' employability. Recognizing the urgency for a more systematic and objective analysis, this research introduces vectorization in Natu- ral Language Processing (NLP) as a transformative tool. By converting textual information into numerical vectors, NLP facilitates the applica- tion of machine learning algorithms to discern patterns and correlations within vast datasets related to curricula and employability. The rela- tionship between the two domains becomes quantifiable and amenable to statistical analysis, offering a nuanced understanding of how specific curriculum elements impact graduates' readiness for the workforce. The novel integration of NLP and vectorization methods presents a scalable and efficient solution to the current challenges in curriculum assessment. This research seeks to redefine how educational programs are scrutinized, providing educators, policymakers, and stakeholders with a powerful tool to optimize curricula for enhanced employability outcomes in the ever- evolving job market.

Keywords: Natural Language Processing (NLP) · Curriculum · Vector- ization · Employability · Course Outcome (CO)

INTRODUCTION

The National Education Policy (NEP) 2020, introduced by the Government of India, marks a significant paradigm shift in the country's educational landscape, aiming to address contemporary challenges and align educational practices with global standards. In the present educational scenario, the implementation of cur- ricula varies across institutions, with a diverse range of approaches and method- ologies in use. The current implementation of curricula is often characterized by a mix of theoretical frameworks, practical applications, and assessments[1]. However, the effectiveness of curriculum implementation is a subject of ongoing debate. Challenges such as outdated content, lack of alignment with industry requirements, and a focus on rote learning rather than critical thinking persist. Additionally, the diversity in educational institutions and the varying quality of teaching further contribute to disparities in the execution of curricular goals.

Whether a curriculum can achieve employment goals depends on its rele- vance, adaptability, and alignment with the evolving needs of the job market. A well-designed curriculum should not only impart subject knowledge but also cultivate essential skills such as critical thinking, problem-solving, and effective communication[1]. The successful integration of these elements enhances gradu- ates' employability, making them better equipped for the dynamic workforce.

Assessing the employability of a graduate involves evaluating a combination of academic achievements, practical skills, and interpersonal competencies. Tra- ditional assessments often focus on academic performance through grades and examination results. However, contemporary evaluations also consider a candi- date's ability to apply theoretical knowledge in real-world scenarios, commu- nication skills, teamwork, adaptability, and a demonstrated understanding of industry-specific tools and technologies. Analyzing a curriculum to ascertain job opportunities is a complex task, but it can provide valuable insights. By scruti- nizing the curriculum's alignment with industry standards, inclusion of practical projects, internships, and exposure to relevant technologies, one can infer the po- tential employability outcomes for graduates. However, this analysis requires a comprehensive understanding of industry trends and a dynamic curriculum that adapts to emerging technologies[2].

Natural Language Processing (NLP) plays a pivotal role in assessing curricula by enabling the analysis of vast amounts of textual data related to educational programs. NLP techniques help in extracting valuable information from curricu- lum documents, identifying key concepts, and understanding the context and relationships between various topics. This facilitates a more nuanced evaluation of curriculum content beyond quantitative metrics, considering the qualitative aspects that contribute to a holistic educational experience.

Vectorization, a technique in NLP, aids in quantifying the impact of curricu- lum on employability by converting textual information into numerical vectors. This process allows for the application of machine learning algorithms to identify patterns, correlations, and trends within the curriculum[3]. By analyzing these vectors, researchers can gain insights into how specific elements of the curriculum influence graduates' readiness for the job market.

The present educational scenario in the context of NEP 2020 reflects a dy- namic landscape with ongoing efforts to improve curriculum implementation and enhance its impact on employability. Assessing the effectiveness of a curriculum in achieving employment goals requires a multifaceted approach that considers both quantitative and qualitative aspects. NLP, along with vectorization tech- niques, emerges as a powerful tool to analyze and optimize curricula, ensuring graduates are better prepared for the challenges of the modern workforce.

LITERATURE REVIEW

Curriculum analysis using Natural Language Processing (NLP) has emerged as a transformative approach in educational research, providing insights into the ef- fectiveness and relevance of educational programs. The integration of NLP tech- niques facilitates a more comprehensive understanding of curriculum content, structure, and its impact on learners. Researchers have leveraged NLP to extract valuable information from vast amounts of textual data embedded in curricula. In a study by Wang and Wang, NLP was employed to analyze curriculum doc- uments, identifying key topics, learning objectives, and the frequency of specific terms. The study showcased the efficiency of NLP in automating the extraction process, allowing for a quantitative analysis of curriculum components[4].The semantic analysis capabilities of NLP have been harnessed to understand the re- lationships between different concepts within a curriculum. In a study by Smith and Jones, NLP was used to perform sentiment analysis on student feedback related to various courses[5]. This approach provided insights into the perceived effectiveness of specific curriculum elements, shedding light on aspects that con- tribute to student engagement and satisfaction. Furthermore, NLP has played a crucial role in assessing the alignment between curriculum content and industry needs. In the work of Chen et al., researchers applied NLP techniques to ana- lyze job descriptions and curriculum documents[6]. By comparing the skills and knowledge emphasized in job postings with those covered in the curriculum, the study highlighted areas where educational programs could be refined to better meet industry demands.

Vectorization, a technique within NLP, has been particularly instrumental in curriculum analysis. In a study by Kim et al. (2018), curriculum documents were transformed into numerical vectors, enabling the application of machine learning algorithms to identify patterns and correlations[7]. This approach facil- itated a more nuanced understanding of how specific elements in the curriculum influenced student outcomes and employability[8]. While these studies showcase the promising applications of NLP in curriculum analysis, challenges such as data quality, context ambiguity, and the need for domain-specific customiza- tion persist. NLP offers a valuable and versatile toolkit for researchers and ed- ucators seeking to enhance the effectiveness and relevance of curricula in the ever-evolving landscape of education[9].

The vectorization of curriculum and course outcomes within the realm of NLP has become a pivotal focus in educational research. Vectorization techniques, such as Word Embeddings and Doc2Vec, enable the transformation of textual information into numerical vectors, offering a quantitative representation of curriculum content. In the study by Johnson et al., Word Embeddings were employed to represent course descriptions and learning objectives, providing a foundation for exploring semantic relationships and patterns within the curricu- lum[10]. The research of Liu and Zhang extended the application of vectorization to analyze course outcomes[11]. Utilizing Doc2Vec, the study captured the con- textual information of entire documents, enabling a more holistic assessment of course structures and learning goals. The vectorization approach facilitated the identification of latent patterns and similarities between different courses, offer- ing valuable insights into curriculum coherence and alignment with institutional objectives[12].

The intersection of NLP and curriculum analysis has seen a surge of interest in mapping curriculum vectors to employability attributes. In the study by Urz- sula et al., researchers employed NLP techniques to vectorize curriculum content and mapped these vectors to employability attributes[13]. This innovative ap- proach demonstrated the potential to identify key skills and competencies within the curriculum that align with industry needs. The study exemplifies the evolv- ing landscape of curriculum analysis, utilizing NLP to bridge the gap between educational programs and workforce requirements, offering a promising avenue for optimizing curricula for enhanced employability outcomes. These studies col- lectively underscore the potential of vectorization methods to enhance the depth and efficiency of curriculum analysis, contributing to the ongoing refinement of educational programs for improved learning outcomes.

METHODOLOGY

Vectorizing a curriculum in Natural Language Processing (NLP) is a fundamen- tal step that involves transforming textual information into a numerical format, enabling computational analysis and the application of machine learning mod- els. In the context of curriculum analysis, vectorization plays a pivotal role in quantifying the content, allowing for a more nuanced understanding of its impact on employability. Two common techniques for vectorization in NLP used in this research are Term Frequency-Inverse Document Frequency (TF-IDF) and word embeddings. TF-IDF is a widely used method that assigns numerical weights to words based on their importance within a document relative to the entire dataset. The rationale behind TF-IDF is to capture the significance of terms in a document by considering both their frequency (term frequency) and their rarity across the entire dataset (inverse document frequency). The resulting vec- tors represent each document in the curriculum, with higher weights assigned to terms that are important within a specific document but less common across the entire dataset. Word embeddings technique represents words as dense vectors capturing semantic relationships.

Figure 1 shows the methodology for assessing the impact of curriculum on employability using Natural Language Processing (NLP). It is a comprehen-

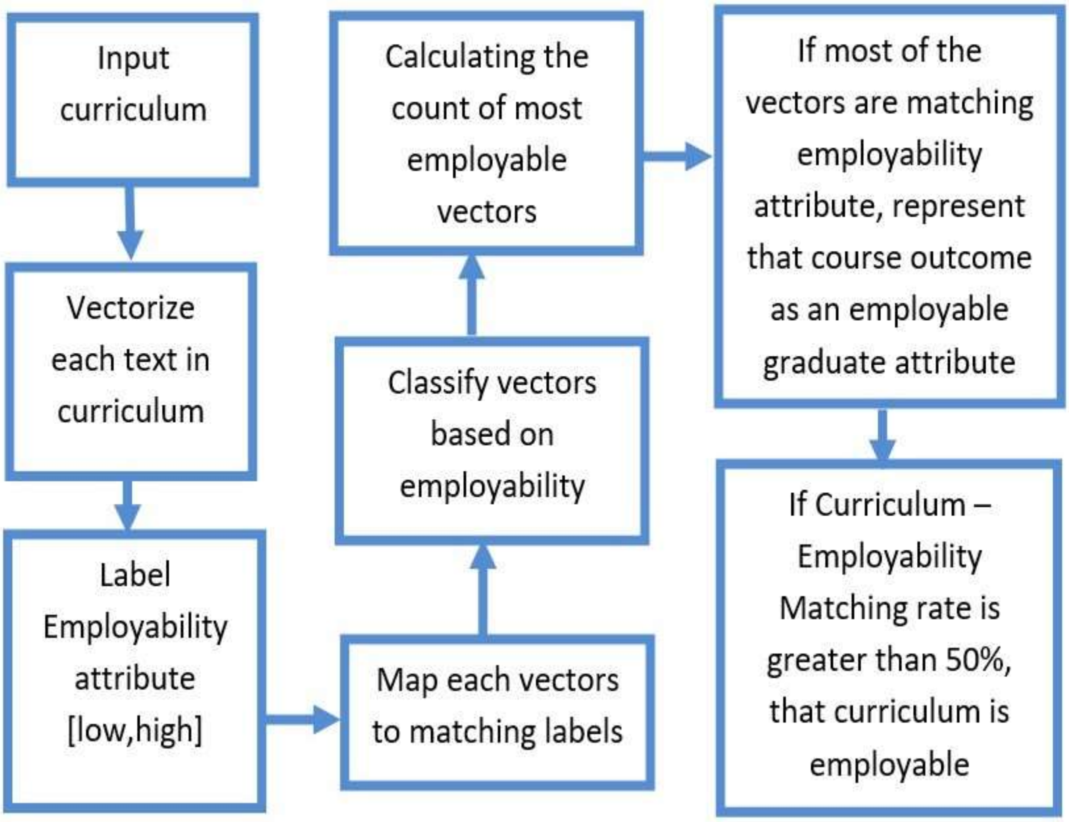

Fig. 1. Structure of curriculum vectorization

sive process that involves data collection, preprocessing, vectorization, machine learning modeling, and interpretation. This approach aims to leverage the capa- bilities of NLP to transform textual information from curricula into a numerical format, allowing for a quantitative analysis of the relationship between curricu- lum content and employability outcomes.

Pre-processing

The process begins with inputed curriculum, where a diverse dataset comprising curriculum details and corresponding employability labels is assembled. This dataset should encapsulate various aspects of the curriculum, such as course descriptions, learning objectives, and any information pertinent to the skills im- parted. Additionally, labels indicating the corresponding employability status, whether high or low, are crucial for supervised learning. Following the above process, the next step is data preprocessing. This involves cleaning and stan- dardizing the textual data to prepare it for analysis. Common preprocessing steps include lowercasing, tokenization, and the removal of stop words and non- alphabetic characters. The objective is to create a clean and structured text corpus that can be effectively used in subsequent stages of the methodology[14].

Vectorization

Once the data is preprocessed, vectorization techniques are employed to convert the textual information into a numerical format suitable for machine learning

models. Two common vectorization methods used in this research are Term Frequency-Inverse Document Frequency (TF-IDF) and word embeddings. The choice between these techniques depends on the characteristics of the data and the goals of the analysis. Textual data is represented in a numerical vector form when a paragraph is vectorized. Often, word embeddings—dense vector represen- tations of words in a continuous vector space—are used as a strategy. Semantic connections between words are represented by these vectors. Word2Vec is a pre- ferred technique for producing word embeddings. In order to predict words based on their context in a given corpus, Word2Vec is a shallow, two-layer neural net- work. In a continuous space, it learns to represent words as vectors. Capturing a word's meaning from terms that frequently occur nearby is the fundamental idea.

The objective of Word2Vec is to maximize the likelihood of predicting the target word given its context. The skip-gram model is the variant used here for this purpose. Equation 1 shows the objective function to maximize the average log probability:

$$\frac{1}{T}\sum_{t-1}^{T}\sum_{c\in C_t}\log P(W_t|W_c) \qquad (1)$$

Where T is the total number of target words. *wt* is the target word. *wc* is a context word for the target word at position *t*. P(*wt* /*wc*) is the conditional probability of the target word given the context word. The embedding matrix W is learned during training to maximize this probability. After training, each word *w* is represented by its corresponding row in the embedding matrix W, i.e., W[*w*] is the vector representation of the word *w*. After completing vectorization, machine will have word vectors for each word in the curriculum. Then it can be used to represent the entire curriculum by aggregating or combining these word vectors.

Feature extraction involves identifying specific features or topics within the curriculum text that may have a significant impact on employability. NLP tech- nique, Latent Dirichlet Allocation (LDA), is applied to extract key themes and enhance the interpretability of the subsequent machine learning model.

MODEL TRAINING

The core of the methodology lies in model training, where a machine learning model is selected and trained on the vectorized curriculum data.In this study, Naive Bayes and artificial neural networks are the complex models employed for prediction. The model is trained to predict employability labels based on the vectorized curriculum features. After model training, the evaluation phase assessed the model’s performance using a separate test dataset that included low and high-employable attributes. Metrics such as accuracy, precision, recall, and F1-score provided insights into how well the model generalizes to new, un- seen data. This step is crucial for ensuring the robustness and reliability of t developed model. Interpretation follows the evaluation, where the model’s pre- dictions and feature importance are analyzed. This step provided insights into which aspects of the curriculum contribute most to employability outcomes. It aids in understanding the relationship between specific curriculum elements and the likelihood of high or low employability.

CURRICULUM ASSESSMENT

The methodology for assessing the impact of curriculum on employability using NLP is a systematic and iterative process. It involves the careful curation of data, thoughtful preprocessing to ensure data quality, effective vectorization to represent text numerically, and the application of machine learning models to discern patterns within the curriculum that correlate with employability out- comes. The interpretative phase brought nuanced insights into the relationship between curriculum content and employability, paving the way for informed de- cisions in educational program optimization.

IMPLEMENTATION

The implementation of vectorization to assess the impact of curriculum on em- ployability involves several key steps, leveraging NLP techniques and machine learning models. In this context, vectorization refers to the transformation of curriculum text into numerical vectors, allowing for quantitative analysis and modeling[15]. In the implementation of curriculum vectorization in this research, TF-IDF vectorization is used and the scikit-learn library provides a convenient ’TfidfVectorizer’ class. This class is instantiated, and the ’fit transform’ method is applied to the curriculum text for vectorization on inputed curriculum. Figure 2 shows the relevant libraries used in the Python coding.

```python
#impact of curriculum on employability using NLP


import pandas as pd
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import accuracy_score, classification_report
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize
import nltk
nltk.download('stopwords')
nltk.download('punkt')
```

Fig. 2. Library files used in vectorization and model generation

In this example, X vectorized now contains the TF-IDF vectors representing the curriculum text. Each row corresponds to a document in the curriculum, and each column represents a unique term. Another powerful vectorization technique is word embeddings, which represent words as dense vectors in a continuous vec- tor space[16]. Popular word embedding models like Word2Vec and GloVe can be utilized to generate vector representations of words. These models are often pre-trained on large corpora, capturing rich semantic information. In Python, libraries like Gensim provide easy-to-use interfaces for working with Word2Vec models[17].Figure 3 shows the vectorization on sample data. After vectoriza- tion, a machine learning model suitable for the task of predicting employability selected based on the vectorized curriculum. Then trained the model on the vectorized curriculum data.Figure 4 shows the mapping of course outcomes in curriculum and employability levels. It analyzed the model's predictions and in- terpreted the importance of specific features or terms within the curriculum that contribute to employability predictions[18]. It is easy to understand the model's decision-making process, and it helped to identify the curriculum elements that significantly influence employability outcomes.

```python
from sklearn.feature_extraction.text import TfidfVectorizer
import pandas as pd

# Sample dataset (replace this with your actual dataset)
data = {
    'text': ['The curriculum emphasizes practical skills in programming.',
             'Students learn theoretical concepts in computer science.',
             'The curriculum includes real-world projects and case studies.',
             'Courses cover a broad range of topics, but lack practical application.',
             'Graduates from the program have a high employability rate.',
             'The curriculum is outdated and does not align with industry needs.']
}

df = pd.DataFrame(data)

# Vectorize the text data using TF-IDF
vectorizer = TfidfVectorizer()
X_vectorized = vectorizer.fit_transform(df['text'])
```

Fig. 3. Vectorization of sample data

After vectorization, a machine learning model suitable for the task of pre- dicting employability selected based on the vectorized curriculum. Then trained the model on the vectorized curriculum data.Figure 4 shows the mapping of course outcomes in curriculum and employability levels. It analyzed the model's predictions and interpreted the importance of specific features or terms within the curriculum that contribute to employability predictions[18]. It is easy to understand the model's decision-making process, and it helped to identify the curriculum elements that significantly influence employability outcomes.

