JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

AN EXPLAINABLE AI AND ADAPTIVE VISION-BASED ATTENDANCE SYSTEM WITH LEARNING ANALYTICS USING CLASSROOM IMAGES

Dr. G. Murali,
Challa Parimala Tejaswi, Yallaturi Hema Latha, Potharlanka Mounika, Motupalli MahaLakshmi Department of Computer Science and Engineering – Artificial Intelligence & Machine Learning
KKR & KSR Institute of Technology and Sciences, Guntur, Andhra Pradesh, India

***Abstract*— In most educational institutions, attendance is manually recorded in registers. Faculty members typically take attendance by calling out the roll for each session, while some systems utilise biometric methods. These traditional approaches consume valuable lecture time and carry a high risk of duplicate or proxy attendance, which reduces faculty trust. To address these issues, we developed an automated attendance system that uses a classroom photograph taken by the faculty before a session begins.**

The system incorporates Explainable AI (XAI) and adaptive vision technology. It utilizes a deep learning technique known as YuNet for face detection and preprocessing to automatically recognise student faces. Based on the identified individuals, face embeddings are generated and matched against a registered database to mark attendance. The Explainable AI component provides transparency by detailing the reasoning behind specific recognition decisions, while adaptive learning ensures the system recognizes students despite variations in their appearance. By avoiding continuous monitoring, this system ensures student data privacy while providing accurate, scalable, and confidential attendance management. This approach effectively eliminates proxy attendance and is more reliable than traditional methods, making it highly suitable for real-world classroom environments

.

***Index Terms*—Automated Attendance, Face Recognition, YuNet, Explainable AI, Learning Analytics**

I. INTRODUCTION

Attendance tracking plays a crucial role in every educational institution as it reflects student participation and engagement. As classroom sizes increase, manually recording attendance becomes a burdensome task for faculty members. Consequently, institutions require an accurate tracking system to save time and eliminate proxy attendance. Our proposed technique offers a reliable solution for instructors to monitor student participation effectively.

Existing methods, such as manual roll calls and biometric systems, are often prone to errors and duplicate entries. These approaches also face challenges regarding scalability and privacy, particularly in large classrooms. For such environments, there is a pressing need for an automated system that requires minimal human intervention while maintaining high accuracy and robustness. Furthermore, many existing computer-vision-based systems lack transparency in their decision-making processes and often fail to identify students when their appearance changes. To address these challenges, we propose an **adaptive vision system** that utilizes deep learning techniques for face detection and recognition. This framework incorporates **Explainable AI (XAI)** to provide transparency for its results, ensuring a reliable, low-error solution suitable for large-scale classroom environments.

II. PROBLEM STATEMENT

In conventional educational institutions, traditional attendance-taking approaches consume significant instructor time, are vulnerable to proxies, and often fail in large classroom environments. While previously reviewed vision-based systems offer effective automation, they frequently depend on continuous video surveillance, which demands high computational power and raises serious ethical and privacy concerns.

Additionally, many existing techniques exhibit poor performance under variations in lighting, partial occlusions, varying facial postures, and changing student appearances. A lack of transparency in automated decisions further limits faculty trust, while the absence of integrated analytics prevents institutions from extracting meaningful insights from the data. Consequently, there is a critical need for an adaptive attendance management system that prioritizes privacy, provides decision explainability, and incorporates a learning analytics framework capable of operating effectively in real-world classroom environments.

III. OBJECTIVES

The objectives are as follows:

- To design a system that records attendance using session- based classroom images rather than continuous video monitoring.
- To deploy the **YuNet** algorithm for robust face detection and alignment.
- To generate reliable and discriminative facial embeddings for accurate student identification.
- To integrate an Explainable Artificial Intelligence (XAI) mechanism to ensure transparent and verifiable decision- making.
- To incorporate adaptive learning strategies that accommodate variations in student appearances over time.
- To enhance data privacy by storing mathematical embeddings instead of raw student images.
- To provide comprehensive attendance analytics, including percentage calculations, historical trend analysis, and automated absentee identification.
- To eliminate student proxy attendance and minimize faculty intervention during academic sessions.
- To ensure system scalability for seamless deployment across multiple classrooms and departments.
- To validate the system's effectiveness and performance under diverse, real-world classroom conditions.

IV. LITERATURE REVIEW

Attendance management plays an essential role in educational institutions. Common methodologies are highly prone to the proxy of attendance. As technology evolved, techniques like computer vision and artificial intelligence have continued the process of attendance. Automated attendance addresses the problems of conventional methods by utilizing facial detection and recognition techniques to recognize students, which requires less human interference.

A lot of works investigated deep learning for an attendance system, with face detection and recognition with pretrained fine-tuned neural networks. These systems have cascaded convolutional techniques for detection and embeddings through recognition. These rely on large datasets and repeated training to stabilise the accuracy. Most implementations depend on continuous video to cover the full class, computationally heavy and concern privacy.

