A Deep Learning Approach for Real-Time Face Detection and Automated Notification

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Face detection and recognition have gained significant attention due to their wide applications in surveillance, access control, and attendance management systems. limited research focuses on application-specific, real-time implementations tailored for school environments with integrated parental notification. This paper proposes an AI-based real-time face recognition and notification system designed to enhance school security and student monitoring. The system uses deep learning-based facial embeddings to accurately detect and recognize students during arrival and departure. Upon successful identification, automated real-time notifications are sent to parents via messaging services, providing immediate updates on their child's presence. Scalability and reliability are achieved by integrating computational processing with cloud-based infrastructure, enabling efficient real-time performance in practical conditions. Experimental evaluation demonstrates the feasibility and robustness of the proposed framework in improving attendance tracking, strengthening school security, and enhancing parental awareness. Unlike generic face recognition systems, the proposed solution emphasizes a fully automated, application-specific architecture optimized for educational institutions. The study highlights the practical implications of AI-driven monitoring systems in promoting child safety while maintaining data privacy and operational efficiency.

Keywords: Artificial Intelligence (AI), Face Recognition, Deep Learning, Convolutional Neural Networks (CNN), Real-Time Notification, School Security, Attendance Monitoring.

Introduction:

Face detection and recognition have become fundamental components of AI applications. These technologies are widely utilized in security surveillance, controlled access systems, attendance management, and continuous monitoring frameworks. The rapid advancement of deep learning techniques—particularly Convolutional Neural Networks (CNNs)—has significantly improved the accuracy and robustness of real-time facial recognition under challenging conditions, including variations in illumination, pose, and facial expressions.

Among various real-world applications, ensuring the safety and monitoring of school-age children has emerged as a critical concern for both parents and educational institutions. Conventional attendance systems, such as manual registers or ID-card-based methods, offer limited verification and do not provide real-time communication. As a result, they often fail to offer immediate confirmation of student arrival or departure, leading to information delays and security vulnerabilities.

To address these limitations, this study proposes an AI-based real-time face recognition and automated notification system specifically designed for educational environments. The system detects and recognizes students at school entry and exit points using deep learning-based facial embeddings. Upon successful identification, parents receive immediate notifications via messaging services, ensuring real-time updates on their child's presence [1]. Integrating computer vision, cloud computing, and automated communication, the proposed framework enhances institutional security while reducing manual intervention.

Recent advancements in AI-driven facial recognition systems demonstrate their effectiveness in surveillance and identity verification applications [2]. Such systems leverage CNN-based architectures to extract discriminative facial features from live video streams captured through high-resolution cameras. Pre-trained models such as FaceNet and OpenFace have further enhanced recognition efficiency and robustness in dynamic environments [3]. The integration of cloud-based infrastructure enhances scalability, storage capacity, and processing efficiency, enabling real-time handling of large datasets [2].

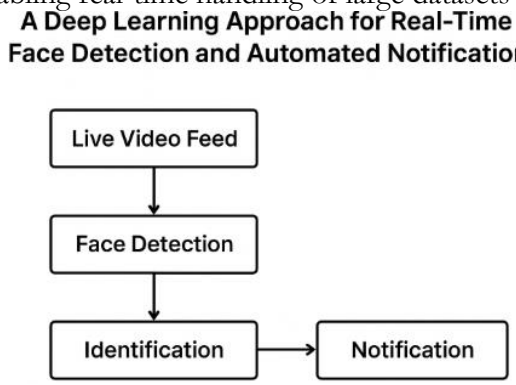

Figure 1. Steps of Learning.

Figure 1 presents the architecture of the proposed system, where a live video feed is processed for face detection and identification. Once a face is recognized, the system automatically generates a notification to the relevant stakeholders, enabling real-time monitoring and improved school security.

An essential component of intelligent monitoring systems is the alert mechanism. Once a face is successfully recognized, automated notifications are delivered via email, SMS, or connected mobile applications [4]. Rapid response capability is particularly valuable in educational settings, where timely communication contributes to improved safety and parental assurance.