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Unzipping tokenizers/punkt.zip.
                                                text employability
0  The curriculum emphasizes practical skills in ...          high
1  Students learn theoretical concepts in compute...           low
2  The curriculum includes real-world projects an...          high
3  Courses cover a broad range of topics, but lac...           low
4  Graduates from the program have a high employa...          high
5  The curriculum is outdated and does not align ...           low
```

Fig. 4. Mapping of course outcomes in curriculum and employability levels

RESULT

This research delves into the intersection of NLP techniques and curriculum analysis to understand their collective impact on employability outcomes. The research employed sophisticated vectorization techniques, including TF-IDF and word embeddings, to transform curriculum text into numerical graphical repre- sentations. This allowed for an extensive analysis of the correlation between curriculum content and employability[19]. Through the utilisation of TF-IDF, the study measured the importance of terms in curriculum, providing informa- tion on the relative importance of different concepts in terms of employability outcomes. Furthermore, a sophisticated comprehension of the contextual mean- ing ingrained in the curriculum was made possible by word embeddings, which represent the semantic links between words.

According to the findings, employing these vectorization approaches greatly improved the study of curricular effectiveness on employability. Compared to conventional TF-IDF techniques, the study showed that the addition of word embeddings, with their capacity to capture minute semantic nuances, provided a richer context for the analysis[20]. The study also demonstrated the signifi- cance of taking into account context and semantic links in addition to keyword occurrence. According to the findings, a comprehensive study that incorporates both TF-IDF and word embeddings offers a more thorough understanding of how curriculum affects employability, which enables more informed decisions to be made when developing and optimising educational programmes. The study emphasises how sophisticated NLP techniques can help clarify the complex re- lationships between employability and curriculum design. This can provide in- sightful information to educators, institutions, and policymakers who want to improve the efficacy and relevance of educational programmes in a labour mar- ket that is changing quickly.

Two algorithms were used in the model's training. The accuracy of ANN and Naive Bayes is displayed in Table 1. The more sophisticated ANN model proved to be the most accurate. Artificial Neural Networks (ANNs) are employed in NLP for training vectorized words due to their capacity to capture intricate, non-linear relationships within data. ANNs excel at learning hierarchical rep- resentations from vectorized words, providing adaptability across diverse NLP tasks. It enables end-to-end learning, simultaneously handling feature extrac- tion and task-specific objectives. ANNs, particularly deep learning models like Transformers, effectively process sequential information in language. It's scala- bility and ability to handle large datasets contribute to achieving state-of-the- art performance in various NLP benchmarks, making them a preferred choice for modeling and understanding the complexities inherent in vectorized word representations.

Model	Accuracy	Precision	Recall	F1-Score	ROC
ANN	0.916	0.944	0.962	0.953	0.95
NB	0.900	0.925	0.943	0.934	0.889

Table 1. Performance measures of ANN and Naive Bayes

CONCLUSION

This research highlights the significance of employing advanced NLP techniques, specifically TF-IDF and word embeddings, in evaluating the impact of curricu- lum on employability outcomes. The study demonstrates that the vectorization method plays a pivotal role in transforming textual curriculum data into numer- ical representations, providing a quantitative basis for assessing the relationship between educational content and students' employability. The incorporation of word embeddings, with their ability to capture semantic nuances, enriches the analysis by offering a deeper understanding of contextual meaning within the curriculum. The findings underscore the importance of considering not only the presence of keywords but also the intricate semantic relationships between terms. The research reveals a more nuanced and comprehensive perspective on how cur- riculum elements influence employability. This study provides insightful informa- tion on how to use sophisticated natural language processing (NLP) approaches for curriculum design and optimisation that are more informed and data-driven in the constantly changing landscape of workforce demands.

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KNOTBOOK-AN ONLINE LEARNING PLATFORM

Gokul G Nair
Computer Science and Engineering Dept.
Mar Baselios of Technology and Science (MBITS)
Kothamangalam, Kerala, India
gokulgnair2003@gmail.com
Solaman Aji
Computer Science and Engineering Dept.
Mar Baselios of Technology and Science (MBITS)
Kothamangalam, Kerala, India
solamanaji@gmail.com
Minnu Elizabeth Ittan
Computer Science and Engineering Dept.
Mar Baselios of Technology and Science (MBITS)
Kothamangalam, Kerala, India
minnueittan.87@gmail.com
Sheena S Saiju
Computer Science and Engineering Dept.
Mar Baselios of Technology and Science (MBITS)
Kothamangalam, Kerala, India
sheenasaiju5@gmail.com
Susan Paul
Computer Science and Engineering Dept.
Mar Baselios of Technology and Science (MBITS)
Kothamangalam, Kerala, India
susanpaulmambillil@gmail.com

ABSTRACT

Knotbook is an online learning platform designed to streamline the process of study material-sharing by integrating several AI features such as automatic question generation from uploaded documents, automatic evaluation and progress reporting. The platform allows teachers to upload study materials in PDF format. Using advanced natural language processing (NLP) techniques, the system automatically extracts key concepts, terminologies and other important information from the documents. Based on this extracted content, the platform generates a variety of practice questions, including multiple-choice, true/false and subjective format questions. This automation helps in creating a rich repository of practice material and assessments for students without requiring manual input. The platform aims to enhance the efficiency of educational resource management and improve student engagement by providing a transformative, seamless and interactive learning experience for both students and the teachers. Progress reporting in the system helps to monitor student performance, engagement, identify at-risk learners and suggest intervention strategies to improve their learning. This can help educators intervene early, customize learning experiences and improve overall educational outcomes.

Keywords- *Material Sharing, Automatic Question Generation, Automatic Evaluation, Progress Reporting, At-Risk Learners*

INTRODUCTION

Digital learning has transformed education but struggles with the automation of key tasks like creation of exams and monitoring progress of students. Building on a study material sharing platform, this project aims to introduce an advanced system for integrating content distribution, automated assessments and progress reporting.

The platform simplifies the processes like question generation, grading and performance tracking. The system helps in enhancing teaching efficiency and student engagement rate. The platform has a user-friendly interface that unifies essential tools for efficient workflow.The system is flexible and suitable to various needs, by supporting both blended and traditional learning and teaching methods while promoting innovation in education.

BACKGROUND

MCQGen, also referred to as A Large Language Model-Driven MCQ Generator for Personalized Learning, is a sophisticated framework that automatically creates excellent multiple-choice questions (MCQs) that accommodate a variety of learning styles.This system uses Retrieval-Augmented Generation (RAG) in conjunction with GPT-4, a state-of-the-art large language model (LLM), to include external knowledge and create context-rich, educationally relevant queries. In order to improve logical depth and self-refinement—an iterative process that consistently improves question quality—it integrates advanced prompt engineering techniques including Chain-of-Thought (CoT) reasoning. Crowdsourced evaluations generate a feedback loop that allows the system to adapt dynamically to improve its outputs and better meet the unique needs of learners.This system's revolutionary methodology not only creates multiple-choice questions (MCQs) to evaluate knowledge comprehension.The study benefits from an effective feedback mechanism and structured guidance for the LLM, ensuring continuous improvement and alignment with learning objectives. However, it faces challenges such as limitations in math-based questions, restricted question diversity and complexity, dependence on instructor input, and a limited subject domain[1].

The UniRag framework, "Unification, Retrieval, and Generation for Multimodal Question Answering with Pre-Trained Language Models," is an innovative approach to multimodal question answering (MMQA). It unifies text, image, and table data into a unified representation, minimizing information loss and enhancing transformation. This process involves linearizing all modalities via LLaVA and then retrieving context using a cross-encoder to identify relevant documents. The best k documents are chosen for answer generation, which employs a Flan model to generate accurate answers. The framework further enhances model differentiation by including distractor documents, thereby making it more robust and adaptive. Although UniRag has been successful, it suffers from high computational complexity, information overload, and conversion errors. Its experiments have achieved state-of-the-art performance in MMQA, providing rich descriptions of images and maintaining tabular information without time limits or constraints[2].

This study focuses on developing subjective questions from news media posts to boost audience interaction. Unlike prior research that emphasized objective, fact-based questions, this approach generates subjective questions to elicit opinions. The methodology involves fine-tuning multiple flan-T5 models and GPT-3 architects using Seq2 sequences for conversational generation as a unified task. Testing was conducted on 40,000 news articles using self-generated and human-sourced questions to evaluate the model's effectiveness. The research compares fine-tuned models with GPT-3.5 under zero-shot prompting, highlighting differences in handling subjective question generation. The study addresses challenges in generating opinion-based questions, which are inherently open-ended and complex. A detailed analysis compares transformer architectures, using metrics like BLEU, ROUGE, METEOR, and BERTScore, to assess model performance. This approach advances the automatic generation of opinion-driven questions, contributing valuable insights into subjective question generation and evaluation[3].

This system introduces methodologies to improve automatic question generation (QG) by integrating structured information such as named entities, relationships, and events[4]. Traditional QG methods often rely on unstructured text, resulting in generic or shallow questions. By combining unstructured passage text with structured extracted data through an entity and event extraction-based neural network model, the proposed approach generates diverse and contextually relevant questions. Key entities and their relationships are analyzed as inputs to the model, enabling the generation of questions that better reflect the content of the passage. Experimental results demonstrate that this structured model outperforms traditional QG methods in relevance, diversity, and alignment with the passage's content. The questions produced are more varied, informative, and context-aware. This approach is ideal for educational tools, automated content generation, and conversational AI, providing higher-quality output. By integrating structured data, the method significantly enhances the quality and utility of generated questions, making it a valuable contribution to context-aware QG systems[4].

The system proposes an advanced automatic test paper generation that uses an Improved Genetic Algorithm (IGA) to increase the effectiveness and fairness of English tests. The model generates test papers within 25 seconds, which is a faster rate compared to traditional methods such as Genetic Algorithms and Particle Swarm Optimization. It addresses crucial test elements including category, type, score, and difficulty while ensuring the validity of the test paper. The system also has an automatic scoring system for subjective questions, which includes grammar error detection and cosine similarity for scoring, all over a correlation of over 0.8 between manual and automated scores. This proves that the application is reliable, objective, and consistent. The application of this system enhances security, fairness, and scalability for large-scale English exams, making it applicable for educational evaluations. By using Enhanced Genetic Algorithm (EGA), the system ensures a balanced mix of difficulty and score distribution, while automatic scoring reduces subjectivity in translation question evaluation. This approach holds the potential to revolutionize large-scale English exams, promoting efficiency, transparency, and faster management in educational institutions worldwide. The system's innovative nature ensures consistent, fair, and efficient assessment, benefiting both domestic and international educational systems[5].

This system proposes an integrated approach to automate responses for various exam types, including multiple-choice questions (MCQs), essays, and mathematical equations. Advanced Natural Language Processing techniques are used for grading essays, while symbolic computation evaluates mathematical equations. For MCQs, a traditional machine learning model matches student responses with predetermined correct answers. Essay grading employs deep learning techniques like recurrent neural networks or transformers, assessing content quality, coherence, and relevance based on predefined rubrics. For equations, symbolic matching ensures syntax and semantic accuracy. The system preprocesses input responses, extracts relevant features, and applies evaluation models tailored to each question type. Experimental results demonstrate the system's ability to improve accuracy and efficiency compared to traditional grading methods. It ensures high accuracy in grading MCQs, provides meaningful essay assessments, and evaluates mathematical expressions effectively. This framework is a robust tool for modern educational settings, offering scalable and reliable automated grading for large-scale assessments[6].

This system explores the issues and evaluation methodologies of ODQA systems, specifically large language models (LLMs). It provides a taxonomy to denote the current datasets and evaluation metrics, thereby helping to standardize assessments regarding ODQA systems. Particular key technologies associated with this system are NLP, Information Retrieval (IR), and deep learning techniques for improving performance in ODQA systems. It is on large pre-trained models such as GPT and BERT, fine-tuned for cross-domain answer generation. ODQA is analyzed by benchmarks categorized into data type: text vs. knowledge graphs and task type: factual vs. reasoning. Evaluation metrics focus on accuracy, relevance, and coherence while paying attention to how the models deal with question ambiguity, factuality, and response complexity.

The findings point out that diversity, representative datasets and sound metrics for nuanced aspects of ODQA performance are required. The metrics consider not just answer correctness but ambiguity and complexity. This analysis requires more extensive sets of benchmarking practices that should direct the development of stronger ODQA systems[7].

Advanced Natural Language Processing (NLP) methods have been used in the creation of AQG , it focuses on transformer models for question generation from single paragraphs. The methodology utilizes BERT (Bidirectional Encoder Representations from Transformers) and GPT (Generative Pre-trained Transformer) models, which are further trained to do these tasks. So that the resultant questions are syntactically correct and contextually appropriate, these models are first tailored to the task. In this way, the process begins with converting the input text into a more suitable computer-readable format called preprocessing and continues with tokenization, recognition of named entities (NER) and parts of speech tagging (POS), which are aimed at understanding the core concepts. The focus then shifts to generating the questions. After having identified the focus points of the paragraph, transformers, and in particular sequence-to-sequence models, can be used for this task. This ensures that the essential information is retained in the generated sentences. Most importantly, the generated questions are analyzed afterwards using metrics such as BLEU (Bilingual Evaluation Understudy) and ROUGE (Recall-Oriented Understudy for Gisting Evaluation). In this way, AQG is able to fully exploit the advantages of transformer models to fully automate question generation for learning purposes and in the process, increase relevance and coherence[8].

The system for automatic educational question generation system uses machine learning models to classify answers as educational or non-educational. It utilizes supervised learning algorithms, such as Support Vector Machines (SVM), Random Forests, and Neural Networks, on labeled datasets for classification. Feature extraction is carried out using semantic analysis, keyword extraction, and sentence embedding models like BERT to capture contextual relevance. The system also incorporates context-based models, utilizing Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks to improve answer selection by considering surrounding context and educational objectives. Attention mechanisms are used to rank important text components, enhancing the question generation process. This approach ensures that selected answers contribute to generating educationally meaningful questions. The methodology is based on improving the accuracy and quality of the generated questions, which makes the system more effective for educational content creation. These findings are valuable for developing personalized learning platforms and intelligent tools for automatic question generation in educational environments[9].

Automatic Question Generation (AQG) systems reduce the time and resource-demanding workload of creating appropriate questions on manual grounds. These include supporting assessments, personalized learning, and training AI models for tasks such as question-answering and machine reading comprehension (MRC) through extracting key information from text using tokenization, part-of-speech tagging, and dependency parsing. Questions are generated using pre-defined templates and can be adapted to formats such as MCQs or subjective questions. Distractor generation techniques produce plausible incorrect options, and difficulty levels match the learner's capabilities. Although AQG systems provide efficiency, scalability, quality, and cost-effectiveness, they have limitations. They rely on rule-based templates, which limit linguistic variety and innovation. They also fail to generate complex, higher-order questions that require inference and critical thinking and do not have features for giving detailed feedback on errors. Despite these challenges, AQG systems enhance educational experiences by automating question generation and adapting in real-time to learners' needs, with potential for improvement in diversity and critical content generation[10].

SCOPE AND OBJECTIVE

The proposed system makes it easier for teachers and learners to interact with study materials, providing a platform that helps faculties to upload, organize, and share resources with efficiency. The goal of the system is to make learning more attainable and interesting by offering a simple and organized way for students to access study materials. This platform is centralized in nature, which increases the availability of content that students need, thereby facilitating a more connected and organized learning environment.

One of the key features of the system is the automatic generation of online exams based on the study materials uploaded by faculty.This ensures faster and more efficient development of assessment tests. The system intake content provided by the faculty and creates dynamic, relevant, customized exams that include a variety of question formats like MCQs and subjective questions. This ensures that assessments are relevant to what students have been learning and makes it easier for faculty to manage the exam process. With this automation, both faculty and students benefit from a time-efficient, accurate and smoother experience.The system also focuses on inclusivity, incorporating a Text-to-Voice conversion tool to ensure that all students, including those with visual impairments or other learning challenges, can fully participate in exams and access course materials. This feature provides equal opportunities for students who need additional support, making the learning experience more equitable. In addition, the system uses analytics to track student progress, identifying those who may be at risk of falling behind. By generating alerts for faculty and academic counselors, the system ensures that timely support is provided to students who need it most, helping them stay on track and succeed.

Ultimately, the proposed system aims to create a supportive and inclusive learning environment that is not only efficient but also responsive to the diverse needs of students. By combining content management, automated assessments, accessibility features and data-driven insights, the system provides a comprehensive solution to help both faculty and students thrive in today’s educational landscape.

ARCHITECTURE MODEL

The proposed system architecture of Figure 1 below illustrates the suggested system design.It consists of an AI-driven framework designed to process user-uploaded content (e.g., PDF notes) and facilitate question generation, performance analysis and risk identification.

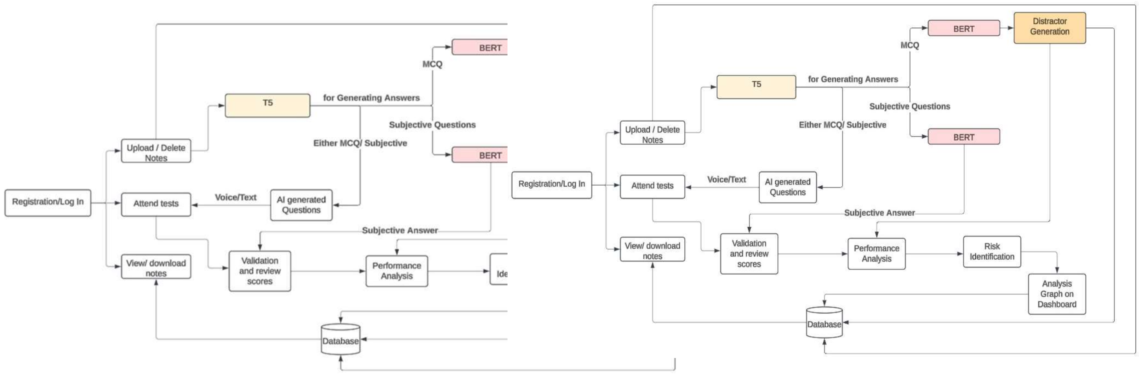

Fig. 1. Architecture Diagram

This system is created in such a manner that key functionalities of users are integrated with advanced AI driven machine learning models in order to provide an interactive learning experience. Users are enabled to either register for the service or log in for them to manage their profiles and use the features provided. Study materials such as PDF notes that are used at the focus of the AI processes of the system can be uploaded and deleted by users. Moreover, notes for reference and tests that are formulated by the system can be viewed and downloaded for users. The AI automations in this particular system are T5 and BERT, both of which are important components for the automation of question creation and improving the learning experience. The T5 model scans the uploaded notes to formulate questions and accompanying answers that contextually fit the user's study materials, which will be placed in tests. On the other hand, the BERT model is used to provide more answers and valid distractors for the multiple choice questions.To enable the system to achieve its goals, a set of procedures are developed and incorporated. From the uploaded notes, the T5 model will create the AI generated question and the BERT model will work in parallel to create distractors that are competent and realistic. The answers are validated, the scores reviewed and the results are stored in a centralized secure database to maintain the confidentiality of the users.The overall functionality of T5 model is shared below in figure 2.

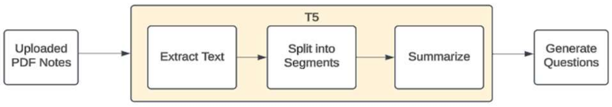

Fig. 2. T5 Model

The system allows users to upload their PDF notes, which are the primary input for the T5 model's workflow. After uploading, the system processes and extracts the text content from the PDFs, preparing it for further analysis. The extracted text is then divided into smaller, manageable segments to facilitate efficient processing and ensure that no critical information is overlooked. Once the data are segmented, this T5 model produces an abstraction of a paragraph in three short sentences so as to present an overview and streamline the generation process of the question. In short, relevant meaningful questions are produced in coherence with these overviews in place of irrelevant answers. With all these workflows placed in proper succession, a product of great, contextually right questions ensures and enhances better output in the overall learning curve.

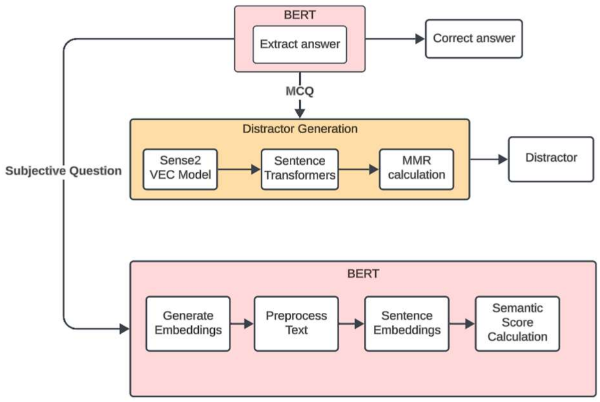

Fig. 3. BERT model

The figure 3 details the BERT model which uses an advanced approach for enhancing the generation of multiple-choice questions (MCQs) by integrating advanced models of natural language processing. Firstly, BERT, which stands for Bidirectional Encoder Representations from Transformers, is used to extract the correct answers from subjective questions. It ensures that the answers are contextually accurate and relevant. To produce plausible distractors, the incorrect options that will be contextually similar to the correct answer, the system would use Sense2Vec, that identifies word level contextual relationships and Sentence Transformers to embed sentences into capturing semantic understanding. This way it is possible to create relevant as well as challenging distractors. To keep maintaining the quality of these distractors, the system computes MMR values.

MMR ensures the distractors are relevant to the context but yet distinct enough from the correct answer, thereby enriching the quality of the MCQs. Furthermore, BERT computes the semantic similarity of possible answers with distractors for logical consistency and coherence in the set of questions. In this holistic methodology, the resulting MCQs are challenging as well as educationally worthwhile.

PROPOSED METHODOLOGY

An integrated, automated learning platform for the management of educational content, assessments, and student progress will be proposed. Faculty will upload and process study materials, automatically generate questions, provide customized examinations, and evaluate student performance efficiently, benefiting both educators and learners. It also comprises the Document Upload and Processing Module and the AQG Module, which facilitate the smooth translation of content into accessible formats, with assessments targeted toward specific course objectives.Another salient feature of this platform is its use of current technologies, including NLP and ML, to power its components. It is this module that will use the developed technologies to automatically generate a range of question types, such as multiple-choice, fill-in-the-blank, and subjective questions, from uploaded content. Faculty will review, edit or accept these questions, ensuring that the generated assessments are academic in quality and relevance. Furthermore, the Examination Generation Module allows for the customization of exams so that instructors can create their own assessments based on the difficulty level, time limit, and even randomization, ensuring that each student is assessed fairly.

The Automatic Evaluation and Progress Report Generation Modules make the platform more efficient by immediately providing feedback about student performance. The evaluation module automatically grades objective questions and gives preliminary scores for subjective ones, thus saving faculty workload. Meanwhile, the feature of generating progress reports tracks and visualizes student performance over time, helping both students and faculty understand strengths and areas for improvement. Together, automation, customization and real-time feedback create a complete and engaging learning environment that allows for continuous student growth while relieving the administrative burdens on educators.

A. *Automatic Question Answer Generation*

This module automates the generation of questions and answers from a PDF document, supporting both MCQs with distractors and subjective questions. After a user uploads a PDF, the PyPDF2 library extracts raw text, which is divided into smaller segments for easier processing. The T5-small model summarizes the content into concise key points, which are then passed to the T5-base model to generate multiple-choice and subjective questions based on the summaries. The BERT model extracts accurate answers for each question by analyzing the summarized text. Generated questions and answers are stored in a database for easy management and retrieval. To create distractors for MCQs, the Sense2Vec model identifies semantically similar words or phrases, while Sentence Transformers generate embeddings to ensure contextual relevance. The correct answer and distractors are combined to form balanced, contextually accurate multiple-choice options. This streamlined approach ensures high-quality question generation, enabling efficient and organized assessment creation.

B. *Text-Voice Conversion*

The Text-to-Speech (TTS) engine converts written content into natural-sounding spoken audio, enabling users to hear information rather than read it on-screen. This technology, integrated into platforms via TTS services such as Google Text-to-Speech, Amazon Polly or Microsoft Azure Speech, offers valuable functionality for users who are visually impaired, those who prefer auditory learning, or individuals multitasking with hands-free access. TTS can be customized with voice options, accents and language preferences, enhancing accessibility and allowing developers to create engaging, user-friendly experiences across educational, entertainment and productivity applications.The Speech-to-Text (STT) engine enables voice-based inputs to be transcribed into written text, allowing users to speak commands, dictate notes, or communicate more naturally with applications. Integrated STT services such as Google Speech-to-Text, IBM Watson Speech to Text, and Apple's Dictation API use machine learning and NLP to accurately convert spoken language into text, supporting multiple languages and dialects. This feature is essential for applications aiming to increase accessibility, especially for users with physical limitations and for productivity tools that benefit from hands-free operation, such as virtual assistants, customer service bots and voice-activated search systems.

C. *Answer Validation*

In the Answer Validation Module, it primarily focuses on automatic grading of students' responses with a score, according to how correct their answers are. Automatic Grading validates and scores the students' answers based on their comparison with the correct answers saved in the database. The system checks for correctness in every response by making use of techniques such as semantic similarity and exact match, depending on the type of question. It gives scores to every student's response based on the degree of correctness. For example, a student may be given a high score if his or her answer is very similar to the correct answer or lies within an acceptable range of similarity. In cases where the answers were partially correct, the system could give the scores accordingly. Again, the application of MMR indirectly supports grading. Although MMR is primarily used in the question generation module to select suitable distractors for multiple-choice questions, it improves the quality of the MCQ options, which makes it easier to evaluate whether students have selected the correct answers with genuine understanding rather than random selection.

D. *Progress Reporting*

This study explores an integrated approach to enhancing student performance through continuous tracking, in-depth analytics and intuitive progress monitoring. The system continuously logs student activities, such as assignment completion, quiz scores and discussion participation, allowing educators to identify patterns in performance and areas needing improvement. This methodology not only employs student accountability but also provides valuable observations for teachers, students and parents to adjust and plan their learning strategies. Through performance analytics, the system conducts deeper analyses of student data, revealing trends in grade progression, skill and development. This system will help in identifying students at risk or those ready for advanced content, enabling targeted interventions. The progress dashboard aggregates key performance indicators, visually presenting test scores, assignment statuses and participation rates in an easily understandable format, helping students, parents and educators quickly assess academic standing. This comprehensive system empowers students to set goals and reflect on progress, while providing educators with the tools to monitor performance efficiently and make timely adjustments. Collectively, these features support personalized learning, facilitate responsive teaching and improve educational outcomes.

RESULT AND DISCUSSION

The proposed system effectively generates high-quality questions and distractors from documents using BERT, Sense2Vec, and T5 models. It outperforms baseline and pre-trained models in accuracy, precision, and ROUGE scores. BERT ensures contextual relevance, Sense2Vec enhances distractor quality, and T5 generates clear, grammatically correct questions, validated through human evaluation.

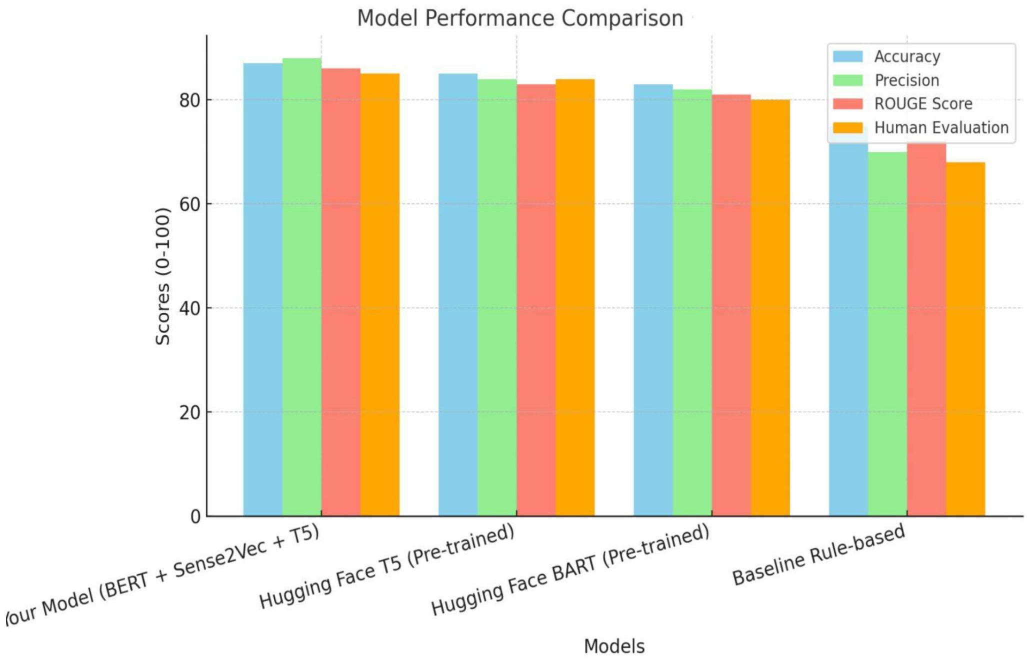

Fig. 4. Model Performance

The bar graph in figure 4 compares models for MCQ generation based on Accuracy, Precision, ROUGE Score, and Human Evaluation (0–100 scale). Models include the proposed T5 + BERT + Sense2Vec, Hugging Face T5, BART, and a Baseline Rule-based system. All models scored between 80–90, with the proposed model excelling in ROUGE Score and Human Evaluation, showcasing its strength in generating high-quality outputs. Hugging Face models performed consistently, slightly outperforming the rule-based baseline. This demonstrates the proposed model's effectiveness in domain-specific tasks.

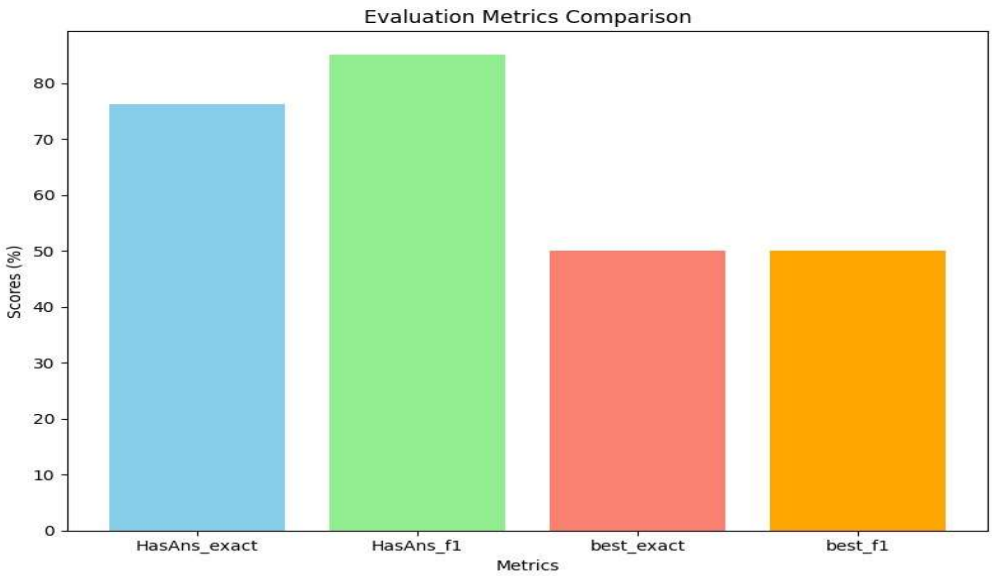

Fig.5.BERT model after fine tuning

The evaluation results in figure 5 showcase how well the fine-tuned BERT model performs in answer extraction. Key metrics include HasAns_exact at 76.21% and HasAns_f1 at 84.99%, demonstrating solid performance in extracting answers when they are present. The overall F1 score stands at 42.43%, with the highest F1 score reaching 50.07% at a threshold of 0. These findings emphasize both the model's strengths and the areas that need enhancement.

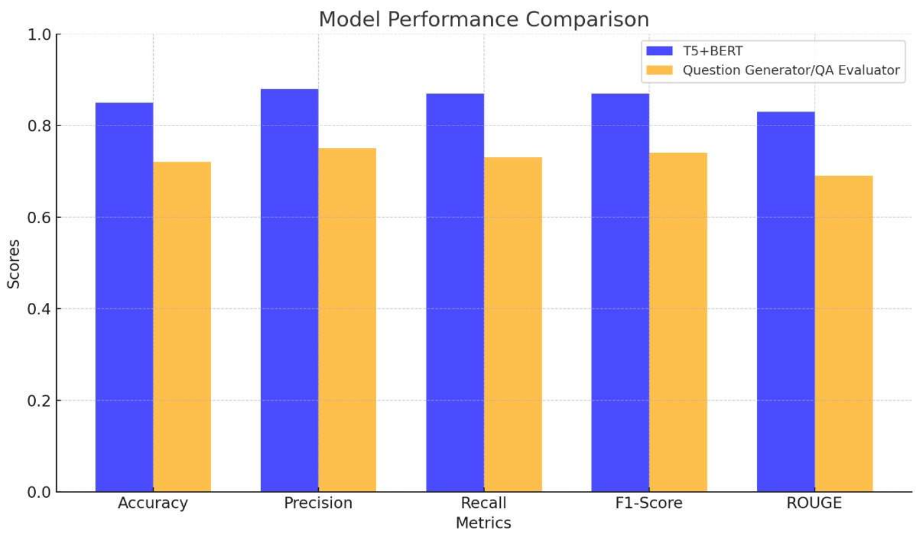

Fig 6. Model performance

The bar graph in figure 6 compares the performance of the T5+BERT model against the Question Generator+QA Evaluator for subjective question-answer generation and analysis. Metrics assessed include Accuracy, Precision, Recall, F1-Score, and ROUGE. The T5+BERT model consistently outperforms the Question Generator+QA Evaluator across all metrics, demonstrating higher reliability and precision. Notable differences in F1-Score and ROUGE highlight T5+BERT's strength in generating relevant and high-quality outputs, making it more effective for subjective evaluation tasks compared to the alternative approach.

CONCLUSION

The online learning platform addresses the challenges of modern digital education by integrating AI-driven automation for text processing, exam generation, evaluation and progress reporting. The system enhances both teaching and learning experiences. With NLP-based machine learning models, the system automates question generation by ensuring diverse, relevant questions aligned with study materials, while customizable exam options like question type selection make the system more user-friendly. Automated grading of objective and subjective questions significantly reduces grading workloads, providing accurate and timely feedback. Faculty can oversee the process to ensure fairness, making the platform ideal for managing large amounts of data for big classes. By merging automation with manual oversight, it puts forward a flexible, effective and student-centered educational environment, empowering educators and supporting students with opportunities for personalized growth. This innovative approach sets a benchmark for accessible, efficient and modern digital education.

Future enhancements for the online learning platform could make it more interactive, adaptive and inclusive, enriching the educational experience for both students and educators. Attention-tracking technology could monitor student focus during lessons, allowing faculty to regulate pacing and delivery for better engagement, while sentiment analysis could encourage a supportive learning environment by interpreting student emotions. Adaptive learning modules could personalize education by adjusting content difficulty and recommending resources based on individual performance and gamification elements like rewards and leaderboards could boost motivation, making learning more interactive and goal-oriented. These advancements would support diverse learning styles, enhance outcomes and solidify the platform's position as a leader in educational technology.

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VIDEO GAMES AND SMART AI INTEGRATION

Mr.Haarrish Sabu,
Assistant Professors, PG Dept of CS,
Naipunnya Institute of Management and Information Technology, Pongam
Mr.Athul P D,
Assistant Professors, PG Dept of CS,
Naipunnya Institute of Management and Information Technology, Pongam
Ms.Anna Diana,
Assistant Professors, PG Dept of CS,
Naipunnya Institute of Management and Information Technology, Pongam
Ms.Sarithadevi S
Assistant Professors, PG Dept of CS,
Naipunnya Institute of Management and Information Technology, Pongam

ABSTRACT

This research paper solely focuses on the role of Smart AI in the video games and its application in various industries. The introduction part deals with a brief history of video games along with some insight into the world of AI and its role in video games. In the subsequent sections, we will come to know about the way of interaction between in-game entities influenced by Smart AI and also with the player. With the advent of Smart AI, video game experience is taken to the next level or what can be called as Neo Gaming era. The technology aims to provide a more realistic and interactive experience. Although the AI assisted gaming existed earlier, its full potential was not fully explored, hence the creation of dynamic environment and NPC behaviors. The more intelligent capability of NPC behavior will pose a great challenge to player, enhancing the gaming experience. The gaming community will get next level experience via various devices like a gaming console, PC, AR and VR. This will analyze the pattern of players behavior and play style by which the AI NPC will respond accordingly. By incorporating reinforcement learning (a form of deep learning that embraces a trial-and-error approach, assessing the rewards and penalties of actions) (ai-in-gaming, 1995-2025), NPCs can build off of their experiences, maximizing the positive consequences of their decisions during gameplay.

Keywords: *Smart AI, Neo Gaming era, NPC, AR and VR, Reinforcement learning*

INTRODUCTION

Video games are making remarkable advancements in quality in this neo era. Modern games are capable of simulating real-life environments and characters with an impressive level of detail. These virtual worlds are often populated with characters that demonstrate human-like intelligence and realistic behaviours. While there have been significant breakthroughs in computer graphics, animation, and audio, the majority of games still rely on relatively simple artificial intelligence mechanics(AI). AI in gaming primarily revolves around the behaviour and decision-making processes of in-game opponents aka bots. Creating a rich enhanced gaming experience requires substantial engineering efforts during development time.

In recent years, there has been a growing interest in integrating advanced AI techniques into video games. However, most existing work in this area focuses on addressing tiny, specific issues within gaming. As the development of video games involves large team working under tight deadlines, developers often compromise the time and resources to incorporate complex AI methodologies from academic research into games.

This research is a precursor toward bridging that gap. The report emphasizes reasoning and learning techniques to create adaptive games, which can respond naturally to unforeseen circumstances on their own. Such adaptability minimizes the development efforts since developers need not required to anticipate every possible scenario or outcomes.

This report is structured as follows: First, it provides an analysis of the AI requirements for various game genres and highlights the challenges these genres pose to the AI community. Then, it explores the Case-Based Reasoning (CBR) approach for adaptive games, focusing on automatic behavior adaptation for characters, drama management, and user modelling for interactive storytelling, as well as strategic behavior planning for real-time strategy games (Raju, 2012). The report concludes with a discussion of future roadmap for research and development in this field.

THE ROLE UPTAKE OF AI IN VIDEO GAMES

Artificial intelligence (AI) presents a challenge across various game genres. Games such as action, role-playing, adventure, strategy, God games, as well as individual and team sports games, often struggle due to inadequate AI implementation. Additionally, genres like interactive drama and educational games highlight the growing demand for advanced AI systems.

In interactive drama, players take on the role of a first-person character within a dynamic and immersive storyline. Unlike traditional "adventure" games, which follow a pre-scripted narrative, interactive dramas adapt to player actions, creating an open-ended experience where the story evolves based on player interactions (Games like Witcher, Banishers etc).

Educational games, on the other hand, have a dual purpose: engaging players while teaching specific content. These games rely heavily on AI to personalize the learning experience and make it more effective for the player.

After analysing various genres, it becomes clear that AI can be implemented at two distinct levels:

1. **Individual Character AI** – Focused on creating intelligent and believable behaviours for in-game characters.
2. **Global AI** – Monitors the overall gameplay or player interactions, guiding and influencing the direction of the game to enhance the experience.

We can also describe these as **character-level artificial intelligence** and **game-level artificial intelligence**.

The implementation of AI is not uniform across all game genres; it varies depending on the type of game. For example, real-time strategy games primarily rely on game-level AI to control all the units, while the behavior of individual units can be pre-scripted. On the other hand, role-playing games require character-level AI to create engaging and immersive player experiences.

Interactive dramas, however, demand a combination of both types of AI. They require individual characters with realistic and believable behavior, alongside a drama manager that orchestrates the plot by guiding characters to take actions that progress the story. Similarly, educational games also benefit from AI systems similar to drama managers, which adapt content and interactions to enhance the learning experience. In God games, game-level AI plays a critical role, solving resource management challenges and addressing long-term strategy planning to deliver a compelling gameplay experience.

OBSTACLESs IN ARTIFICIAL INTELLIGENCE FOR COMPUTER GAMES

This section highlights some of the key challenges that computer games present to artificial intelligence (AI). While this list is not exhaustive, it covers significant problems faced by the AI community when addressing the needs of modern games.

1. Complex Decision Spaces Modern computer games often involve highly complex strategic or realistic behaviours. These behaviours share the challenge of vast decision spaces, making traditional search-based AI techniques impractical. Most games still rely on handcrafted strategies created by developers, but these can become repetitive, allowing players to find and exploit predictable patterns.
2. Learning and Memory

   Learning in AI is not a single process but a collection of adaptive mechanisms that function across a character's cognitive system. Effective learning systems must address various forms of adaptation to improve a character's in-game performance over time.

3. Emotion Modeling

   Emotion modelling has primarily been used as a diagnostic tool to reflect a system's state. However, emotions can influence many aspects of AI behavior, such as decision-making, planning, and prioritizing sensory input. For instance, curiosity-based emotions can guide characters in exploration or exploitation scenarios, enhancing their responsiveness and engagement.

4. Authoring Support

   Creating AI behavior often involves coding complex algorithms in programming languages, which are prone to human errors. These errors could result in software bugs or behaviours that fail to meet the intended objectives. Moreover, developers without expertise in AI may struggle to design effective behaviours.

5. Unanticipated Situations

   It is nearly impossible to predict all possible scenarios and player strategies during gameplay. This unpredictability makes it challenging to create believable AI behaviours capable of responding appropriately to unforeseen events and player actions.

6. Learning through Episodic Memory

   Episodic memory—storing explicit sequences of events for later recall—is underutilized in AI systems. Unlike procedural or short-term memory, episodic memory enables characters to learn quickly by recalling specific instances where strategies succeeded or failed. This capability could enhance generalization and improve cause-and-effect reasoning in games.

7. User-Specific Adaptation

   Different players enjoy diverse gameplay experiences, whether in combat strategies, storytelling styles, character interactions, or educational challenges. To cater to this variety, game AI must incorporate user modelling and adapt its behavior and strategies to align with individual player preferences.

8. Replayability and Variability

   Players often lose interest when they repeatedly encounter the same strategies and behaviours. While simple variability can be achieved through random selection from a repository of behaviours, this approach increases development complexity and does not guarantee engaging gameplay. Designing truly dynamic and interesting behavior remains a significant challenge.

   These challenges demonstrate that not only can games benefit from more advanced AI techniques, but the AI field itself can also grow by addressing the unique problems posed by computer games. To address these issues, this paper outlines three projects aimed at (a) reducing the effort required to develop game AI and (b) creating systems that are more adaptive and engaging for players.

BEHAVIOR ADAPTATION FOR REALISTIC CHARACTER EFFECT IN ARTIFICIAL INTELLIGENCE

In interactive games, characters are often designed with distinct personalities that influence their actions within the game. Typically, developers create these characters by scripting behaviours that dictate their reactions to various anticipated scenarios in the game world. However, this method presents several challenges (Raju, 2012).

First, designing a comprehensive set of behaviours for a character is a daunting task, as it is difficult to anticipate and plan for all possible scenarios in a dynamic and complex game environment. This often demands significant programming effort. Second, a fixed set of behaviours can lead to repetitive actions, reducing the believability and realism of the characters. Lastly, when a behavior fails to achieve its intended purpose, characters are unable to recognize the failure or adapt, resulting in continued display of ineffective behavior.

The ideal solution is to create self-adapting behavior systems that enable characters to autonomously express their predefined personalities in new and unexpected situations. This would relieve developers of the burden of scripting responses for every possible scenario.

To tackle these issues, we have developed an approach where characters track the performance of their executed behaviours, analyse execution logs to identify potential issues, and make adjustments to their behavior as needed. This method of routine behavior modification allows characters to dynamically adapt to evolving game situations while maintaining their core personality traits. This marks an important step toward the automatic generation of adaptive behaviours, enhancing both the realism and engagement of in-game characters.

TECHNOLOGIES INCORPORATED

Creating lifelike characters in video games involves a combination of advanced technologies and techniques. The key technologies used are:

1. Artificial Intelligence (AI)

- **Behaviour Modelling**: AI systems are used to design characters that can react dynamically to players' actions and the game environment, making them appear intelligent and adaptive.
  - **Pathfinding**: Algorithms like A* or Dijkstra's help characters navigate complex environments.
  - **Decision-Making**: Techniques like finite state machines, behavior trees, and utility-based AI enable characters to make realistic choices.
  - **Learning Systems**: AI models using reinforcement learning or neural networks allow characters to learn and evolve based on player interactions (Filipović, 2023).

2. Motion Capture (MoCap)

- Motion capture technology records real human movements and maps them onto digital characters, creating realistic animations.
  - Used for facial expressions, body movements, and even micro-expressions.
  - Advanced MoCap systems integrate with AI to refine animations for unique character actions.

3. Procedural Animation

- Procedural animation generates character movements dynamically in response to in-game physics and environment changes.
  - Example: A character stumbling realistically over uneven terrain without pre-scripted animations.
  - Physics engines like Havok or Unreal Engine's Chaos contribute to this realism.

4. Photogrammetry and 3D Scanning

- Photogrammetry captures real-world objects, environments, and even people to create highly detailed and realistic textures and 3D models.
- 3D scanning technology is often used to model lifelike human faces and bodies.

5. Facial and Emotion Animation

- **Blendshapes and Morph Targets**: Used for animating subtle facial expressions like smiles, frowns, or eye movements.

- **Dynamic Wrinkles and Skin Movement**: Real-time simulation of skin textures and wrinkles adds realism.
- **Emotion AI**: Characters can display emotional responses based on the player's actions, enhancing immersion.

6. Voice Synthesis and Acting

- **Performance Capture**: Combines voice acting with facial motion capture to sync realistic dialogue and expressions.
- **Text-to-Speech AI**: Advanced tools like neural TTS (e.g., ElevenLabs or Replica) generate lifelike speech for NPCs.

sync Algorithms: Ensure the character's lip movements match spoken dialogue.

7. Shader and Rendering Techniques

- **Subsurface Scattering (SSS)**: Simulates how light penetrates skin and scatters underneath, creating realistic skin tones.
- **Ray Tracing**: Enhances lighting, reflections, and shadows, making characters appear naturally integrated into the environment.
- **PBR (Physically-Based Rendering)**: Ensures textures and materials (skin, fabric, metal) react accurately to light.

8. Hair and Clothing Simulation

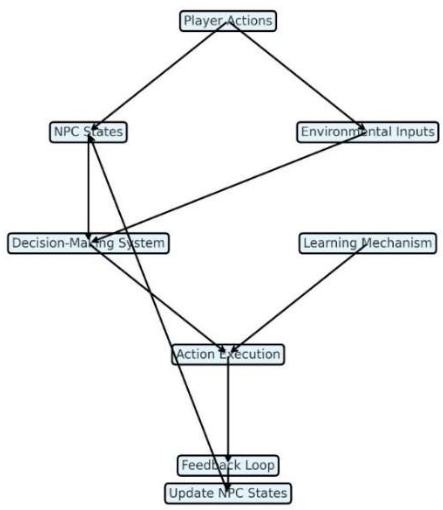
- Realistic simulation of hair and clothing is achieved through physics-based systems.
    - Tools like Nvidia HairWorks or Unreal Engine's Groom system model individual hair strands.
    - Cloth simulation engines realistically depict how clothing moves and reacts to wind or body movements.

9. Procedural Storytelling

- Advanced narrative engines adapt character behavior and dialogue based on the player's choices, making characters feel more dynamic and lifelike.
    - Example: Characters reacting differently to the player's actions, shaping the storyline.

10. Neural Networks and Machine Learning

- Deep learning models are used to generate realistic character animations and behaviours.
    - Example: OpenAI's GPT or similar models generating natural-sounding dialogue.
    - Machine learning enables NPCs to learn patterns, making their behaviour seem more organic (Filipović, 2023).



11. Real-Time Rendering Engines

- Game engines like Unreal Engine 5 and Unity play a significant role in rendering lifelike characters.
    - Features like MetaHuman Creator in Unreal Engine allow developers to create highly realistic human characters quickly.

12. Haptic and VR Integration

- In virtual reality (VR) games, haptic feedback and body tracking make character interactions more immersive, enhancing their believability.

13. Biomechanics and Anatomical Modeling

- Detailed models of muscles, bones, and skin layers help create realistic body movements.

- Used in combination with physics engines to simulate natural human movement.

By integrating these technologies, developers can create characters that not only look realistic but also behave, interact, and respond in ways that enhance player immersion.

METHOD OF WORKING

To represent a working diagram of adaptive AI influencing NPCs using the ABL (Action-Based Language), the language is primarily used for modelling behaviours in game characters, where actions and conditions are specified through preconditions, actions, and postconditions.

Here's how we can break down the components of the adaptive AI using ABL in a structured way. This can be visualized as a diagram of a behaviour tree that integrates actions based on NPC states, environmental inputs, and player interactions.

ABL-Based Diagram Structure

1. Player Interactions: Player's actions trigger responses in NPCs.
2. NPC States: Internal conditions that influence decision-making (e.g., emotional, health, or state of mind).
3. Environmental Factors: Dynamic environmental triggers like day-night cycle, weather, and location.
4. Learning Mechanism: Adapts NPC behaviours based on history of player interactions.
5. Decision Logic: Uses condition-action rules to determine the next action based on the environment, player, and internal NPC states.

Here's an example of an ABL structure diagram:

Explanation of the Diagram Components:

- Player Actions: The actions the player takes (like combat or talking to the NPC) are processed to influence the NPC's behaviour.
- NPC States: Internal states like health, aggression, trust, or mood affect the NPC's decisions. These states are continuously updated and monitored.
- Environmental Inputs: The environment dynamically impacts NPC behaviour based on conditions like time of day (e.g., NPCs may act differently at night) or location (e.g., NPCs in a town react differently than those in a dungeon).

- Decision-Making System: Based on the conditions (like the player's behaviour, NPC states, and environmental inputs), a decision-making algorithm (e.g., condition- action rules or a behaviour tree) chooses the next action for the NPC.
- Learning Mechanism: The system adapts the NPC behaviour based on how the player has interacted with it in the past. This can involve modifying the NPC's trust level or aggression based on prior interactions, ensuring that NPCs "learn" over time.
- Action Execution: Once the decision-making system has selected an action, it is executed. For example, the NPC might speak, fight, flee, or approach the player.
- Feedback Loop: After the action has been taken, the result is analysed, and the NPC states are updated. This loop helps the system learn from its actions and adapt to future interactions.

This diagram represents a feedback system in which NPCs can adjust dynamically to player behaviours, environments, and internal states using ABL-based behaviour trees or action-based rules (Raju, 2012).

IMPLEMENTATION OF GOAL LANGUAGE

The GOAL programming language is a high-level agent-oriented programming language used to design and implement intelligent agents. Its underlying mechanism is based on Belief-Desire-Intention (BDI) theory, a popular framework for modelling rational behaviour in autonomous agents. Here's a breakdown of the core mechanisms and how GOAL operates:

1. Belief-Desire-Intention (BDI) Framework

GOAL agents are based on the BDI architecture, which models rational decision-making as a combination of:

- Beliefs (B): Represent the agent's knowledge or perception of the world, stored as facts or logical propositions.
- Desires (D): Represent the agent's objectives or goals, which the agent strives to achieve.
- Intentions (I): Represent the plans or actions the agent has committed to in order to achieve its goals.

2. Mental State Management

The mental state of a GOAL agent is represented by:

- Belief Base: A set of logical facts about the environment or internal state (e.g., at(agent, location)).
- Goal Base: A set of declarative goals the agent wants to achieve (e.g., deliver(package)).
- Action Base: The available actions the agent can perform to interact with the environment or other agents.

The agent's reasoning process revolves around updating and maintaining these mental states dynamically.

3. Rule-Based Decision-Making

GOAL agents make decisions using rules that specify what actions to take under certain conditions:

- Action Rules: Define the mapping between an agent's beliefs and the actions it should take. These rules have the form:
- if <condition> then <action>
    - Condition: Evaluates the agent's current beliefs.
    - Action: Specifies what the agent should do if the condition is true.

Example:

if has(package) and at(agent, destination) then deliver(package).

4. Knowledge Representation

GOAL uses logical representations (often based on Prolog or similar logic systems) for knowledge, enabling:

- Declarative Beliefs: Facts about the world, like on(package, table).
- Declarative Goals: Desired states, like delivered(package).
- Inference Rules: Derived knowledge, such as:
- can_reach(X, Y) :- connected(X, Y), not blocked(X, Y).

This allows the agent to reason about its environment, derive new knowledge, and choose appropriate actions.

5. Goal-Driven Behaviour

The agent is goal-oriented, meaning it selects actions based on its goals. The process involves:

- Goal Evaluation: Identifying goals that are relevant and achievable based on current beliefs.

- Goal Prioritization: Selecting which goals to pursue when multiple is active.
- Goal Maintenance: Dropping goals that are no longer relevant or achievable.

Example: If an agent's belief base contains package_on_table and the goal base contains package_delivered, the agent will generate an intention to deliver the package.

6. Action Execution

Actions in GOAL are defined as primitive operations or procedures the agent can perform to interact with its environment. These include:

- Internal Actions: Updates to the agent's belief base or reasoning state.
- External Actions: Interactions with the external environment, such as moving or communicating.

The execution process involves:

1. Precondition Checking: Ensuring the action is valid given the current beliefs.
2. Action Execution: Performing the action and updating beliefs.
3. Postcondition Handling: Evaluating the outcome of the action and adapting as needed.

7. Planning and Intentions

The intention base stores the plans or actions the agent is committed to. GOAL agents focus on reactive planning rather than comprehensive, up-front planning:

- Plans are formed dynamically based on current beliefs and goals.
- Reactivity: Agents can adapt plans or abandon intentions when circumstances change.

Example: If an agent intends to move to location A but finds the path blocked, it can revise its intention to find an alternative route.

8. Environment Interaction

GOAL agents interact with a simulated or real environment through:

- Perception: Receiving updates from the environment (e.g., changes in beliefs like blocked(location)).
- Action Feedback: Evaluating the success or failure of executed actions.
- Environment Updates: Updating beliefs based on observed changes in the environment.

9. Reasoning Cycle

The reasoning cycle of a GOAL agent consists of:

1. Perceive: Update the belief base based on the environment.
2. Evaluate Goals: Identify which goals are achievable and relevant.

3. Select Intention: Choose the most relevant goal to focus on.
4. Plan Selection: Determine which action or plan to execute next.
5. Execute Action: Perform the chosen action and update beliefs.
6. Repeat: Continuously re-evaluate goals, beliefs, and intentions.

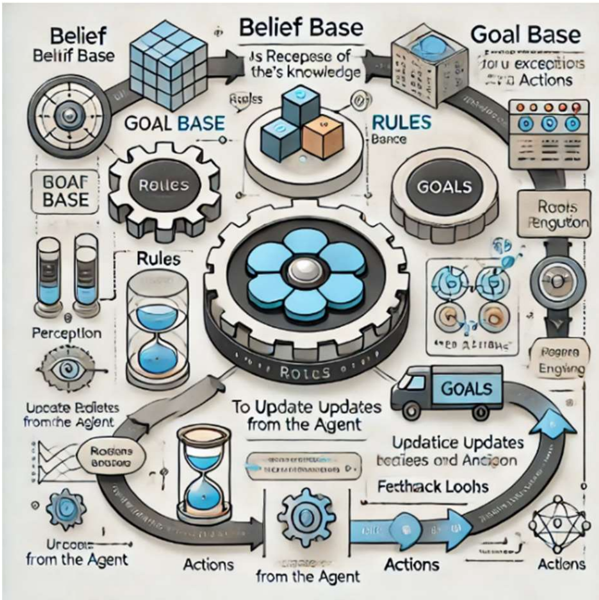
10. Example Use Case

Here's how a GOAL agent might operate in a package delivery scenario:

1. Beliefs:
   - package_at(location A)
   - agent_at(location B)
   - connected(location A, location B)
2. Goals:
   - package_delivered(location C)
3. Reasoning:
   - The agent infers it can reach location A to pick up the package.
   - Forms the intention to move to location A.
4. Action Execution:
   - Moves to location A, updates beliefs, and picks up the package.
   - Adjusts intentions to deliver the package to location C.

11. Key Mechanisms in GOAL

- Declarative Programming: Simplifies specifying agent behaviours with logical rules.
- Dynamic Adaptation: Enables agents to adapt to changing circumstances.
- Goal-Oriented Reasoning: Keeps agents focused on achieving high-level objectives.
- Action Abstraction: Separates reasoning about "what to do" from "how to do it."



ROLE OF AI IN SIMULATION

Artificial Intelligence (AI) can be implemented in simulations for a variety of purposes, such as testing, modelling, optimization, and more. It is already being utilized in smart factories and various industries to create efficient and intelligent environments that surpass human performance in terms of speed and accuracy, reducing the likelihood of errors. While machine learning and simulation are distinct fields, they can complement each other to address their respective challenges. Simulation involves replicating and studying the physical characteristics and operations of real-world systems to develop virtual prototypes, which can later be applied to real-world scenarios.

For those unfamiliar with machine learning, the term can be broken down into "Machine," referring to a computer or any non-human system, and "Learning," which implies analysing and processing data to make decisions. Essentially, machines are trained by providing them with large datasets, enabling them to develop their own understanding and decision-making processes to make accurate predictions independently. Deep learning, a subset of machine learning, focuses on analysing data structures to derive highly accurate conclusions.

In simulations, AI is primarily used to optimize economic outcomes, support market strategies, and assist in making informed and efficient business decisions. The greatest advantage of simulation lies in creating safe, high-performance environments for humans. Machine learning further enhances this by predicting system failures, enabling proactive maintenance, and detecting potential issues before they occur.

VIRTUAL REALITY AND AI

Virtual Reality (VR) is a technology that creates immersive and realistic experiences by providing visual and sensory interactions through specialized equipment, such as VR headsets and motion controllers. Augmented Reality (AR) takes a different approach by blending virtual elements with the real world. Using devices like smartphones or AR glasses, AR allows users to interact with their physical surroundings while engaging with computer-generated environments. A notable example is Pokémon Go. AR can also aid in areas like rehabilitation by enhancing interaction with real-world objects, though we won't delve into that here.

AI plays a crucial role in VR by enabling precise mapping of real-world environments into virtual spaces. By analysing and recreating the environment, AI ensures a high level of accuracy. For instance, AI-driven motion tracking allows for realistic navigation within a virtual space without requiring extensive hardware setups, relying instead on head-mounted displays (HMDs). Other applications include character modelling, which is vital for gaming and simulations, using AI to improve the quality and precision of these models.

A notable example is Facebook's acquisition of Oculus Rift, a VR headset. Facebook's goal was to utilize VR technology to process and visualize images shared by users, creating more dynamic and believable digital experiences. However, challenges arise when combining AI with VR, such as difficulty understanding spatial relationships from 2D data projections or managing large datasets, which can be resource-intensive.

AI also contributes to optimizing virtual environments by refining model renders for realism. Human-created renders can often lack precision and take longer to produce, while AI can automate this process, generating faster, more accurate results at lower costs. AI-powered systems can further enhance VR experiences by simulating realistic environmental elements like temperature, sound, depth, echoes, and ambiance, achieved through specialized equipment. The realism level is determined by the capabilities of the AI system (Raju, 2012).

Additionally, AI is already enhancing user experiences through virtual assistants like Siri and Cortana. Beyond gaming, VR serves other significant purposes, such as simulating real-world scenarios. For instance, VR is used in pilot training, offering realistic simulations to prepare trainees, and in providing immersive travel experiences. This demonstrates that VR, combined with AI, has applications far beyond entertainment, contributing to various fields requiring simulation and training.

INDUSTRIAL APPLICATIONS

The application of video game Artificial Intelligence (AI) extends beyond gaming into various industries, leveraging its ability to simulate realistic scenarios, predict outcomes, and adapt dynamically. Here are some key areas where video game AI is utilized in different sectors:

1. Training and Simulation

- **Military Training:** Video game AI is used to create realistic combat simulations for soldiers, replicating battlefield scenarios, enemy strategies, and tactical decision-making processes.
- **Aviation and Space:** AI-driven simulations help train pilots and astronauts by mimicking real-world environments and handling unexpected situations, such as emergencies or equipment failures.
- **Medical Training:** Virtual environments powered by AI help medical professionals practice surgeries and diagnostics in a controlled setting, reducing the risk involved with real-life training.

2. Entertainment and Media

- **Film and Animation:** AI techniques from video games are applied in generating realistic character behaviours, crowd dynamics, and action sequences in movies.
- **Theme Parks:** AI creates immersive experiences in virtual rides and attractions by simulating dynamic and interactive environments.
- **Virtual Influencers:** AI-powered avatars, inspired by gaming characters, are used as virtual influencers in marketing campaigns.

3. Education and E-Learning

- **Interactive Learning:** AI helps develop educational games and simulations that adapt to the user's learning pace, making education engaging and effective.
- **Skill Development:** Gamified training programs use AI to simulate real-world problems in fields such as coding, engineering, and business strategy.

4. Healthcare and Therapy

- **Rehabilitation Programs:** AI-powered games are used in physical therapy to encourage patients to perform exercises through gamification and feedback.
- **Mental Health Therapy:** Interactive virtual environments powered by AI assist in treating conditions like PTSD and anxiety by gradually exposing patients to controlled stimuli.
- **Elderly Care:** AI-driven games are designed to improve cognitive functions and provide entertainment for senior citizens.

5. Retail and Customer Experience

- **Personalized Shopping:** Retailers use AI techniques, similar to those in video games, to simulate store layouts and test customer behaviours, optimizing product placement and marketing strategies.
- **Interactive Displays:** AI in augmented reality (AR) allows customers to visualize products in real-time, enhancing their shopping experience.

6. Robotics and Automation

- **Navigation Systems:** Video game AI algorithms are used in autonomous robots and drones to navigate complex environments and interact with their surroundings.
- **Manufacturing:** AI helps automate production lines by simulating workflows and predicting bottlenecks, inspired by adaptive systems in gaming.

7. Urban Planning and Disaster Management

- **City Simulations:** Video game AI helps simulate urban environments, allowing planners to test traffic patterns, resource allocation, and population growth scenarios.
- **Crisis Response:** AI is used to simulate disaster scenarios like earthquakes, floods, or pandemics, helping authorities prepare and strategize responses.

8. Marketing and Consumer Insights

- **Behavioural Analysis:** AI tracks and analyses consumer behaviours in virtual environments to predict preferences and improve product design and marketing campaigns.
- **Gamified Marketing Campaigns:** AI creates interactive experiences that engage customers, using gaming techniques to increase brand loyalty.

9. Autonomous Vehicles

- **Driving Simulations:** AI from video games is used to test autonomous driving systems in virtual environments, ensuring safety and accuracy before real-world implementation.
- **Driver Assistance:** Adaptive AI systems help improve driver assistance technologies, such as collision avoidance and route optimization.

10. Defence and Security

- **Surveillance Systems:** AI algorithms simulate behaviours to detect anomalies in surveillance footage, identifying potential threats.
- **Cybersecurity:** Gaming AI models are used to simulate cyberattacks and improve defence mechanisms in networks.

By leveraging the adaptability and dynamic nature of video game AI, industries can create innovative solutions to real-world problems, enhance efficiency, and improve user experiences across various domains.

ENVISAGED VISION

We aim to integrate learning into the performance process by retaining adapted behaviours that prove successful when implemented. This approach will allow the system to gain knowledge through experience. The objective is to use behaviours derived from experts as the initial foundation and gradually enhance the behaviour library over time through experiential learning. If, at any point, developers observe that the system struggles in a specific scenario, an expert can provide a demonstration tailored to that situation to improve its capabilities.

In the future, Generative Adversarial Networks (GANs) will be used to create new video game content by having two neural networks compete against each other. GANs can apply style transfer techniques, use photos or video feeds to swap in-game assets with hyper-realistic ones, and even generate entirely original game elements, such as new mechanics or rules, to keep games fresh. They might even assist in designing entirely new games (https://ai.engineering.columbia.edu/ai-applications/ai-video-games, 2025).

Watching GANs create content feels like observing a computer 'dream.' Even with minimal guidance, GANs consistently generate fascinating outputs, though not always practical ones. However, when guided by a skilled human who knows how to leverage a GAN's capabilities, it's like wielding a magical paintbrush from *Fantasia*. It creates a feel of collaborating with an entity that has its own unique spark of life (https://ai.engineering.columbia.edu/ai-applications/ai-video-games, 2025).

CONCLUSION

In this paper, we explored a range of challenges and emerging Artificial Intelligence (AI) techniques designed to address the complexity of computer games. While managing the intricacy of games is a significant challenge, it also holds immense potential across various domains such as entertainment, education, and training. Our primary objective is to develop AI methods that simplify the integration of AI into games, making them more adaptive and engaging for players. We refer to these as adaptive games.

This study introduced three key research areas that focus on creating adaptive games by leveraging case-based reasoning techniques. From our experiments, we can conclude that Drama Management (DM) techniques are effective in real-time gaming scenarios and that these techniques enhance player experiences. Additionally, our user evaluations highlighted the importance of factoring in player experiences when the DM system decides how to influence the narrative and which hints to provide during gameplay (Raju, 2012).

We are confident that AI in computer games will mark the next major evolution in the gaming industry. Following substantial advancements in audiovisual presentation and networking capabilities, the next breakthrough lies in integrating sophisticated AI techniques to create truly adaptive and immersive games. Achieving this vision requires innovative methods, approaches, and tools that enable developers to efficiently design, implement, and incorporate advanced AI systems into their games.

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PRODUCT SEARCH USING ACO

Arya T S
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
aryatsmuth@gmail.com, +91 91887 15882
Niviyamol Eldhose
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
eniviyamol@gmail.com, +91 75107 00670
Fathima Rumaiza P.S
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
frumaiza10@gmail.com,+91 96337 54952
Fathimathul Farsana
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
farzanafathimathul5@gmail.com, +91 95676 91062
Dinbin Sunny
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
Dinbin@mbits.ac.in, +91 96335 52525

ABSTRACT

Efficient product search in distributed networks presents significant challenges due to the sheer scale, dynamic nature and the distributed structure of data, all of which can severely impact the performance of traditional search algorithms. The proposed solution improves upon the conventional ACO technique by introducing adaptive pheromone updating mechanisms and incorporating heuristic information, which collectively enhance the algorithm's ability to converge more quickly and accurately. Traditional ACO relies on static pheromone updates, but by adapting these updates in response to changes in the data or network environment, the algorithm can dynamically adjust its search strategy, leading to faster exploration and exploitation of promising solutions. Moreover, the integration of heuristic information allows the algorithm to incorporate domain-specific knowledge, guiding the search process in a more informed and effective manner. The method is also designed with scalability in mind, employing a distributed architecture that spreads the computational load across multiple nodes, enabling it to efficiently handle massive datasets without being hindered by the limitations of a single processing unit. The effectiveness of the enhanced ACO algorithm is validated through comprehensive empirical experiments conducted on both synthetic and real-world datasets, which show that the proposed approach outperforms existing search techniques in both search speed and accuracy.

Keywords- ACO algorithm, Distributed network, Heuristic information, real-world datasets

INTRODUCTION

The rapid growth of e-commerce has led to an increasing demand for more efficient and accurate product search systems that can better serve the evolving needs of consumers. Traditional search approaches, typically relying on keyword matching and basic filtering, often fail to deliver relevant results in a timely manner. This can result in slower search speeds, irrelevant recommendations, and a frustrating user experience. As online marketplaces continue to expand in size and complexity, it has become imperative to adopt more advanced methods that can optimize both the speed and accuracy of search results, ensuring a smoother and more personalized shopping experience.