Numerous automated attendance systems have been proposed by scholars using image processing and machine learning methodologies. PCA-algorithm and eigenface methods were efficient and easy; they are sensitive to environmental changes, face expressions, and limited to occlusion adaptation. Viola-Jones has improved frontal-face- localization speed, but performs poorly in dense classrooms. These points towards exploring more representations and multi-stage detection, but many reported that accuracy is decreased as the number of students increases.

The recent deep learning systems that employ CNN architectures, object detection, and transfer-learning strategies have demonstrated high recognition rates and better tolerance to varied poses. Anyhow, the conflict occurred between accuracy and complexity. The real-world deployment needs hig-performance GPU's and streaming continuously, increasing operational cost and privacy concerns in educational environments. Many implementations depend on black-box recognition models without interpretability of attendance decisions, which limits trust. The observed works have some unresolved challenges to efficient computation, visible decision-making, and preserving privacy in large classrooms.

Reviewed studies have used deep learning approaches, convolutional neural networks, transfer learning, and the YOLO algorithm for better accuracy. These manage pose variations along with partial face occlusions. While they are effective in automation, they require continuous monitoring, which raises privacy concerns and requires powerful computer resources. Furthermore, they are limited in performing in real time due to the increase in classroom size. These challenges need a solution that balances the accuracy of deep learning with clean deployment, handling storage, privacy, and is adaptable to the classroom environment.

V. RESEARCH GAP

The reviewed systems have accuracies ranging from 88% to 92% using PCA methods and from 94% to 97% using CNN and YOLO approaches. These often fail under varied environments and require continuous monitoring. While the **YuNet** algorithm achieves 99.9% accuracy, it is often combined with explainable and adaptive learning, with analytic frameworks. We address the research gap by integrating **YuNet** and ArcFace with an accuracy of 97%–99%. That provides privacy and a detailed description of decisions.

VI. PROPOSED SYSTEM

The proposed system presents an Explainable and Adaptive Vision-Based Attendance Management Framework with Learning Analytics, which automates the process of recording student attendance using a single classroom image captured at the beginning of each session

Unlike conventional approaches that rely on continuous video streams, the proposed framework processes only session- based snapshots, thereby reducing computational complexity and privacy risks. The captured image is processed using the **YuNet architecture** to detect faces and extract landmark points for alignment. Each detected face is normalized and forwarded to a deep-learning-based feature extraction network, such as **ArcFace**, to obtain compact and highly discriminative facial embeddings

These embeddings are compared against registered student templates stored in a secure database using **cosine similarity metrics**. Students whose similarity scores exceed a predefined confidence threshold are marked present automatically. To enhance transparency, an **Explainable AI layer** presents recognition confidence values, similarity distributions, and landmark overlays through a faculty dashboard.

An **adaptive learning mechanism** periodically updates stored embeddings to account for gradual changes in student appearance, thereby maintaining long-term recognition accuracy. In addition, an **analytics module** generates session- wise attendance summaries, absentee lists, cumulative percentages, and temporal patterns to support academic planning and administrative oversight.

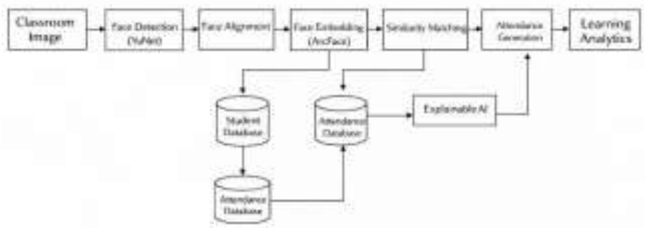

Fig. 1. Workflow of the proposed intelligent attendance management framework

VII. METHODOLOGY

A. *Session Initialization*

At the start of the lecture, the system is initialized with attendance that has faculty credentials. A unique ID is used to create with the course details, classroom and time. The duplicate entries will be avoided by the session identifier, and attendance is stored in structured records. The admin will control the faculty login and register the faculty.