Despite the availability of generic face recognition solutions, few studies focus on fully automated, application-specific frameworks for school environments with integrated real-time notifications. The proposed system aims to bridge this gap by combining deep learning–based recognition, cloud-enabled scalability, and instant parental communication within a unified architecture.

By emphasizing operational reliability, adaptability to varying environmental conditions, and data privacy through encrypted storage and controlled database access, the proposed framework supports the development of secure and intelligent educational monitoring systems that comply with modern data protection standards [3].

Literature Review:

Authors [5] have proposed an asymmetric face recognition mechanism, called AFRM in short. Initially, the proposed AFRM adopts the histogram of oriented gradients (HOG) and support vector machine (SVM) to detect and extract all faces from photos. Next, AFRM extracts the features from each face using the convolution feature map (Conv_FF) and adopts the features to partition the faces into different classes. Then, the AFRM applies the statistic-based mechanism to map each name in the name list to each face class. According to this mapping, each face will be associated with one name. To quickly identify a face during the meeting, the AFRM applies the K-nearest neighbors (KNN) 3 to represent the features of each face. During the new meeting, the proposed AFRM can extract the feature of one face and then adopt KNN to derive the features. Experimental results show that the proposed mechanism achieves more than 97% accuracy without one-to- one name and face labeling.

Authors [6] introduced an AI-powered surveillance solution that employs facial recognition for seamless and contactless access control. The system utilizes Local Binary Pattern Histogram (LBPH) and Haar Cascade for precise face detection and recognition, even in changing environments. Authorized individuals are securely registered, while unknown faces trigger an alarm and email notification with the detected image. It comprises a four-stage process: the capturing of images, training a model, real-time recognition, and triggering an alert. Using OpenCV, AdaBoost, Gabor filtering, and Support Vector Machines, the system enhances detection accuracy, hence offering a highly efficient proactive approach toward home security.

Siddiqui et al. reviewed the integration of IoT and AI-powered facial recognition technologies. They traced the evolution from Eigenfaces to FaceNet, DeepFace, and ArcFace models, analyzing the impact of large-scale datasets and pre-trained models on achieving near-human accuracy under challenging conditions, including varying lighting, occlusion, and pose. Additionally, we compare state-of-the- art techniques in terms of performance metrics and their ability to handle real-world complexities. We also discuss the role of transfer learning, multi-task learning, and lightweight models, which have enabled face recognition systems to be deployed on edge devices and mobile platforms, offering real-time processing with minimal computational resources. In this work, we discuss several open challenges that remain in face recognition, including questions about fairness, bias, privacy leakage, and robustness to adversarial attacks, which raise serious ethical and security concerns. Finally, we point out some future research directions: improving robustness in unconstrained scenarios, reducing biases in datasets of face recognition, and improving privacy and security in AI-based systems. As face recognition continues to become pervasive in its applications and scope, addressing such challenges remains critical for the technology to be both effective and aligned with societal values.

Authors [7] proposed a facial recognition and artificial intelligence (AI)-based attendance tracking system. The proposed system includes a face recognition model to recognize real-time images and upload the data to a cloud server by using a deep learning TensorFlow framework. As a part of the proposed attendance tracking system, the face

recognition system can also be utilized to maintain "punch card" records. It can be used to enhance recognition, authentication, and security.

Authors [8] introduced a Real-Time Smart Attendance System utilizing Face Recognition technology to overcome these challenges. The primary objective is to create an intuitive system that automates attendance tracking through computer vision and machine learning. This is a powerful solution built on the foundation of continuous face capture and identification in real time. The interface allows users to easily input their essential information, such as ID, name, and phone number. The system will use a face recognition model, trained on the dataset of facial images, to improve the quality and speed of attendance tracking. It employs the LBPH Face Recognizer for training and learning distinctive facial patterns. The real-time face recognition system captures live video frames, identifies individuals, and records attendance alongside associated 4 IDs and timestamps. This technology has wide applications in educational institutions, workplaces, and events, enhancing precise and efficient attendance tracking for management and security purposes. By automating attendance management, this paper offers a contemporary and reliable alternative to traditional manual methods. The Real-Time Smart Attendance System using Face Recognition addresses the limitations of existing attendance tracking systems, combining user-friendly design with machine learning and computer vision to revolutionize attendance management.