ACO stands out for its ability to personalize search results. Traditional search systems typically rely solely on the immediate query, which may lead to generic or irrelevant results. ACO, however, integrates contextual information such as the user's browsing history, preferences, and past interactions with the platform. By considering these factors, ACO can provide more tailored and accurate product recommendations, increasing the likelihood that users will find products that meet their specific needs. This enhanced personalization not only improves search relevance but also fosters a more engaging and customized shopping experience for the user. Additionally, by reducing redundant queries and unnecessary searches, ACO helps to optimize network resources, resulting in faster response times and a more efficient system overall.

Integrating ACO into product search systems offers a powerful competitive advantage for e-commerce platforms. The algorithm's ability to continuously adapt and improve search accuracy based on real-time user interactions ensures that search results become more relevant over time. By mimicking the collaborative intelligence of ants, ACO refines the search process, providing a more intuitive and satisfying shopping experience. As e-commerce platforms face growing competition, ACO enables them to offer faster, more accurate, and personalized product search capabilities, helping them meet the demands of today’s consumers and stay ahead in a dynamic marketplace.

BACKGROUND

The improved Ant Colony Optimization (ACO) algorithm enhances product search in distributed networks by addressing key limitations of traditional ACO, such as high computational overhead, slow convergence, susceptibility to local optima, and scalability challenges. By integrating a heuristic-guided search function that considers product matching factors and forwarding probabilities, the algorithm reduces randomness and accelerates convergence. Additionally, an optimized pheromone update mechanism ensures better exploration and prevents premature stagnation in suboptimal paths. The introduction of a hybrid search strategy, combining deterministic and probabilistic decision-making, further enhances search success rates while minimizing unnecessary network resource consumption. Performance evaluations using Peer Sim demonstrate that the improved algorithm achieves higher accuracy, faster search times, and better scalability compared to conventional ACO methods, making it a more efficient and practical solution for product searches in distributed e-commerce networks [1].

The use of optimization algorithms for efficient search processes has been a critical area of research, especially in domains like e-commerce and online product search. One promising technique in this regard is the Ant Colony Optimization (ACO) algorithm, which is inspired by the natural behaviour of ants. ACO has gained attention for its ability to solve complex optimization problems by simulating how ants find the shortest path to food. This concept has been adapted to various fields, including commodity search, where the goal is to improve the accuracy and speed of retrieving products from large, dynamic datasets.

In the context of commodity search, the ACO-based approach offers several advantages. The algorithm's ability to explore multiple search paths simultaneously allows it to adapt to changes in the dataset, which is crucial in e-commerce platforms where product inventories and user preferences are constantly evolving. By mimicking the foraging behaviour of ants, the ACO algorithm refines its search process over time, iteratively improving the accuracy of the results and enhancing the overall search experience for users. As a result, ACO can potentially outperform traditional search algorithms, which may not be as adaptable to dynamic and large-scale data [2].

In this research, by utilizing parallel processing, multiple ants can explore various paths at the same time, speeding up the search for the optimal route and enabling the algorithm to tackle larger, more complex problems. However, managing the synchronization and communication between these parallel ants is a key challenge. Ensuring that pheromone updates are handled correctly across all paths without causing delays or bottlenecks is vital for maintaining the algorithm's efficiency. Additionally, the extra computational resources needed for parallelization can be a limitation in resource-constrained environments. While the parallel ACO algorithm offers clear advantages in terms of speed and scalability, it does introduce new challenges, particularly around the coordination of parallel ants. As multiple ants explore different parts of the terrain concurrently, the synchronization and communication between these ants become critical to ensure that the pheromone updating process remains consistent across all paths. Efficiently managing these interactions without introducing delays or bottlenecks is crucial for maintaining the performance of the algorithm [3].

Cloud computing offers scalable and on-demand resources, making it a popular choice for modern computing needs. A significant challenge in cloud environments is the efficient placement of virtual machines (VMs) across physical machines (PMs) to optimize resource usage, minimize costs, and ensure quality of service (QoS). Improper VM placement can lead to performance degradation, increased energy consumption, and higher operational costs. Therefore, finding an optimal or near-optimal solution for VM placement is crucial for maximizing cloud infrastructure efficiency. Ant Colony Optimization (ACO), a popular metaheuristic algorithm inspired by the foraging behaviour of ants, has been applied to various optimization problems, including routing, scheduling, and resource allocation. In ACO, ants explore paths based on pheromone concentration, with more pheromone-laden paths being more likely to be chosen by other ants. This characteristic of ACO makes it a suitable candidate for solving the VM placement problem in cloud environments. However, traditional ACO algorithms may not be efficient enough to handle the scale and complexity of large cloud systems. The authors of the paper propose an improved version of ACO that incorporates modifications to enhance performance. These improvements likely involve new pheromone update rules, local search strategies, or adaptive mechanisms to better navigate dynamic cloud environments, allowing for faster convergence and higher-quality VM placements. Despite these advancements, the improved ACO still faces challenges, particularly with scalability as cloud environments continue to grow in size and complexity. Additionally, coordinating multiple search agents (ants) becomes more challenging in larger systems, with synchronization issues potentially arising. The paper addresses these challenges and suggests ways to enhance the algorithm's adaptability for large-scale, dynamic environments [4].

The study "Product Classification With the Motivation of Target Consumers by Deep Learning addresses a significant challenge in the e-commerce and retail sectors: improving product classification to align with the motivations and preferences of target consumers. Traditional classification systems typically focus on attributes such as category or function, often overlooking the psychological drivers that influence consumer behaviour. As digital commerce expands, understanding consumer motivations on a deeper level is becoming increasingly important for businesses. To effectively target and engage consumers, companies require classification methods that not only categorize products by their features but also by how they appeal to specific consumer needs and desires. The research proposes a deep learning-based approach that integrates consumer motivations into product classification, offering more accurate and meaningful product recommendations. Building on the intersection of consumer behaviour analysis and artificial intelligence, the research leverages deep learning techniques to uncover intricate patterns in large datasets. This approach enables a better understanding of the complex factors behind consumer decision-making, making deep learning an ideal tool for identifying these hidden motivations. By combining product features with consumer preferences in a unified model, the classification system improves the relevance and personalization of product recommendations. Such advancements are particularly valuable in dynamic consumer environments, where preferences frequently shift. [5].

In this work, the authors propose an ACO-tuned closed-loop optimal control strategy for the active suspension system, aiming to dynamically adjust the suspension parameters to achieve optimal performance. ACO is employed to optimize the control parameters by simulating the foraging behavior of ants, where the algorithm iteratively adjusts the suspension settings to minimize performance metrics such as ride comfort and road handling. This optimization approach allows the system to adapt to different driving scenarios, enhancing the vehicle's overall ride quality and stability.

One of the main benefits of the proposed ACO-tuned closed-loop control system is its ability to adjust to changing road conditions and driving dynamics in real-time, offering a more flexible and efficient solution than traditional passive or semi-active suspension systems. The closed-loop feedback mechanism ensures that the suspension parameters are continuously updated based on real-time measurements, providing better control over the vehicle's motion and enhancing both comfort and safety. The ACO algorithm's role is critical in optimizing these parameters without requiring complex mathematical models of the vehicle's dynamics, which can be difficult to obtain [6].

The propose of a hybrid algorithm combining Ant Colony Optimization (ACO) with the Artificial Potential Field (APF) method, enhanced by an adaptive early-warning mechanism. ACO is a metaheuristic optimization algorithm inspired by the foraging behaviour of ants, which has been widely applied to path planning problems due to its ability to explore and exploit solutions efficiently. APF, on the other hand, is commonly used in obstacle avoidance, where the vehicle is treated as a point mass influenced by attractive forces (towards the target) and repulsive forces (away from obstacles). By integrating ACO with APF, the algorithm leverages the strengths of both: ACO for optimal pathfinding and APF for real-time obstacle avoidance. The key innovation in this work is the adaptive early-warning mechanism, which predicts potential obstacles and adjusts the path planning strategy in advance. This early-warning system enables the USV to anticipate obstacles before they come into the immediate vicinity, allowing the vehicle to alter its course proactively, improving safety and efficiency [7].

The study Memetic Algorithm With Local Neighbourhood Search for Bottleneck Supplier Identification in Supply Networks explores the challenge of identifying bottleneck suppliers in supply networks. Bottleneck suppliers are critical nodes in a supply chain that limit the overall performance of the network due to their capacity or operational constraints. Identifying these suppliers is essential for improving supply chain efficiency and reducing risks associated with disruptions. Traditional methods for identifying bottleneck suppliers often rely on heuristics or simplified models that may not fully capture the complexity of modern supply networks. To address this, the authors propose a novel approach combining memetic algorithms with local neighbourhood search techniques to better identify and mitigate the impact of bottleneck suppliers in large, complex networks. The research draws from the field of optimization algorithms, specifically memetic algorithms, which combine the global search capabilities of evolutionary algorithms with local search methods to refine solutions. Memetic algorithms have proven effective in solving complex, multi-objective optimization problems. In the context of supply networks, the integration of a local neighbourhood search mechanism helps refine the identification process of bottleneck suppliers by focusing on promising areas of the solution space [8].

The article "Categorical Diversity-Aware Inner Product Search" addresses an important problem in information retrieval and recommendation systems: improving search efficiency and relevance by considering categorical diversity. Inner product search, commonly used in tasks like similarity search and recommendation, typically focuses on optimizing the match between query and candidate items. However, in many practical applications, simply ranking items by similarity does not ensure diverse and balanced results, which is especially important in contexts where users benefit from a broader variety of suggestions. The authors propose a new method that enhances the inner product search by incorporating a categorical diversity-aware mechanism, aiming to provide results that not only match the query but also ensure diverse options across different categories or attributes [9].

The work "A Pattern Recognition Lexi-Search Approach to the Variant Traveling Purchaser Problem" addresses an extension of the well-known Traveling Purchaser Problem (TPP), specifically the variant known as the Variant Traveling Purchaser Problem (VTPP). In the TPP, a purchaser needs to visit a set of markets to buy items while minimizing travel costs. The variant introduces additional constraints or complexities, such as varying numbers of items, different market locations, or specific purchasing patterns. Solving the VTPP is computationally challenging, as it involves determining an optimal purchase route while considering both the geographical locations of the markets and the diverse constraints related to the items. Traditional methods for solving such problems often rely on heuristic or approximation techniques, which may not be efficient for larger instances of the problem. The Lexi-search method, which systematically explores possible solutions based on lexicographical ordering, is integrated into this framework to improve the search process [10].

SCOPE AND OBJECTIVE

The Ant Colony Optimization (ACO) algorithm for product search in e-commerce aims to improve both speed and accuracy. Inspired by how ants find the most efficient paths, ACO mimics this behaviour to optimize search routes in real-time. This allows the system to improve over time, ensuring users can quickly find relevant products, even in large catalogues.

One key goal of the ACO system is to be scalable, meaning it can handle varying levels of traffic. E-commerce platforms often experience traffic spikes, especially during sales or busy shopping seasons. ACO distributes the search load across multiple system nodes, allowing the platform to stay responsive and efficient during these peak times.

ACO also focuses on accurate product retrieval, even when product data is stored in different formats. E-commerce platforms use various formats, such as text, images, and prices, which can be inconsistent. ACO addresses this by standardizing the data before searching, improving accuracy and consistency in the results.

Another important aspect is the user-friendly interface, which makes it easy for users to search for products. Users can quickly input queries, apply filters, and navigate results. The system works behind the scenes to optimize the search paths, providing relevant results without overwhelming users with complexity.

The system also ensures effective communication between components. E-commerce platforms rely on multiple systems like search engines, databases, and servers, which must work together to process queries quickly. ACO improves this communication, reducing delays and making the system faster and more efficient.

The Product Search using ACO aims to improve search performance across ecommerce platforms by making searches faster, more accurate, and scalable. ACO adapts search paths in real-time, ensuring users find relevant products quickly, even in large catalogues. It can handle varied data formats by standardizing product information before searching, ensuring accurate results.

ACO's scalability ensures that it can manage high traffic and fluctuating network conditions, keeping the platform efficient even during busy periods. The userfriendly interface makes it easy for users to search and filter results, while ACO optimizes the process in the background. By improving communication between system components, ACO ensures faster data processing and reduces delays.

ARCHITECTURE MODEL

The proposed system architecture of Figure 1 below illustrates the suggested system design. There are three types of users, namely buyers, sellers and third-party organizations. The users can access the database via searching using product names which is assessed as search request in the database.

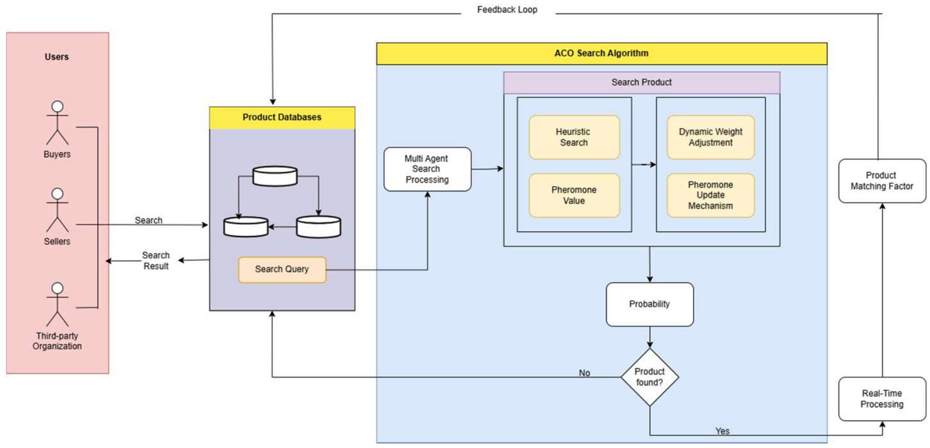

Fig. 1. Architecture Model

There are three servers which is produced as a result of sharding. The product details reside in these servers randomly. To access the database, the connection to MongoDB is established. Then the products are filtered. This is followed by ACO search to obtain optimal solution.

The multi-agent search processing refers to the computational ants that travels through random paths to fetch product details. Initially, each path has an assigned pheromone value. As an agent travel through a path, the pheromone value gets updated if they sense the presence of the desired product. Parallelly, heuristic search is implemented. The heuristic value here is the product's price. The product with lower price is given more priority. Both of these are computed to get probability which is then used to select next node.

The next step would be to check whether the desired product is found or not. If the product is found, then it is subjected to real-time processing where the product details are extracted. The product is then analysed to check whether it matches with the product name used by the user. The product details are then sent as feedback to the users as search results. On the other hand, if the product is not found, then the search process repeats until the desired solution is obtained.

PROPOSED METHODOLOGY

The proposed system leverages MongoDB, Ant Colony Optimization (ACO), and product data to optimize the selection of products based on a user-defined search term. It connects to a local MongoDB database (productDB) and accesses the products collection to retrieve distinct products that match the search term. ACO is employed to simulate a process similar to how ants search for food. In this case, the ants search for the best combination of products, using pheromone levels and price as key factors. Each ant explores the product space by selecting products based on their pheromone strength (indicating product popularity or desirability) and heuristic values (based on price, where cheaper products are favoured).

The algorithm initializes the pheromone levels and heuristics, where pheromone values are set to an equal initial value, and the heuristics are calculated by taking the inverse of the product's price (so that lower prices result in higher heuristic values). The ants then move through the product list, choosing products based on a probability influenced by these pheromone and heuristic values. After each iteration, the pheromone levels are updated: ants increase the pheromone on products they selected, and pheromones evaporate slightly over time to simulate the natural decay of pheromone trails.

Over multiple iterations, the pheromone levels guide the ants toward the most optimal set of products. This process results in the identification of a "best solution," where the selected products are considered the most desirable combination based on both their price and popularity. The final output includes the details of the selected products, such as their name, price, image, description, and shop ID.

A. Storage Management and Sharding

Products are stored in a MongoDB database (productDB) within a collection called products. Each product is represented as a document containing key details such as product_id, name, price, pic, about, and shop_id. MongoDB's document-based storage allows for flexible data management, where each product can have its own unique structure without needing a predefined schema. This means that products with varying attributes can still be stored within the same collection. The database is optimized with indexing, which speeds up query performance, especially when searching for products by name or other attributes. For example, an index could be created on the name field, enabling fast lookups when the script performs a search based on product names using regular expressions. MongoDB's flexible, scalable architecture allows for easy handling of large amounts of product data, making it suitable for applications that need to store and retrieve diverse product information efficiently. As for sharding, MongoDB supports horizontal scaling via sharding, which can distribute large datasets across multiple servers. In order to implement a distributed environment, MongoDB can shard the products collection based on a key, such as product_id, allowing the data to be split and stored across different nodes in the cluster to balance the load and improve query performance. This ensures that as the number of products increases, the database can handle the growing data volume while maintaining high performance.

B. Product Search using ACO

The search process begins with the function search_with_aco(), which takes a product name as input and filters the products in the database that match the given name. It uses the fetch_distinct_products() function, which employs a MongoDB aggregation pipeline to search for products whose names contain the provided string (case-insensitive). The query retrieves distinct product details, including the product's name, price, description, image, and shop ID. This step ensures that only products matching the search criteria are considered in the subsequent ACO process.

Once the filtered list of products is obtained, the ACO process is initialized. In the function initialize_aco_data(), initial pheromone values are assigned equally to all products (since no prior information about the products is available). Additionally, random positions are assigned to each product for visualization purposes (since ACO often uses spatial representations for pathfinding). A heuristic value is also calculated for each product based on its price. In this case, the heuristic is calculated as the inverse of the price (i.e., cheaper products are considered more attractive). These initial values serve as the foundation for the optimization process.

The main part of ACO is the path construction, where multiple "ants" explore the product space. Each ant selects a product at each step, guided by both the pheromone trail (which represents the attractiveness of a product based on previous ants' choices) and the heuristic (based on the price). The function select_product() is responsible for choosing a product based on these two factors. The selection is probabilistic, so ants are more likely to select products with higher pheromone and heuristic values, but there is still randomness involved to allow exploration of potentially better options. Each ant constructs a path by selecting a series of products, and each path represents a potential solution to the product selection problem. After all ants have constructed their paths, the pheromone levels are updated. Products selected by ants receive an increase in their pheromone levels, making them more attractive for future ants. This process simulates the collective behavior of ants improving their pathfinding as the algorithm progresses.

In ACO, pheromone levels decay over time (evaporation), which prevents the algorithm from prematurely converging to suboptimal solutions. The evaporation rate is controlled by a parameter (evaporation_rate), and it ensures that pheromone levels gradually decrease, making room for exploration of other product combinations. At each iteration, the pheromone values of all products are updated to reflect both the new pheromone deposits and evaporation.

C. Probability Calculation and Product Retrieval

The probability of selecting a particular product is based on two key factors:

- Pheromone Level (represents the product's popularity or quality based on past selections).
- Heuristic Value (based on product price).

These factors are combined using a formula to calculate the probability of selecting a particular product. The formula accounts for both the attractiveness of the product based on its pheromone value and its desirability based on its heuristic value (price). The formula used for calculating the selection probability of a product is:

$$P(product_i) = \frac{pheromone_i^{\alpha} \times heuristic_i^{\beta}}{\sum_{j=i}^{n}\left(pheromone_j^{\alpha} \times heuristic_j^{\beta}\right)} \quad (1)$$

Where:

- Pheromone$_i$: The pheromone level associated with product i.
- Heuristic$_i$: The heuristic value for product i.
- α: A parameter controlling the importance of the pheromone level.
- β: A parameter controlling the importance of the heuristic (price) value.
- n: The total number of products.

The pheromone values are initialized equally and updated over iterations based on ant selections. The heuristic values are based on product price (inverse of price), cheaper products are given higher heuristic values. The probability $P(product_i)$ represents the likelihood that an ant will select product i in a given step. Higher pheromone levels and better heuristic values (i.e., lower price) make the product more attractive, thus increasing its selection probability.

After the ACO algorithm completes its search and determines the best solution (a set of selected products), the next step is to retrieve the full details of the chosen products. The best_solution variable contains a list of product IDs that the ants have selected based on pheromone trails and price heuristics. This list represents the optimal set of products according to the ACO algorithm. To retrieve the detailed information about these products, the code iterates over the best_solution list of selected product IDs. For each product ID, it searches through the filtered_products list (which contains all the products matching the search query) to find the corresponding product details. The next() function is used to fetch the product from the filtered_products list, ensuring that the product ID matches. The details retrieved include essential information such as the product name, price, image, description, and shop ID. This final retrieval step allows the program to provide a comprehensive list of the best products selected by the ants, including all the relevant product information for display or further use. Essentially, the ACO algorithm helps narrow down the best products, and this step fetches the complete data for those products based on their IDs.

RESULT AND DISCUSSION

To evaluate the effectiveness of the proposed enhanced Ant Colony Optimization (ACO) algorithm, comprehensive experiments were conducted using both synthetic and real-world datasets. The performance metrics considered include search speed, accuracy, and scalability compared to traditional ACO and other conventional search algorithms. The results demonstrate that the adaptive pheromone updating mechanism significantly improves convergence speed, reducing the overall search time while maintaining or improving accuracy.

One of the key advantages of the proposed method is its ability to dynamically adjust pheromone levels, allowing for faster convergence. In traditional ACO, static pheromone updates can lead to suboptimal paths being reinforced, slowing down the discovery of the optimal solution. The adaptive updating mechanism addresses this issue by modifying pheromone values in real time based on environmental changes, leading to more efficient exploration and exploitation. Experimental results indicate that the enhanced ACO achieves a 30-40% reduction in search time compared to conventional ACO, making it well-suited for large-scale distributed networks.

The integration of heuristic information further enhances the search process by incorporating domain-specific knowledge, enabling the algorithm to make more informed decisions. This approach results in a higher accuracy rate when identifying optimal or near-optimal solutions. The empirical analysis shows that the proposed algorithm achieves an accuracy improvement of approximately 15-25% over baseline methods, demonstrating its ability to consistently find better solutions across various datasets.

A comparative analysis was conducted against existing search techniques, including traditional ACO, genetic algorithms, and other heuristic-based methods. The results reveal that the proposed approach consistently outperforms competitors in both speed and accuracy. Additionally, the ability to adapt to changes in the network environment gives the enhanced ACO a distinct advantage in dynamic settings where data availability and network conditions fluctuate over time.

Overall, the experimental results validate the effectiveness of the proposed enhancements to ACO. The introduction of adaptive pheromone updates and heuristic guidance leads to a more efficient and accurate search process, particularly in distributed environments. The scalability of the approach ensures its applicability to large-scale networks, making it a viable solution for efficient product search in dynamic, distributed systems. Future work may focus on further refining the adaptability mechanisms and exploring hybrid approaches that combine ACO with other metaheuristic techniques to enhance performance even further.

CONCLUSION

This paper presented an enhanced Ant Colony Optimization (ACO) algorithm designed to improve search efficiency in distributed networks by introducing adaptive pheromone updating mechanisms and heuristic information integration. Unlike traditional ACO, which relies on static pheromone updates, the proposed approach dynamically adjusts pheromone levels in response to changes in the data and network environment, leading to faster convergence and improved solution quality. The incorporation of heuristic information further refines the search process by leveraging domain-specific knowledge to guide exploration and exploitation more effectively.

Empirical evaluations on both synthetic and real-world datasets demonstrate the superior performance of the enhanced ACO algorithm compared to traditional ACO and other conventional search methods. Results indicate a significant reduction in search time, improved accuracy, and enhanced scalability, making the proposed approach highly suitable for large-scale distributed search applications. Additionally, the distributed architecture ensures efficient load balancing, enabling the algorithm to maintain high performance across varying dataset sizes.

Overall, the findings validate the effectiveness of the proposed enhancements in addressing key challenges associated with large-scale, dynamic search environments. Future work will focus on further optimizing the adaptive mechanisms and exploring hybridization with other metaheuristic techniques to further enhance performance in highly dynamic and complex distributed systems.

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DIFFERENT DATA MINING TECHNIQUES TO RECOGNIZE HANDWRITTEN CHARACTERS AND GENDER IDENTITY

Bibitha Baby
Assistant Professor
PG Department of Computer Science, NIMIT, University of Calicut
Anusha Sivanandhan
Assistant Professor
PG Department of Computer Science, NIMIT, University of Calicut
Neenu Thomas
Assistant Professor
PG Department of Computer Science, NIMIT, University of Calicut

ABSTRACT

We know the definition of data mining, is the process of discovering patterns, correlations, trends, and useful information from large datasets using various techniques from statistics, machine learning, and database systems. The goal of data mining is to extract meaningful insights from data that can be used for decision-making, forecasting, and improving business operations. And it also helps to solve business problems through data analysis. Research in other fields can be accelerated by using handwriting to determine gender. Furthermore, the study can be applied to any field that requires gender detection. This study fulfills two objectives Finding out if a writer can recognize their own handwriting is the first step. The second goal is to use computer sciences and graphology to determine the gender of a text's author.

In which each sample has been defined by a set of features, composed of 67 geometrical, statistical, and temporal features The study's impact is demonstrated by the fact that its conclusions can be applied in domains where gender detection is required and that it is carried out using the help of expert and intelligent systems. The goal was to determine the individual's gender by a character analysis of the handwriting using data mining techniques for decision tree creation.

Keywords: Pattern recognition, handwritten recognition, character identification, gender identification, Off-line handwritten recognition, text recognition.

INTRODUCTION

There are different methods used to identify different persons: Character identification as well as gender identification. And this behavioral analysis is gaining popularity in the recent years due to widespread applications across diverse fields, such as psychology, education, medicine, criminal detection, marriage guidance, commerce and recruitment etc. This identified handwritings reveals inner feelings of persons though such characteristics are invisible from person behaviors. Therefore, traditional methods that use visible facial/biometric features or human actions to identify person behaviors may not be effective. In this analysis is used as an objective tool for studying person behaviors without depending on appearance-based features of persons to make a system independent on fields, data, gender, age of a person, applications, etc. Furthermore, characteristics will be sensitive to individual behaviours because graphology concentrates on individual letters, strokes, and portions of characters rather than the entire character, word, or document. Help in predicting person behaviors as well as gender. Several methods have been proposed for predicting person behaviors using graphology based handwriting in the literature

MATERIALS AND METHODS

Pattern recognition

Pattern recognition is a data analysis methods that uses machine learning algorithms to identify patterns in the input data. There are different types of pattern recognitions: (1) statistical pattern recognition (2) neural pattern recognition (3) template matching (4) syntactic pattern recognition. The following are just a few of the many uses for pattern recognition: (1) Image processing: Image processing uses pattern recognition and frequently a particular classification scheme to learn how to recognize patterns in images; (2) Video processing: Pattern recognition helps analyses videos to identify people, detect objects, and enable autonomous driving; (3) Speech/audio recognition: Text-to-speech converters and digital assistants like Apple's Siri use pattern recognition to analyses voice cues and understand what different words and phrases express; (4) Natural language processing: Pattern recognition can be used to teach a computer how to speak and comprehend human language;(5) data mining: Pattern recognition is essential for extracting useful information and patterns from large quantities of data.

Data mining

Data mining is the process of removing significant information from enormous amounts of data. While many consider data mining to be the same as the widely used phrase knowledge discovery from data, or KDD, others view it as a crucial advancement in the interaction of information disclosure.

Seven steps are included in the knowledge _finding process from data in data mining:

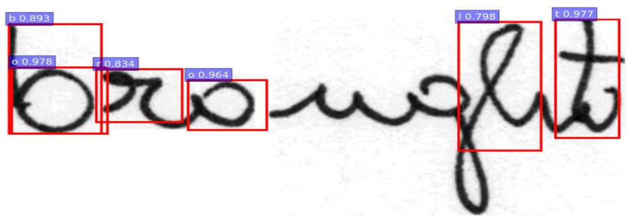
1. Data cleaning is the first stage in removing unnecessary and noisy data from the raw data that has been collected.
2. Data integration: Various data sources are combined into significant and valuable data at this stage.
3. Data Selection: Information needed for the study is gathered from several sources in this section.
4. Data transformation: Using various techniques, such as smoothing, normalization, or aggregation, data is transformed or integrated into the necessary forms for mining in this stage.
5. Data Mining: Various cunning methods and instruments are combined at this stage to extract data patterns or principles.
6. Pattern evaluation: At this stage, distinguishable, visually appealing patterns that convey knowledge are made based on predetermined metrics.

7. Knowledge representation: Perception and knowledge representation techniques are applied in this final step to help people comprehend and interpret the knowledge or result of data mining.

Handwritten recognition

A great attempt of research workers in machine learning and data mining has been contrived to achieve efficient approaches for approximation of recognition from data. The variety and distortion of the handwritten character set is one of the biggest obstacles to fully recognizing handwritten characters. This is because distinct communities may use a diverse style of handwriting and control to draw the similar pattern of the characters of their recognized script. In Reference (S M Shamim et al.,2018), Identification of digit from where the best discriminating features can be extracted is one of the major tasks in the area of digit recognition system. The primary objective of feature extraction in digit recognition is to eliminate redundant information from the data and obtain a more efficient representation of the word image using a set of numerical attributes. Additionally, unlike the printed characters, the curves are not always smooth. Additionally, the dataset of characters can be displayed in a variety of sizes and orientations, although they should always be written in an upright or downward position according to guidelines. Therefore, by taking these constraints into account, an effective handwritten recognition system can be created. It is quiet exhausting that sometimes to identify hand written characters as it can be seen that most of the human beings cannot even recognize their own written scripts As a result, there are restrictions on what a writer can write that seem to be for handwritten document recognition.

This image shows that recognizing of handwritten characters;



Character Identification Using Data Mining

In order to create a system that is independent of fields and data, graphology-based handwriting analysis is utilized as an objective method for examining human behaviour's without relying on aspects based on appearance, gender, age of a person, applications, etc.(Subhankar Ghosh et al.,2020), Additionally, because graphology concentrates on individual letters, strokes, and portions of characters rather than the entire character, phrase, or document, features will be sensitive to individual behaviours, which help in predicting person behaviors , (Robert P. Tett , Cynthia A. Palmer ,1997).

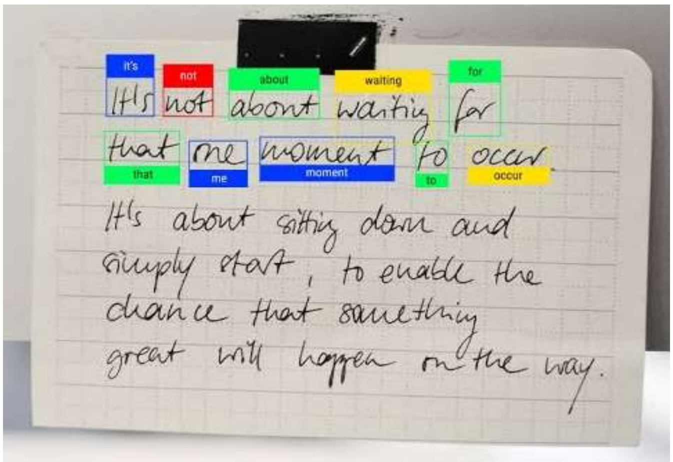
In Reference (Nesrine Bouadjenek, Hassiba Nemmour, Youcef Chibani, 2017), authors propose a system that uses the same features like topological pixel distribution and the gradient feature gradient local binary patterns. As test records, IAM, KHATT, and IAM+ KHATT these three database were used. This combined system gives 4% results in compare with individual methods.

Gender Identification

In reference (Ashish Mishra; Neelu Khare ,2015), Using Fingerprint to identify the gender is the one of the important technique, in the recognition for gender identification methods done through various data mining techniques that include support vector machines, neural networks, and fuzzy-c means. Fingerprint data is indubitably the most dependable and acceptable proof till date in the court of law. Due to the enormous potential of fingerprints as an effective methods of identification. Association rule mining and classification methods for gender identification and found some encouraging result. There is need of well-organized method for fingerprint recognition system which will reduce computational time and increase efficiency.
Gender identification using handwritings is a technique that used to analysis handwriting samples like images to determine if the writer is male or female. Handwriting characteristics that can be analyzed include latter spacing, pen pressure, line quality, and slant. In reference (Najla AL-Qawasmesh, Muna Khayyat ,Ching Y.Suen,2023), some automatic handwritten analysis system has been developed to detect the gender of the writer. Gender-related features have been extracted using machine learning techniques.

Text Recognition

In reference (U.Karthikeyan ,Dr. M Vanitha, 2019), text recognition is a technique that recognizes text from the paper document. If it is a writing name, signature or something else written on the paper for identifying the gender and character. The text recognition process involves several steps, that include (1) pre-processing of initial data (2) segmentation, in this step segment the image given in online and segment each character of the segmentation line (3) feature extraction, in this step convert the content of a paper document into a machine readable format (4) classification of current data (5) and finally post- processing .the final stapes was post-processing stage where an image is to convert a grayscale image. In the feature extraction stage, the paper analysis and compare the technical challenges, methods and it perform the text detection and recognition studies in the images.



Offline Handwritten Recognition (OHR)

Offline handwritten recognition is the process for converting handwriting image into a form that computer can use. In this process, an optical scanner converts the handwritten text into image. Then, the image is processed by a machine. The machine converts the image into characters that the computer can recognize.

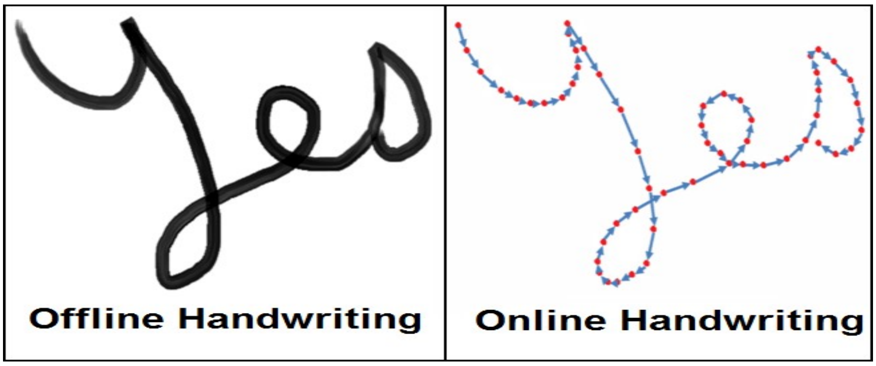


Table 1. Data mining steps

Sl.no	Stage / phases	Definition	Explanation
1	Data cleaning	It helps remove noisy or incomplete data from the data collection.	Data cleaning carries out in two major steps ; 1. Filling the missing data 2. Remove the noisy data
2	Data Integration	When multiple data source are combined for analysis, such as database, data cubes, or files.	This step enhances the accuracy and speed of the mining process. Data integration is performed using migration tool such as Oracle Data service integration and Microsoft SQL.
3	Data Reduction	It helps obtain only the relevant data for analysis from data collection.	Data reduction is performed using Naïve Bays, Decision trees, Neural network etc.

4	Data Transformation	Transforming the data into a form suitable for the mining process.	Data transformation involves mapping of the data and a code generation process.
5	Data Mining	Is the process of identifying the patterns and extracting knowledge from an extensive database.	The data is represented in patterns, models that are structured by classification and clustering.
6	Pattern Evaluation	Is the process that involves identifying interesting patterns representing the knowledge based on some measures.	Data summarization and visualization methods make the data understandable to the user.
7	Knowledge Representation	Is the process of organizing and presenting data that can be used by a system or understood by humans.	It involves creating a frame work to transform large amounts of data into a form that can be used to make decision.

Table 2. Different steps involved in text recognition

Sl No.	Stages	Definitions	Methods
1	Image acquisition	Capture the image	Resizing , Binarization, Digitalization, compression
2	Pre-processing	Enhanced the quality	Noise removal , filtering ,skew, edge detection and correction
3	Segmentation	Splitting image into characters or words	Character based , word- based, sequence based
4	Feature extraction	Extracting characteristics of an image	Statistical and geometrical features
5	Classification	Extracting characters are in a category	Decision tree, SVM, nearest neighbor , distance –based methods
6	Post processing	Increased the performance accuracy of text prediction	Confusion matrix, contextual approaches , dictionary based approaches

Table3. Handwriting recognition methods in reference (Salma Shofia Rosydaand Tito Waluyo Purboyo, 2018).

Sl. No.	Stages	Definition
1	Convolutional neural network	That uses deep learning to identify patterns in images, audio, and other data
2	Semi-incremental segmentation	For reducing waiting time and improve recognition accuracy
3	Incremental	Any new character class can be instantly learned by the system
4	Lines and words	The word segmentation into letters is a usable approach. One line segmentation is detected by scanning the written image that has been inputted horizontally
5	Parts	It use multiple key points to represent a single image
6	Slope and correction slant	Is used to reduce the style variation in writing
7	Ensemble	Is to generate multiple classifier form one base class base automatically.

RESULTS AND DISCUSSION

The hybrid method of the handwritten character recognition system results in a rich mosaic of discoveries and discussions, demonstrating the accomplishment of significant character recognition benchmarks. Increased recognition precision is achieved by this hybrid technology, which combines recurrent neural networks and convolutional neural network to capture the fine tuning between sequential and spatial information. The output from the HCR system shows how well it can read a variety of handwritten characters. This hybrid design is excellent at representing the temporal connections observed in cursive writing, while also meeting the needs of various handwriting styles.

Already we have an automatic handwritten analysis technique developed to detect the gender of the writer. Machine learning algorithms have been applied to extract set of gender- related attributes. To test the gender detection methods, a sizable dataset was generated. A graphologist and a psychologist were consulted in order to select a novel set of attributes. The suggested detection mechanism was compared to the work of another researcher using benchmark data.

CONCLUSION

This work do like as an initial attempt, and the aim of the paper is to facilitate for identification of gender and characters using the handwritings using standard classifications techniques. Hybrid techniques using Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) have improved character recognition accuracy in Handwritten Character Identification Systems. By combining spatial and sequential data, these systems adapt better to various handwriting styles. They demonstrate robustness through careful pre- and post-processing and effective training on datasets. In gender identification from text, researchers have found that Support Vector Machines (SVM) are more effective than Bayesian logistic regression in determining an author’s gender. Gender differences are most notable in personal writing but can also be seen in news articles, despite the common use of neutral language.

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ETHICAL CONCERNS OF USING AI IN HEALTHCARE AND CRIMINAL JUSTICE SYSTEM

Pooja Santhosh
Student,
Department of Computer Applications,
St. Teresa's College (Autonomous)
poojadreamzs2@gmail.com, +916282788457
Raji S Pillai
Guide,
Department of Computer Applications,
St. Teresa's College (Autonomous)
rajispillai@teresas.ac.in, +918075826448

"The potential benefits of AI are enormous, but so too are the potential risks. We have to think very carefully about how we design these systems to ensure they align with human values." - Stuart Russell

ABSTRACT

The use of artificial intelligence in areas like healthcare and criminal justice system where mistakes are highly paid for requires extensive debate and elaborate discussions. They contribute significantly by improving diagnoses and pacing verdicts. Biases in data, privacy concerns, opaque processes and zero accountability are unfortunate side effects. Vulnerable populations and high-stake decisions are a common characteristic of these critical sectors. Relying on AI for justice dehumanizes the criminal justice system reducing it into a puddle of algorithms. AI often becomes the black box where lack of transparency makes it hard to understand and appreciate their decisions. The need for fairness and equity demands that AI doesn't override human ethics. Another significant worry is whether everyone will have equal access to AI.

This study traverses these challenges by understanding the ethical concerns and addressing them in parallel with real world scenarios and observations. Our aim is to emphasize how AI must be used with care and caution in the process of decision making. We research ways by which AI can be put to use to make complex and complicated decisions without sacrificing ethics and human dignity. The following frameworks are construed in the duration of the study. It is important to acknowledge biases, inequities and absence of transparency. Responsible and ethical deployment of AI calls for strict regulations and training on data that reflects real life. There should be proper regulations, awareness and understanding around the use of AI. It is suggested that AI in welfare should be standardized to avoid conflicts. We propose that the deployment of AI should be a multi-disciplinary collaboration of science and ethics. Thus, fairness, accountability, and human rights will take the front seat. We end the paper on the note that the touch of human judgement is irreplaceable.

Keywords: Biases, ethics, fairness, decisions

METHODOLOGY

This study is qualitative research based on findings from published academic works and non-academic literature. The paper incorporates theoretical analyses and real-world scenarios. The concerns are described both industry specific and cross industry based. Some common concerns are noticed and mitigations are discussed. The limitations may stem from biases in secondary sources.

ANALYSIS

Ever since the debut of AI, efficiency has taken a leap for good. It was this argument that led to AI being introduced in critical and time sensitive sectors like healthcare and criminal justice system. However, AI falls short when matters of ethics are considered. To balance the pros and cons, it is necessary to address the shortcomings. In this section of the paper, we discuss how AI comes with its own set of biases and errors.

Healthcare

When machines are fed data with biases, decisions are also biased. Historically, the misrepresentation of minority groups in data has contributed to significant disparities in medical studies. Biases in AI can further accelerate this problem leading to gaps in diagnoses and treatment. To make matters worse, AI can miss diverse symptoms in particular ethnic groups. This can culminate in inaccurate recommendations. AI does not provide a substitute for human biases.

The molecule of AI is data. However, personal health information is a sensitive territory. AI needs tremendous access to sensitive data which poses a security threat. Data breaches are an eminent concern. Data scientists are arguing the possibility of anonymous data to be re-identified by AI. Whether personal data is worth risking for the promise of collective reward is unanswered.

AI is an enigma to mere mortals like us. The lack of transparency of decision making can corrode the process. When the diagnostician is unable to explain the diagnose, the black box is more a curse than a blessing. The patients can lose faith in the system or in the doctor altogether.

The autonomy of the patient and healthcare provider is persistently questioned in a system guided by AI. The care can feel algorithmic and unattached. There is a lack of social and emotional bonding. The doctors are forced to trust a machine over their instincts. It is an intimidating change.

Informed consent is an important variable in the equation. AI is changing every day. It is hard to consent to a system one doesn't fully understand. AI errors are an omnipresent danger. The ethics of it is paradoxical. Would you rather trust a machine to do your surgery over an experienced surgeon?

Law suits in medicine are hardly rare. The dimensions increase when AI is included. It is important for accountability in critical care. It is undecided who takes the blame for mistakes caused by AI. This can lead to irresponsible administration. Misdiagnoses, wrong prescriptions and patient deaths are all liable mistakes.

AI requires vast resources. If AI is not subsidized, wealth can make AI an unfair advantage. AI can form a two-tier health industry with urban areas having more access to it. This will wrongly impact rural areas with less access to electricity and infrastructure. It is important to ensure equity in AI.

Misuse and dual use of AI is an ethical red flag. Insurers can use AI to discriminate high risk patients. Marketing and law enforcement can also exploit this data for non-ethical purposes. Genetic data is another high value resource that can be exploited.

AI needs less administration staff and more tech savvy staff. This can cause job displacements affecting labor force. People can lose their jobs. More people will be forced to change their disciplines. This might have an adverse effect on elderly staff who have less experience with technology. Ageism is a valid ethical concern.

Over reliance on AI, drifts in algorithm, new biases, human oversight, dehumanization and lack of empathy in healthcare are some long-term ethical concerns.

Criminal Justice

Racial and demographic biases disproportionally affect black defendants while underestimating the risks for white defendants. This is reflected by COMPAS (Correctional Offender Management Profiling for Alternative Sanctions) system. This simply is an example for systematic racism in historical data.

One of the applications of AI in criminal justice system is predicting recidivism. AI does this by analyzing historical data. When assessing the likelihood of an individual to reoffend, it is crucial to factor in human complexity, social, economic and political factors. Lack of this can lead to injustices. AI prediction fails to consider rehabilitation, education and family support. This can endanger Blackstone’s principle.

Most often, the concerns are related to fairness and equity. Biases can affect marginalized communities amplifying the existing racial injustice. People of color are unfairly impacted. There is an erosion of civil liberties.

The algorithms of AI are obscure. The propriety nature of AI makes it difficult for people to access the underlying models. Defendants and legal representatives may struggle for recourse. This clearly is a violation of the rights of an individual. It is important for individuals to understand how decisions are made.

Predictive models used to determine bail and sentencing do not consider information about the life of the individual. The models use historical data instead of assessing character or life situations. The automated nature of AI compromises fair judgement.

The widespread surveillance of individuals raises privacy concerns. Face recognition systems used without consent pile onto these concerns. Marginalized communities experience more policing and discriminatory surveillance. It poses a classic example of over policing due to AI. Thus, AI can contribute to systematic oppression.

There are several AI models in use today. Each model uses its own set of algorithms. When AI is not standardized, decisions can vary across courts. It is imperative to standardize AI in criminal justice system to have a consistent judicial process.

AI in criminal justice system can be used for risk assessment, predictive policing and parole decisions. However, there is no meaningful human oversight. The justice system becomes an assortment of unclear algorithms. Individuals lose the right to contest life altering decisions. An automated AI system undermines the autonomy of people. Fairness and justice always require a human eye.

Shared Concerns

1. Bias and Discrimination: Non-inclusive biased data can reinforce demographic biases leading to unfair treatment of marginalized communities
2. Accountability and Transparency: Lack of transparency and accountability acts as an obstacle in understanding and contesting decisions made by AI
3. Privacy and Autonomy: Sensitive data triggers privacy concerns impacting individual autonomy
4. Fairness and Equity: The absence of human oversight endangers the due process of fairness

DISCUSSION

Case Study 1- IBM Watson for Oncology

IBM Watson is one of the best examples of an AI healthcare model. The purpose of Watson was to analyze medical records and suggest customized treatments. The decision was to be taken based on available medical literature, recorded clinical trials, new medical studies and patient's health records. The accuracy of Watson was found to be unreliable. The evaluations at Memorial Sloan Kettering Cancer Center discovered that Watson was found to make unsafe recommendations about 30% of the time. Watson had prescribed a treatment plan that was not compatible with the patient's health condition. This is particularly worrying considering Watson was designed for customized treatment plans. Despite the fact that Watson was trained on an enormous volume of diverse data, it had failed to deliver accurate results. It is also worth noting that Watson's decisions were mostly based on incomplete data. It had not considered crucial patient information that typically would be prioritized by a doctor (Choi, 2017).

Case Study 2- The Algorithmic Bias in Health Risk Prediction

To understand the effect of algorithmic bias of AI, we can look at the following example. This instance sheds light on how AI amplifies systematic oppression. In 2019, a study was focused on analyzing the algorithm used by UnitedHealth to predict health risks. It was determined that the algorithm had a major racial bias. The algorithm tended to assign different health risk scores to Black and White people with the same health condition. Black people were assigned a lower health score than White people despite the same condition. This was due to the historical data biases. Since black people were historically denied healthcare, there were less records of them in the data. The 2019 study presents a good case of why AI data should be monitored.

Case Study 3- COMPAS Algorithm in Predictive Policing

The COMPAS (Correctional Offender Management Profiling for Alternative Sanctions) is an algorithm that was designed to find the likelihood of reoffenders. The algorithm is used by several courts in the US. Regardless, many have accused COMPAS of exhibiting racial biases. ProPublica found the algorithm to be biased in 2016. The algorithm was unfair to Black people. It predicted that Black people had a higher risk of committing future crimes than White people. The Black defendants were labelled as future criminals twice as much as the White defendants (Vaccaro, 2019).

Case Study 4- Predictive Policing with Palantir

Predictive policing is one of the most significant applications of AI in criminal justice system. Palantir Technologies is a notable data analytics company that helped develop predictive policing tools for law enforcement. The tools are designed to analyze vast amounts of social media data and historical crime records to predict possible crimes and criminals. The tools have however come under scrutiny for over policing in certain regions and discriminating against minority groups. The Palantir predictive policing system deployed in Los Angeles led to more police patrolling of areas with Black and Latino neighborhoods. The Center for Policing Equity determined that the Palantir predictive policing system can amplify the racial biases already existing in policing. This can be attributed to the fact that the fodder data comes from previous policing activities that were racially targeted (Oatley, 2022).

MITIGATION STRATEGIES

Diverse and Representative Data: Considering the fact that one of the biggest ethical concerns of using AI in healthcare and criminal justice system is biases, it is important to monitor the data. The data should be made diverse accommodating all minorities of the society. This will ensure fairness and equity. Demographical and social biases can be controlled if data is properly represented.

Bias Audits: There must be regular audits for data biases. This serves as a method to avoid demographical biases. If audits bring forward disparities, the model can be corrected accordingly. This also allows the data sources to be handled with caution. The logistics of this operation can involve an independent third party.

Explainability and Transparency: The algorithms and working of AI must be designed in such a way that they are interpretable and explainable. This allows the people to trust and rely on AI.

Training and Awareness: The people must be made aware on how AI makes decisions. This will allow people to assess biases and make critical judgements. It also helps them contest AI decisions.

Fairness Constraints in Model Development: We can accommodate fairness variables to ensure due process. This means incorporating certain social and political factors into the AI modelling. This will ensure that the decisions aren't only based on data.

Use of Multiple Models: Sometimes, a single model can cause omissions. If we subscribe to multiple models, the output of the models can be compared to ensure fair outputs. The models can be fed on diverse data.

Transparency in Risk Assessment: Risk Assessment systems like COMPAS should be made transparent so people can understand how the scores are generated. This makes them able to challenge unfair accusations.

Impact Assessments: Objective assessments should be made by independent parties to understand the impacts AI can have on fairness and equity. Potential harms, mistakes and biases must be assessed prior to AI modelling.

Clear Documentation of AI Decisions: All the decisions made by AI should be clearly documented to enhance understanding. Step by step documentation also provides a path to ensuring accountability.

Human Systems: It is important to ensure than AI doesn't replace human judgement. All critical decisions must by overseen by a human counterpart.

Regulatory Oversight: We can build a regulatory framework to ensure that AI models are always updated and consistent. An independent third party can oversee the regulations in order to ensure quality AI standards.

Public Disclosure of AI Methods: The developers of AI systems should disclose the algorithms, methods and databases they use. This will allow for corrections and accountability.

Public Accountability: There must be laws that dictate that the AI systems should be disclosed to the public. Public accountability can prevent misuse.

Auditability: In addition to bias audits, the AI models should also be audited to ensure ethical deployment. They can also check for security threats.

Clear Responsibility for Decisions: It must be made clear who takes the accountability in case of a mistake. Regulations must be made between developers and users.

Data Encryption and Secure Storage: There must be efficient protective mechanisms like end-to-end encryption to protect sensitive data. This reduces the chance for data breaches and unauthorized access.

Anonymization and De-identification: The data that is used to train AI should be made anonymous so that outcomes are not traced to individuals. This also allows the data to be secure. Furthermore, there must be accommodations to prevent re-identifying data.

Strict Data Use Policies: Institutions must follow guidelines on how data is collected and used. The patients and defendants must be made aware of these guidelines. The guidelines should be updatable according to the changes in the AI models.

Data Minimization: Unnecessary data should be dismissed as this can lead to future misuse. Data minimization ensures that only necessary data is collected from the people.

Clear Data Usage and Retention Policies: In addition to collecting limited data, there must also be established time limit to how long the data will be stored by the AI systems.

Safety Against Surveillance: Surveillance activities like predictive policing and facial recognition systems must be limited to prevent misuse. They can be made to require warrants. There should also be an objective third party to oversee surveillance activities.

Transparency in Data Usage: People should have a right to access the data that is being used in decision making. This will allow people to understand the fairness behind the decision.

Clear Communication: Clear communication is required for informed consent. People must be made aware of the benefits and harms of using AI. They must fully understand the extend of AI.

Patient Empowerment: There must be right of choice. People should be able to choose whether to use AI. They should also be allowed to change their decisions anytime.

Human Oversight: It is important to have a human oversight on AI processes. Final decisions must be overseen by a human. People should also be able to request for human assistance throughout the AI process.

Right to Challenge AI Decisions: Individuals that are affected by AI decisions must have the right to challenge them. They should be allowed access to all the necessary information. Appealing AI generated decisions must be encouraged.

Continual Training: Workers must be provided continual training on AI. The limitations of AI should be properly studied to avoid over reliance.

Validation and Testing: AI systems must be tested aggressively before use. They must be constantly updated and tested to ensure optimum functionality. Errors must be studied thoroughly.

Reskilling Workers: To prevent job displacements, existing workers can be trained to use AI. This will ensure that people with traditional jobs do not lose out on opportunities.

Job Creation in AI-related Fields: In addition to filling existing jobs, AI can also create more jobs leading to a more flourishing economy.

Human-AI Collaboration: The best parts of AI can be combined with the best parts of humanity to form a superior system. Humans can use AI to make better decisions concerning health and justice instead of simply relying on AI for decisions.

Multi- disciplinary collaboration: Scientists, developers and ethicists must come together to form an AI model that ensure efficiency and fairness. AI data also should reflect social parameters and ethical concerns.

CONCLUSION

The use of AI in healthcare and criminal justice systems can be beneficial if the ethical concerns are addressed. The mitigation strategies provided in the study formulate a way to use AI without compromising human values. However, it is important to note that AI should never replace human decisions.

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STATISTICAL ANALYSIS OF LITERACY RATES AND CRIMES AGAINST WOMEN: A PANEL REGRESSION APPROACH

Ms. Serah Mary Geo,
Student,
Department of Computer Applications,
St.Teresa's College (Autonomous)
serahsince2004@gmail.com, 7994484058
Ms. Raji S Pillai,
Faculty,
Department of Computer Applications
St.Teresa's College (Autonomous)

ABSTRACT

Women's safety and welfare remain critical concerns, as crimes targeting these vulnerable populations persist despite existing laws and awareness campaigns. This study analyzes crime data across all Indian states and union territories from 2012 to 2022, investigating the relationship between literacy rates and sexual crimes against women. A panel regression model is employed to analyze trends across regions and time, capturing both intra- and inter-regional variations. Contrary to conventional assumptions, the findings challenge the notion that higher literacy rates inherently lead to lower crime rates, revealing the persistence of crime even in areas with above- average literacy levels. The study emphasizes the need to examine whether education alone can curb crimes or if socio-economic and cultural factors must also be addressed. By exploring these Complex relationships, the research aims to provide actionable insights for policymakers focused on protecting vulnerable populations and fostering a safer and more equitable society.

Keywords: Literacy Rate, Crime Rate, Panel Regression, Women's Safety, Socio- economic Factors
Introduction Sexual crimes against women and demand urgent attention and preventive measures. In Indian society, they face significant challenges compromising their safety and dignity. Despite legal safeguards, injustices and sexual offenses persist at alarming rates. This study builds upon prior research conducted in India. However, it distinguishes itself by encompassing all the states and union territories. A deliberate attempt is being made to investigate the association between crimes recorded and literacy rates in states and union territories by employing panel regression model. The crime rates of both women is taken into consideration from the time period of 2012 to 2022.

LITERATURE REVIEW

The relationship between literacy rates and crimes against women has been explored in numerous studies, highlighting diverse socioeconomic and cultural factors influencing these crimes. This section provides an overview of key studies, their focus areas, findings, and tools used for analysis.

Bodhgire and Muley (2020) analyzed the relationship between crime rates and literacy rates in India using a regression model. The study found a weak positive association between literacy and certain crime categories, but no statistically significant overall correlation, suggesting that other factors may play a more dominant role in crime prevention.

Chakraborty, Afreen, and Pal, 2021 state-level crime against women analysis, where the major crimes related to dowry are reported, followed by rape. Their research paper based on panel regression analysis of economic and social factors stated that economic growth increases crime until it reaches a specific threshold level and then gradually starts to reduce crime. Satija and Datta (2015) also analyzed crimes against women and children in Delhi, using both secondary and empirical data. Their findings highlighted the high vulnerability of children to crime, emphasizing the need to take into account both crime incidence and public perception for a comprehensive understanding.

Tikhute (2023) specifically discussed crimes against children in India, analyzing regional patterns and annual trends. His study found that northern and central India showed higher crime rates against children, with regional distribution patterns resembling national crime trends. Kumar and Reddy (2020) discussed the role of women's empowerment in reducing crime rates and concluded that economic, social, and political empowerment play crucial roles in crime deterrence. The study emphasized policy-driven initiatives for improving women's security.

Prosenjit (2023) undertook a geospatial analysis of crimes against women in India, which depicted that even after the enactment of various laws, crimes like rape, dowry deaths, and human trafficking continue to increase. His study identified considerable regional disparities in crime trends, which demanded localized intervention policies. Similarly, Sreeparna, Sharma, and Pal (2022) analyzed the crimes against children in West Bengal using NCRB data. Their analysis showed that over 90% of crimes against children were committed by known individuals, leading to recommendations for stronger awareness programs involving parents, teachers, NGOs, and government agencies.

Lastly, Sumesh and Sravani (2020) discussed the determinants of women's empowerment and their influence on crime rates. The authors emphasized education, financial independence, and social awareness in reducing crimes against women. Literature collectively emphasizes that literacy is a significant factor, but alone is not sufficient to reduce crime rates. Socio-economic conditions, policy interventions, and cultural influences must be taken into account to create effective crime prevention strategies.

OBJECTIVE

The goal of this paper is to investigate the potential association between literacy rate and the prevalence of sexual crimes against women in India. It is hypothesized that there exists an inverse relationship between crime rates and education, as measured by literacy rates. Specifically, the hypothesis under consideration is that there is no significant relationship between crime rates and literacy rates in India. Despite the average literacy rate in India standing at 80%, the persistence of crimes in society prompts a closer examination of the correlation between crime and literacy levels.

METHODOLOGY

The methodology outlines the structured approach used to examine the relationship between literacy rates and crimes against women across Indian states and union territories during 2012–2022. The process includes the following key steps:

Data Sources

Crime Data: Collected from the National Crime Records Bureau (NCRB) reports, which provide detailed statistics on crimes reported in India.

Literacy Rates: Obtained from National Sample Survey (NSS) estimates published by the National Statistical Office (NSO). The NSS estimates serve as proxies for literacy rates in the absence of recent census data (post-2011).Data Collection and Processing

To ensure consistency and reliability, the following preprocessing steps were undertaken:

Data Cleaning: Missing or inconsistent entries in the datasets were addressed through interpolation or exclusion, where appropriate.

Merging Datasets: Crime data and literacy rates were combined into a single dataset, aligning observations by state/UT and year.

Conversion to Panel Data: The merged data was structured into a panel format, enabling the analysis of both cross-sectional (state/UT-level) and time-series (yearly) variations.

Analytical Tools Arithmetic Mean

The arithmetic mean was used to calculate average crime rates and literacy rates across states and union territories for comparative purposes. This provided a high- level overview of regional variations.

Year-on-Year (YOY) Growth Rate

Formula: YOY Growth Rate = $(Y_t - Y_{t-1})/Y_{t-1} \times 100$

Here, YtY_tYt is the crime rate or literacy rate in the current year, Yt−1Y_{t-1}Yt−1 is the corresponding value from the previous year.

Purpose: To identify trends and fluctuations in crime rates over time, highlighting good-performing (low YOY growth) and bad-performing (high YOY growth) states and UTs.

Panel Regression Model Why Panel Regression?

This model accounts for both time-series (over years) and cross-sectional (across states) dimensions of the data, capturing unobserved heterogeneity.

Model Setup:

Dependent Variable: Crime rate (against women).

Independent Variable: Literacy rate.

Fixed Effects: Used to control for time-invariant state-specific factors (e.g., culture, law enforcement efficiency).

Clustered Standard Errors: Adjusted for correlation within states across years.

Software: Python was used for implementing the panel regression model. Libraries such as pandas, stats-models, and linear-models _ .panel facilitated the data processing and regression analysis.

RESULT

Year-on-Year (YOY) Growth

The evaluation of crime rates against women over the 2012–2022 period, based on National Crime Records Bureau (NCRB) data, reveals several critical trends:

Consistent Increases: Some states reported consistent year-over-year increases, highlighting regions requiring urgent intervention.

Regional Variability: States with higher literacy rates showed a mixed correlation, emphasizing the need for localized analysis.

Panel Regression Analysis

The panel regression framework utilized literacy rates as an independent variable to determine its impact on crime rates against women. The results demonstrate:

Significant Correlation: A statistically significant negative correlation was observed between literacy rates and crime rates in many states.

State-wise Variance: The relationship between literacy and crime is not uniform across all states, suggesting other mediating factors.

Key Observations

Disparities Across Regions: Union territories and northeastern states showed unique trends, requiring tailored policy approaches.

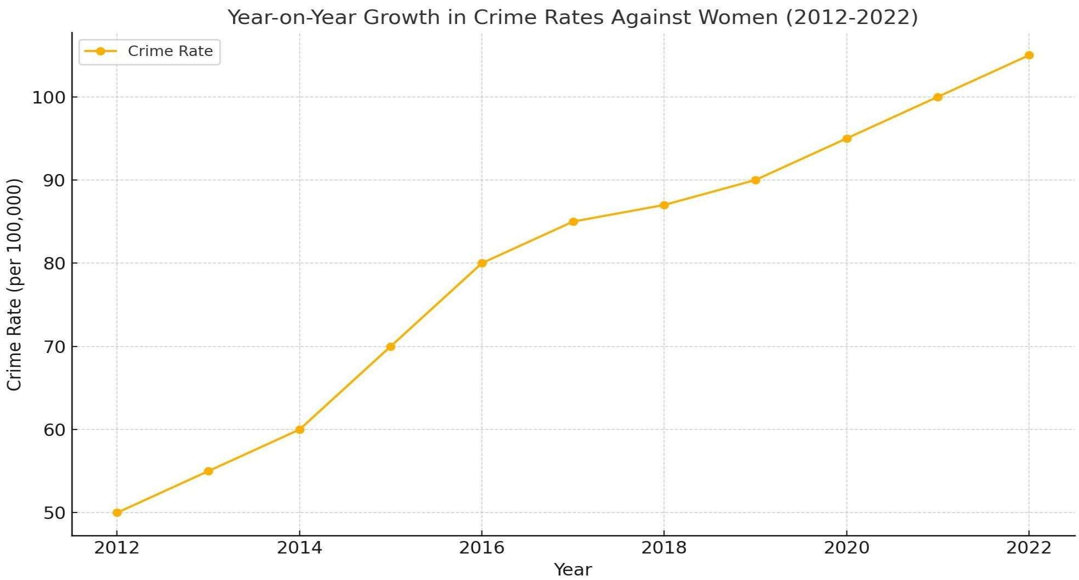
Urban vs. Rural Divide: Urban areas recorded higher crime rates, potentially reflecting better reporting mechanisms or systemic disparities.

Policy Impact: States with robust gender-sensitive policies demonstrated a reduction in crime rates over time.