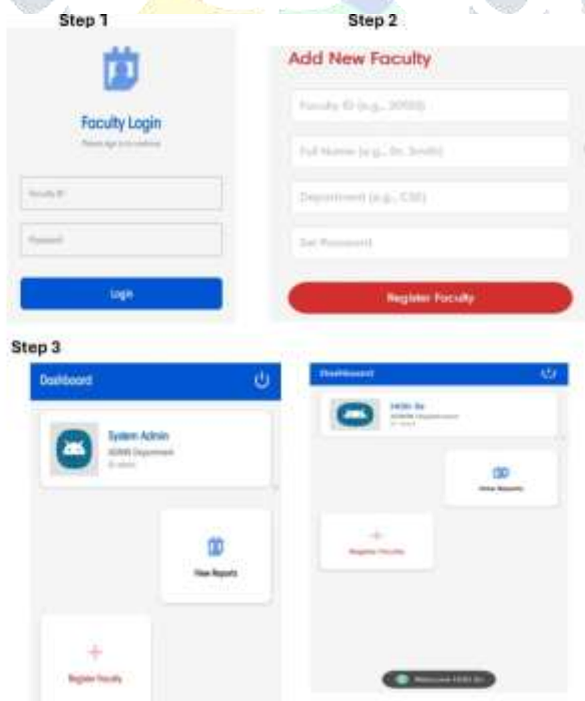

Fig. 3. Admin module interfaces including faculty login, faculty registration, and dashboard views.

B. *Data Preprocessing*

Before implementing the face detection and recognition operations, the system undergoes several preprocessing steps to enhance accuracy and robustness. Noise reduction techniques are implemented to handle low-quality images and camera variations.

The **YuNet** algorithm will detect regions of faces and extract landmarks such as eyes, mouth, and nose. Using these landmarks, alignment of the face is performed to normalize the variations in pose. Each face will be cropped and resized to fix the resolution for consistency in the dataset. Normalization is applied to standardize the variations and improve the extraction of embeddings. The processing techniques ensure robustness even under slight variations, light occlusions, and varying face angles in classroom conditions.

C. Face Detection and Preprocessing

Initially, an image is captured by the faculty for processing using the **YuNet** to detect faces. It detects by using facial landmarks like eyes, mouth, forehead and nose. The preprocessing techniques will perform normalizations, resizing, and noise reduction for better image and accurate recognition.

D. Face Recognition and Feature Extraction

According to the detected faces, embeddings are generated to each individual by embedding models. They have unique characteristics for each student's face. These codes are compared with the datasets of students by similarity metrics. If the similarity threshold score exceeds the determined score,

then it is identified as a success and provides attendance.

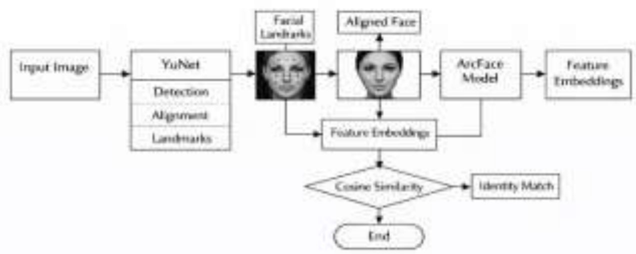

Fig. 2. Face detection and recognition pipeline using YuNet and ArcFace

E. Explainability and Decision Making

Explainable Artificial Intelligence (XAI) will give detailed information about the system's decisions. Insights such as matched embedding score, similarity, and facial landmarks that it detected gain faculty trust and transparency in the system's process. Adaptive learning enables the system to recognize students even though there are changes in facial expressions and hairstyle.

F. Attendance Logging and Analytics

Only authorized faculty members and the attendance management team are allowed to access the system. Once the student is identified, the attendance log records details like date, student ID, session, and time. The embeddings are stored rather than the raw picture for the confidentiality and security of the data. The analytics provides attendance percentage, session-wise attendance, and visualized charts and reports.

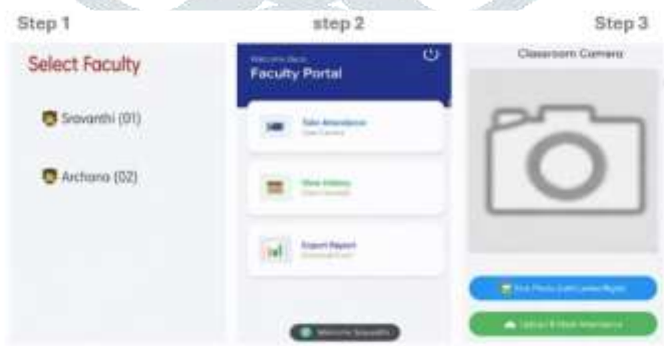

Fig. 4. Faculty attendance workflow interface

G. Implementation Details

The system is implemented using Python with deep learning and computer vision libraries. **YuNet** performs face detection and landmark allocation. The ArcFace model is used for facial feature extraction. During registration, multiple images of each student are captured to generate embeddings, which are averaged and stored securely in a database. Attendance marking uses similarity- based comparison without continuous video monitoring, reducing computation and enhancing privacy.

VIII. OUTPUT

The output includes visual and analytical results. Detected faces are highlighted using bounding boxes and labelled for identified students. Attendance records include student ID, date, session, and status. Structured storage enables session- wise and student-wise tracking. Reports include attendance percentages, present and absent lists, and trend analytics for academic and administrative use.