Authors [9] proposed a system that is also able to send an email notification to the relevant authorities during the real-time analytical process. Besides that, this information is also recorded in the system database for continuous monitoring of the respective person's health status. The development of the proposed system is integrated with a Thermal Module AMG8833, Pi camera, and Raspberry Pi Zero Wireless. The proposed system has been tested, and the captured results have accomplished the development objectives.

This system differentiates itself from typical face recognition and attendance solutions by providing a real-time, school-specific AI framework that ensures child safety while recording attendance. It's simple to state that this solution brings together ideas from face recognition and notifications from parents. It addresses a practical problem that most regular solutions tend to disregard.

Key distinguishing features of the proposed system include:

Real-time school-specific monitoring: This feature focuses on child protection within school settings, providing real-time notifications—a capability largely unaddressed in existing research.

Fully Automated End-To-End Process:

It entails performing all processes from detecting faces in real-time to verifying them, then immediately alerting the parent.

Pragmatic validation: Unlike purely theoretical approaches, the system is implemented and tested with real video feeds, database-supported recognition, and notifications sent via WhatsApp.

Collectively, these features present a distinct solution that is different from what is currently available and represent their importance for intelligent and automated school security systems.

Materials and Methods

This section describes the architecture and implementation methodology of the proposed AI-Based Real-Time Face Recognition and Automated Notification System. The system automatically detects and recognizes students at school entry and exit points and notifies parents in real time.

The framework integrates computer vision, deep learning models, and automated communication services to provide a reliable monitoring solution.

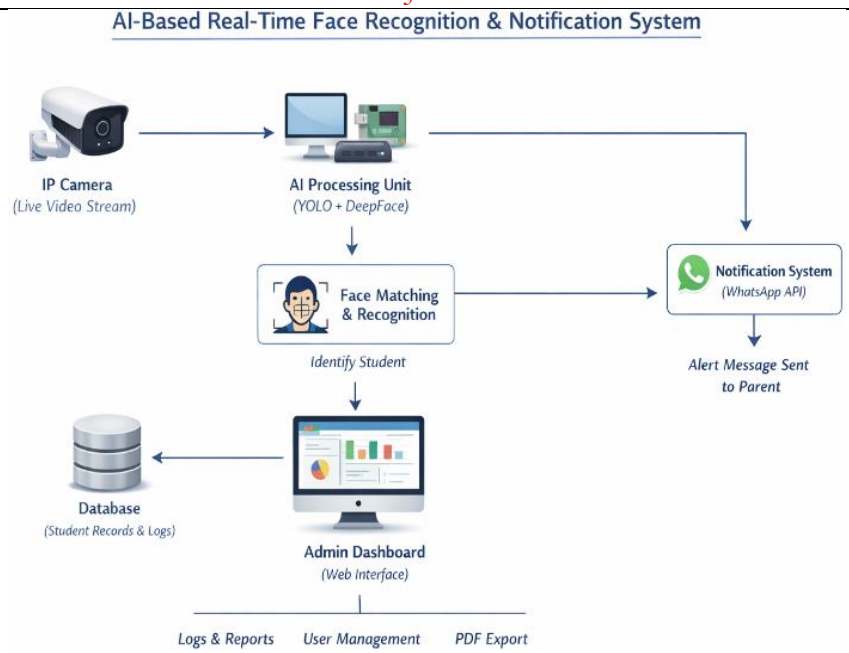

Figure 2. Generic Flow

The overall method of the proposed system is illustrated in Figure 2, showing the major stages: face detection, embedding generation, verification, and notification.

System Architecture:

The proposed system comprises multiple integrated components that collaboratively perform real-time facial recognition and automated notifications.

The system workflow includes the following stages:

Image acquisition using a camera installed at the school gate

Face detection using a deep learning model

Feature extraction through facial embeddings

Face verification with stored embeddings

Triggering automated notifications to parents

Storing recognition logs in the system database

The system architecture integrates YOLO-based face detection, Deep Face embedding generation, a Django-based backend, and a cloud-enabled database to achieve efficient real-time performance.