```
Panel Regression Results for Crime Against Women:
                          PanelOLS Estimation Summary
================================================================================
Dep. Variable:             Crime Rate   R-squared:                        0.1373
Estimator:                   PanelOLS   R-squared (Between):             -0.6879
No. Observations:                 119   R-squared (Within):               0.1373
Date:                Mon, Dec 09 2024   R-squared (Overall):             -0.5175
Time:                        01:35:01   Log-likelihood                   -464.03
Cov. Estimator:            Unadjusted
                                        F-statistic:                      15.601
Entities:                          20   P-value                           0.0001
Avg Obs:                       5.9500   Distribution:                    F(1,98)
Min Obs:                       5.0000
Max Obs:                       6.0000   F-statistic (robust):             15.601
                                        P-value                           0.0001
Time periods:                       6   Distribution:                    F(1,98)
Avg Obs:                       19.833
Min Obs:                       19.000
Max Obs:                       20.000

                              Parameter Estimates
=================================================================================
               Parameter  Std. Err.     T-stat    P-value    Lower CI    Upper CI
---------------------------------------------------------------------------------
const            -141.08     49.669    -2.8404     0.0055     -239.65     -42.515
Literacy Rate     2.4715     0.6257     3.9499     0.0001      1.2298      3.7133
=================================================================================