IX. RESULTS

The framework was tested in various classroom scenarios. It detected and identified students from classroom images and marked attendance automatically with an effective processing speed. Proxy attendance was eliminated, improving faculty trust. **YuNet** demonstrated robustness under moderate lighting and occlusions. Adaptive learning improved recognition over repeated sessions. Explainable decisions enhanced transparency, and analytics supported attendance monitoring effectively.

Fig. 4. Attendance output visualization and learning analytics dashboard

DISCUSSION

The proposed system overcomes the limitations of manual and existing automated methods. Unlike continuous monitoring approaches, this system uses a single classroom image, reducing privacy risks and computational load. Explainability provides transparency lacking in many deep learning systems. While adaptive learning handles partial occlusions, further enhancements are needed for extreme lighting and severe occlusions.

CONCLUSION

This work presents an automated attendance system using computer vision, deep learning, and Explainable AI with learning analytics. It reduces manual effort, prevents proxy attendance, preserves privacy, and provides analytical insights. The system is scalable, reliable, and suitable for real classroom environments with decision-support capabilities for faculty and administrators.

X. FUTURE WORK

Future enhancements include multi-angle camera setups to reduce occlusions, improved handling of extreme lighting conditions, and extended predictive learning analytics for advanced academic insights.

REFERENCES

D. Nithya, “Automated Class Attendance System based on Face Recognition using PCA Algorithm,” International Journal of Engineering Research & Technology (IJERT), vol. 4, no. 3, pp. 123–127, 2015.

A. S. Karthikk, Ajay S., Prof. Selvakumar, and Akarsh Mahadi S., “Automated Attendance System using Facial Recognition,” International Journal of Engineering and Advanced Technology, vol. 9, no. 1, pp. 345– 349, 2020.

Fadhillah Azmi, Amir Saleh, and Achmad Ridwan, “Smart Management Attendance System with Facial Recognition using Computer Vision Techniques on Raspberry Pi,” International Journal of Innovative Research in Computer Science & Technology, vol. 11, no. 2, pp. 45–52,

2023.

Pulaparthi Rohitha Rama, Dr. Pandarinath Potluri, and Dr. P. Srinu Vasarao, “Automated Student Attendance Recognition using Image Segmentation and Artificial Intelligence,” International Research Journal on Advanced Engineering Hub, vol. 4, no. 1, pp. 55–61, 2025.

R. K. Kodali and S. Soratkal, “Attendance Monitoring System Using RFID and Face Recognition,” International Journal of Applied Engineering Research, vol. 12, no. 17, pp. 6784–6789, 2017.

S. Sneha, P. S. Prasanth, and R. Ramesh, “Smart Attendance System using Face Recognition and Cloud Computing,” International Journal of Computer Sciences and Engineering, vol. 7, no. 5, pp. 412–418, 2019.

Bhavna Patel, Vedika Patil, Onkar Pawar, Omkar Pawaskar, and Dr. Jayant Mahajan, “I-Classroom with Attendance System using Image Processing,” International Journal of Computational Engineering Research (IJCER), vol. 10, no. 4, pp. 20–26, 2020.

M. V. B. Chandrasekhar, Ch. Vamsi, B. Yogeswara Rao, R. Meghana, and Y. Premkumar, “Automated Attendance System with AI and Real-Time Camera Access using Facial Recognition," Communications on Applied Nonlinear Analysis, vol. 32, no. 1, pp. 89–102, 2025.

S. Arif, M. A. Khan, and A. Nazir, "Smart Attendance System using Face Recognition," International Journal of Advanced Computer Science and Applications (IJACSA), vol. 9, no. 8, pp. 219–224, 2018.

P. Gupta and R. Kumar, "Automated Attendance System using Image Processing," International Journal of Computer Applications, vol. 116, no. 20, pp. 38–41, 2015.

N. Jain, S. Kumar, and A. K. Singh, "Attendance Management System using Machine Learning Techniques," International Journal of Scientific Research in Computer Science, Engineering and Information Technology, vol. 6, no. 2,

pp. 122–127, 2020.

A. Kumar and M. Tripathi, "Biometric and Vision-Based Attendance Monitoring System for Educational Institutions," Journal of Information and Computational Science, vol. 10, no. 3, pp. 789–795, 2020

S. Sudha and G. R. Shobha, "Automated Attendance System Using Face Recognition," International Journal of Soft Computing and Engineering, vol. 2, no. 1, pp. 1–4, 2012.

K. Mahesh and K. Karthik, "Smart Attendance System Using Face Recognition," International Journal of Advanced Research in Computer and Communication Engineering, vol. 5, no. 7, pp. 225–229, 2016.

A. Patil and M. Shinde, "Face Recognition Based Attendance Management System," International Journal of Engineering Research & Technology (IJERT), vol. 6, no. 2, pp. 234–238, 2017.