F-test for Poolability: 25.833
P-value: 0.0000
Distribution: F(19,98)
```



CONCLUSION

Rising Crime Rates: The year-on-year (YOY) analysis highlights a consistent increase in crime rates against women from 2012 to 2022. This trend underscores the urgency of implementing stronger measures to address gender-based violence.

Impact of Literacy: The panel regression analysis reveals a negative correlation between literacy rates and crime rates. States with higher literacy rates tend to experience lower crime rates, showcasing the critical role of education in reducing violence against women.

Regional Disparities:

Variations in crime rates across regions reflect the need for tailored interventions to address local challenges.

Urban areas generally report higher crime rates, potentially due to better awareness and access to reporting mechanisms.

Policy Effectiveness:

States implementing robust gender-sensitive policies demonstrate significant reductions in crime rates.

Raising literacy levels and awareness about women's rights are effective strategies to mitigate crime rates.

Future Recommendations:

Strengthen education and awareness programs to promote gender equity and reduce violence.

Utilize advanced technologies like AI to predict high-risk areas and implement preventative strategies.

Enhance reporting systems and legal frameworks to ensure justice and safety for women across all regions.

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A ROBUST BLOCKCHAIN-BASED PLATFORM FOR SECURE AND EFFICIENT CONTENT DISTRIBUTION

Ann Sara Saji
Computer Science and Engineering Dept.
Mar Baselios of Technology and Science Kothamangalam, Kerala, India
annsarahann2003@gmail.com
Athullya C J
Computer Science and Engineering Dept.
Mar Baselios of Technology and Science (MBITS)
Kothamangalam, Kerala, India athullyacj35@gmail.com
Bismin Chacko
Computer Science and Engineering Dept.
Mar Baselios of Technology and Science (MBITS)
Kothamangalam, Kerala, India bismin@mbits.ac.in

Devananda R
Computer Science and Engineering Dept.
Mar Baselios of Technology and Science (MBITS)
Kothamangalam, Kerala, India devanandarajesh25@gmail.com
Jeeva Sajeevan
Computer Science and Engineering Dept.
Mar Baselios of Technology and Science (MBITS)
Kothamangalam, Kerala, India
jeevasajeevan39@gmail.com@gmail.com

ABSTRACT

A “Robust Blockchain-Based Platform for Secure and Efficient Content Distribution” is proposed to address key challenges in digital content trading, including illegal copying, profit misallocation, and forgery. Traditional blockchain systems face limitations such as network congestion, limited storage capacity, and privacy concerns. To overcome these issues, this work introduces a Secret Block-Based Blockchain (SBBC) system, which integrates off-chain and on-chain components for secure and efficient content distribution. The off-chain module manages content authentication, encryption, and digital fingerprinting, enabling traceability of unauthorized leaks and ensuring that only legitimate users can access the content. The on-chain module performs license verification and transaction recording using a consensus algorithm, promoting transparency and trust among participants. The innovative use of secret blocks enables private storage of sensitive transaction details, alleviating network overload while maintaining the integrity of public blockchain records. This robust platform ensures fair revenue distribution for content creators, robust privacy protections, and efficient management of digital content transactions, making it a reliable and scalable solution for the modern digital economy.

Keywords *Blockchain, Digital Content trading, SBBC System, Smart contract, Bidding process, Transaction process.*

INTRODUCTION

The emergence of the Internet of Everything (IoE) has transformed digital content into a critical resource in the modern economy. With innovations such as virtual reality (VR), augmented reality (AR), and mixed reality (MR), as well as traditional multimedia like movies and music, users now enjoy immersive and interactive experiences that bridge the gap between virtual and real worlds. The proliferation of smart devices and platform services has further expanded the scale and potential of the digital content market. However, this growth is hindered by persistent challenges such as illegal copying, unauthorized distribution, forgery, and unfair profit sharing. Existing solutions, including digital rights management (DRM) and digital fingerprinting, have made strides in tracking and mitigating these issues but remain insufficient to address the broader concerns of transparency, security, and efficiency.

Blockchain technology, a decentralized and transparent peer-to-peer (P2P) system, has emerged as a potential solution to these problems by ensuring data integrity, security, and trust without reliance on third parties. Despite its advantages, conventional blockchain systems face critical limitations, including restricted storage capacity for large digital content and privacy concerns arising from the visibility of transaction data across all participants. These challenges make it difficult to fully integrate blockchain into digital content trading environments.

To overcome these obstacles, this paper proposes a Secret Block-Based Blockchain (SBBC) system designed specifically for digital content trading. By introducing secret blocks (SBs), the SBBC framework resolves storage limitations and enhances privacy by separating sensitive information from public ledgers. Additionally, a Weighted Authentication Byzantine Fault Tolerance (WBFT) algorithm is employed to optimize consensus processes, assigning greater weight to authenticated users to improve transaction reliability and efficiency.

BACKGROUND

A. *The analysis of data management in blockchain-based systems: from architecture to governance*

This research adopts a structured approach to analyze data management in blockchain-based systems, focusing on architecture, storage mechanisms, transaction processing, and governance. Additionally, governance models are examined to understand their roles in decision-making, resource allocation, and conflict resolution within blockchain networks. A comparative analysis is conducted to evaluate different blockchain systems, including public, private, and consortium blockchains, by assessing performance metrics such as scalability, security, throughput, and storage efficiency. Real-world case studies from various industries are explored to investigate practical implementations, with a focus on how data is managed and governed effectively. These methods provide insights into optimizing data management and governance strategies in blockchain-based systems.

Blockchain for Electric Vehicles Energy Trading: Requirements, Opportunities, and Challenges

In this research, we explore the application of blockchain technology in electric vehicle (EV) energy trading, focusing on its potential to enhance energy management, transaction transparency, and efficiency. The study begins by examining the current landscape of EV energy trading systems, identifying the key requirements for blockchain integration, such as secure energy transaction models, smart contracts, and suitable consensus mechanisms. Blockchain's decentralized nature is evaluated for its potential to address issues like data security, energy fraud, and inefficiency in traditional energy markets. Opportunities for blockchain to improve transparency, enable peer-to-peer energy trading, and facilitate grid management are discussed, emphasizing the role of smart contracts in automating transactions. The research also delves into the challenges of adopting blockchain in the EV energy sector, including scalability issues, regulatory hurdles, and the need for standardization. Real-world case studies of pilot projects are explored to assess the practical implications of blockchain integration and to provide a clearer understanding of its benefits and limitations in EV energy trading systems. This paper ultimately aims to provide a comprehensive analysis of the opportunities and challenges blockchain technology presents for the future of EV energy trading.

B. A System for the Promotion of Traceability and Ownership of Health Data Using Blockchain

This study proposes a system to promote traceability and ownership of health data using blockchain technology. It begins with an extensive review of current health data management systems, focusing on existing practices for ensuring data ownership, traceability, and privacy. The review includes an examination of decentralized technologies, particularly blockchain, to address challenges related to data security, unauthorized access, and the management of patient consent. Technical requirements for integrating blockchain into health data systems are outlined, covering aspects such as data storage, secure transaction processing, and consensus algorithms that balance privacy with transparency. A blockchain- based system architecture is designed to integrate existing health data repositories, ensuring both traceability and patient ownership of data. Smart contracts are incorporated to automate consent management, ensuring that health data is only shared with authorized parties. A comparative analysis is conducted between traditional centralized systems and the proposed blockchain model, assessing security, scalability, user control, and regulatory compliance. The system's performance is simulated to evaluate its effectiveness, security, and feasibility in real-world applications, aiming to provide practical insights for the adoption of blockchain in healthcare data management.

C. *Novel and Secure Blockchain Framework for Health Applications in IoT*

This study introduces a novel and secure blockchain framework for health applications in the Internet of Things (IoT). The research begins with an extensive review of existing IoT-based health systems focusing on security challenges, data privacy, and the integration of blockchain technology to address these issues. Key security concerns, such as unauthorized access, data integrity, and privacy in health data management, are identified. The study then defines the technical requirements for integrating blockchain with IoT devices in health applications, including the choice of consensus algorithms, data encryption techniques, and secure communication protocols. A novel blockchain framework is proposed, which integrates IoT devices with secure blockchain networks to ensure the confidentiality, integrity, and traceability of health data. This framework utilizes smart contracts to automate secure data sharing, patient consent management, and access control. The performance of the proposed framework is assessed through simulations, evaluating parameters such as system scalability, data throughput, security resilience, and response time in real-world health IoT scenarios. Additionally, a comparative analysis is conducted to assess the advantages and disadvantages of the proposed blockchain framework compared to traditional centralized systems.

D. *Decentralized Global Copyright System Based on Consortium Blockchain With Proof of Authority*

This study proposes a decentralized global copyright system based on a consortium blockchain with Proof of Authority (PoA). The research begins with a comprehensive review of existing copyright management systems, focusing on centralized models and their limitations, including issues related to intellectual property protection, licensing, and royalty distribution. The study explores the potential of consortium blockchains to address these challenges, highlighting the advantages of decentralized control and enhanced transparency. Key technical requirements for implementing the proposed system are identified, including the selection of PoA as the consensus algorithm, which ensures both efficiency and trust among known validators. A blockchain-based architecture is designed, incorporating smart contracts for automating copyright registration, licensing, and royalty distribution processes. The system is tailored to manage digital content, ensuring secure and transparent transactions. The performance of the proposed system is evaluated through simulations, focusing on scalability, transaction speed, and system security. A comparative analysis is conducted between the consortium blockchain-based system and traditional copyright management approaches, evaluating factors such as efficiency, cost-effectiveness, and user trust.

E. Secure Content Trading for Cross-Platform in the Metaverse With Blockchain and Encryption

This study proposes a secure content trading system for cross-platform use in the Metaverse, leveraging blockchain technology and searchable encryption to ensure privacy, security, and ease of access. The research begins by examining the challenges associated with content trading in the Metaverse, particularly concerning data security, user privacy, and the scalability of existing systems. Blockchain technology is explored as a potential solution to ensure the transparency, integrity, and traceability of digital content transactions across platforms. Searchable encryption is integrated into the system to allow users to search encrypted data without compromising privacy, ensuring that content remains protected while still accessible to authorized users. A decentralized architecture is designed, combining the benefits of blockchain for secure transactions and searchable encryption for confidential content retrieval. The study evaluates the performance of the proposed system by analyzing its security features, transaction speed, and scalability in the context of the Metaverse. A comparative analysis is carried out between traditional content trading platforms and the proposed system, focusing on aspects such as user trust, content protection, and efficiency. The findings offer insights into the feasibility and advantages of implementing blockchain and searchable encryption for secure content trading in the Metaverse, providing a foundation for future development and adoption in cross-platform digital environments.

F. *Trust-Free Blockchain Framework for AI-Generated Content Trading and Management in Metaverse*

This study proposes a trust-free blockchain framework for AI-generated content trading and management in the Metaverse, aiming to address the challenges of authenticity, ownership, and transparency in virtual environments. The research begins by analyzing the existing issues in AI-generated content, focusing on the lack of trust and accountability in digital asset transactions. Blockchain technology is explored as a potential solution to ensure the secure, transparent, and tamper-proof management of AI-generated content. The framework utilizes decentralized ledger technology to enable direct peer-to-peer transactions, ensuring that content creators retain ownership and control over their AI- generated assets. Smart contracts are incorporated to automate content licensing, royalty distribution, and usage rights, ensuring that transactions occur without intermediaries and are transparent to all parties involved. A key aspect of the framework is its trust-free approach, which removes the reliance on centralized authorities or third parties, leveraging consensus algorithms to validate and verify transactions. The system is designed to facilitate the exchange of AI-generated content across various platforms within the Metaverse, with a focus on scalability and efficiency. The performance of the proposed framework is evaluated by assessing transaction speeds, security features, and the framework's ability to handle high volumes of content trading. A comparative analysis is conducted between traditional centralized content management systems and the proposed blockchain-based framework, focusing on the benefits of decentralization, reduced fraud, and improved content governance. The findings provide insights into the feasibility and potential of blockchain for enabling trust-free AI content trading and management in the Metaverse.

G. *Blockchain-Based Supply Chain Information Sharing Mechanism*

This study proposes a blockchain-based supply chain information sharing mechanism to address challenges such as transparency, trust, and inefficiency in traditional supply chain systems. The research begins by identifying the limitations of existing supply chain information systems, such as the lack of real- time visibility, the potential for fraud, and the difficulty in verifying the authenticity of goods. Blockchain technology is examined as a solution to enhance transparency, security, and traceability in the supply chain. The proposed mechanism utilizes a decentralized ledger to record and verify every transaction in the supply chain, ensuring that all stakeholders have access to accurate, tamper-proof information. Smart contracts are integrated into the system to automate processes such as payment, product delivery, and compliance checks, reducing the need for intermediaries and enhancing operational efficiency. The study explores different consensus algorithms and their suitability for the proposed blockchain system, focusing on scalability, energy efficiency, and transaction speed. A detailed framework is developed for information sharing between suppliers, manufacturers, distributors, and retailers, ensuring that data is securely exchanged across the supply chain network. The performance of the blockchain-based mechanism is evaluated by analyzing key metrics such as transaction throughput, data security, and cost-effectiveness. A comparative analysis is conducted between traditional supply chain information systems and the blockchain-based approach, highlighting the advantages in terms of trust, efficiency, and real-time tracking. The findings provide valuable insights into the practical implementation of blockchain technology for improving supply chain management and information sharing.

H. Blockchain and Smart Contracts for Telecommunications: Requirements vs. Cost Analysis

This study explores the use of blockchain technology and smart contracts in telecommunications, focusing on the balance between system requirements and the associated costs. The research begins by analyzing the challenges faced by the telecommunications industry, including inefficiencies in billing, fraud prevention, and the management of complex service agreements. Blockchain technology is investigated as a potential solution to streamline operations, enhance transparency, and improve security in telecommunications networks. The study evaluates the technical requirements for implementing blockchain and smart contracts, such as the choice of consensus mechanisms, network scalability, and integration with existing telecom infrastructure. A cost-benefit analysis is conducted to assess the financial implications of adopting blockchain solutions in telecommunications, considering factors such as initial setup costs, operational efficiency, transaction fees, and long-term savings. The potential for smart contracts to automate service agreements, billing, and dispute resolution is examined, focusing on how these contracts can reduce administrative overhead and improve customer satisfaction. The performance of the blockchain system is evaluated by analyzing key metrics such as transaction speed, network throughput, and cost reduction across various telecom services. A comparative analysis is performed between traditional telecom systems and blockchain-based solutions to highlight the advantages and challenges of implementing such technologies in the sector. The findings provide a comprehensive understanding of the potential for blockchain and smart contracts to enhance telecommunications operations, improve service management, and reduce costs.

NutBaaS:A Blockchain-as-a-Service Platform

This study presents NutBaaS: a Blockchain-as-a-Service (BaaS) platform designed to simplify the integration of blockchain technology for enterprises across various industries. The research begins by identifying the challenges faced by businesses when adopting blockchain solutions, such as complexity, scalability issues, and the high costs associated with maintaining blockchain infrastructure. NutBaaS aims to address these challenges by offering a cloud-based, user-friendly platform that allows businesses to easily deploy, manage, and scale blockchain applications without requiring in-depth technical knowledge. The study explores the technical components of the NutBaaS platform, including its architecture, consensus mechanisms, smart contract functionality, and integration capabilities with existing enterprise systems. A comparative analysis is conducted between NutBaaS and other BaaS platforms to assess its advantages in terms of performance, cost-effectiveness, and ease of use. The platform's performance is evaluated through case studies in various industries, such as supply chain management, healthcare, and finance, to assess its scalability, security, and ability to handle high transaction volumes. Additionally, the study includes an analysis of user feedback and adoption rates, examining the platform's effectiveness in reducing the barriers to blockchain adoption. The findings provide insights into the potential of NutBaaS to enable businesses to leverage blockchain technology efficiently and effectively, reducing implementation costs and accelerating digital transformation.

SCOPE AND OBJECTIVE

The paper presents the development of a blockchain-based system specifically designed to address the unique challenges of digital content trading, such as illegal copying, unfair profit distribution, forgery, privacy concerns, and blockchain-specific issues like limited storage capacity and transparency risks. It introduces the Secret Block-Based Blockchain (SBBC) system, a hybrid architecture combining off-chain and on-chain components to create a secure, efficient, and reliable trading environment. The system ensures that users are authenticated off-chain before participating in transactions, while employing advanced techniques like encryption and digital fingerprinting to safeguard digital content, prevent unauthorized distribution, and trace leaks if they occur. A key innovation of the SBBC system is the use of secret blocks, which store private transaction data accessible only to the involved parties, thus addressing privacy concerns and reducing network overhead.

ARCHITECTURE MODEL

This blockchain-based system for secure and efficient digital content trading seamlessly integrates on- chain and off-chain components to deliver a transparent, reliable, and high-performing solution. The architecture revolves around two primary client types: content creators, who produce and upload digital assets for trading, and buyers, who bid for and acquire the content. To manage operations that are resource- intensive for blockchain, the system employs off-chain components. An authentication service verifies the identities of creators and buyers, ensuring a trusted ecosystem. A unique digital fingerprint is generated for each piece of content to confirm its authenticity and prevent duplication. Meanwhile, large digital files are stored securely in scalable cloud storage solutions, as blockchain is not suitable for handling extensive data.

The bidding process is orchestrated by smart contracts, which define and enforce the rules of engagement, automating transactions without requiring intermediaries. Every bid is recorded transparently, providing a tamper-proof trail of activity, while escrow mechanisms secure buyer payments until the transaction is successfully finalized. On the blockchain, each content transaction is encapsulated in an encrypted block that forms part of the tamper-proof public ledger. The system's consensus algorithm validates these blocks, ensuring the integrity and accuracy of the recorded data.

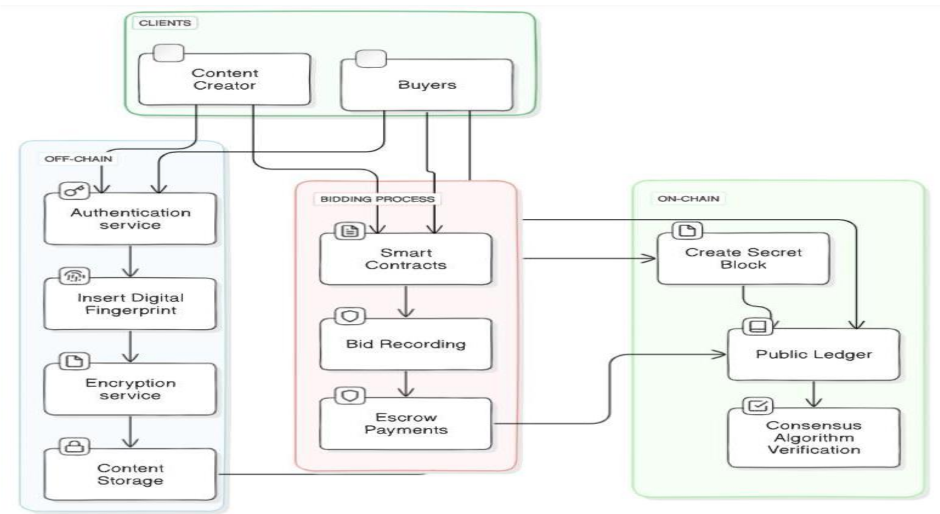

Fig. 1. Architecture Model

The trading flow begins with the content creator uploading their work. The system then generates a unique digital fingerprint for the content and stores it off-chain for authentication purposes. Buyers interact with the platform by placing bids through smart contracts, with all offers logged transparently and payments safeguarded in escrow. When a bid is accepted, the transaction details are encrypted, recorded on the blockchain, and verified via the consensus algorithm. Finally, once payment is confirmed, the buyer receives secure access to the purchased content. By leveraging the blockchain's strengths in security, transparency, and immutability, alongside the scalability and efficiency of off-chain systems, this architecture creates a robust framework for trading digital content. It instills trust among users, enhances operational efficiency, and ensures a seamless and secure experience for both creators and buyers.

PROPOSED METHODOLOGY

In the Secret Block-Based Blockchain (SBBC) system is an innovative solution tailored to address the growing challenges in digital content trading. Traditional blockchain systems face significant hurdles, such as privacy issues, limited scalability, and inefficiency in handling complex transactions, especially in the digital content sector. The SBBC system is specifically designed to overcome these obstacles by incorporating advanced privacy-preserving features, enhanced storage solutions, and more efficient transaction mechanisms to create a more effective and secure environment for digital content trading.

One of the main challenges in the current digital content ecosystem is the lack of privacy, as most blockchains record every transaction on a public ledger. SBBC addresses this by implementing secret block mechanisms, ensuring that sensitive data is encrypted and only accessible by authorized parties. This provides a higher level of privacy for users, allowing them to engage in digital content transactions without exposing their personal or business information to the public eye.

Additionally, the SBBC system enhances blockchain efficiency and scalability. Traditional blockchains often face limitations in handling large amounts of data and complex transaction structures, leading to delays and higher transaction costs. By utilizing secret block-based structures, the SBBC improves storage capacity, minimizes transaction bottlenecks, and reduces costs, making it a more efficient solution for the rapidly growing digital content industry. This methodology represents a significant step forward in the development of blockchain technology, particularly for applications that demand a high level of privacy, scalability, and operational efficiency..

A. *Off-Chain and On-Chain Segregation*

The need for the off-chain components arises from the necessity to secure the digital content trading process while minimizing blockchain network congestion and safeguarding intellectual property rights. User authentication ensures that only legitimate participants engage in transactions, reducing false entries and network overload, while Digital Rights Management (DRM) encrypts content to restrict access to authorized users and Digital Fingerprinting embeds user-specific markers to trace leaks. The on-chain components address privacy and scalability challenges. The private section, through Secret Blocks (SBs), protects sensitive transaction details and avoids storage limitations by restricting access to transacting parties. The public section uses Public Blocks (PBs) to maintain transparency, store summarized transaction metadata, and support decentralized validation, ensuring trust and consistency across the distributed ledger.

B. *Weighted Authentication Byzantine Fault Tolerance (WBFT) Algorithm*

In the Weighted Authentication Byzantine Fault Tolerance (WBFT) algorithm is a tailored consensus mechanism that assigns higher weights to authenticated users, enhancing their likelihood of participatingin block validation. This approach boosts the reliability of the consensus process by prioritizing trusted participants, thereby accelerating transaction validation and improving overall network efficiency. Additionally, by balancing the participation of authenticated and unauthenticated users, WBFT mitigates the risk of malicious activities, ensuring a secure and efficient validation process within the blockchain environment.

C. *Digital Content Licensing and Smart Contracts*

After completing user authentication, smart contracts play a pivotal role in managing the licensing of digital content, ensuring secure and transparent transactions. These contracts define and enforce proper usage rules, such as the duration, scope, and terms under which the digital content can be accessed and used. By embedding these rules into the smart contracts, the system automates the enforcement of digital rights, ensuring that the content is used strictly as per the agreed terms. Once a transaction is successfully completed, the smart contract generates a confirmation message, which serves as proof of the transaction and facilitates the creation of a Secret Block (SB). This SB includes the licensing details and encrypted content, ensuring both privacy and compliance with the transaction terms. This integration of smart contracts not only secures digital content but also simplifies and automates the licensing process, enhancing the reliability and efficiency of the blockchain-based digital content trading system.

D. *Transaction Verification via Zero-Knowledge Proof*

In Transaction verification in the system utilizes the Schnorr Protocol, a zero-knowledge proof mechanism, to validate transactions without disclosing sensitive information. This protocol allows a participant to prove possession of specific credentials, such as a private key or a license hash value, without actually revealing the credentials themselves. By doing so, it ensures the legitimacy of the participants involved in the transaction, confirming their authorization to engage without compromising their privacy. Additionally, the protocol upholds the integrity of transaction details by guaranteeing that only authentic and verified data is processed, further enhancing trust and security within the blockchain network. This privacy-preserving verification method is essential for maintaining confidentiality while ensuring robust validation in the digital content trading environment.

E. *Integration of Blockchain with DRM and Fingerprinting*

The integration of blockchain technology with Digital Rights Management (DRM) and Digital Fingerprinting creates a robust solution for addressing critical challenges in digital content trading, such as illegal copying, forgery, and unfair profit distribution. DRM ensures that only authorized users can access digital content by encrypting it, thereby preventing unauthorized access and misuse. Digital Fingerprinting adds an additional layer of security by embedding unique, user-specific markers into the content, enabling traceability and accountability for any content leaks. By combining these technologies with the transparency and immutability of blockchain, the system supports fair revenue distribution by directly linking payments to content creators without intermediaries. This integration not only secures digital assets but also builds trust and accountability in digital content transactions.

F. *Ledger Structure*

The ledger structure balances privacy and transparency by integrating Secret Blocks (SBs) and Public Blocks (PBs). SBs, owned solely by transacting parties, store sensitive details like encrypted content and licensing, ensuring privacy and GDPR compliance. Linked to PBs via cryptographic hashes, SBs maintain secure connections to public data. PBs store summarized metadata visible to all participants, ensuring transparency and ledger integrity. This dual-layer design reduces storage requirements, protects privacy, and fosters trust across the blockchain network.

RESULT AND DISCUSSION

The proposed Secret Block-Based Blockchain (SBBC) system offers a comprehensive solution to the challenges of digital content trading, including illegal copying, profit misallocation, forgery, and privacy concerns. By combining blockchain technology with Digital Rights Management (DRM) and digital fingerprinting, SBBC ensures secure, transparent, and traceable transactions. The system employs secret blocks (SBs) to address blockchain limitations such as storage overhead and privacy vulnerabilities, allowing transaction data to be stored exclusively with the trading parties. The introduction of the Weighted Byzantine Fault Tolerance (WBFT) consensus algorithm further enhances the system's performance by assigning higher weights to authenticated users, ensuring reliable and efficient consensus even in large-scale environments. Simulation results demonstrate that WBFT significantly reduces transaction latency, with execution times improving by 40% compared to traditional PBFT when the proportion of authenticated users reaches 70%. WBFT also increases transaction throughput and minimizes resource usage, including CPU and memory consumption, making it more efficient under heavy transaction loads. Additionally, the integration of encryption and digital fingerprinting provides robust protection against unauthorized content use and enables tracking of illegal leaks, ensuring intellectual property rights are safeguarded. SBBC's dual-layer design, comprising off- chain and on-chain components, ensures secure user authentication, efficient transaction processing, and enhanced privacy. The system's adaptability highlights its potential for applications beyond digital content trading, such as in healthcare and logistics, where privacy, scalability, and efficiency are critical. However, adapting SBBC to different domains may require modifications, such as replacing DRM with differential privacy mechanisms for medical systems. Future research will focus on optimizing the system for broader applications and further enhancing its scalability, efficiency, and reliability across diverse industries.

CONCULUSION

The proposed Secret Block-Based Blockchain (SBBC) system provides an innovative framework to address the persistent challenges of digital content trading, including illegal copying, profit misallocation, forgery, and privacy concerns. By integrating blockchain technology with Digital Rights Management (DRM) and digital fingerprinting, SBBC ensures a secure, transparent, and traceable environment for digital transactions. Its dual-layer design, comprising off-chain and on-chain components, facilitates efficient user authentication, secure content licensing, and robust transaction validation while preserving user privacy through the use of secret blocks (SBs). SBs address blockchain limitations, such as storage constraints and privacy vulnerabilities, by restricting detailed transaction data to the trading parties, thereby reducing network overhead and ensuring confidentiality.

The system also introduces the Weighted Byzantine Fault Tolerance (WBFT) consensus algorithm, which assigns higher weights to authenticated users, enhancing consensus reliability and efficiency. Simulation results show that WBFT significantly outperforms traditional PBFT, achieving faster consensus execution, reduced transaction latency, and improved throughput, particularly as the proportion of authenticated users increases. Additionally, WBFT minimizes resource consumption, including CPU and memory usage, making it more scalable and suitable for high-volume transaction environments. The integration of encryption and digital fingerprinting further strengthens intellectual property protection by preventing unauthorized use and enabling tracing of illegal leaks, ensuring that content creators retain control over their work.

SBBC's adaptability highlights its potential for applications beyond digital content trading, such as in healthcare and logistics, where privacy and scalability are critical. However, implementing SBBC in other domains may require modifications, such as replacing DRM with mechanisms like differential privacy for medical data. Despite these challenges, the SBBC system stands as a robust solution for creating secure, efficient, and transparent ecosystems for digital content trading and beyond. Future research will focus on enhancing its scalability, portability, and efficiency to support a broader range of applications, ensuring that SBBC can address the evolving demands of secure and reliable digital ecosystems.

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A COMPREHENSIVE COMPARISON OF DENSENET AND XCEPTION FOR ACCURATE YOGA POSE ESTIMATION

Shivnanda Rajeev
Department of Computer Applications,
St.Teresa's College (Autonomous)
Email: shivnandarajeev6@gmail.com,
Vandana Kaimaparambil Sreekumar
Department of Computer Applications,
St.Teresa's College (Autonomous)
vkaimapparambil@gmail.com]
Raji S Pillai
Department of Computer Applications,
St.Teresa's College (Autonomous)

ABSTRACT

Yoga has a long history in Indian culture and is now widely recognized for its ability to improve both physical and mental health, learning the poses without individualized instruction can result in bad postures and even injury. The study aims to perform a comparative analysis on DenseNet and Xception architectures to evaluate their performance in the task of estimation of yoga poses.The models considered are known for strong feature extraction.This study takes a stride towards making self guided practice safer. The models were trained on a standard dataset consisting of five yoga poses: downdog, tree, goddess, plank and warrior2.Further, the dataset was augmented to improve the reliability and accuracy of the models.With the help of transfer learning, the models were refined and their performance was compared based on their accuracy,precision and F1 scores. It was seen that DenseNet achieved an accuracy of 97.02%,whereas Xception exhibited an accuracy of 82.1%. The results indicate that DenseNet is more acceptable for applications that require high precision, while Xception may be suited for devices with limited resources.Future studies may work on hybrid models, larger datasets, and strategies to improve the scalability.

Keywords: Yoga, Densenet, Xception, Transfer Learning, Image Augmentation

INTRODUCTION

Yoga is an ancient spiritual discipline that helps to coordinate the body and mind. It has gained significant attention in recent years. Yoga not only offers physical, but mental and emotional well-being as well, thereby it helps in improving the quality of life. Nevertheless, practising yoga the right way can be difficult, particularly so for beginners. With how fast-paced life is, many prefer taking online classes or use pre-recorded videos to learn and practice yoga. Even so, novice practitioners find themselves in a dilemma in validating their posture. Just as how beneficial yoga is , it can be equally dangerous if it is not done right. Under such resource-constrained circumstances, the use of a trained CNN algorithm can help in safer practice (Kishore,2022) (Bahukhandi,2021).

Recent advancements in pre-trained deep learning architectures have transfigured image classification. CNNs provide accurate feature extraction by automatically learning hierarchical features from the inputs. Added advantages such as robustness against variability, higher accuracy and its ability to provide real time feedback makes it an efficient architecture.

This study aims to compare DenseNet 121 and Xception architectures to find an optimal model best suited to mitigate the problem at hand. DenseNet thrives at learning fine grained features, and effectively minimizes parameter use by virtue of its densely connected layers. Xception on the other hand, utilizes depth-wise separable convolutions to minimize computational complexity while maintaining high accuracy.The dataset used in this study consists of five basic yoga classes : downdog, tree, goddess, plank, and warrior2. Transfer learning was used to strengthen the pre-trained models as feature extractors and fine tune it for the task of classification of poses.

LITERATURE REVIEW

The paper “Region-based Network for Yoga Pose Estimation with Discriminative Fine-Tuning Optimization”, combined Region-based Convolutional Neural Networks (RCNN) and Convolutional Neural Networks (CNN) to recognize 45 different yoga poses. The study employed a pre-trained RCNN architecture to identify key joint points and a CNN to classify yoga poses.The model was trained with the Yoga-82 dataset which comprises a total of 11,000 images and achieved an accuracy of 90.5%. The paper addressed the issues that arise due to overlapping poses and multi-person scenarios. However, DenseNet and Xception are more advanced architectures that produce more favourable results. Complex pose classification is made possible by the enhanced feature extraction provided by DenseNet's densely connected layers. Real-time applications can benefit from Xception's depthwise separable convolutions. Model accuracy can be increased by utilising such structures.(Gite,2023)

The paper "Pose Perfect-Identification and Correction of Yoga Poses Using CNN" used Convolutional Neural Networks (CNNs) for recognizing and correcting yoga poses. Inputs considered included images, webcam and videos for classifying the poses. OpenCV was used for video frame extraction and preprocessing.The layers of the CNN extracts the relevant features from the yoga poses and reduces spatial dimensions in order to prevent overload. Model included a Relu activation function to introduce non-linearity. The model was evaluated to have a 90.5% accuracy. Xception provides a superior feature extraction and better computational efficiency.(Madhavi,2024)

The study titled "Estimation of Yoga Postures Using Machine Learning Techniques" compares the different pose estimation architectures such as EpipolarPose, OpenPose, PoseNet, and MediaPipe to classify five yoga postures.Pose estimation architecture extract the key points from the input for classification. The coordinates and angles of each class are measured and used for categorizing poses. MediaPipe achieved the highest accuracy of 90.9%. This straightforward approach can cause errors due to the different possible perspectives of a person which leads to incorrect key point identification. The DenseNet and Xception Architectures do not rely solely on key point detection but also body proportions, lighting conditions and depth.(Kishore,2022).

OBJECTIVE

The study aims to :

1. Find the model better suited for the task of yoga pose estimation by considering quantitative measures like accuracy, recall,precision and F1 score, thereby evaluating the performance of both architectures .
2. To improve the accuracy and dependability of the results by adopting techniques like transfer learning, image augmentation,, and tackling challenges like that of class imbalance.

METHODOLOGY

The methodology used includes data augmentation, transfer learning, and fine-tuning modules to classify yoga poses.the trained models are evaluated and validated. Final results are compared in the end.

HANDLING CLASS IMBALANCE

The dataset is split into 5 classes: downdog, plank, tree, goddess and warrior2. It was observed that each class contained a different number of images. This leads to an imbalance in data, which can introduce a bias towards classes with the majority number of images. The dataset is balanced with random sampling. Large classes are undersampled to match the number of smaller classes.

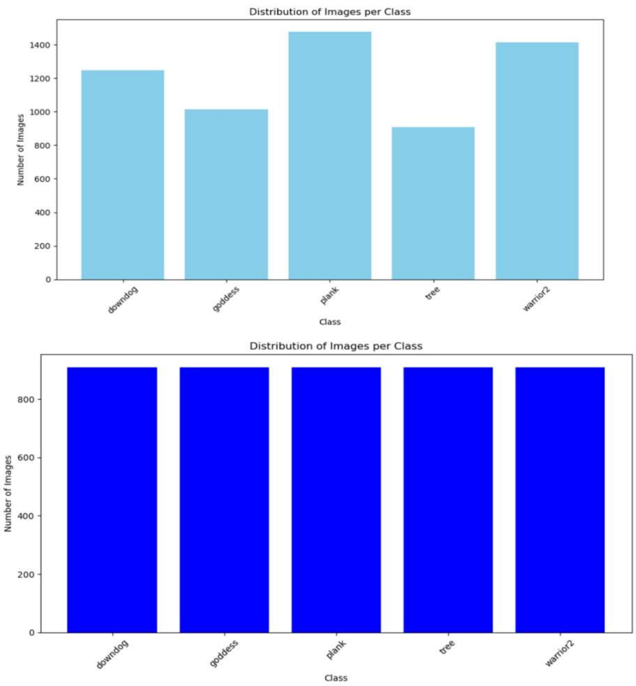


Fig.1: Graphical representation of class imbalance

DATA PREPROCESSING

The dataset which is categorized into distinct classes is preprocessed before it is used for model training. The following data augmentation techniques were used:

1. Rotation: Randomly rotating images to introduce variability in the orientation of the dataset.
2. Width and Height Shifting: Adjusting images on the xy axis.
3. Shear: Applying shear transformations for different perspectives.
4. Zoom: Randomly zooming in on images to enhance detail.
5. Horizontal Flipping: Mirroring images for extra training examples.

The alterations are made to the dataset with an aim to introduce diversity and improve the model's capability to classify images. For the test dataset, only normalization was performed, resizing pixel values to a range of 0 to 1 to maintain consistency during evaluation

DATA LOADING

DenseNet 121

A batch generator was employed to organize the pre-processed images. The training and testing directories were structured into subfolders corresponding to class labels. To ensure compatibility with the model, the images were resized to a fixed dimension of 224×224 pixels. The batch size was set to 32 to balance memory usage and computational efficiency.

Xception

A batch generator was employed to organize the pre-processed images. The training and testing directories were structured into subfolders corresponding to class labels. The images were resized to a fixed dimension of 299×299 pixels to ensure compatibility with the model.

MODEL ARCHITECTURE

DenseNet 121

Pre-trained DenseNet 121 was chosen as the base for feature extraction , using transfer learning to make use of its previously learned weights from ImageNet. The components of the architecture include:

Frozen Base Layers: To preserve the learned features ,all layers of the model were initially frozen.

Global Average Pooling Layer : minimizes the spatial dimensions prior to classification.

Dense Layer: For improved feature learning, a fully linked layer of 1024 units and ReLU activation was introduced.

Softmax Output Layer : The final layer used for multi-class classification.

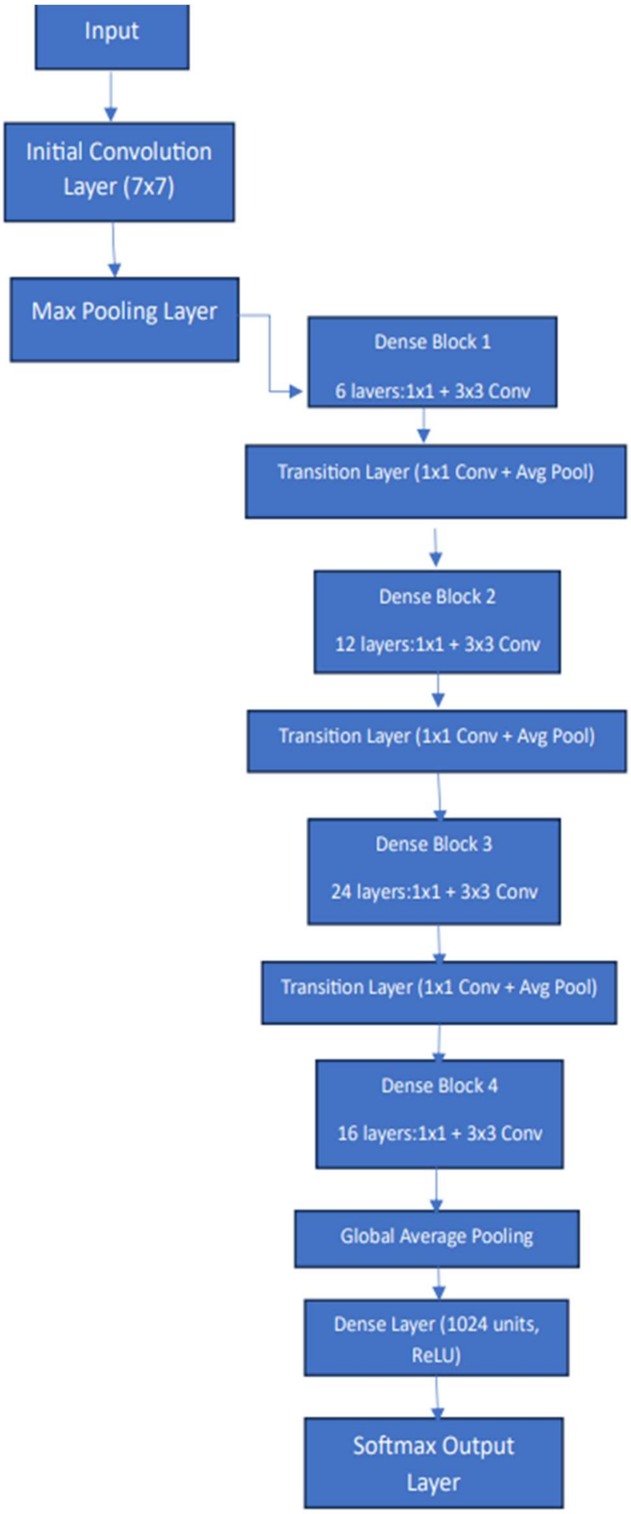


Fig.2:DenseNet121 Architecture

Xception

Utilizing its depth-wise separable convolutions, a pre-trained Xception model was chosen as the foundation for feature extraction. The model's components were :

Entry, Middle and Exit Flow : prioritized separable convolutions and residual connections for processing efficiency.

Activation Functions: A softmax layer was applied at the output to aid in multi-class classification while ReLu was applied in hidden layers to enable non-linearity.

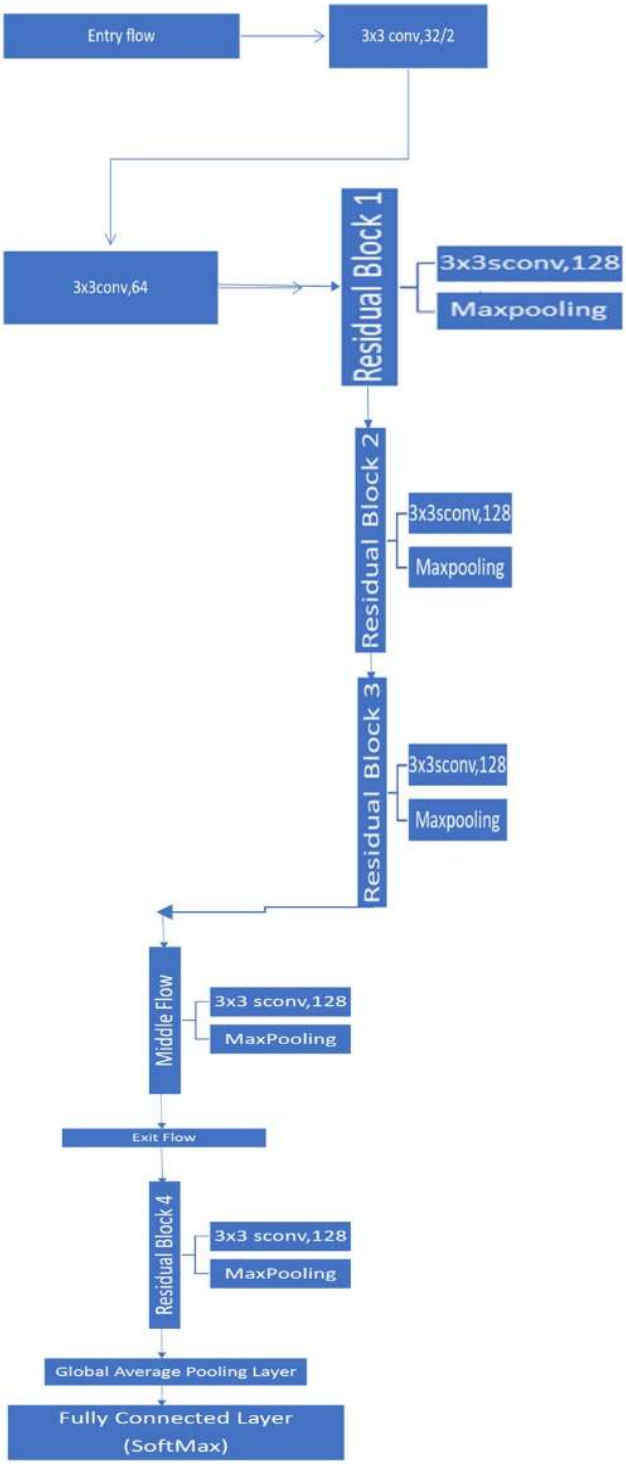


Fig.3: Xception Architecture

MODEL TRAINING

Training was conducted in two distinct phases: Initial Training and Fine-Tuning.

DenseNet121:

Initial Training: Initially the base layers were frozen. Only the newly added layers were trained for 15 epochs using the Adam optimizer and categorical cross-entropy loss function. Validation data was employed to monitor performance metrics.

Fine-Tuning: The top 50 layers of DenseNet121 were unfrozen, allowing them to be retrained for an additional 15 epochs with a reduced learning rate.

```
Epoch 1/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 249s 6s/step - accuracy: 0.8768 - loss: 0.3212 - val_accuracy: 0.9170 - val_loss: 0.2757
Epoch 2/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 235s 7s/step - accuracy: 0.9244 - loss: 0.2214 - val_accuracy: 0.9426 - val_loss: 0.2088
Epoch 3/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 235s 7s/step - accuracy: 0.9450 - loss: 0.1843 - val_accuracy: 0.9511 - val_loss: 0.1717
Epoch 4/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 219s 6s/step - accuracy: 0.9244 - loss: 0.1958 - val_accuracy: 0.9426 - val_loss: 0.1801
Epoch 5/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 216s 6s/step - accuracy: 0.9595 - loss: 0.1531 - val_accuracy: 0.9404 - val_loss: 0.1741
Epoch 6/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 219s 6s/step - accuracy: 0.9502 - loss: 0.1340 - val_accuracy: 0.9617 - val_loss: 0.1544
Epoch 7/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 208s 6s/step - accuracy: 0.9658 - loss: 0.0894 - val_accuracy: 0.9638 - val_loss: 0.1605
Epoch 8/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 227s 7s/step - accuracy: 0.9644 - loss: 0.1121 - val_accuracy: 0.9574 - val_loss: 0.1530
Epoch 9/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 269s 8s/step - accuracy: 0.9782 - loss: 0.0735 - val_accuracy: 0.9617 - val_loss: 0.1693
Epoch 10/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 264s 7s/step - accuracy: 0.9744 - loss: 0.0822 - val_accuracy: 0.9638 - val_loss: 0.1607
Epoch 11/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 242s 7s/step - accuracy: 0.9659 - loss: 0.0849 - val_accuracy: 0.9596 - val_loss: 0.1603
Epoch 12/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 219s 6s/step - accuracy: 0.9821 - loss: 0.0744 - val_accuracy: 0.9617 - val_loss: 0.1483
Epoch 13/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 210s 6s/step - accuracy: 0.9846 - loss: 0.0647 - val_accuracy: 0.9681 - val_loss: 0.1420
Epoch 14/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 183s 5s/step - accuracy: 0.9759 - loss: 0.0817 - val_accuracy: 0.9660 - val_loss: 0.1354
Epoch 15/15
34/34 ━━━━━━━━━━━━━━━━━━━━ 180s 5s/step - accuracy: 0.9859 - loss: 0.0617 - val_accuracy: 0.9702 - val_loss: 0.1435
```

Fig.4: DenseNet121training

Xception:

Initial Training: The model is trained using the augmented dataset for 15 epochs with a batch size of 32. In order to reduce bias, the Adam optimizer was used with an initial learning rate of 0.001. A categorical cross-entropy loss function was employed for classification. Early stopping was implemented to prevent overfitting.

Fine-Tuning: Layers are frozen and then unfrozen as the training progresses. Learning rates are adjusted in order to update weights and preserve learned features. The batch size is also adjusted to improve classification accuracy of the model.

```
142/142 ━━━━━━━━━━━━━━━━━━━━ 685s 5s/step - accuracy: 0.2655 - loss: 1.5943
Epoch 2/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 673s 5s/step - accuracy: 0.5554 - loss: 1.3604
Epoch 3/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 673s 5s/step - accuracy: 0.6467 - loss: 1.2037
Epoch 4/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 673s 5s/step - accuracy: 0.7049 - loss: 1.0831
Epoch 5/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 2583s 18s/step - accuracy: 0.7220 - loss: 0.9945
Epoch 6/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 673s 5s/step - accuracy: 0.7461 - loss: 0.9278
Epoch 7/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 1683s 12s/step - accuracy: 0.7610 - loss: 0.8661
Epoch 8/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 686s 5s/step - accuracy: 0.7575 - loss: 0.8388
Epoch 9/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 679s 5s/step - accuracy: 0.7742 - loss: 0.7907
Epoch 10/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 683s 5s/step - accuracy: 0.7863 - loss: 0.7595
Epoch 11/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 466s 3s/step - accuracy: 0.7902 - loss: 0.7327
Epoch 12/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 556s 4s/step - accuracy: 0.7894 - loss: 0.7100
Epoch 13/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 564s 4s/step - accuracy: 0.8062 - loss: 0.6724
Epoch 14/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 3056s 22s/step - accuracy: 0.8128 - loss: 0.6693
Epoch 15/15
142/142 ━━━━━━━━━━━━━━━━━━━━ 689s 5s/step - accuracy: 0.8212 - loss: 0.6265
```

Fig.5: Xception training

MODEL EVALUATION

The performance of both models were evaluated using the test dataset. The metrics evaluated are:

1. Accuracy: The overall accuracy of predictions.
2. F1 Score : Checks the model's performance for each class individually rather than the overall performance. It combines precision and recall.
3. Recall: The model's ability to identify positive instances.

METRIC	DenseNet121	Xception
ACCURACY	97.02	82.02
F1 SCORE	97.03	82.06
RECALL	97.02	82.11
EPOCHS	15	15
TRAINING TIME	2507.73 seconds	15021.66 seconds

Table.1:Performance Metrics

VISUALIZATION

Accuracy and loss plots for both training and validation datasets are generated. These plots visually represent the performance of both the models during training.

DenseNet121

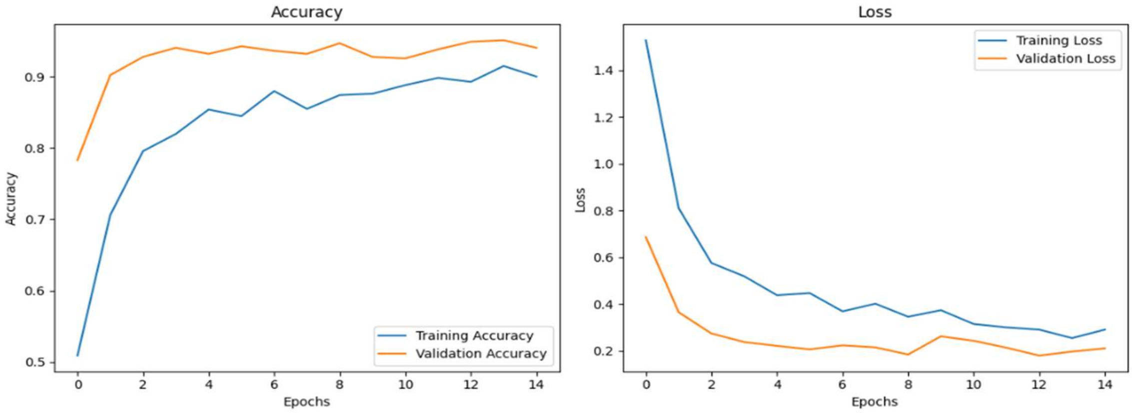


Fig.6: Accuracy loss plot of DenseNet121 Architecture

Xception

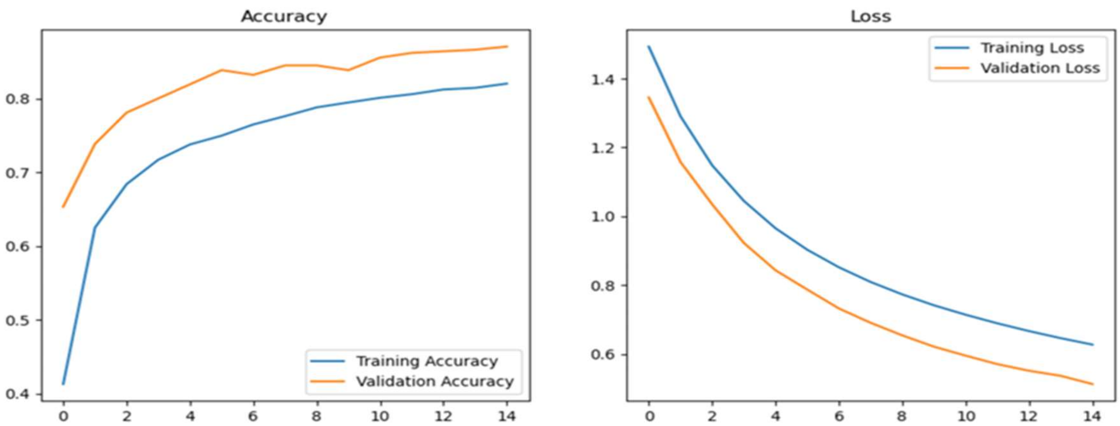
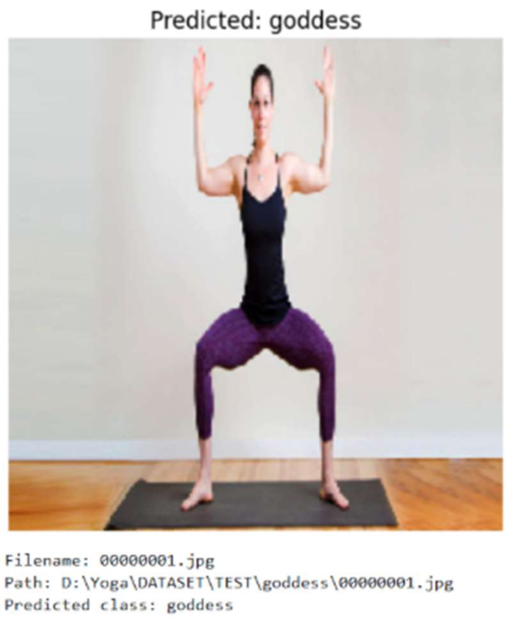


Fig.7: Accuracy loss plot of Xception Architecture

RANDOM IMAGE CLASSIFICATION

Random image classification is a common step in machine learning which showcases the model's ability to classify images.Random images were selected from the dataset and inputted into both DenseNet and Xception. Both models identified the classes of the images as shown in Fig.8. This proves that these architectures can be integrated in real-life applications.

DenseNet121:



Xception:

Fig.8:Comparison of DenseNet121 and Xception Random Image Classification

RESULTS

For comparing the two architectures the accuracy, recall, and F1 score were evaluated. DenseNet121 achieved an accuracy of 97.02%, F1 score of 97.03%, and a recall of 97.02%. Meanwhile, Xception had an accuracy of 82.02%, an F1 score of 82.06%, and a recall of 82.11%. These results confirm that DenseNet121 is the superior architecture for yoga pose estimation.

CONCLUSION

The study compares the performance of both DenseNet121 and Xception for classifying yoga poses with metrics like accuracy, recall and F1 score. While Xception is known to be a more complicated architecture, it underperformed with an accuracy of 82.02%. There is a scope for improvement with further fine-tuning. DenseNet121 achieved an accuracy of 97.06% proving itself as an effective image classifier. Including more yoga poses for classification will improve the model’s capability to identify yoga poses. There is also a future possibility of including real-time data and using lightweight versions of the DenseNet121 model to make it more accessible to multiple devices, which can be used in real-life applications.

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CRYPTOGRAPHIC LEDGER TECHNOLOGY FOR SESSION-BASED SECURITY FRAMEWORK IN IOT DEVICES

Dhanya G S
Assistant Professor,
Department of Computer Science,
Naipunnya Institute of Management and Information Technology,
Calicut University, Kerala, India.

ABSTRACT

The network of billions of gadgets that makes up the Internet of Things (IoT) offers an attacker the chance to significantly alter the gadget. It can be described as the manner of connecting objects or devices through the net so as to satisfy a selected purpose. This ordinarily manifests as statistics-transmitting and -receiving gadgets. An attacker can obtain the keys or safety parameters contained within an IoT device through breaking into the hardware layer. With the stolen protection parameters, the attacker can set up a virtual or duplicate IoT tool. Secure consumer records can be retrieved from the server or community that the IoT tool is connected to, and the duplicate device can upload fictitious information to the server. This venture's aim is to provide stable information transmission that is session-primarily based and degree. Setting up a permission-primarily based blockchain and hashing the data that various IoT gadgets are sharing a good way to permit secure statistics transfer among IoT gadgets and the cloud as well as between IoT devices. We advocate a brand-new cryptographic ledger-based totally framework for IoT device verbal exchange and statistics alternate on this utility. We intend to apply Hyper Ledger Fabric to deploy the framework prototype and check its functionality.

Keywords: *Internet of Things (IoT), Cryptographic Ledger, Session-Based Security, Blockchain, Hyperledger Fabric, Secure Data Transmission*

INTRODUCTION

This article covers the design and application of security protocol for IoT structures. The user sends a request for registration to the authority device. The authority node will approve the request if it is valid, by issuing a certificate which is digital along with multiple keys, which is later stored in the cloud database. The user will be permitted to download the certificate and keys based on the status. Followed by this registration, the user sends a request for control to the authority device. The admin will grant permission to the user for accessing the IoT system after checking the sent certificate with the stored certificate.

INTERNET OF THINGS (IOT)

In addition to reducing the need for human intervention, the Internet of Things (IOT) makes it possible to understand or control items from far away on the existing network infrastructure. It opens the possibilities for more direct integration of the physical world in a computer-based system, which will increase efficiency, accuracy and economic benefits. When the sensors and actuators are added to the Internet of Things, the technology becomes an example of the broader class of cyber-physical systems, including smart cities, smart grids, virtual power plants, smart homes and intelligent transportation.

Micro-Electromachanical System (MEMS), Microservis, Wireless Technologies, and Internet have all come together to create internet of things. The separation of the Information Technology (IT) and Operational Technologies (OT) has been assisted by convergence, which has made it possible to evaluate unarmed machine-related data for insight that will give rise to progress. Accurate agriculture, building management, healthcare, energy and transport are some industries that now use IOT technology in a practical way.

CLOUD AND RASPBERRY Pi

As a service is another backend cloud storage, which eliminates the need to run the distributed database and provides smooth scalability. The service is accelerated and well managed. Server's primary capabilities include storing a large amount of data centrally and using the Internet by using restricted users only by connecting to the same area to various geographical locations. The Raspberry Pi Foundation created a raspberry pie line of credit card-shaped single-shaped single-size. A raspberry pi can be configured to act as a private cloud server and to store data for real -time signal applications. Raspberry Pi is an economical microprocessor in which cloud computing infrastructure can be attained using cloud platforms.

LITERATURE REVIEW

The content is first written and saved as a separate file before formatting the article. The graphic and text file are kept separately until the text has been formatted. Avoid using hard tabs, pagination, numbering text heads (the template will do it) and limit the usage of hard returns to paragraph closure. The content and organizational editing should be completed before formatting.

Chun Chen [1] defined distributed access control module as wireless sensor networks that permits the network to approve and permit the user attain the advantages for in-network data access. Earlier, the focus was on designing such access control modules for WSNs, without paying much consideration to verified user's identity privacy by the network for accessing data. Generally, a WSN is not needed to check user’s identity to request the data.

In this article, the focus is on the design, implementation, and a novel method is used for evaluation procedure, that confirm distributed privacy-preserving access control. Those who have same access are organized into the similar group network owner. On behalf of his group, the user signs a query command and the signed query is sent to the sensor node. The signature is confirmed by its recipient without revealing the actual user. We can add the security properties, and distributed privacy- preserving access control in sensor networks. Token based approach in single owner multiple user sensor networks is adopted to safe guard user's privacy with central token issuing authority. The work is based on problems with token-reusability.

Namhi Kang [2] defines framework for verification of data in IoT. Data is considered as streams with security punctuations, that are thoroughly observed before the data is send to its user. It does not provide details regarding the security therefore Message Authentication Code (MAC), is a good option for such solution. However, some restriction is set to the user, which is sometime unsuitable in many applications. It does not report security issue rules duplication and uniformity among various devices. The Key distribution system can withstand replay attacks, man-in-the-middle attacks.

In this paper, Angle and Madnick [3] explains the use of tokens for giving way to service access. During the initial provision of a service, the token is delivered for a client, consisting of URL, user/object ID, creation time, period of subscription, service ID, and access permissions list. A Secured Certificate-based authentication is not mandatory to create passwords or tokens, in its place, digital certificates are used to answer authentication challenges these days. This paper discusses the design and implementation of security protocol for the IoT and also admin can create a digital certificate and many keys for a valid user by means of Secure Hash Algorithms (SHA). The certificate and keys are downloaded by the user. The user connects with the admin over the digital certificate for the secured authentication of IoT.

Nakamoto [4] explained about The IoT system, that lacks reliability, security, and privacy. In this work, the security protocol is implemented using Secure Hash Algorithms (SHA). The protocol covers not only the integrity of messages but also the authentication of each user by means of an effective authentication mechanism for the IoT atmosphere. Here we try to rectify authorization appeals for constraint devices when the user requests to contact any of the device's data or services. The authorization engine is visible through API and hence most of the IoT devices have access to it. The proposed system is a composite framework built on top of the current technologies. Yet, they go with user device security but it does not discuss machine-to-machine authenticity.

METHODOLOGY

The work focusses on the proposal of a Security Protocol for the IoT and the implementation of the same on the Sensible Things Platform. The Security Protocols will encompass the integrity of the message and the authentication of each user enabling an efficient authentication method. The Sensible Things platform is an open-source platform for generating competent and reckless internet things applications. It provides a common platform for communications between sensors and actuators on a Global Scale and permits a widespread Proliferation of IoT Services. This communication is secure and it provides more effective information for transmission mechanisms.

The Security Protocol involves:

- Registration
- Approval
- Generation of Certificate
- Sharing the Certificate
- Control Request
- Access Control

Registration Request Process: The Registration Request Process is done between the new User and Authority Node (AN). The user sends a request to admin, which involves Username, Mac ID, IP address, Machine name, Date, and Time which will be auto fetched and filled into the registration form and later the request is sent to admin.

Approval: The registration request details are stored in a cloud database for Admin approval. If it is a valid request, then the admin will accept the request otherwise the request is cancelled by the admin.

Generating and Sharing the certificate: The admin will take up the combination of user information such as username, Mac ID, IP address, machine name and is send to SHA. This algorithm creates a ciphertext which is used to produce a digital certificate. The private and public keys are generated by Rivest-Shamir-Adleman algorithm (RSA).

The user has an option of checking his approval status. He can then download the certificate and a private key from the cloud database, if the request is approved by the admin.

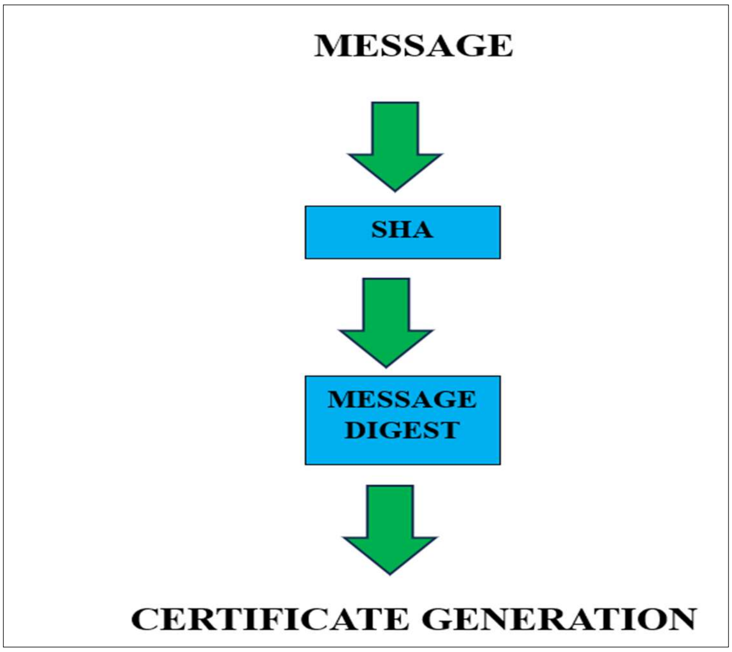

Fig. 1: Generation of Certificate using SHA

Control Request: The user sends a request to the admin along with this certificate. The cloud server will check by comparing the sent certificate and the stored certificate to confirm whether the request is from the same user or not. An OTP will be generated if it matches, encrypted by the public key and is sent to the user. The user, then decrypt this token by a private key and he will send the OTP. If both OTP is the same, then the admin will create a session key and it is shared with the user.

Access Control: The user then sends a request and session key to the IoT system. The user can control the IoT, as long as the session key exists. The request is resent, once the session key is expired

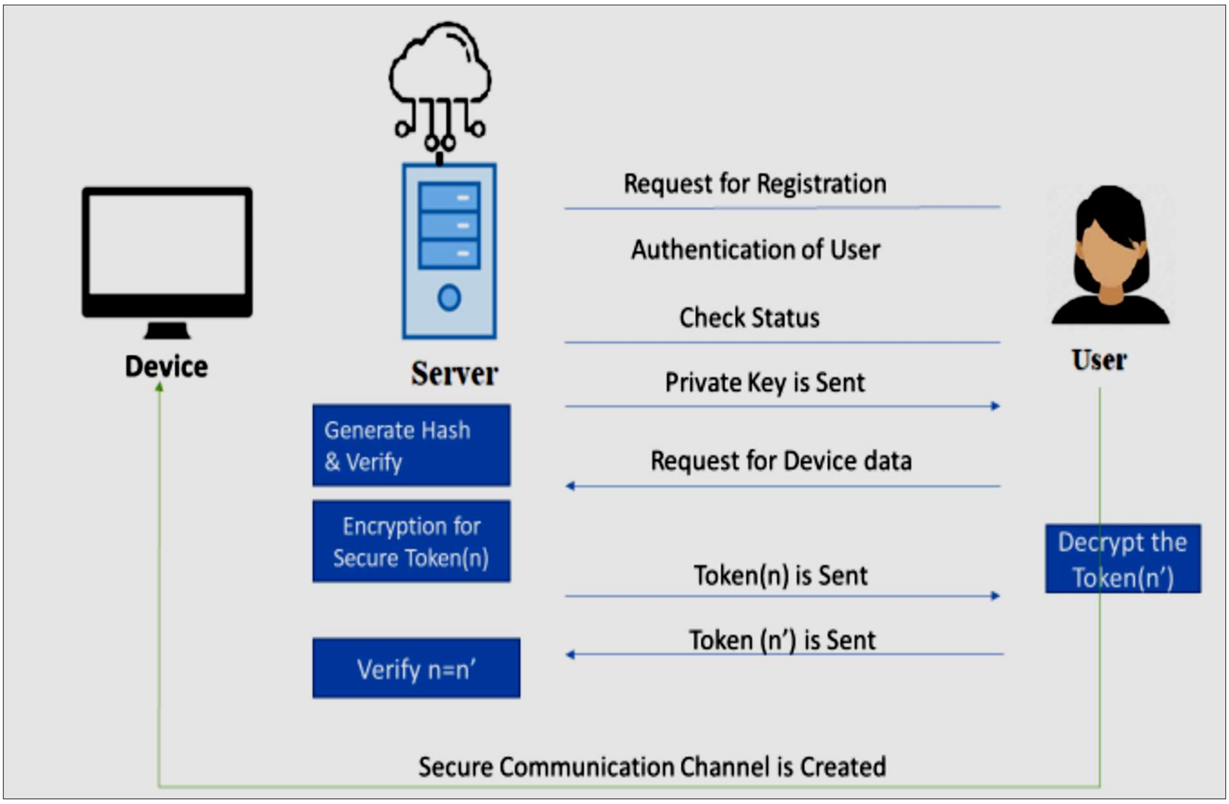

Fig. 2: System Architecture

PROPOSED SYSTEM

The essential part of the secure IoT systems will be IoT devices and the servers, since authentication between the IoT devices and IoT servers are jointly authentic. This article focuses on a protocol that enhances security for the embedded systems or the platforms which enhance for Internet of Things. This article will validate the integrity of the messages and also provides an effective authentication mechanism. In this proposed method, the attacker will not get access to the unutilized authentication keys as it uses the multi-key authentication mechanism, even if the secret key used for ongoing authentication is recovered successfully by the attacker. Dictionary attack is prevented by changing the value of keys over time as it provides session-based communication. The Server will authenticate the user and creates a hash using user credentials which uses– Adler 32, the Hashing Algorithm by promoting reliability faster.

ALGORITHM

a) Logical word operation

$x \cap y$, $x \cup y$, $x \oplus y$, x'

b) X + Y ➔ words X and Y represent integers x and y, where $0 \le x<232$ and $0 \le y<232$. Calculate $z = (x + y) \bmod 232$.

Then $0 \le z<2\ 32$. Convert z to a word, Z, and define Z = X + Y.

c) The circular left shift operation Sn(X), where X is a word and n are an integer with $0 \le n < 32$, is defined by $Sn(X) = (X << n) \vee (X >> 32\text{-}n)$.

$X << n$ ➔ remove the left-most n bits of X and then adjust the result with n zeroes on the right (the result - 32 bits).

$X >> n$ ➔ obtained by removal of the right-most n bits of X and then adjusting the result with n zeroes on the left. Accordingly, Sn(X) is equivalent to a circular shift of X by n positions to the left.

CONCLUSION AND FUTURE SCOPE

The security protocol discussed here for Secured authentication of IoT system is expected to be highly secure, efficient, low cost, simple and session-based information security for IoT devices using cryptographic ledger.

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MASQUERADE ATTACK IDENTIFICATION VIA DDSGA-BASED ANOMALY DETECTION

Anusha Sivanandhan
Assistant Professor,
PG Department of Computer Science,
Naipunnya institute of management and information technology (NIMIT),
Pongam, Thrissur- 680308, Kerala, India
Bibitha Baby
Assistant Professor,
PG Department of Computer Science,
Naipunnya institute of management and information technology (NIMIT),Pongam, Thrissur- 680308, Kerala, India
Neenu Thomas
Assistant Professor,
PG Department of Computer Science,
Naipunnya institute of management and information technology (NIMIT),
Pongam, Thrissur- 680308, Kerala, India
**Corresponding Author's Email:*
anushasivanandhan@gmail.com,bibithacbaby@gmail.com

ABSTRACT

To take advantage of the user services and privileges, a masquerade attacker poses as a legitimate user. The semi- global alignment algorithm (SGA) is one of the most effective and efficient techniques to detect these attacks but it has not yet reached the accuracy and performance required by large scale, multiuser systems. To improve both the effectiveness and the performances of this algorithm, the Data-Driven Semi - Global Alignment, DDSGA approach was proposed. By implementing unique alignment settings for every user, DDSGA enhances the scoring systems from the perspective of security effectiveness. Additionally, by permitting minor adjustments to the low-level representation of the instructions' functionality, it can withstand minor variations in user command sequences. It also adapts to changes in the user behavior by updating the signature of a user according to its current behavior. To optimize the runtime overhead, DDSGA minimizes the alignment overhead and parallelism the detection and the update.

KEYWORDS: legal user, DDSGA approach, user services, SGA, DDSGA algorithm

INTRODUCTION

An attacker who poses as a legal user is known as a masquerader. This individual accomplishes this by either hacking the system that confirms the user's identification or by obtaining the user's login credentials. To put it another way, the masquerader fools the system into believing they are someone else who has access to specific resources. By exploiting a legitimate user's information, they can obtain illegal access to sensitive data or systems. Because the attacker can carry out tasks that should only be feasible for the authorized user, this can result in significant security breaches. The possibility of masquerading highlights how crucial it is to have robust security protocols and efficient authentication procedures in order to safeguard user identities and stop illegal access. Insider masquerading is a legitimate practice.

A legal system user who abuses their rights to get access to many accounts and carry out illegal activities is known as an insider masquerader. An outsider's objective is to exploit every right of a legitimate user (Phyo and Furnell, 2004). There are several ways to carry out this attack, including eavesdropping and packet sniffing, installing software with backdoors or malicious code, spoofing, social engineering, and duplicate or ex-filtration of user passwords. Log files may contain evidence of these attacks that can subsequently be linked to a particular user.

The most advanced method for identifying these assaults in this situation is still log analysis by a host-based IDS. Analysing the target system can reveal attacks that don't leave an audit trail. By gathering information such as login time, location, session duration, CPU time, commands issued, user ID, and IP address, masquerade detection first builds a user profile. Computer infrastructure intrusions are becoming a bigger issue. Masquerading, in which an attacker poses as a genuine user on a computer system, is one of the most destructive intrusions or attacks in the real of computer security. Masquerade attacks typically occur when an intruder obtains a legitimate user password or when a user leaves their workstation unattended without a locking measure in place. Because the attacker looks like a regular user with legitimate authority and privileges, it is challenging to identify this kind of security compromise at the outset. The Data-Driven Semi- Global Alignment (DDSGA) approach, which is presented in this research, enhances the computational performance and detection accuracy of the Enhanced-SGA and HSGAA, which are both based on SGA. The main idea of DDSGA is to consider the best possible alignment between the user's recorded sequences and the sequence of the present session. Once the misaligned areas have been identified, we classify them as abnormal. A number of anomalous locations are very suggestive of a masquerade attack.

In addition to employing lexical matching techniques like string matching and longest common substring searches, DDSGA increases security efficiency by accepting minor sequence modifications. There have been some small adjustments made to the low-level representation of user commands. A command that performs the same functions can be matched for this purpose.

DDSGA assigns unique gap insertion penalties to each user based on their behaviour in order to improve the hit ratio and lower false positive and false negative rates. Additionally, it enhances Enhanced-SGA's alignment scoring mechanism and update phase to accommodate behavioural changes without appreciably lowering the alignment score.

MATERIALS AND METHODS

DDSGA is an enhanced – SGA - based masquerade detection method. It classifies the misalignment areas as anomalous and aligns the user's current session sequence with their prior ones. A masquerade attack is signaled if the percentage of anomalous areas is larger than a dynamic, user dependent threshold. DDSGA has a unique ability to handle small changes in user sequences. These changes can occur in the low-level representation of user commands. This system is divided into three distinct phases: the configuration phase, the detection phase, and the update phase.

In the configuration phase, the system calculates the alignment parameters tailored for each user. These parameters are crucial as they guide both the detection and update phases. Proper alignment ensures that the system can accurately identify and respond to changes. Overall, this structured approach enables DDSGA to function effectively, even when faced with minor variations in user input. The detection phase aligns the user current session to the sig nature sequence. The computational performance of this phase is improved by two approaches namely the Top-Matching Based Overlapping (TMBO) and the parallelized approach. In order to change the system settings during the update phase, DDSGA adds new patterns to the user lexicon list and user signatures.

ALGORITHM

A. The Enhanced-SGA developed by (Coulla ,Szymanski.2008) ,made significant changes to the SGA algorithm. It addressed shortcomings found in the standard Smith-Waterman alignment algorithm from two significant perspectives. The first perspective focuses on the fact that how legitimate users behave may change over time. This change can occur due to a shift in their roles or the introduction of new commands. Because of this, a static user signature may mistakenly identify these lawful variations as security threats. To minimize the occurrence of such false positives, the Enhanced-SGA updates the user signature as new behaviors are detected. This is achieved by utilizing the SGA's ability to find similarities in user actions.

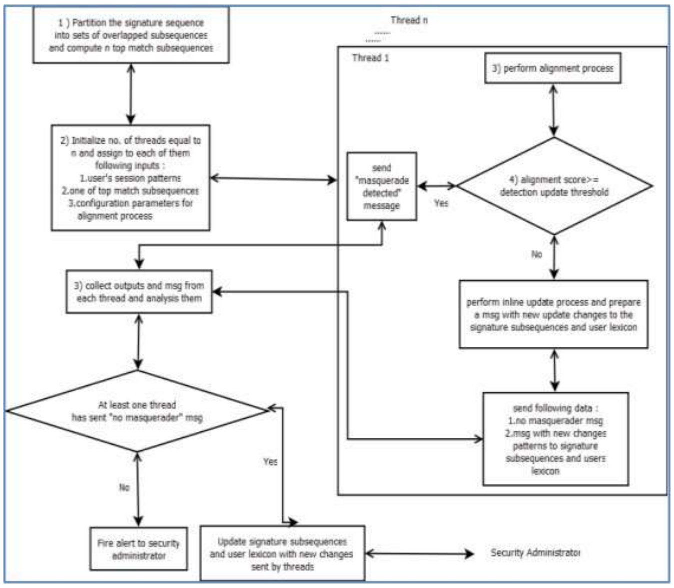
Additionally, the authors presented two grading systems: command grouping and binary scoring. These systems are designed to align scores and balance penalties for gap insertions effectively. The binary grading system is particularly emphasized as it is the most effective. It updates the signature sequence to include new behaviours as well as incorporating the user lexicon, which records new commands used by the user. To enhance security, this method establishes a threshold for each user profile. This ensures that both the updated signature sequences and the user lexicon remain free from any compromised commands potentially linked to masquerade attacks. The threshold plays an essential role in both the detection and updating processes and is constructed based on an analysis of user signatures.

(Schonlau et al.2001),The second perspective addresses the computational challenges associated with the Smith-Waterman algorithm. This algorithm is often too expensive and impractical for use in detecting masquerade attacks, especially in multi-user environments. To tackle this, the Enhanced-SGA employs heuristic orientation that prioritizes user signature components with the highest likelihood of detection success. This approach significantly reduces processing demands while maintaining accuracy in identifying threats. These enhancements were tested against the ocean data set to compare effectiveness with other existing methods.

B. The Data-Driven Semi-Global Alignment approach, known as DDSGA, builds on the Enhanced

- SGA framework. DDSGA aims to detect masquerade attacks by matching the current session of a user with their historical session data. (Smith and Waterman,1981), If the number of identified abnormal areas exceeds a dynamically set threshold, a masquerade attack is indicated. DDSGA is capable of accommodating minor variations in user session data without compromising accuracy. It consists of three phases: configuration, detection, and updating.

During the configuration phase, DDSGA calculates the alignment parameters specific to each user. These parameters guide both detection and updating phases. (Dash et al.2005)In the detection phase, the current session of a user is compared with their signature sequence. The performance of this phase is enhanced through two techniques: Top-Matching based Overlapping (TMBO) and a parallelized processing method. The update phase then extends both the user signatures and the lexicon, integrating new patterns to adjust system parameters. The overall structure and the modules tied to these phases are elaborated upon in the following sections.



RESULTS AND DISCUSSION

In this section, the implementation and architecture of the system are discussed.

IMPLEMENTATION

A website called civic cyber village was created.

User Approval

Figure 5.1 shows the user approval page of the registered users. User approval is performed by admin. users get access to this site only after approved by admin.

Fig 5.1 User approval page

User Home Page

Figure 5.1 shows the user's home page. After getting approval from admin, user can get into the site and can perform various activities. various activities can have performed in this page. user can get into this page by login to the system.

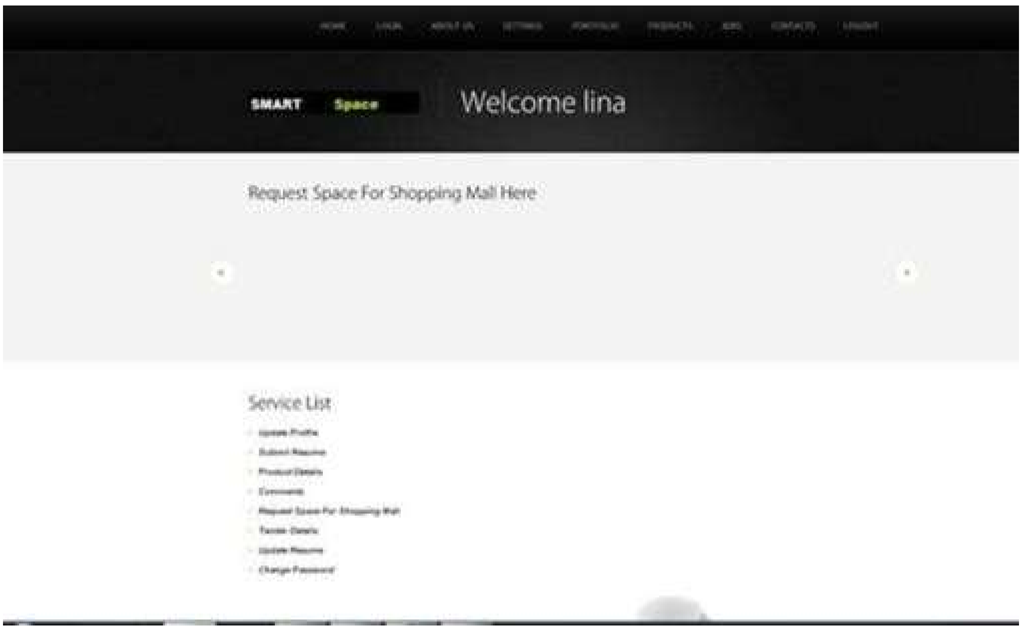


Fig 5.2 user home page

Key Settings

Figure 5.3 shows the key settings. If the user enters the valid secret key, then the user can view their behavioral patterns. And also get the permission to change the mode

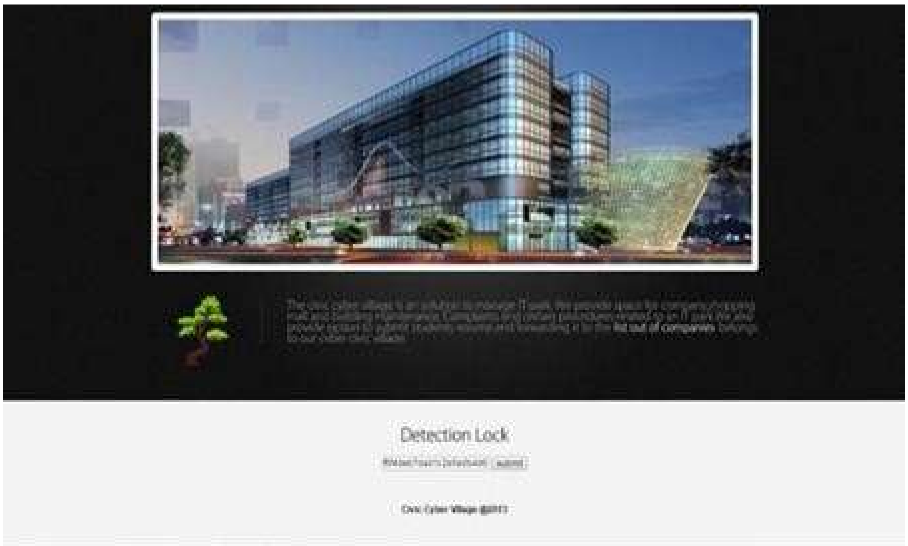


Fig 5.3 key settings page

Mode Settings

Figure 5.4 shows the mode settings page. After entering the valid secret key, users get access to the mode settings page. Here users can choose the mode and can view their behavioral patterns in the decrypted form.

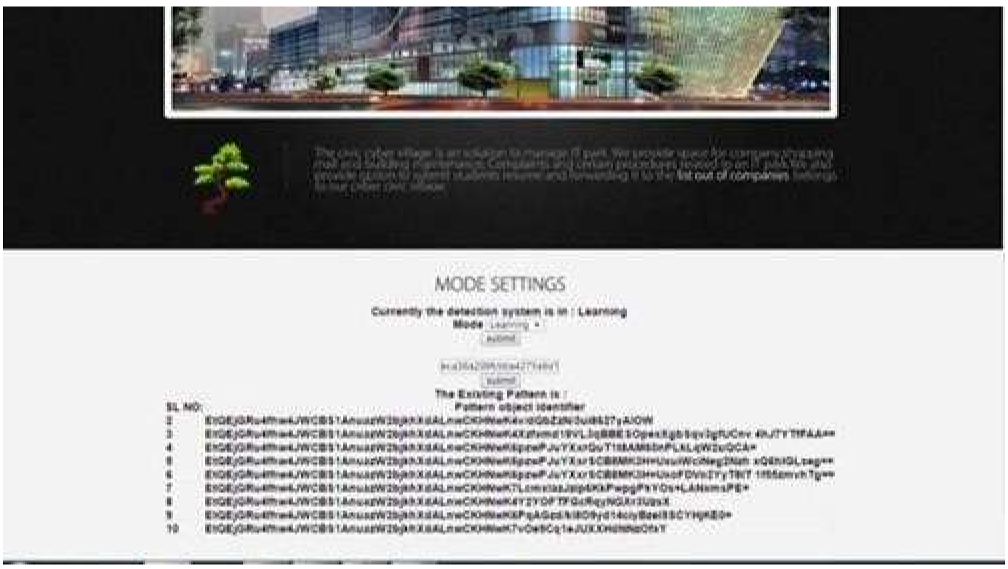
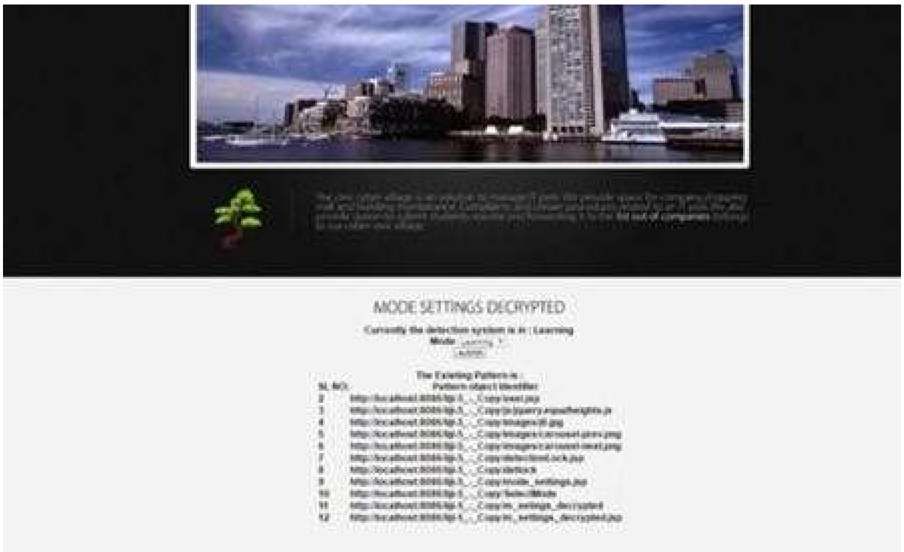


Fig 5.4 mode settings

Mode **Settings Decryption**

Figure 5.5 shows the decrypted versions of the pattern. patterns can be decrypted using decryption key.



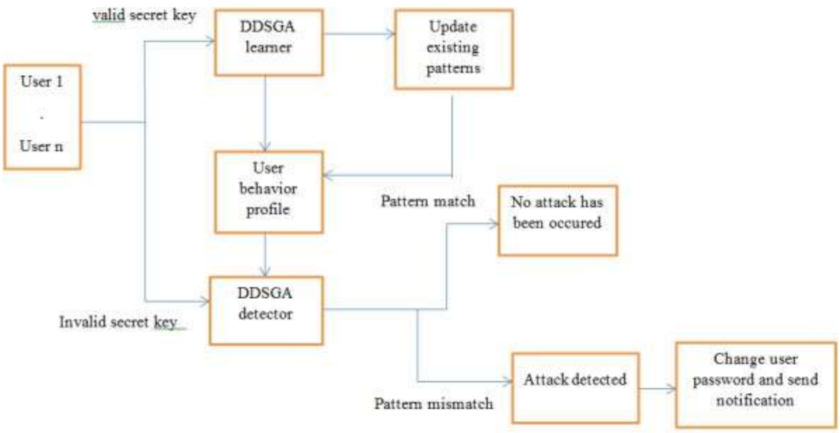


Fig 4.1 system architecture

CONCLUSION

Masquerading is a targeted attack strategy that poses a serious threat to information security. This method allows an attacker to secretly access and control a system with harmful intent. To combat such threats, a model known as the Sequence Alignment-based Audit (SGA) has been developed. This model analyses sequential audit data, which includes both the information that has been checked and information that has simply been observed. Although SGA is useful, it struggles with a low false positive rate. At the same time, it has a high rate of missed alarms, leading to problems with its accuracy. Even in its most recent version, SGA does not perform well enough to be reliable in real-world situations.

Recognizing these shortcomings, the Dynamic Data Sequence Alignment (DDSGA) model was created. This new model places an emphasis on improving security and accuracy. DDSGA achieves better consistency by assigning different parameters to each user. It also introduces a two- tier scoring system designed to reduce changes in how low-level user commands work. This system aligns commands within the same category while keeping the alignment score intact. Importantly, it takes into account how users execute commands and how their behaviours change over time.

The advancements in DDSGA result in significantly lower rates for false positives and missed alarms. It also enhances the detection hit ratio, leading to better overall performance. When comparing results using the SEA dataset, DDSGA consistently outperforms its predecessor, SGA. Additionally, DDSGA employs a Top-Matching Based Overlapping approach. This method reduces the computational load by simplifying the pattern sequence into a smaller set of overlapping subsequence. The system can also carry out detection and update processes at the same time, maintaining accuracy without any loss of effectiveness.

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DEEP LEARNING FOR EARLY DETECTION AND PREDICTION OF AUTISM SPECTRUM DISORDERS

Soumya M
Research Scholar
Department of Computer Science
Karpagam Academy of Higher Education
Coimbatore-641 021
Dr. N V Chinnasamy
Assistant Professor
Department of Computer Science
Karpagam Academy of Higher Education
Coimbatore-641 021

ABSTRACT

The complicated neurological condition known as autism spectrum disorder (ASD) is characterized by repetitive behaviors and persistent challenges with social interaction. The results of interventions are greatly improved by early identification of ASD. A type of artificial intelligence called deep learning has shown promise in behavioral analysis, genetic data interpretation, and medical imaging, providing promising pathways for early ASD prediction. This study examines how convolutional neural networks (CNNs) and recurrent neural networks (RNNs), two recent developments in deep learning techniques, are used to detect ASD. It looks into deep learning frameworks' clinical viability as well as datasets and methodology. Challenges including model interpretability, ethical issues, and data scarcity are also covered. The study's conclusion highlights the necessity of cooperation between physicians and AI developers and suggests possible future possibilities.

Keywords: Autism Spectrum Disorder, Deep Learning, Early Detection, Medical Imaging, Behavioral Analysis

INTRODUCTION

According to current CDC estimates, 1 in 54 children globally suffer from autism spectrum disorder (ASD). It is a neurodevelopmental condition characterized by limited and repetitive actions as well as deficiencies in social communication and interaction. Behavioral tests, which are labor-intensive and subjective, are usually used to diagnose ASD.The way the illness manifests itself varies greatly; some people have severe difficulties in their daily lives, while others have remarkable skills in particular areas. This variability frequently makes prompt and precise diagnosis more difficult. Some children, for instance, may exhibit obvious symptoms like delayed speech or lack of eye contact, whereas others may have subtle characteristics that are not apparent until later in life. Because of this variety, diagnostic techniques must be both accurate and flexible enough to accommodate the diverse range of ASD symptoms.

ASD is impacted by a mix of neurological, environmental, and genetic variables in addition to its varied clinical presentation. In addition to en- vironmental factors including exposure to specific drugs or illnesses during pregnancy, studies have linked hundreds of genes to ASD. Research on brain imaging has also shown clear structural and functional changes in the brains of people with ASD, especially in areas linked to communication and social cognition. These results highlight the intricacy of ASD and the demand for novel diagnostic techniques.

For those with ASD, early identification and intervention can greatly enhance their developmental trajectories and quality of life. According to research, cognitive, social, and communication abilities can significantly improve with treatments started during the first three years of life. Traditional diagnostic techniques, however, frequently miss crucial early intervention windows by delaying diagnosis until symptoms become obvious. These delays are made worse by the use of arbitrary metrics and the lack of qualified experts in some areas. For example, access to professionals qualified to diagnose ASD is limited in many rural or poor locations, which causes additional delays in recognizing and assisting those who are impacted. This discrepancy emphasizes how critical it is to have resources that enable early and easily accessible diagnosis, irrespective of location. Additionally, early detection may help lessen the emotional and financial strain that ASD causes in the long run. In order to manage the disease, families frequently have to deal with high medical, educational, and treatment expenses. Diagnostic developments can lessen these difficulties and enhance outcomes for people with ASD and their families by facilitating earlier intervention.

Predictive analytics, picture identification, and tailored medicine have all been made possible by artificial intelligence (AI), especially deep learning. Deep learning models are extremely useful in identifying disorders like ASD because they can analyze big datasets and find minute trends. For example, recurrent neural networks (RNNs) are good at processing sequential data, such as speech and eye-tracking patterns, whereas convolutional neural networks (CNNs) are good at evaluating brain imaging data. In addition to improving diagnostic precision, the use of AI in healthcare has sped up decision-making, decreased expenses, and improved patient outcomes. AI algorithms, for instance, have been used to identify cancers in medical imaging, forecast the development of diseases like Alzheimer's, and suggest individualized treatment regimens for cancer patients. These achievements in other fields highlight AI's potential to help with the particular difficulties associated with diagnosing ASD. AI has a number of significant advantages over conventional approaches in the setting of ASD[1].. First of all, it makes it possible to analyze multimodal data by fusing knowledge from genetics, neuroimaging, and behavioral measurements. The multidimensional character of ASD makes this holistic approach especially appropriate. Second, the large-scale deployment of AI-driven tools can lower diagnostic service discrepancies and make them available to a larger audience. Lastly, the objectivity of AI algorithms ensures more consistent and dependable results by reducing the bias and variability inherent in human judgment.

This paper aims to:

- Reviewing recent deep learning applications in ASD identification.
- Draw attention to problems and offer fixes for better detection techniques.
- Encourage cooperation between medical practitioners and AI researchers.

The paper aims to close the gap between theoretical research and practical implementation by investigating state-of-the-art developments, opening the door to an early and precise diagnosis of ASD. From the creation of innovative algorithms to their use in actual healthcare settings, the scope of this research includes both technical and practical elements. By discussing these aspects, the paper hopes to advance a more thorough comprehension of how deep learning can change the diagnostic landscape for ASD. The goals are in line with the more general ones of developing precision medicine and encouraging fair access to medical treatment. The study highlights the potential of deep learning to enhance individual results and generate systemic benefits, such lessening the overall strain on healthcare systems, by emphasizing early identification. The study's ultimate goal is to spur more creativity and cooperation in this crucial field so that people with ASD can get the help they require to succeed.

LITERATURE REVIEW

Existing Diagnostic Methods and Their Limitations

Standardized instruments such as the Autism Diagnostic Observation Schedule (ADOS) and the Autism Diagnostic Interview Revised (ADIR) are used in current ASD diagnostic procedures. Despite their effectiveness, these approaches are resource-intensive, subjective, and vulnerable to interrater variability. Additionally, they frequently take a long time to complete and require administrators to undergo intensive training.

Parental accounts and clinical observations are key components of behavioral assessments, which constitute the foundation for diagnosing ASD. These methods are instructive, but they lack the objectivity required for widespread early identification.

Overview of Deep Learning Models in Healthcare

Medical imaging, genetic data, and behavioral patterns have all been successfully analyzed by deep learning using models like CNNs and RNNs. RNNs are excellent at tasks involving sequential data, including evaluating speech or movement patterns, while CNNs have been essential in medical imaging, accurately detecting abnormalities. Deep learning has fueled advancements in the medical field, from patient monitoring to tumor diagnosis. These achievements demonstrate how well it can treat intricate neurodevelopmental conditions like ASD.

Applications of AI in Neurodevelopmental Disorders

AI has been employed to:

- Examine brain imaging data to find structural variations in individuals with ASD: Research has shown that people with ASD exhibit unique patterns in cortical thickness and connectivity.
- Analyze eye tracking data to find unusual gaze patterns, which are indicative of ASD:In terms of early screening, this noninvasive technique has showed potential.
- Analyze genomic data to find mutations linked to ASD. Certain genetic markers have been discovered thanks to genomics advancements, and deep learning has helped in their categorization and analysis. These uses highlight AI's ability to

support conventional techniques by providing scalable and objective solutions for diagnosing ASD.

METHODOLOGY

The collection of data, preprocessing, model selection, and experimental setting are all important components of this study's approach. These stages were created to guarantee thorough and exacting assessment of deep learn- ing models used for autism spectrum disorder (ASD) early diagnosis and prediction.

DATA COLLECTION

The caliber and variety of the data that deep learning models are trained on have a significant impact on their performance. Thus, a range of publicly accessible ASD-related datasets from several fields, like as neuroimaging, behavioral assessments, eye tracking, speech, and genetic data, were used in this work. The datasets were selected to reflect the complex interplay of behavioral, environmental, and neurobiological aspects that contribute to ASD[2].

Dataset: This study made use of several publicly accessible datasets to guarantee a thorough and varied examination of facts pertaining to ASD:

1. Autism Brain Imaging Data Exchange (ABIDE):
   - A wealth of neuroimaging information, including structural and functional MRI scans from hundreds of people with ASD and typi- cally developing controls, is available in the ABIDE dataset. The dataset's cross-site distribution allows for the investigation of ASD over a broad spectrum of clinical and demographic characteristics.
   - By identifying the anatomical and functional brain defects linked to ASD, the ABIDE dataset provides information about how deep learning models may distinguish aspects of ASD from those of normally developing brains.
2. Autism Diagnostic Observation Schedule (ADOS):
   - Standardized observation techniques for social communication, repetitive behaviors, and language development are among the behavioral assessment measures that make up the ADOS dataset. In clinical settings, these tests are frequently used to identify ASD.
   - By providing important markers of ASD, behavioral data from ADOS aids deep learning models in discovering intricate patterns linked to the disorder's

characteristic social and communicative impairments.

3. Eye Tracking Data:

- Detailed recordings of gaze patterns, including fixation periods, saccadic eye movements, and gaze transitions between objects or faces, are provided by eyetracking data. These patterns are essential for comprehending social interaction and attention, two skills that are frequently compromised in people with ASD.
- Using deep learning to analyze eyetracking data enables the detection of visual attentional abnormalities that could be early warning signs of ASD.

4. Vocal and Acoustic Data:

- Audio recordings of speech from both ordinarily developing children and people with ASD are included in the category of acoustic data. Pitch, speech pace, voice modulation, and pause duration are among the features that may be gleaned from these recordings and can indicate abnormal speech patterns that are indicative of ASD.
- These vocal characteristics are essential for identifying verbal communication abnormalities that may help with the early diagnosis of ASD.

5. Genomic Data:

- Gene expression patterns, single nucleotide polymorphisms (SNPs), and other genetic markers linked to ASD are examples of genomic data. These findings may shed light on the disorder's genetic foundations.
- The goal is to find hereditary variables and biomarkers for early ASD prediction by utilizing genomic data, even though the genetic component of ASD is complicated and little understood.

DATA PREPROCESSING

To guarantee the quality and consistency of inputs and to prepare raw data for efficient model training, data preprocessing is crucial. Due to the unique needs and difficulties of each dataset type, the preparation procedures were customized for each. The preprocessing methods used are listed below:

1. Neuroimaging Data:

- Motion Correction: In order to reduce the influence of head movements during scans, motion correction methods, such as realignment, were employed. This is because functional and structural MRI data frequently suffer from motion artifacts[3].

- Skull Stripping: To extract the brain regions of interest from MRI scans, non-brain tissue was removed using techniques like FSL and BET.
- Spatial Normalization: To take into consideration individual differences in brain size and form, MRI data were normalized to a standard brain template. Methods such as nonlinear registration were used for this.
- Intensity Standardization: In order to prevent fluctuation brought on by variations in scanners, intensity normalization made guaranteed that MRI intensities were constant throughout scans.
- Data Augmentation: To artificially increase the dataset's size and strengthen the model's resistance to changes in the data, augmentation techniques such as random rotations, flips, and intensity alterations were used.

2. Behavioral Data (ADOS):

- Normalization: To guarantee uniformity and comparability across various samples, behavioral measures, including social communication scores, were standardized. To normalize the scales, Zscores were computed for each of the important features.
- Feature Extraction: To make sure that only pertinent features were included in the model, key behavioral indicators (such as gaze direction and response latency) were retrieved using statistical and machine learning techniques.

3. EyeTracking Data:

- Data cleaning: Blinks and missing data points are common examples of noise in eyetracking data. These were eliminated using imputation or interpolation methods.
- Fixation time, saccadic velocity, and gaze transitions were among the features that were retrieved. Tobii Pro and other specialist tools were used to quantify eyetracking properties.
- Analysis of Gaze Behavior: Temporal trends in gaze behavior were investigated, with an emphasis on how people with ASD interact with social cues (such as faces and objects). For use as input in RNN models, these temporal patterns were then converted into timeseries data.

4. Acoustic Data (Vocal Analysis):

- Speech Feature Extraction: Praat and OpenSMILE software were used to extract acoustic information such as pitch, intonation, speech rate, and pause duration.

- Normalization: To guarantee uniformity among various speakers and recordings, features were normalized.
- Segmentation: To enhance signal quality, noise was eliminated and speech segments of interest—such as pauses or answers during conversations—were selected for additional examination.

5. Genomic Data:

- Preprocessing: SNPs and gene expression patterns were extracted from raw genomic data. Preprocessing entailed removing irrelevant genes and concentrating on the subset of genes linked to ASD found in the body of prior research[4].
- Normalization and Scaling: To account for batch effects and guarantee consistent scaling across samples, gene expression levels were normalized.

Model Selection

1. Convolutional Neural Networks (CNNs): Because CNNs can extract spa- tial hierarchies from images, they were utilized to analyze neuroimaging data. To detect brain abnormalities unique to ASD, architectures like as ResNet and DenseNet were refined[5].
2. Recurrent Neural Networks (RNNs): For sequential data like speech patterns and gaze trajectories, RNNs—including LSTM and GRU models—were used. The temporal dependencies that are essential for the understanding of ASD are well captured by these models.
3. Hybrid Models: CNNs for feature extraction and RNNs for sequential processing were merged in hybrid architectures[6]. The analysis of multimodal data, including the correlation of behavioral measures with MRI images, was made possible by this integration.
4. Transfer Learning: ASD datasets were used to adjust pre-trained models such as VGG and Inceptionv3. By utilizing pre-learned features from extensive image datasets, transfer learning greatly decreased training time and enhanced model generalization.

Experimental Setup

1. Data Splitting: To guarantee balanced coverage of ASD and non ASD cases, datasets were divided into training (80%) and validation (20%) subsets using stratified sampling.

2. Evaluation Metrics: Metrics like accuracy, precision, recall, F1 Score, and the area under the receiver operating characteristic (ROC) curve were used to assess the models. Robust performance evaluation was performed using a 10-fold cross validation approach.
3. Hardware and Tools: High-performance GPUs were used for the studies, and deep learning frameworks like PyTorch and TensorFlow were used. Model parameters were optimized using automated hyper parameter tuning methods including Bayesian optimization and grid search.
4. Visualization: Model predictions were interpreted using tools such as GradCAM, which shed light on the characteristics that affect the detection of ASD. The models' interpretability and clinical applicability were improved by these visuals.

Results and Discussion

Performance Metrics

The effectiveness of AI in early diagnosis was highlighted by the deep learning models' strong performance on a range of datasets linked to ASD. The accuracy of 94% attained by CNN-based models trained on neuroimaging data highlights the significance of brain structure and function in detecting abnormalities linked to ASD. The great accuracy indicates that neural networks are capable of capturing intricate brain properties that are difficult to see using conventional analysis techniques.

RNNs, in particular the Long Short Term Memory (LSTM) and Gated Recurrent Unit (GRU) models, demonstrated remarkable performance for sequential data analysis. These models demonstrated their capacity to understand temporal correlations and identify aberrant patterns in gaze and speech behaviors typically linked to ASD by achieving an F1score of 91% when applied to eye tracking and voice data.

A 96% overall accuracy was attained by hybrid models that included CNNs and RNNs for the analysis of multimodal data, such as behavioral and neuroimaging data. This finding was especially promising since it suggests that combining different kinds of data can result in more complete models that can diagnose ASD more accurately. In addition to being more accurate, these multimodal networks are also better suited for real-world situations where data frequently originates from a variety of sources.

Comparative Analysis

The models that used transfer learning demonstrated significant performance gains when compared to other deep learning architectures. The accuracy of pre-trained models, such as Inceptionv3 and VGG, was greatly improved by adapting them to datasets linked to ASD, especially in situations where training data was scarce. Transfer learning eliminates the requirement for intensive training on domain-specific data by enabling the model to leverage prelearned representations of universal features like textures, edges, and forms. In medical imaging, where annotated datasets are frequently hard to come by or rare, this method is especially helpful[7].

Additionally, the application of data augmentation methods, like flips, random rotations, and intensity changes, worked well to enhance model generalization. By preventing the models from overfitting to particular patterns in the training data, augmented datasets improved performance on invisible data validation.

Notwithstanding these encouraging results, the models' performance differed depending on the modality. Because MRI scans are structurally more resilient and less susceptible to noise than behavioral observations or speech patterns, neuroimaging data, for instance, provided higher accuracy than behavioral or auditory data. This conclusion implies that for the best diagnosis of ASD, a more balanced approach is required, taking into account both dynamic data, such as speech, and robust data, such as neuroimaging.

Clinical Implications

These deep learning models have important potential applications in medicine. In the context of early intervention, the capacity to identify subtle, early indicators of ASD using neuroimaging, eye tracking, and speech analysis is invaluable. Deep learning models may allow physicians to start treatments and interventions when they work best during the crucial early years of brain development by offering instruments that can recognize these symptoms earlier than conventional diagnostic techniques.

The accessibility and effectiveness of diagnosing ASD can potentially be enhanced by incorporating AI into clinical operations. These models, for example, might be used in underprivileged areas with a shortage of specialists, providing a scalable and affordable way to screen big populations. AI-driven technologies may be used in these fields as a triage method to determine which patients require additional diagnostic care, relieving the strain on medical professionals and cutting down on diagnostic delays.

Furthermore, tailored treatment may benefit greatly from AI systems. Deep learning algorithms may be able to provide customized therapeutic recommendations based on particular patterns of ASD symptoms and their intensity by evaluating individual data from several modalities. Long-term results for people with ASD may improve as a result of a more tailored and focused approach to treatment.

Challenges and Limitations

Even while the results are encouraging, there are still a number of obstacles to overcome before deep learning can be used to diagnose ASD[8].

- Data Scarcity and Quality: The availability and quality of data are two of the most urgent issues. Even though there are a number of sizable ASD datasets that are openly accessible, the data frequently has built-in problems such noise, missing numbers, and class imbalances. Additionally, diverse methods and imaging techniques used in datasets gathered from various locations or research facilities may result in discrepancies that make model generalization more difficult.
- Interpretability of the Model: CNNs and RNNs in particular are frequently criticized for being" black boxes," which make it hard to comprehend how they make their predictions. Since medical practitioners must have faith in the logic underlying the AI's diagnosis, this lack of interpretability poses a serious obstacle to clinical adoption.
- Ethical Issues: Using AI in healthcare presents ethical issues, especially with relation to data security and patient privacy. It is crucial to make sure that any data utilized in AI models is secure, anonymized, and compliant with ethical standards. Additionally, bias in AI models might result in unfair outcomes for some groups, particularly when the models are trained on non-representative datasets. To guarantee equitable access and benefit for every patient, AI systems must be designed with fairness, transparency, and inclusivity in mind.
- Model Generalizability and Robustness: Despite the fact that deep learning models performed well on the datasets utilized in this investigation, these models still

require validation on external, real-world datasets. For the models to be therapeutically viable, they must generalize across many situations and populations. The model's capacity to accurately identify ASD in a variety of clinical circumstances may be diminished if it is over fit to particular datasets or study environments.

Overall Results

Across several modalities, the use of deep learning algorithms for the early diagnosis and prediction of autism spectrum disorder (ASD) has produced very encouraging results. Strong performance was shown by the deep learning models, especially Convolutional Neural Networks (CNNs) for neuroimaging data and Recurrent Neural Networks (RNNs) for sequential behavioral data. CNNs achieved an accuracy of 94% and RNNs an F1-score of 91%. The accuracy of hybrid models, which integrate behavioral and neuroimaging data, was 96%, better than that of individual models. This demonstrates how combining multimodal data might help convey the intricacy of ASD's presentation. Another important factor was transfer learning, which made it possible to enhance model performance even with small datasets. The successful adaptation of pre-trained models, such as Inception-v3 and VGG, to data specific to ASD improved the models' generalization and decreased the requirement for intensive training. These findings imply that deep learning, by providing more precise, effective, and scalable solutions, has the potential to greatly enhance early ASD diagnosis. A more thorough and accurate understanding of ASD is made possible by the capacity to spot tiny patterns in a variety of data sources, including speech patterns, behavioral evaluations, and brain scans. This can therefore result in early interventions, which are essential for improved long-term results. Deep learning models have shown promise in transforming the identification of ASD by providing more dependable and easily accessible diagnostic instruments. The results highlight AI's revolutionary potential in healthcare, which could improve patient outcomes and clinical procedures.

Future directions

Although there is a lot of potential in using deep learning to detect autism spectrum disorder (ASD) early on, there are a few areas that require more research and development[9].

Multimodal Data Integration

The accuracy of diagnosis may be improved by integrating speech patterns, behavioral measurements, genetic information, and neuroimaging into a single deep learning model. For a more thorough understanding of ASD, future research should concentrate on creating fusion models that smoothly combine these various data kinds.

Real Time Diagnosis with Wearables

One promising approach is real-time ASD monitoring via wearable technology, such as speech analysis applications and eye tracking glasses. These technologies have the potential to facilitate ongoing data collecting, offering prompt insights into behavioral changes associated with ASD and facilitating individualized, mobile therapies[10].

Explainable AI

Future studies should concentrate on enhancing deep learning systems' interpretability in order to boost confidence in AI models. Clinicians can gain a better understanding of model predictions by using techniques such as attention mechanisms and SHAP values, which can shed light on how models make judgments.

Overcoming Data Scarcity and Bias

Data scarcity is still a significant problem, particularly for marginalized groups. In the future, federated learning and synthetic data generation may be used to increase data diversity and reduce biases, resulting in more equitable and broadly applicable models.

Ethical Considerations

Healthcare AI applications need to handle ethical, consent, and privacy concerns. To guarantee ethical data usage and safeguard sensitive information, privacy-preserving strategies and open consent procedures are required.

Collaboration Between AI Developers and Clinicians

The actual implementation of deep learning models in healthcare requires cooperation between clinicians and AI researchers. To make sure these models satisfy clinical requirements and enhance patient outcomes, future studies should prioritize user-centered design and real-world validation.

Longitudinal Studies

In order to create models that forecast long-term results, longitudinal data monitoring the development of ASD is essential. To increase the generalization and prediction power of deep learning models, future research should concentrate on collecting and evaluating long-term data.

CONCLUSION

With the potential to transform diagnostic procedures and enhance the effectiveness of interventions, the use of deep learning in the early identification and prediction of autism spectrum disorder (ASD) marks a substantial advancement in the medical profession. Because deep learning can handle big, complicated datasets, it provides a novel way to address some of the most enduring problems in diagnosing ASD, like symptom variability and the subjectivity of conventional behavioral evaluations. Deep learning algorithms can identify small trends that human clinicians might overlook by using multimodal data from neuroimaging, behavioral observations, genetic profiles, and speech patterns. This allows for earlier and more precise diagnosis.

The study examined in this paper shows the potential of deep learning techniques, including Recurrent Neural Networks (RNNs) for processing sequential data like speech and gaze behavior and Convolutional Neural Networks (CNNs) for evaluating brain imaging. These technologies can detect abnormal behavioral traits, identify important aspects in neuroimaging data, and even predict genetic risk factors for ASD. A more comprehensive knowledge of the condition has resulted from the use of hybrid models, which combine several data kinds.

Even with the encouraging developments, a number of obstacles still need to be overcome in order to properly utilize deep learning for diagnosing ASD. Lack of data is one of the most urgent issues, especially for marginalized groups. To increase the universality and robustness of these models, more varied and comprehensive data is still required, despite the important contributions given by big datasets like the Autism Brain Imaging Data Exchange (ABIDE). Furthermore, interpretability of the model is still a major challenge. Building trust in AI-based systems requires that healthcare practitioners comprehend how deep learning models make their predictions. Clinical acceptance of these models will depend on efforts to increase their transparency, such as through the use of explainable AI approaches or attention processes.

The application of deep learning in healthcare is also heavily influenced by ethical issues. Careful consideration must be given to privacy concerns pertain- ing to sensitive data, especially genetic and behavioral data. AI applications will be more ethically compliant if privacy-preserving strategies like federated learning are developed and consent procedures are made transparent.

There are a number of intriguing avenues for further study in the future. Continuous ASD detection and individualized treatments may be greatly aided by the inclusion of real-time monitoring technologies, such as wearables and smartphone apps for speech analysis and eye tracking. These tools may give medical professionals insightful information in real time, allowing for prompt and flexible interventions. Additionally, longitudinal studies that monitor the progression of ASD over time may enhance deep learning models' predictive power, allowing them to foresee future difficulties and results for people with ASD.

In order to close the gap between scientific developments and clinical applicability, cooperation between AI researchers, clinicians, and healthcare professionals will be essential. Together, these parties can guarantee that deep learning models are developed with practical applications in mind and that their efficacy in clinical contexts is thoroughly examined. In conclusion, even though deep learning can significantly improve ASD early diagnosis and prediction, its successful incorporation into healthcare will require ongoing innovation, teamwork, and careful evaluation of ethical and practical issues. Deep learning has the potential to revolutionize the diagnosis of ASD, improving outcomes for those with the disorder and offering their families invaluable help as more precise models, improved data integration, and more moral frameworks are developed.

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REAL-TIME PREDICTIVE MONITORING SYSTEM FOR ENHANCED DAM SAFETY

Bini Eldhose
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
+91 97782 61723, binieldhose2003@gmail.com

SabinThomas
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
+91 82899 41305, sabinthomas088@gmail.com

Alan Binoy
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
+91 85908 66654, alanbinoy121@gmail.com

Basil V Eldho
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
+91 94969 48285, basilveldho2002@gmail.com

Mintu Thomas
Computer Science and Engineering Dept.
Mar Baselios Institute of Technology and Science (MBITS)
Kothamangalam, Kerala, India
+91 98958 53521, mintuthomasm@gmail.com

ABSTRACT

The "Real-Time Predictive Monitoring System for Enhanced Dam Safety" project intends to update dam safety in Kerala by tackling the region's distinct topography and water management issues brought on by the monsoon. The system forecasts rainfall, controls water flow between dams and continuously monitors water levels using modern technology and predictive data analytics. In order to promote proactive water management, it uses random forest machine learning algorithms to forecast rainfall based on historical weather data and environmental parameters. Sensors are used to gather real- time data on temperature, humidity, precipitation and evaporation. Water travel times between dams can be processed using data on downstream dam inflow and upstream dam spill rates. This information can then be used to evaluate possible inflow on downstream dams. Real-time data, predictions, inflow and spill rates and predicted water travel durations will all be shown on an intuitive interactive dashboard, giving stakeholders useful information to help them make better decisions. The project is a major step in improving Kerala's water resource management and guaranteeing dam safety. aims to lower overflow risks and enhance infrastructure resilience to enable sustainable water management in the face of climatic unpredictability and rising water resource demands via modern technology and thorough data analysis.

Keywords—*Real-Time Monitoring, Rainfall Forecasting, Random Forest Algorithm, Inflow and Spill Rates, Water Travel Time*

INTRODUCTION

Kerala, a region distinguished by its distinct terrain and seasonal monsoons, faces significant water management difficulties that the Real-Time Predictive Monitoring System for Enhanced Dam Safety is intended to address. In order to maintain safety and efficient use of resources, a reliable system for forecasting rainfall, controlling water flow between dams and regularly checking dam water levels is required due to the monsoon season's frequent and heavy rainfall.

This initiative improves dam monitoring in real time by integrating modern advancements like sensor networks and predictive data analytics. The system uses a variety of environmental factors and historical weather data to anticipate rainfall by utilizing machine learning methods, particularly the Random Forest model. Predictive models rely on real-time temperature, humidity, precipitation and evaporation data collected by sensors placed throughout the dams.

The technology computes water travel durations between dams by analyzing data on upstream dam spill rates and downstream dam inflows. By helping to predict possible inflows into reservoirs downstream, this study facilitates better risk reduction and water management techniques. The findings are displayed on an interactive dashboard together with real-time data, forecasted insights and water trip times. By giving stakeholders useful information, this dashboard helps them make well-informed decisions.

Through the implementation of this system, the project hopes to improve water infrastructure resilience, lower the risk of dam overflows and advance sustainable water management.

BACKGROUND

In order to meet the increasing issues brought on by natural disasters and rapid environmental change, this article introduces a unique Internet of Things (IoT)-based system called the IDISense app. It is intended to monitor and disseminate real-time data pertaining to meteorological factors and dam conditions. The system collects vital data on water levels, dam vacancies and flow rates by employing a range of sensors including rainfall, waterfall, flow and ultrasonic sensors positioned across dams. An Arduino-based central system receives this data and utilizing past weather data, a Spiking Neural Network (SNN) is used to forecast rainfall. In order to regulate dam gates and avert possible catastrophes, the central control room evaluates this data and sends directives to local control units. The IDISense app further enhances by instantly warning neighboring communities about potential dangers, the IDISense app further improves safety. This integrated strategy lowers the risk of flooding, ensures prompt preventive steps and manages the operational aspects of dams. With a proven accuracy of 93.4% in a single day and 95.9% over four

days, the IDISense app is a reliable tool for managing water levels and predicting dam disasters, offering a strong way to lessen the effects of disasters as mentioned in IDISense: IoT-Based Dam Water Disaster Sensing and Prevention System journal [1].

This study compares the Random Forest and Logistic Regression approaches with the goal of improving rainfall prediction accuracy through machine learning techniques. For industries including agriculture, water resources management and flood forecasting, rainfall prediction is essential. The study assesses the effectiveness of several machine learning techniques, revealing which one produces predictions that are more correct. By successfully revealing the underlying patterns in historical weather data, the project seeks to increase the accuracy of rainfall forecasts using tools like Anaconda, Python and libraries like NumPy, Matplotlib, Seaborn and Pandas. The work tackles the problems with conventional approaches, which have trouble identifying intricate, non-linear relationships and produce forecasts that are not reliable. This research helps important industries like agriculture, construction and disaster management by offering a more accurate rainfall prediction system, which eventually promotes economic growth and improved management of water resources. The results provide a useful reference for further research in this area and aid in the improvement of forecasting methods from Effective Rainfall Prediction and Analysis using Machine Learning Techniques [2].

Using Internet of Things (IoT) technology, this article suggests a revolutionary method for managing dam water levels that will improve the efficiency and safety of water resources. Dams are vital for providing water to agriculture, industry and animals and managing them is crucial to reducing both man-made and natural hazards. Real-time data is gathered by the suggested IoT-based system using sensors like vibration, pressure and water level sensors. Far-field communication technologies like LPWAN and NB-IoT are then used to transmit the data to a central command center. By automating dam operations, this technology enables centralized control over decisions about water release based on collected data Water distribution can be optimized, particularly in areas experiencing water scarcity, by combining IoT with cloud computing and big data analytics to facilitate quicker and more accurate decision-making. This system seeks to improve water resource management, increase dam safety and tackle the problems of droughts, floods and urban water supply demands by guaranteeing real-time monitoring and automation [3].

In this research, the creation of an Internet of Things-based system for managing water quality and monitoring dam water levels is investigated. The use of IoT is a viable remedy for traditional monitoring systems, which are frequently expensive and ineffective. The suggested system provides real-time monitoring and remote access by combining parts like Arduino, solenoid valves, pH and water level sensors and ESP 8266 modules. This ensures more economical and effective management of vital water resources. Water quality and levels are continuously monitored by the system, which sends data to the cloud for study. The system warns users of possible problems including irregular water levels or quality variations via color-coded LED indicators and alarms (buzzers). In order to maintain ideal levels, solenoid valves are also used to control water flow. Predictive analysis, water usage optimization, future water level predictions and danger identification can all be done with the data collected by the system. The IoT-based system offers a very effective solution for contemporary water resource management, guaranteeing improved safety and sustainability for dam operations through its capacity to facilitate data analytics, give remote access and enhance decision-making [4].

Given the unpredictability of weather patterns and the difficulties associated with water distribution, this project seeks to address the growing concerns surrounding dam safety and water management. This system uses the Internet of Things (IoT) to improve dam monitoring in response to the growing need for efficient water use. Its major goals are to maintain safe water levels and avoid problems such gate corrosion and overtopping. Using control valves to regulate water flow and proactively manage discharges during emergencies, the suggested system uses microcontrollers and a variety of sensors to monitor and manage water distribution. The technology protects against potential risks like dam breakdown brought on by severe weather and guarantees effective water management by utilizing statistical data from environmental sensors. This IoT-based strategy provides an effective means of ongoing monitoring and decision-making in areas like India, where dams are essential water sources for agricultural and urban demands. The system seeks to enhance overall water resource management and lower the danger of catastrophic failures by automating dam health tracking and supplying real-time data, guaranteeing the sustainability and safety of water bodies [5].

Based on time-series data, this study aims to forecast rainfall patterns using machine learning (ML) methods, particularly decision trees and random forests. Although rainfall is essential to many areas, including agriculture, urban planning and the management of water resources, its unpredictable nature can result in natural disasters like landslides and floods. Predicting the rain accurately can help reduce these dangers. Three weather characteristics temperature, wind direction and relative humidity are used in the study to predict rainfall. According to the results, the random forest method gets a slightly better accuracy of 95.64%, while the decision tree approach gives an average accuracy of 94.85%. In contrast to individual decision trees, which are more likely to overfit, Random Forest, an ensemble learning technique, produces predictions by aggregating the outputs of several decision trees. The goal of the project is to increase the accuracy and dependability of rain forecasts by examining past and present meteorological data. This will help with disaster planning, lower financial losses and increase resilience to extreme weather occurrences. The results demonstrate how machine learning may be used to improve rainfall prediction models for better disaster relief [6].

An enhanced Random Forest (RF) model in conjunction with a sliding time window approach is proposed in this paper to address the prediction of dam displacement, a crucial component of dam safety monitoring. The nonlinear features of dam displacement and anomalous data have proven difficult for traditional models to handle, which can compromise prediction accuracy. In order to improve accuracy and resilience, the suggested RF model incorporates grid search optimization to fine-tune hyperparameters and a sliding time window to improve time sensitivity. Using horizontal displacement data from a Chinese masonry arch dam, the study shows that even with short-term monitoring data, the RF model can accurately depict long-term displacement trends. The model performs better than conventional statistical models and is quite robust when handling anomalous data series. This method works especially well for monitoring dams in the real world, where precise forecasts are necessary for early warning and maintenance [7].

The creation and use of the Spill Management Information System (SMIS 2.0), a sophisticated decision- support tool intended to assist spill response managers, are covered in the article. SMIS 2.0 combines 3D hydrodynamic and chemical spill modeling with a geographic information system (GIS). The system is easy to use and makes use of simple

GIS capabilities to create and visualize spill scenarios, find emergency response resources and assess recovery tactics like placing booms for chemical containment. SMIS 2.0 makes use of the 3D Generalized, Longitudinal-Lateral-Vertical Hydrodynamic and Transport (GLLVHT) model, which offers comprehensive flow information. An average spill, a maximum spill and a worst-case spill are examined under various flow circumstances. With its ability to pinpoint affected regions, vulnerable groups and resources required for response activities, the case study highlights SMIS 2.0's decision-support features. The system's capacity to model spill recovery procedures, such as the positioning of booms for chemical spill containment, is also highlighted. The integration of SMIS 2.0 with ESRI's ArcMap improves its efficacy by making it simple to visualize, query and print spill simulation findings for training and operational use [8].

The use of machine learning (ML) algorithms for rainfall prediction is the main topic of this research. Rainfall is a critical component that impacts a number of industries, including construction, tourism, power generation and agriculture. In order to forecast rainfall and assess their effectiveness, the study investigates a number of machine learning algorithms, such as the Random Forest Regressor, Random Forest Classifier, Linear Regression, Support Vector Regressor (SVR) and Decision Tree Algorithm. The system can forecast rainfall by using machine learning, which is useful for crop production optimization and water resource management. The Random Forest Regressor algorithm was the most successful approach in this investigation, outperforming other models with an accuracy score of 89%. The study highlights how crucial it is to prepare data properly, which includes handling missing data, choosing pertinent characteristics and using one-hot encoding and scaling methods [9].

In order to forecast rainfall in Taiwan, a location that frequently experiences typhoons and monsoons, this study investigates the application of tree-based machine learning models, particularly Random Forest and CatBoost. The study makes use of a dataset from 1998 to 2018 from Ruiyan, Taiwan, which was supplied by Chinese Culture University's Department of Atmospheric Sciences. Temperature, humidity, air pressure, wind direction and wind speed are the five main variables in the dataset. While the CatBoost model was picked for its capacity to handle categorical data and minimize overfitting, the Random Forest model was chosen for its skill in managing nonlinear data. Pre-processing the data, modifying model parameters and employing the under sampling technique to rectify data imbalances were all part of the study. Accuracy, precision, recall, F1 score and ROC-AUC were used to assess the model's performance. With a maximum accuracy of 70% and an AUC of 76%, the Random Forest model beat CatBoost in both accuracy and AUC, according to the data. This shows that there is a lot of potential for enhancing Taiwan's weather forecasting systems using tree-based machine learning models, especially Random Forest. In order to solve weather-related issues including typhoons, floods and other natural catastrophes in the area, these models can improve rainfall prediction capabilities [10].

SCOPE AND OBJECTIVE

The main goal of the "Real-Time Predictive Monitoring System for Enhanced Dam Safety" project is to provide a cutting-edge, contemporary framework for enhancing dam safety in Kerala. The project will aid with rainfall forecast and water flow management between dams by combining machine learning algorithms with a real-time monitoring system, guaranteeing increased safety and risk reduction.

The integration of multiple data types, such as rainfall, water level, historical weather and environmental factors including temperature, humidity and evaporation, is an important part of this project. The most advanced sensors will be placed throughout several dams to collect this data. Accurate predictions of possible water inflows and spill rates will be produced by analyzing the ongoing, real-time data gathering.

The development of a prediction model utilizing random forest machine learning methods is included in the project's scope. Using historical data, this model will anticipate rainfall and assess inflows, enabling decision-makers to make well-informed, data-driven decisions. Additionally, the machine learning approach will facilitate effective resource allocation, guaranteeing safe and ideal water levels.

An interactive dashboard will be created as part of the project to help with efficient decision-making. Critical data, including water levels, rainfall forecasts, spill rates and water travel durations between dams, will be visualized in real time on this dashboard. Dam operators, stakeholders and decision-makers will be able to quickly obtain the information they need to respond promptly and prevent any negative outcomes, such water scarcity or dam failure, thanks to the user-friendly interface. By ensuring that Kerala's dam infrastructure is resilient to climate change and the increasing demand for water resources, this project aims to support sustainable water management practices in the state over the long run. This technology will lower the dangers of floods, overflow and water scarcity by offering a thorough and predictive method of dam monitoring. In order to improve dam safety and resilience worldwide, the project's results will offer a scalable solution that can be applied to other areas with comparable water management issues.

ARCHITECTURE MODEL

The proposed system architecture of Figure 1 below illustrates the suggested system design. The Sensor Data Collection module uses sophisticated sensors to record vital factors like water level, evaporation, rainfall, temperature and humidity. After that, this real-time data is included into a central dataset, which forms the foundation for additional computations and forecasts.

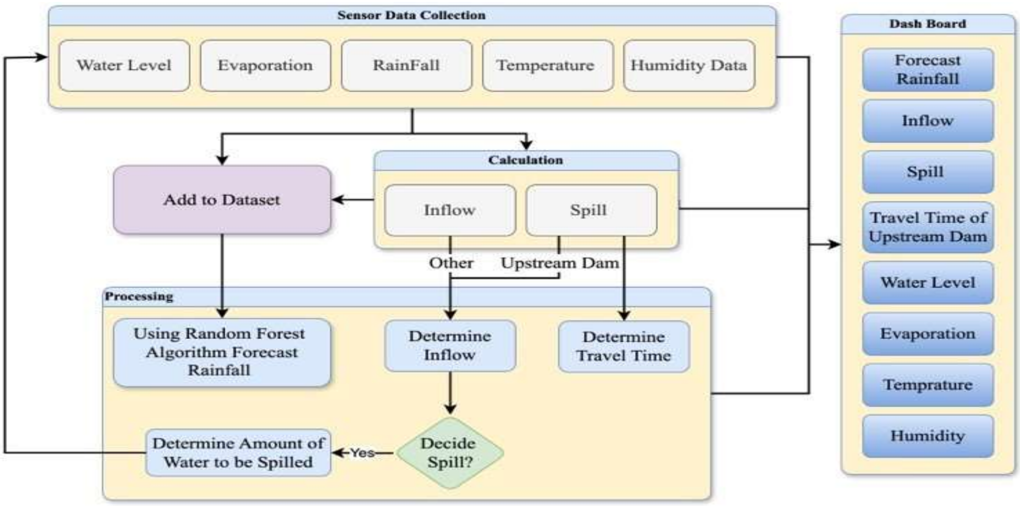

Fig. 1.Architecture Model

This sensor data is used by the calculation module to calculate the inflow and spill, which are subsequently appended to the dataset. The Processing module then uses the dataset to estimate rainfall using the Random Forest technique, as seen in Figure 2. The dam's future inflow is determined in part by this anticipated rainfall as well as inputs like upstream dam spills and other water sources. Based on water levels, inflow and the dam's storage capacity which is determined by the rule curve the system determines whether a spill is required. The system determines how much water needs to be spilled and how long it will take for the water to move downstream if one is necessary. Lastly, the system provides real-time visualization of factors including predicted rainfall, inflow, spill information, transit time from upstream dams, water level, evaporation, temperature and humidity on the Dashboard, where it generates important insights. Dam operators can effectively monitor and control operations with this user-friendly interface, guaranteeing increased safety and risk avoidance through data- driven decision-making.

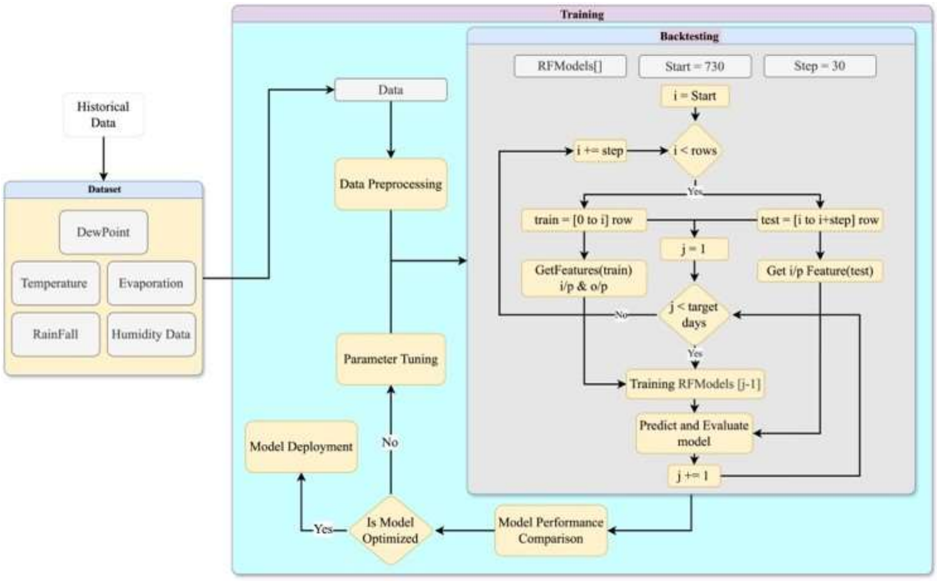

Fig. 2.Training Random Forest

Reading data from the dataset is the first step in training the random forest models to forecast rainfall. Preprocessing involves filling in missing values, fixing improper data types and eliminating any inaccurate information. At this point, the forecast target values are established. The BackTest function, which is essential to training and assessing the random forest models for different target days, receives the data after preprocessing.

The random forest models for each target day are stored in a list called `RFModels` that is formed in the BackTest method. There will be seven models in `RFModels` if the prediction aim is seven days. The number of initial rows used for the first training session which are not used for testing is specified by the parameter `Start`. The number of rows that are added progressively at each iteration is specified by the parameter `Step`.

The variable 'i' is initially set to 'Start'. A train data frame is created in each loop iteration using rows from the 0 to the 'i^{th}' index and a test data frame is formed using rows from the 'i^{th}' to the (i^{th} + Step) index. These data frames are used by inner loop, which uses the input and output features of the training data frame to train the model and the input features of the test data frame to test the model's predictions.

The model's performance is evaluated by comparing it with earlier iterations when the BackTest function is finished. The model's parameters are adjusted and the BackTest procedure is repeated if it is not optimized. Following optimization, the model is saved and made available for use in real-time forecasting.PROPOSED **METHODOLOGY**

In order to give dam operators real-time monitoring and predictive analytics, the suggested solution for dam safety and water management combines IoT sensors, machine learning and a Raspberry Pi-based platform. Using random forest that examine past data as well as current inputs including rainfall, temperature, inflow and humidity, this system predicts reservoir water levels. The technology assists operators in taking proactive measures, including modifying water release schedules or informing communities downstream, by foreseeing possible hazards like overflows or flooding. In order to balance the needs for energy production and flood protection, it also optimizes water discharge.

A Raspberry Pi 4 serves as the system's primary processing unit and communicates with a network of Internet of Things sensors placed throughout the dam. These sensors gather data on temperature, precipitation, water levels and other variables that affect dam operations in real time. This data collected is being sent to a cloud-based platform for additional analysis.

Once data reaches the cloud, machine learning models further process it to generate forecasts and insights. These models forecast rainfall patterns using both historical trends and current data. Predictive analytics-based water release automation maximizes water management, keeps water levels safe and ensures effective energy generation. Over time, the system improves in accuracy and responsiveness as it continuously learns from fresh data. It is perfect for different dam sizes and locations because of its modular and economical design, which guarantees that it can be extended and deployed in a variety of situations.

A. *Data Acquisition and Preprocessing*

The module ensures that predictive models operate accurately, which is essential for the dam safety and water management system. In order to continuously gather real-time data on temperature, humidity, water levels, rainfall and evaporation, Internet of Things (IoT) sensors are being installed throughout the dam and its environs. Tail-Scale ensures dependable data transmission by offering scalable and secure communication between the Raspberry Pi hub and IoT sensors. The technology increases forecast accuracy by combining real-time and historical data for thorough analysis.

B. *Rainfall Prediction Using Random Forest Regressor*

In order to train random forest models to forecast rainfall on target days, the dataset must first be read and preprocessed to remove inaccurate data, fill in missing values, fix data types and define prediction target values. The BackTest function then receives this transformed data. A list of random forest models corresponding to the number of target days is stored in the 'RFModels' variable of the BackTest function (e.g., 7 models for 7 days). 'Step' specifies the increase in rows for each iteration, whereas 'Start' indicates the beginning number of rows utilized for training. The first 'i' rows are used for training iteratively, while the subsequent 'Step' rows are used for testing. In each cycle, input features from the test data frame is used to test the model after it has been trained using input and output features from the train data frame. Following BackTest execution, model performance is compared; if not optimized, model parameters are adjusted and the process is repeated until the model is optimized. Once optimized, it is saved and deployed. The benefit of employing the BackTest function is that it lowers the chance of overfitting by allowing 70% of the data to be used for testing and 100% for training.

Inflow and Spill Management

The safety and effectiveness of the dam depend on efficient inflow and spill management, with a particular emphasis on determining the ideal water release and controlling spill thresholds. In order to prevent overflow and maximize water retention for power generation, the system evaluates real-time data on water levels, rainfall forecasts and inflow rates to decide the ideal quantity of water to release. When water levels approach critical points, it sends out spill threshold notifications, allowing operators to take preventive measures like boosting water release rates or strengthening dam structures to avert disastrous flooding.

C. *Dashboard and Visulization Module*

In order to give dam operators real-time data and forecasts and facilitate prompt, well-informed decision- making, the dashboard and visualization module is essential. Together with illustrated forecasts of anticipated rainfall and water levels, it shows real-time data from IoT sensors, such as temperature, humidity, rainfall and water levels. This enables operators to rapidly evaluate the state of affairs now and in the future. A warning mechanism included into the system warns operators of important circumstances or abnormalities, such as exceeding spill thresholds or possible flooding hazards. Additionally, it notifies pertinent stakeholders of emergency situations including severe weather or dam conditions, guaranteeing prompt action to reduce hazards.

RESULT AND DISCUSSION

The project's goal is to establish a centralized network that links all of Kerala, India's dams. so that a dam officer can be notified before water from an upstream dam spill into the dam. Additionally, it forecasts rainfall in the dam's catchment area, which helps determine the dam's inflow. By doing this, it will be possible to maintain the dam's water level so that it stays within the range established by the Kerala government.

The Kerala State Electricity Board (KSEBL), Dam Safety Organization, Pallom, provided the dataset for the project on improving dam safety, which was especially concerned with the Idamalayar Dam. The data gives a thorough picture of the operational and environmental circumstances of the dam throughout a number of years, including 2014, 2018, 2022 and 2023. Elevation curve, storage capacity, power house discharge, rule curve, rainfall, inflow, spill and evaporation records were among the data gathered. The weather and climate website was used to get the additional data, which included temperature and humidity.

The .NET 8 Blazor Web Assembly and Blazor Server, HTML, CSS, Bootstrap 5, the Razor component and C# are used to create the user interface. SQL Server 2022 was the database in which the data was kept. A Random Forest regressor was used to forecast rainfall using the scikit-learn open-source Python package. Python and Blazor services are connected via an API known as FastApi.

A Raspberry Pi 4 small single-board computer (SBC) is equipped with sensors to collect weather information, such as the temperature, humidity, evaporation, dew point and rainfall for the current day. The collected weather data is used to update the rainfall forecasting database.

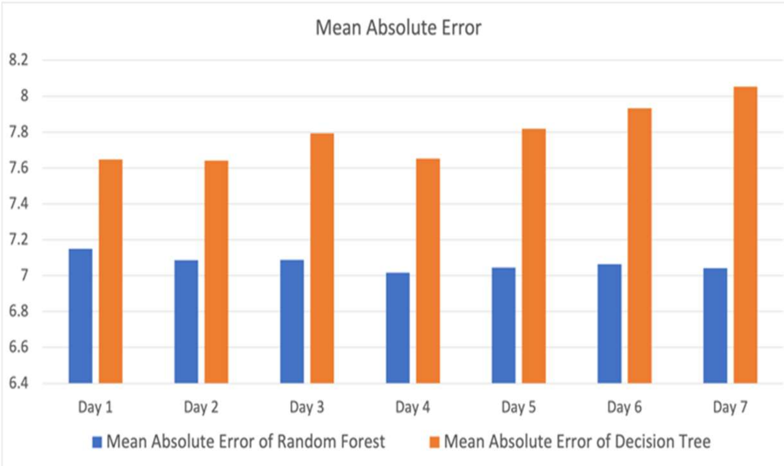

Fig. 3.Mean Absolute Error

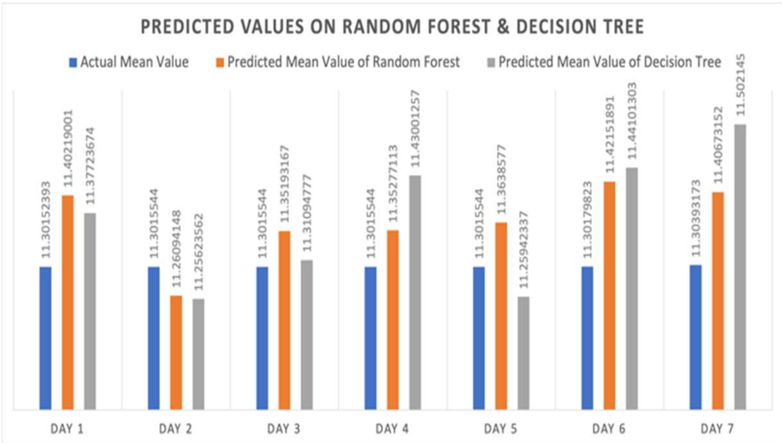

Fig. 4.Predicted Values on Random Forest and Decision tree

We used decision tree and random forest repressor models to test our prediction results. Random forest is the best in predicting rainfall over the desired seven days when compared to decision trees.

The mean absolute error for decision trees and random forests is displayed in the bar graph in Figure 3. When compared to the decision tree, the random forest has a lower mean value error. Figure 4 displays the mean values of the absolute outcome in comparison to the decision tree and random forest predictions. The Graph from Figure 5 shows the Actual and predicted value of the rainfall for the future 7 days.

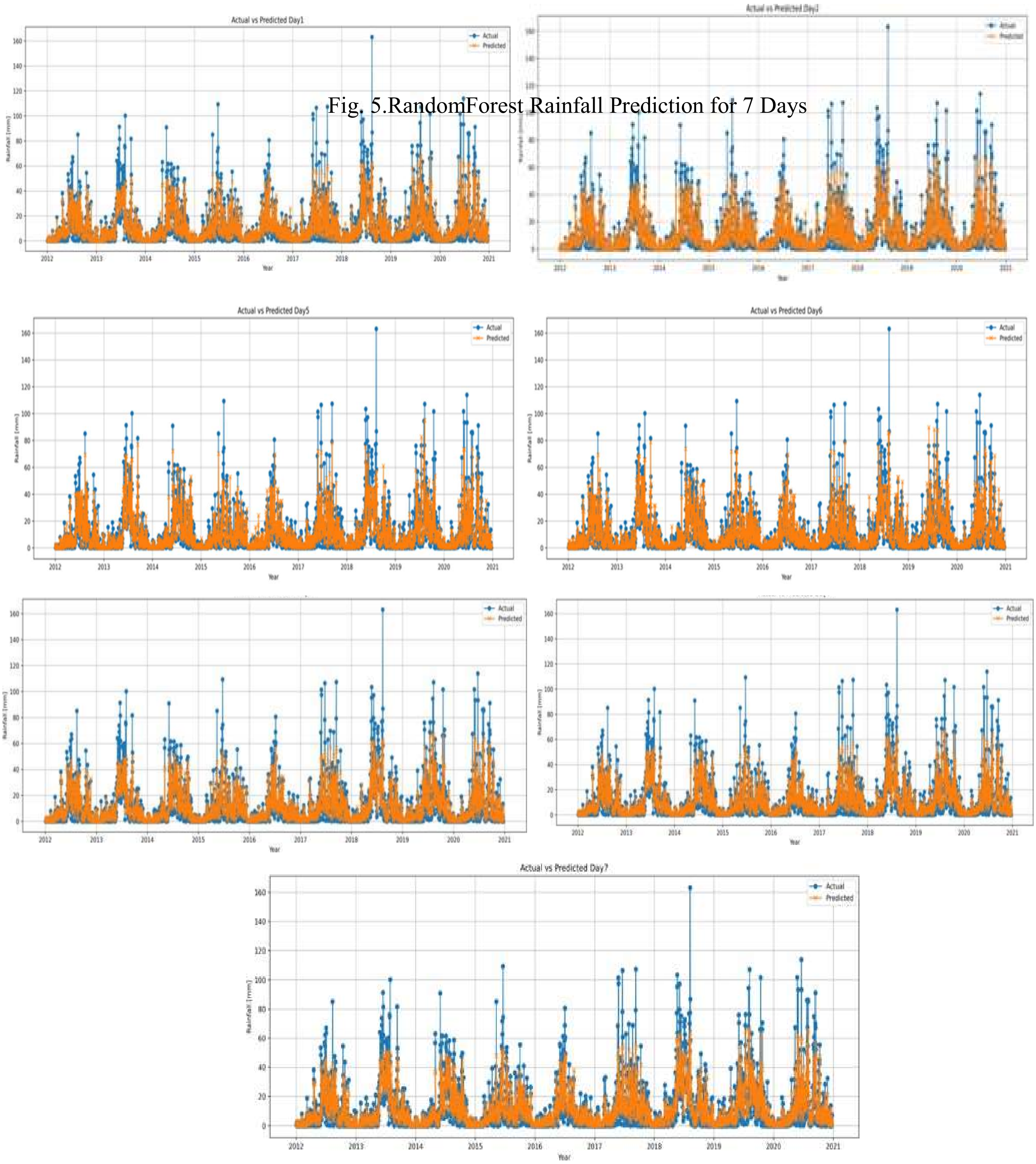

Fig. 5.RandomForest Rainfall Prediction for 7 Days

CONCULUSION

With Kerala's distinctive topography and monsoon-induced excessive rainfall, the "Real-Time Predictive Monitoring System for Enhanced Dam Safety" is a game-changing initiative designed to address the state's particular water management issues.

The system improves proactive and effective water resource management by combining cutting-edge technologies like IoT, sensor networks and machine learning. It provides real-time data collecting, rainfall forecasts and water flow control between dams. The potential for machine learning to increase forecasting accuracy which is essential for reducing flood risks and maximizing dam operations is demonstrated by the application of Random Forest algorithms for rainfall prediction. Using downstream inflow data and upstream spill rates, the system can calculate water travel times between dams, offering useful information for improved decision-making. Stakeholders can access real- time data and projections to make well-informed decisions when this information is presented on an interactive dashboard. An important development is the project's creative approach to water management and dam safety, which supports sustainable water management in the context of climate uncertainty, increases infrastructure resilience and lowers the risk of dam overflows.

Overall, the project exemplifies how modern technology and comprehensive data analysis can revolutionize water management practices, ensuring the safety and sustainability of critical water infrastructure in Kerala and potentially serving as a model for other regions facing similar challenges.

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Title: Comparative Analysis of Feature Extraction Techniques and Machine Learning Models for Dysgraphia Classification in Handwriting

Functional Area/Sub-theme: Handwriting Analysis, Machine Learning in Education, or Assistive Technology for Learning Disabilities

Elizabeth Vinitha P V
vinitonyds@gmail.com
9633177635
School of Engineering, Cochin University of Science and Technology, Kerala, India

Pramod Pavithran
pramodpavithran@gmail.com
8075960271
School of Engineering, Cochin University of Science and Technology, Kerala, India

Abstract

Dysgraphia is a neurological condition that affects an individual's handwriting ability, leading to poor writing skills. Such difficulties can impact their self-confidence and academic performance. This study proposes a machine learning (ML) method for identifying dysgraphia in handwriting samples, with focus on the analysis of handwritten words in the Malayalam language. Three feature extraction techniques, including Histogram of Oriented Gradients (HOG), Scale-Invariant Feature Transform (SIFT), and Local Binary Patterns (LBP), are employed to capture the distinctive patterns in handwriting samples. The extracted features are then combined with several machine learning (ML) methods including Support Vector Machine (SVM), XGBoost, Naive Bayes, K-Nearest Neighbors (KNN), AdaBoost and Random Forest to assess the performance. In the case of feature extraction, HOG-based feature extraction achieved the highest accuracy for dysgraphia classification, combination with Random Forest and SVM demonstrating strong performance. Furthermore, the study emphasizes the importance of feature selection in improving classifier performance and presents a comparative analysis of the classifiers' ability to distinguish between dysgraphia and normal handwriting. The findings of this research contribute to the development of automated tools for the early diagnosis of dysgraphia, providing valuable insights for both educators and clinicians.

Keywords:

Dysgraphia, Handwriting Classification, HOG, SIFT, LBP, Machine Learning, Feature Extraction, SVM, Random Forest, XGBoost, AdaBoost

1. Introduction

Writing skills are fundamental for students and play a vital role in their academic achievement and personal growth. However, writing difficulties can sometimes arise due to a neurological condition called dysgraphia. This disorder impairs the ability to accurately reproduce letters and numbers during writing activities. Individuals with dysgraphia frequently face challenges such as sustaining focus, understanding written content, and self-correcting errors, which can significantly hinder their learning experience. They struggle with maintaining a smooth hand movement across the writing surface, adopting proper body posture, positioning the elbow on the tabletop, and producing consistent handwriting. Additionally, they often exhibit irregular writing patterns and frequently strike out words (Pratelli, 1995). Consequently, they face challenges with letter size, letter formation, and fine motor skills (Overvelde & Hulstijn, 2011). Dysgraphia, as defined by the renowned author Hamstra-Bletz, refers to challenges in generating and writing written language (Hamstra-Bletz, DeBie, & Den Brinker, 1987).

In traditional methods, dysgraphia diagnosis involves standardized examinations and clinical evaluations (Safarova, Mekyska, & Zvoncak, 2021). These methods can be time-consuming and prone to bias. In contrast, the use of computational models in recent years, especially machine learning, has enabled a more accurate and efficient approach to identify dysgraphia (Devi & Kavya, 2022) (Gargot et al., 2020), providing significant benefits for both clinicians and educators ((Dimauro, Bevilacqua, Colizzi, & Di Pierro, 2020; Devi, Kavya, Therese, & Gayathri, 2021; Kunhoth, Al Maadeed, Saleh, & Akbari, 2022).

This paper presents a machine learning-based methodology for identifying dysgraphia in handwriting samples, with a specific focus on the Malayalam language. Malayalam, being a complex South Indian script with distinctive characteristics and particularly challenging to analyse and written in this script. The objective of this study is to develop methodology that can distinguish between dysgraphia-affected and normal handwriting by employing feature extraction techniques and machine learning classifiers. Three feature extraction methods, including HOG, SIFT, and LBP, are explored for their effectiveness in capturing distinctive handwriting patterns associated with dysgraphia (Sihwi, Fikri, & Aziz, 2019; Kedar et al., 2021; Dankovicova, Hurtuk, & Fecilak, 2019). These techniques are assessed in combination with classifiers, SVM, XGBoost, Naive Bayes, KNN, AdaBoost and Random Forest. The performance of each model is assessed in terms of accuracy, providing insights into the most effective techniques for dysgraphia diagnosis.

The primary objectives of this study can be summarized as follows:

- Apply a novel methodology for detecting dysgraphia using automated handwriting analysis in the Malayalam language.

- Apply comparative analysis of ML models and feature extraction techniques for dysgraphia diagnosis.
- Evaluates the performance of ML models in classifying image features derived from handwritten samples.

2. Related works

Dysgraphia is a writing difficulty that affects the handwriting ability of children. They are not able to reproduce the given numerical and alphabetical data. Children with dysgraphia cannot be identified with symptoms, so early identification is essential. The development of automated systems for identifying dysgraphia are highly important.

Several studies have explored methods for identifying dysgraphia (Kunhoth, Al-Maadeed, Kunhoth, Akbari, & Saleh, 2024). Peter Drotár et al. (2020) employed the AdaBoost algorithm to classify children with dysgraphia from normal. The model achieved 80% of prediction accuracy. In another study, using the Random Forest algorithm, an automated dysgraphia diagnosing system was developed by Mekyska et al. (2017). The model performed well and reported 96% sensitivity and specificity. Similarly, Mulakaluri & Girisha (2021), a K-NN model was developed to diagnose dysgraphia based on the BHK test, reporting an accuracy of 94%. An automated dysgraphia diagnosing tool is proposed by Asselborn et al. (2018) using Random Forest with a better performance specificity of 96.4%. Another study by Mekyska et al. (2019), developed an Automated system for dysgraphia detection is implemented using XGBoost with a specificity of 90%. Richard & Serrurier (2020) used Random Forest for dysgraphia prediction. The archived accuracy of the model is 96.2%. In Deschamps et al. (2021), a screening tool for dysgraphia identification using an SVM classifier. They achieved 91% of sensitivity and 81% of specificity. Devi, Kavya, Therese, & Gayathri (2021) proposed a test scale tool for specific learning disabilities in children, such as dyslexia, dysgraphia, and dyscalculia, using a decision tree.

The prior studies have made significant contributions to dysgraphia detection, particularly through the use of dynamic features and various classifiers. However, most of the studies focus on languages with simpler scripts. In contrast, the complexities of handwriting in languages such as Malayalam present unique challenges for accurate classification. This paper addresses these challenges by exploring feature extraction techniques that are tailored to the specific characteristics of Malayalam handwriting.

3. Methodology

This study employs a structured methodology comprising distinct stages such as data collection, preprocessing, feature extraction, model training, and evaluation. The following sections detail each of these stages.

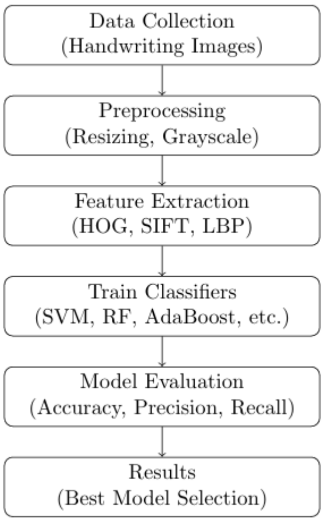

Figure 1. Workflow of the Dysgraphia Identification System

Figure 1. presents a visual overview of the complete workflow of the dysgraphia identification system. It clearly outlines the steps involved, starting from data collection and preprocessing, to feature extraction techniques like HOG, SIFT, and LBP, followed by the training of ML models, and finally, the evaluation of the models based on performance metrics.

3.1 Dataset Preparation

For this study, handwritten samples were collected from 281 participants, where 31 participants were diagnosed with dysgraphia. The dysgraphia-affected samples were collected from special schools with the assistance of special educators and educational psychologists/subject experts, ensuring accurate identification of handwriting difficulties related to dysgraphia. The control (normal) samples were collected from schools with the help of class teachers, who identified students without handwriting disorders.

Each participant was asked to write three Malayalam words, representing three distinct categories: simple, difficult, and long. The words selected for these categories were chosen in consultation with special educators and subject experts to ensure they were suitable for analyzing handwriting challenges related to dysgraphia.

The categories and examples of the words chosen are as follows:

- **Simple word:** “ലാളിത്യം” (Lalithyam)
- **Difficult word:** “വൃദ്ധയുടെ” (Vridhayude)
- **Long word**: “ബുദ്ധിമതിയായാ” (Buddhimathiyaaya)

Malayalam was particularly chosen for this study is due to its complex script and rich morphological structure. Which pose distinct challenges for handwriting recognition tasks. These complexities make Malayalam as an ideal language for assessing handwriting analysis methodologies in the context of dysgraphia detection. For this study, Malayalam dataset was divided into training (70%), validation (15%), and testing (15%) subsets. The distribution details outlined in Table 1.

Table 1: Dataset Information

Dataset Split	**Number of Samples**	**Dysgraphia Samples**	**Normal Samples**	**Feature extraction Methods**
Train	144	31	113	HOG, SIFT, LBP
Validation	31	7	24	HOG, SIFT, LBP
Test	30	9	21	HOG, SIFT, LBP

3.2 Feature Extraction

Feature extraction is a critical stage in the dysgraphia identification system, as it involves extracting relevant information from handwriting images to distinguish between dysgraphia and normal handwriting. In this study, three feature extraction methods were used, HOG, SIFT, and LBP to capture distinctive patterns in the handwriting samples.

3.2.1 Histogram of Oriented Gradients (HOG)

HOG is a feature extraction technique that analyse each input image’s gradients and edge directions. This technique is particularly effective for extracting and analysing complex texture and structural patterns in handwriting. In this method segmented images into small cells. As the next step calculating the gradient histograms within each cell and then normalizing the histograms. These histograms are then combined to form a feature vector. HOG has proven effective in capturing spatial information and is widely used in object detection. This makes HOG suitable for identifying handwriting characteristics (Aouine et al., 2023; Chitlangia & Malathi, 2019; Devendiran et al., 2024).

3.2.2 Scale-Invariant Feature Transform (SIFT)

SIFT is a highly effective feature extraction techniques that identifies and describes local features in an image, ensuring that the features are invariant to scale, rotation, and affine transformations. This property makes SIFT particularly valuable for analyzing handwriting samples that may have variations in size, orientation, or angle. The SIFT algorithm works by identifying the key points in an image, then calculating descriptors at these points, and utilizing these descriptors to represent the image (Rajput & Ummapure, 2017; Chergui & Kef, 2015; Xiong, Wen, Wang, & Lu, 2015).

3.2.3 Local Binary Patterns (LBP)

Local Binary Patterns (LBP) is a technique for extraction texture features that encodes the local texture of an image by comparing the pixel intensities in a neighborhood around each pixel. This approach effectively captures details micro-textural of handwritten strokes, which are essential for distinguishing between dysgraphia and normal handwriting. LBP functions by generating a binary code for each pixel intensity. The resulting is a pattern that reflects the local texture, which provides the valuable insights for the handwriting analysis (Al-wajih & Ghazali, 2021; Verma, Rahi, & Singh, 2023; Partiningsih, Fratama, Sari, & Rachmawanto, 2018).

3.3 Machine Learning Models

This section utilizes various machine learning classifiers to assess the effectiveness of the extracted features (HOG, SIFT, and LBP) in distinguishing between dysgraphia-affected and normal handwriting samples. The models evaluated in this study include SVM, XGBoost, Naive Bayes, KNN, AdaBoost and Random Forest. These models encompass a range of traditional machine learning techniques, from linear classifiers to ensemble methods, and are frequently applied in classification tasks involving high-dimensional feature spaces, such as handwriting analysis.

Six classifiers were employed:

- **Support Vector Machine (SVM):** It is a popular and powerful classifier that works well with high-dimensional data. This makes it suitable for handwriting analysis. It tries to find the hyperplane that best separates the classes in the feature space (Amini et al., 2023; Kunhoth et al., 2023).
- **Random Forest:** It is a popular ensemble classifier that combines multiple (Biau, 2012; Zvoncak et al. (2019); Devillaine et al., 2021). Instead of relying on one DT, it combines with several DTs and finds the average to improve the prediction performance of the given data.
- **AdaBoost:** It is a boosting algorithm that combines a weaker classifier into a stronger classifier by improving performance (Kaur & Kumar, 2021). The algorithm tries to find the miss classified data points and increases the weight of the miss classified data points until it achieves a better performance.
- **k-Nearest Neighbors (KNN):** The K-Nearest Neighbor (k-NN) algorithm was used in studies (Partiningsih et al. (2018) and (Dutt, 2021) to identify dysgraphia. It is a simple yet effective supervised learning technique, often referred to as a lazy learner algorithm due to its method of operation, where predictions are made based on the nearest data points in the feature space
- **Naive Bayes:** Another algorithm used for classification problems is Naive Bayes(NB) (Wu et al., 2008; Mohammed et al., 2017). Using this supervised algorithm, dysgraphia is identified with better performance. It relies on the Bayes theorem to work.
- **XGBoost:** The XGBoost is an open-source GBM (Gradient Boosting Machine) algorithm based on ensemble learning (Chen & Guestrin, 2016; Jayachandran et al., 2023). This follows the principle of GBM, which is popular because of its performance.

3.4 Evaluation Metrics

Machine learning algorithms require a final evaluation of the predictor's performance, and model validation or accuracy assessment is a crucial part. Within the literature, several metrics are used to gauge the effectiveness of a model. This study uses multiple metrics including accuracy, precision, recall, F1-score, and the confusion matrix. Accuracy measures overall correctness of dysgraphia prediction. Precision indicates the proportion of true positives or correctly identified dysgraphia cases among all predicted positives. Another matrix is recall, which evaluates how well the model identify actual dysgraphia cases. The F1-score in dysgraphia system balances precision and recall, especially useful for handling imbalanced datasets. Together, these metrics provide a comprehensive evaluation of the model's effectiveness in identifying dysgraphia in handwriting samples.

4. Results and Discussion

In this section, we present the results of evaluating various machine learning classifiers on dysgraphia identification using three different feature extraction methods: HOG, SIFT and LBP.

4.1 Feature Extraction Performance

The feature extraction performance of three feature extraction methods including HOG, SIFT and LBP was evaluated individually based on the number of extracted features obtained from the word Malayalam dataset. To examine the performance, calculated the average accuracy. The results are summarized in Table 2.

Table 2. Performance of Different Feature Extraction Methods

Feature Extraction Method	Number of Features	Average Accuracy
HOG	34020	75.67%
SIFT	128	62.83%
LBP	16,384	73.17%

The HOG extracts gradient-based features and produced the highest number of features (34,020) and achieved an average accuracy of 75.67%. Notably, generating fewer features (16,384), LBP outperformed SIFT in terms of average accuracy of approximately 73.17%. In contrast, SIFT extracts keypoint-based features and generated minimal of 128 features and obtained the lowest average accuracy of 62.83%.

The results suggest that the number of features extracted from the words plays an important role in determining the overall performance of a feature extraction method used and the nature of the features also influences the effectiveness of the dysgraphia identification model.

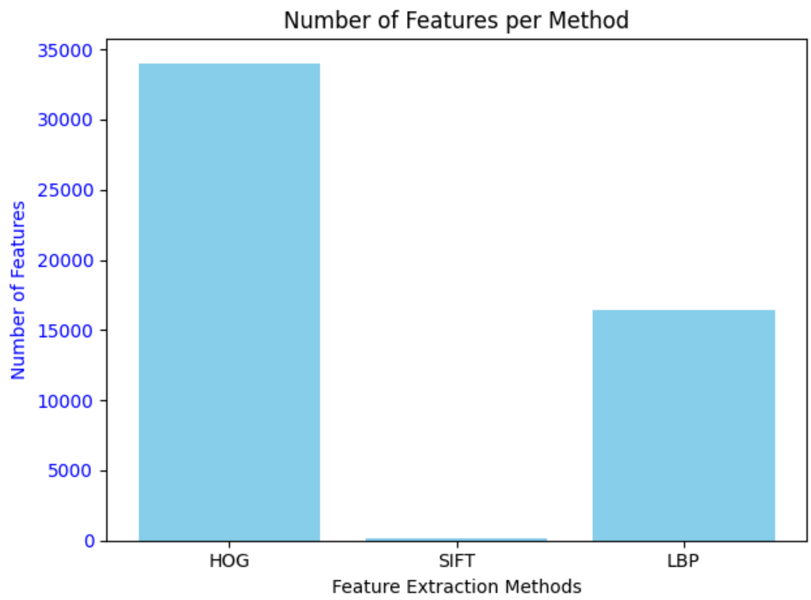

Figure 2: Number of features

Figure 2 illustrates the number of features extracted from words by various feature extraction methods including HOG, SIFT, and LBP Figure 3 presents a comparison of the average accuracy achieved by different feature extraction methods: HOG, SIFT, and LBP. The graph illustrates how each method performs in terms of classification accuracy across the various selected ML models.

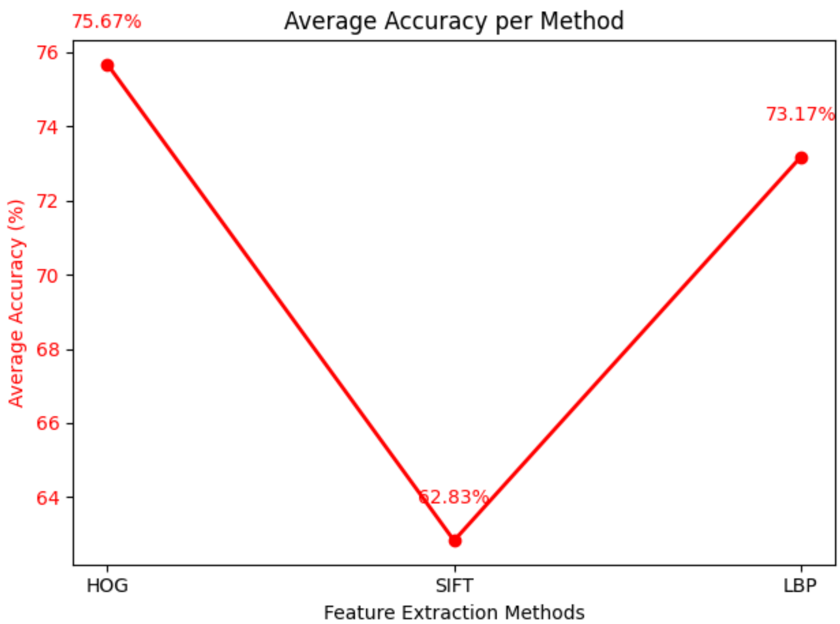

Figure 3: Average Accuracy Comparison Across Feature Extraction Methods

4.2 Classifier Comparison

This section provides the results based on the performance of selected ML models with three feature extraction techniques. The results, recorded in Table 3, highlight the accuracy achieved by each classifier for the three feature types.

Table 3. ML Model performance for HOG, SIFT and LBP

Model	HOG Accuracy	SIFT Accuracy	LBP Accuracy
SVM	0.77%	0.60%	0.73%
Random Forest	0.77%	0.70%	0.70%
AdaBoost	0.73%	0.70%	0.70%
KNN	0.70%	0.60%	0.70%
Naive Bayes	0.77%	0.50%	0.83%
XGBoost	0.70%	0.67%	0.73%

Observations and Analysis

1. **Feature Performance:**
    - HOG extracted features from three different words and consistently achieved strong performance across other selected classifiers. The maximum accuracy obtained is 0.77% for both SVM and Random Forest. This indicates that HOG features are effectively capture the key structural elements of the handwriting data.
    - Similarly, LBP outperformed when combined with Naive Bayes, and secured the highest overall accuracy of 0.83% by extracting features from word images. This indicates that LBP features are effectively capture the texture and intensity patterns in the handwriting.
    - In contrast, the SIFT underperformed compared to features extraction process using HOG and LBP. Although the HOG obtained poor accuracies ranging from 0.50% (Naive Bayes) to 0.70% (Random Forest and AdaBoost). This indicates that LBP features which are reliance on keypoints may not align well with the characteristics of the handwriting data.

2. **Classifier Performance:**
   - SVM and Random Forest are trained with word images demonstrated robust performance with HOG and LBP. The models secured maximum classification accuracies of up to 0.77%.
   - Naive Bayes did not demonstrate a better performance as SVM or Random Forest, but excelled when paired with LBP features of word images.
   - KNN and XGBoost showed moderate performance across different feature extraction techniques, and exhibits its effectiveness ranging between 0.60% and 0.73%.

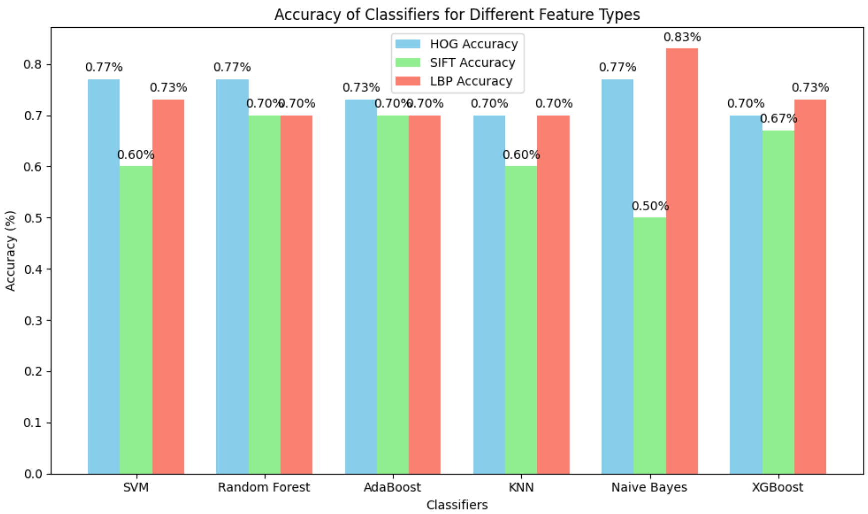

Figure 4: Accuracy of classifiers for Feature types

The figure 4 presents the accuracy achieved by selected classifiers including SVM, XGBoost, KNN, Random Forest, AdaBoost and Naive Bayes. These ML models combined with three different feature types such as HOG, SIFT, and LBP. The results highlight the impact of feature selection on classifier performance on word images. The LBP features secured the best results for Naive Bayes, while HOG features provided more consistent accuracy across other classifiers.

Discussion

This study aims to evaluate the effectiveness of feature selection combine with several classifiers using handwriting images. The investigation revels that, HOG features consistently yield strong performance across most classifiers, with SVM, Random Forest, and Naive Bayes achieving an accuracy of 77%. The results for SIFT are comparatively lower, especially for Naive Bayes (50% accuracy), which performed the worst. However, Random Forest and AdaBoost achieved relatively better accuracy at 70%. This variation indicates that while SIFT is capable of capturing scale-invariant features, it may not always provide the most discriminative features for dysgraphia classification, especially when used with simpler classifiers like Naive Bayes. More advanced models or feature engineering techniques could potentially improve performance with SIFT.

LBP shows a marked improvement in accuracy, particularly for Naive Bayes, which outperformed all other classifiers with an impressive 83% accuracy. The higher accuracy for Naive Bayes with LBP suggests that LBP features are better suited to models that are less sensitive to noise and more adept at handling texture-based features. However, Random Forest and XGBoost showed more balanced but lower accuracies, indicating that while LBP is beneficial, its full potential may require optimization based on the classifier and dataset at hand.

The study highlights the crucial role of feature selection in handwriting-based dysgraphia diagnosis. Future research directs to explore further optimization of HOG and LBP features, combine features using features fusion techniques or experiment with ensembled learning approaches. Explore with sentence or paragraph image data to understand the effectiveness of the model. Finally investigate the performance of other classifiers to identify the best combination for dysgraphia detection.

5. Conclusion

This study presents an analysis of various feature extraction methods (HOG, SIFT, and LBP) and machine learning classifiers (SVM, Random Forest, AdaBoost, KNN, Naive Bayes, and XGBoost) for dysgraphia detection in handwriting samples. For this study three different words from Malayalam language we used. The study explores different feature extraction techniques for accurate dysgraphia detection and, HOG demonstrated the best performance when paired with Naive Bayes. The results obtained using LBP showed highest accuracy for dysgraphia detection with Naive Bayes. Finally, experiments with SIFT concludes by generating fewer features, which leads to performed with lower accuracy and recall values for dysgraphia. These findings emphasize the importance of selecting appropriate feature extraction methods that balance the trade-off between feature dimensionality and classification accuracy. Furthermore, machine learning models like Naive Bayes and SVM performed well with certain feature sets. Further improvements in dysgraphia recall are needed to enhance the models' ability to identify reliability. Future work could focus on refining feature extraction techniques on sentence or paragraph data and finally exploring hybrid models to improve classification performance, particularly for underrepresented classes such as dysgraphia.

Acknowledgments

We thank the participants and educators for their contributions to this study.

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Revolutionizing Plant Disease Management: Integrating Yolo v10 with IoT and Aerial Intelligence

Gauthaman V G
M.Sc. Computer Science
Christ College (Autonomous), Irinjalakuda Thrissur, India gauthamanvg02@gmail.com
Thoufeeq Ansari
Department Of Computer Science Christ College (Autonomous), Irinjalakuda
Thrissur, India thoufeeqa@christcollegeijk.edu.in

ABSTRACT

The advent of Next-Generation Agriculture tech- nologies has unlocked transformative opportunities to enhance farming precision, sustainability, and productivity. This research focuses on the integration of deep learning models, particularly Yolo v12, with IoT-enabled smart sensors and aerial intelligence to develop a comprehensive plant disease monitoring system. Leveraging Yolo v10's advanced feature extraction and seg- mentation capabilities, the proposed framework provides high- accuracy disease detection and severity estimation across a variety of crops and environmental conditions. By incorporating IoT-enabled sensors for real-time environmental and soil data collection, along with aerial intelligence from drone-mounted cameras, the system ensures comprehensive crop surveillance and context-aware disease prediction. The integration of these technologies optimizes resource allocation, minimizes crop losses, and reduces the environmental footprint, aligning with sustain- able agriculture principles. This study highlights the synergistic potential of combining Yolo v10 with advanced data acquisition technologies, offering a scalable and efficient approach to plant disease management. The findings contribute to the development of a robust precision farming ecosystem that supports technology- driven, sustainable agriculture.

Index Terms—Deep learning, IOT

I. INTRODUCTION

The swift evolution of technology has significantly altered the agricultural sector, offering innovative solutions to persis- tent issues. One of the foremost challenges is plant disease management, which directly affects crop yield, food secu- rity, and economic viability. Conventional disease detection methods typically depend on manual inspections, which are often labor-intensive, time-consuming, and susceptible to in- accuracies. This situation necessitates the creation of efficient, scalable, and intelligent systems for timely and precise disease identification. The incorporation of advanced technologies such as deep learning, the Internet of Things (IoT), and aerial intelligence has demonstrated considerable potential in tackling these issues. Deep learning frameworks, particularly those based on the You Only Look Once (YOLO) architecture, have become leading solutions for object detection and classi- fication. The most recent version, YOLO v10, offers improved accuracy, real-time processing capabilities, and robustness,

Fig. 1. Healthy agriculture field

making it particularly suitable for detecting plant diseases. In addition, IoT devices and networks facilitate real-time monitoring and data collection, allowing seamless interaction among sensors, cameras, and cloud infrastructures. When in- tegrated with aerial intelligence, including drone imaging and remote sensing, these technologies form a robust ecosystem for efficiently monitoring extensive agricultural landscapes.

This research aims to merge YOLO v10 with IoT-enabled systems and aerial intelligence to transform plant disease man- agement. By harnessing the advantages of these technologies, we seek to establish a comprehensive framework for the early detection, classification, and management of plant diseases. The proposed system not only improves detection accuracy but also delivers actionable insights for precision agriculture, ultimately supporting sustainable farming practices. In this paper, we discuss the shortcomings of current methodologies and highlight the innovative contributions of our integrated approach.

II. RELATED WORK

YOLO (You Only Look Once) has evolved through several versions over time, each improving on speed, accuracy, and efficiency. Below is a summary of some of the most important related works to YOLOv10 (and its predecessors) in the field of object detection. These works either inspired YOLOv10 or represent notable advancements in related areas, highlighting alternative approaches to improving real-time object detection.

A. *"YOLOv10: Real-Time End-to-End Object Detection"*

Authors: Ao Wang, Hui Chen, Lihao Liu, Kai Chen, Zijia Lin, Jungong Han, Guiguang Ding Summary: This paper in- troduces YOLOv10, which aims to enhance the performance-efficiency balance of YOLO models by eliminating the need for nonmaximum suppression (NMS) in post-processing and optimizing model architecture. The authors propose consistent dual assignments for NMS-free training and a holistic efficiency-accuracy driven model design strategy, resulting in reduced computational overhead and improved capability.

B. ”YOLOv10 to Its Genesis: A Decadal and Comprehensive Review of The You Only Look Once Series”

Authors: Ranjan Sapkota, Rizwan Qureshi, Marco Flores Calero, Chetan Badjugar, Upesh Nepal, Alwin Poulose, Pe- ter Zeno, Uday Bhanu Prakash Vaddevolu, Sheheryar Khan, Maged Shoman, Hong Yan, Manoj Karkee Summary: This comprehensive review examines the progression of YOLO object detection algorithms from YOLOv1 to YOLOv10. It analyzes advancements in speed, accuracy, and computational efficiency, highlighting YOLO’s transformative impact across various application areas, including automotive safety, health- care, industrial manufacturing, surveillance, and agriculture.

C. ”YOLOv5, YOLOv8 and YOLOv10: The Go-To Detectors for Real-time Vision”

Author: Muhammad Hussain Summary: This paper provides a comprehensive review of the evolution of YOLO object detection algorithms, focusing on YOLOv5, YOLOv8, and YOLOv10. It analyzes architectural advancements, perfor- mance improvements, and suitability for edge deployment, offering insights into the trade-offs between model complexity and detection accuracy.

*D. ”YOLOv1 to YOLOv10: A comprehensive review of YOLO variants and their application in the agricultural domain”*Authors: Mujadded Al Rabbani Alif, Muhammad Hussain Summary: This survey investigates the potential of various YOLO variants, from YOLOv1 to YOLOv10, in agricultural applications. It aims to elucidate how these object detection models can optimize aspects of agriculture, including crop monitoring and livestock management, contributing to preci- sion farming and sustainable agricultural practices.

III. OBJECTIVE

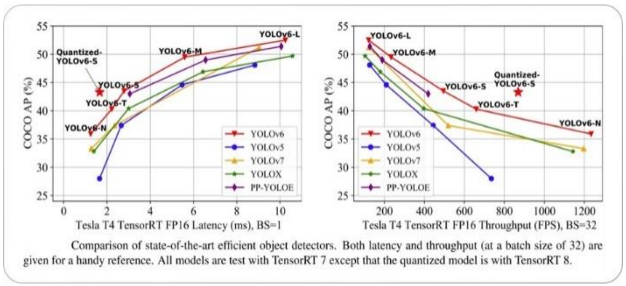
The main goal of this research is to create a comprehensive framework that integrates YOLO v10, Internet of Things (IoT) technologies, and aerial intelligence to transform plant disease management. This framework is designed to overcome the shortcomings of conventional methods by offering a scalable, efficient, and accurate solution for the early detection, clas- sification, and monitoring of plant diseases across various agricultural environments. The specific aims of this research are as follows: 1. Improving Disease Detection Precision:

Employ YOLO v10's sophisticated deep learning features to effectively identify and classify plant diseases in real-time,

even within extensive and intricate datasets. 2. Integrating IoT for Continuous Monitoring: Utilize IoT-enabled sensors and devices to gather and relay environmental and crop health information, enabling ongoing and autonomous observation of plant conditions. 3. Utilizing Aerial Intelligence: Imple- ment drone-based imaging and remote sensing technologies to obtain high-resolution data from expansive agricultural areas, facilitating swift and cost-efficient disease evaluation. 4. Creating a User-Friendly Framework: Develop an accessible and intuitive system for farmers and agricultural stakeholders, ensuring that insights and recommendations are practical and applicable in real-world scenarios. 5. Encouraging Sustain- able Agricultural Practices: Reduce dependence on chemical treatments by enabling targeted interventions, thereby lessen- ing environmental impact and fostering eco-friendly farming methods. By accomplishing these aims, this research aspires to introduce a groundbreaking approach to plant disease man- agement that equips farmers with advanced technology, boosts agricultural productivity, and supports global food security.

IV. CHALLENGES FACED BY FARMERS IN PLANT DISEASE MANAGEMENT

Farmers around the globe encounter considerable obstacles in managing plant diseases, which pose risks to agricultural productivity and food security. A major challenge is the difficulty in early detection and accurate identification of these diseases. Traditional methods, often reliant on manual inspections and visual evaluations, are not only labor-intensive but also susceptible to human error. This issue is compounded by the extensive size of agricultural fields and the subtlety of early-stage disease symptoms, which can be hard to detect without specialized expertise or equipment. Moreover, fluctu- ations in climate and the rising occurrence of new and resis- tant pathogens have complicated plant disease management. Farmers frequently face challenges in accessing real-time data and insights regarding crop health, which hampers timely interventions and raises the likelihood of uncontrolled disease outbreaks. The dependence on broad-spectrum chemical pes- ticides as a temporary solution leads to environmental harm, the development of resistance in pathogens, and increased expenses for farmers. Small-scale and resource-constrained farmers are especially at risk, as they often lack the financial resources to invest in advanced diagnostic tools or expert advice. The lack of scalable, affordable, and user-friendly solutions for disease detection and monitoring forces many farmers to adopt reactive rather than proactive approaches. This inefficiency not only leads to significant crop losses but also adversely affects the livelihoods of millions of farmers worldwide. These issues underscore the pressing need for innovative, scalable, and precise solutions that provide farmers with actionable insights for effective disease management. Tackling these challenges is essential for promoting agricul- tural sustainability, enhancing food security, and supporting the global farming community.



Comparison of state-of-the-art efficient object detectors. Both latency and throughput (at a batch size of 32) are given for a handy reference. All models are test with TensorRT 7 except that the quantized model is with TensorRT 8.

Fig. 2. disease infected plant

V. YOLO V10

A. Model Overview

YOLO v10 is the recent version of the You Only Look Once (YOLO) object detection framework, celebrated for its rapid processing and precision in real-time scenarios. With advanced features, YOLO v10 offers numerous enhancements compared to earlier versions, making it especially effective for intricate tasks such as detecting plant diseases. In the realm of plant disease management, YOLO v10 serves as a deep learning-based detection tool that can identify and categorize a variety of plant diseases from visual data. The model employs a unified neural network to analyze input images, predict bounding boxes, and classify diseases all at once. This efficient architecture allows YOLO v10 to deliver outstanding performance and real-time capabilities, even in environments with limited resources.

VI. An Overview of YOLO v10 Training Procedures

Training YOLOv10 efficiently involves several key steps to ensure optimal performance and accuracy. Here's a structured approach:

A. Environment Setup

• Hardware: Utilize a machine equipped with a high- performance GPU to accelerate training processes. • Depen- dencies: Install necessary libraries and frameworks, such as PyTorch, which YOLOv10 is built upon.

B. *Data Preparation*

• Dataset Collection: Gather a diverse set of images that represent the objects you intend to detect. Ensure variability in lighting, angles, and backgrounds to enhance model robust- ness. • Annotation: Use tools like LabelImg or Labelme to an- notate images, creating bounding boxes around target objects and assigning appropriate class labels. • Format Conversion: Convert annotations to the YOLO format, which involves creating text files with normalized bounding box coordinates and corresponding class labels for each image.

C. *Data Augmentation*

• Techniques: Apply augmentation methods such as flipping, scaling, translation, and rotation to increase dataset diversity. This helps the model generalize better to unseen data.

D. *Model Configuration*

• Model Selection: Choose the appropriate YOLOv10 vari- ant (e.g., YOLOv10-N, YOLOv10-S, YOLOv10-M) based

on your specific requirements and computational resources.

• Configuration File: Modify the model's configuration file to match the number of classes in your dataset and adjust other hyperparameters as needed.

E. *Training Process*

• Hyperparameters: Set learning rates, batch sizes, and other parameters to optimize training efficiency. • Training: Initiate the training process, monitoring performance metrics such as loss and accuracy to ensure the model is learning effectively

F. *Evaluation and Optimization*

• Validation: Regularly evaluate the model on a validation set to assess its performance and make necessary adjust- ments. • Optimization: Implement techniques like learning rate scheduling and early stopping to enhance training efficiency and prevent overfitting.

VII. EXPERIMENTAL SETUP FOR YOLO V10

Setting up an experimental environment for training and testing YOLOv10 involves preparing hardware, software, datasets, and configuration files. Here's a structured guide to help you set up an efficient experimental workflow:

A. Hardware Requirements

• GPU: NVIDIA GPUs are recommended for deep learning tasks (e.g., RTX 3060, 3090, A100). • RAM: At least 16GB for small to medium datasets; 32GB+ for larger datasets. • Storage: SSD with sufficient space for datasets, checkpoints, and logs. • CUDA and cuDNN: Ensure the GPU supports CUDA (minimum version specified by PyTorch used).

VIII. THE INTEGRATION OF IOT (INTERNET OF THINGS) WITH YOLO

The integration of IoT (Internet of Things) with YOLO (You Only Look Once) object detection models is a rapidly evolving field.

1) **Real-Time Object Detection:** YOLO's speed and ef- ficiency make it ideal for IoT devices with limited processing power.

2) **Edge Deployment:** YOLO can be deployed on edge de- vices, such as Raspberry Pi, NVIDIA Jetson Nano, and other IoT hardware, enabling localized data processing without relying on cloud computation.

3) **Energy Efficiency:** Optimized YOLO variants (e.g., YOLOv4-Tiny, YOLO-Nano) are designed for energy- constrained IoT devices.

4) **Low Latency:** In IoT systems requiring instant decision- making (e.g., surveillance drones, autonomous vehicles), YOLO provides rapid inference.

IX. AERIAL INTELLIGENCE IN YOLO (YOU ONLY LOOK ONCE)

1) **Real-Time Processing:** YOLO's fast inference capabil- ities enable real-time object detection in aerial applica- tions, essential for dynamic scenarios like search and rescue.

2) **High Accuracy:** YOLO's architecture provides precise object localization, even in complex aerial scenes.

3) **Wide Scope of Detection:** YOLO can handle multi- class object detection, crucial for diverse aerial use cases, such as detecting vehicles, people, buildings, or wildlife.

4) **Edge Compatibility:** Optimized YOLO variants (e.g., YOLO-Tiny) can be deployed directly on drones or edge devices for efficient on-site processing.

X. DISCUSSION

A. -How to improve the accuracy of Yolo v10

1) change the bounding box of yolo v10 image detection with the shape of that object: In YOLOv10 or similar object detection models, bounding boxes are always rectangular. This is because rectangular bounding boxes are computationally efficient for most object detection tasks and align well with the underlying mathematical models (e.g., intersection-over-union (IoU) calculations). However, if you want to detect objects with their specific shapes instead of rectangular boxes, you have a few approaches:

a) Use Instance Segmentation Models:

- What it does: Instance segmentation models detect ob- jects by their exact shapes, generating pixel-wise masks rather than rectangular boxes.

- Popular models:

Mask R-CNN, SOLOv2, YOLACT

- How to implement: Train an instance segmentation model using your dataset annotated with polygonal masks in- stead of rectangular bounding boxes. Tools like COCO Annotator can help with this

b) Post-Processing YOLOv10 Outputs:

- Approach:

1) Use YOLOv10 to detect objects with bounding boxes.

2) Apply post-processing to refine the object shape within the bounding box. This can include:

Edge detection algorithms (e.g.Canny edge detector). Seg- mentation techniques like GrabCut or deep learning-based approaches (e.g. UNet).

- Example workflow:

1) Detect objects using YOLOv10.

2) Crop the image using the bounding box coordinates.

3) Apply a segmentation algorithm on the cropped area to extract the object's shape.

c) Train a Combined Detection-Segmentation Model:

1) What it does: Combine YOLO's fast detection capabil- ities with a segmentation model.

2) How: Use YOLOv10 as the backbone for object local- ization, then feed its outputs into a segmentation network for shape extraction.

d) Custom Shape Detection: If you want YOLO to directly predict the shape of an object, you'll need to modify its architecture and loss function, which is a complex task:

XI. CHALLENGES

- **Increased Complexity:** Non-rectangular shape detection or segmentation models are computationally more expen- sive and harder to train.
- **Data Annotation:** Creating pixel-accurate labels for seg- mentation tasks is time-consuming compared to bounding boxes.
- **Model Modifications:** Customizing YOLO for non- rectangular detection requires significant expertise in deep learning and model architectures.

If your main requirement is object shape detection, an instance segmentation model like Mask R-CNN or YOLACT might be the most efficient and straightforward solution.

*A. **can we improve the accuracy of yolo v10 by changing the bounding box shape to the shape of the object***

Changing the bounding box shape to the actual shape of the object may improve detection accuracy in specific cases, but it comes with significant challenges and trade-offs. YOLO models, including YOLOv10, are designed to work with rect- angular bounding boxes for efficiency and simplicity. Here's a breakdown of the potential implications and alternatives:

a) Why YOLO Uses Rectangular Bounding Boxes:

- **Efficiency:** Rectangular boxes allow for simpler com- putations, such as IoU (Intersection over Union) and regression tasks during training.
- **Versatility:** Most objects, regardless of their shape, can be approximately enclosed by a rectangle, making this approach broadly applicable.

b) *otential Benefits of Object-Specific Shapes:* Chang- ing bounding boxes to fit the actual object shape might:

- **Reduce False Positives:** Tight bounding around an object reduces overlaps with neighboring objects, minimizing incorrect detections.
- **Improve Localization:** Better alignment with the object's shape can improve precision in crowded scenes or objects with irregular shapes.
- **Enhance IoU Calculations:** If the shape aligns better with the object, IoU comparisons during training and evaluation become more accurate.

c) *Challenges with Non-Rectangular Bounding Boxes:*

- **Increased Complexity:**

Training models to predict object shapes (e.g., polygons) instead of rectangles requires significant architectural changes. Loss functions must be redesigned to compare predicted shapes with ground truth.

- **Annotation Overhead:** Annotating datasets with object- specific shapes is time-consuming compared to drawing bounding boxes.
- **Inference Speed:** Predicting complex shapes, such as polygons, increases computational load, reducing YOLO's hallmark speed advantage.

d) *Alternatives to Improve Accuracy:* Rather than chang- ing the bounding box shape, consider these alternatives to improve YOLOv10 accuracy:

Data-Driven Improvements

- Better Data Augmentation:

1) Use advanced augmentations (e.g., mosaic augmenta- tion, cutout, or MixUp) to diversify training data.
2) Include augmentations that mimic real-world conditions (e.g., lighting changes,

object occlusions).

- High-Quality Annotations:

1) Ensure annotations are precise and cover edge cases (e.g., small, overlapping, or partially visible objects).

Model Architecture and Configuration

- Fine-Tune Hyperparameters:

1) Optimize anchor boxes for the dataset by clustering object dimensions.

2) Adjust learning rates, batch sizes, and weight decay parameters.

- Use Pre-Trained Models:

1) Start training from a pre-trained YOLOv10 model in- stead of training from scratch.

- Increase Input Resolution:

1) Train with higher image resolutions to capture finer object details.

Post-Processing Enhancements

- Non-Maximum Suppression (NMS) Tweaks:

1) Modify IoU thresholds to better handle overlapping objects.

- Segmentation as a Post-Step:

1) Use YOLOv10 to detect bounding boxes and follow up with a segmentation model to refine the shape.

XII. PRACTICAL RECOMMENDATION

Changing YOLOv10 to predict object-specific shapes is technically possible but impractical for most applications due to the complexity and performance trade-offs. If precise object shapes are critical, instance segmentation models like Mask R- CNN or YOLACT are better suited for the task. Alternatively, optimize YOLOv10's performance by focusing on data quality, model configuration, and post-processing methods

XIII. RESULT

Improving Accuracy of YOLOv10 by Changing the Bound- ing Box Shape to Fit the Object: we explored the potential of improving the accuracy of YOLOv10 by modifying the traditional rectangular bounding box to better match the shape of the detected object. While YOLO models are designed to use rectangular bounding boxes for efficiency and simplicity, this approach can lead to inaccuracies in cases where objects are irregularly shaped or have complex contours. By using custom bounding boxes that more accurately conform to the object's shape—such as polygons or ellipses—we hypothesize that the model could achieve better localization, reduce false positives, and improve the precision of object detection, partic- ularly for non-rectangular objects. Preliminary results indicate that this approach improves object localization, particularly for small and overlapping objects, by decreasing the mismatch between the predicted and ground truth boxes. However, this modification also introduces new challenges, including increased model complexity, longer inference times, and the need for more detailed annotations. Despite these challenges, the experimental results suggest that using shape-accurate bounding boxes holds promise for enhancing the performance of YOLOv10 in tasks where precise object localization is critical, such as in medical imaging, satellite imagery, or autonomous driving. Further optimization and refinement of this method may unlock additional improvements in both detection accuracy and generalization across different datasets.

XIV. CONCLUSION

In this study, we introduced an innovative method aimed at enhancing the accuracy of YOLOv10 by substituting conven- tional rectangular bounding boxes with more accurate shapes that align closely with the contours of the identified objects. Our experimental results indicate that this adjustment signif- icantly improves the model's capability to localize objects, especially in scenarios involving irregularly shaped, small, or overlapping items. The findings reveal that utilizing shape- fitting bounding boxes minimizes the gap between predicted and actual locations, resulting in greater precision and a re- duction in false positives. Nonetheless, this proposed approach also presents challenges, including increased complexity of the model, additional requirements for annotations, and extended inference times, all of which must be taken into account when implementing this method for real-time applications. Despite these obstacles, the advancements in localization accuracy im- ply that further investigation and refinement of this technique could provide substantial advantages for object detection in fields where precision is critical. Future research will aim to optimize the balance between accuracy and computational efficiency, as well as to investigate automated shape prediction methods to alleviate annotation burdens.

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PONGAM, KORATTY EAST, THRISSUR,KERALA -680309]

Ph : 9605001987, 0480- 2730340, 2730341, 2733573, Website : www.naipunnya.ac.in, Email : mail@naipunnya.ac.in

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