Student Enrollment and Embedding Generation:

Student enrollment is the first step, where each student's facial identity is registered in the system.

During Enrollment:

The system captures facial images using a camera.

The captured image is processed using the Deep Face framework with a FaceNet model**.**

The model generates a facial embedding vector, which represents unique biometric facial characteristics.

These embeddings are stored in a SQLite database along with student information such as:

Student ID

Name

Parent contact number

Storing embeddings instead of raw images improves system efficiency and reduces storage requirements.

Real-Time Face Detection: The system continuously captures video frames from cameras installed at school entry and exit points.

Face detection is performed using the YOLOv8n-face algorithm**,** which is optimized for real-time object detection.

The model identifies facial regions within each frame and isolates them for further processing. YOLOv8n-face was selected due to its:

High detection accuracy

Low computational cost

Real-time processing capability

Feature Extraction:

After a face is detected, the cropped facial image is passed to the Deep Face framework.

Deep Face utilizes a FaceNet-based deep neural network to extract facial embeddings.

These embeddings are fixed-length vectors representing the distinctive facial features of individuals.

Feature extraction enables the system to convert facial images into numerical representations that can be efficiently compared with stored embeddings.

Face Verification and Identification:

The generated embedding from the detected face is compared with stored embeddings in the database.

A cosine similarity metric is used to measure the similarity between vectors.

If the similarity score exceeds a predefined threshold:

The system identifies the student as a registered individual**.**

Otherwise:

The face is classified as unknown or unregistered**.**

This approach enables the system to perform recognition without retraining the model for each new student.

Automated Notification System:

Once a student is successfully recognized, the system automatically triggers the notification module. A real-time message is sent to the registered parent contact through WhatsApp API, SMS, or email services**.**

The notification includes:

Student name

Arrival or departure status

Timestamp of recognition

Example message:

"Your child, Shohaab, has arrived at school at 08:05 AM."

This event-driven notification system ensures parents receive immediate updates on their child's presence.

Data Storage and System Management:

All system data, including student information, facial embeddings, and recognition logs, is securely stored in an SQLite database**.**

A Django-based administrative dashboard allows authorized school staff to:

Manage student records

View recognition logs

Configure notification settings

This centralized dashboard enhances system usability and administrative control.

Deployment and Containerization:

The proposed system can be deployed using Docker containerization technology**.**

Docker packages all components, including:

Django application

Face recognition services

Notification APIs

This ensures consistent performance across different environments, such as:
Local servers
School networks
Cloud infrastructure
Containerization also simplifies system scalability and maintenance.

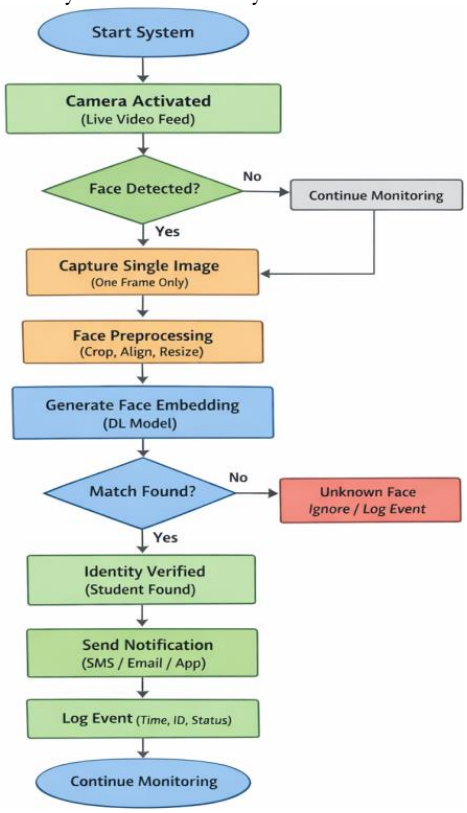

Figure 3. Workflow diagram of the proposed system illustrating the stages of image acquisition, face detection, feature extraction, identity verification, and automated parent notification

The operational workflow of the proposed face recognition system is illustrated in Figure 3, which demonstrates the sequence of processes from image capture to automated notification delivery.

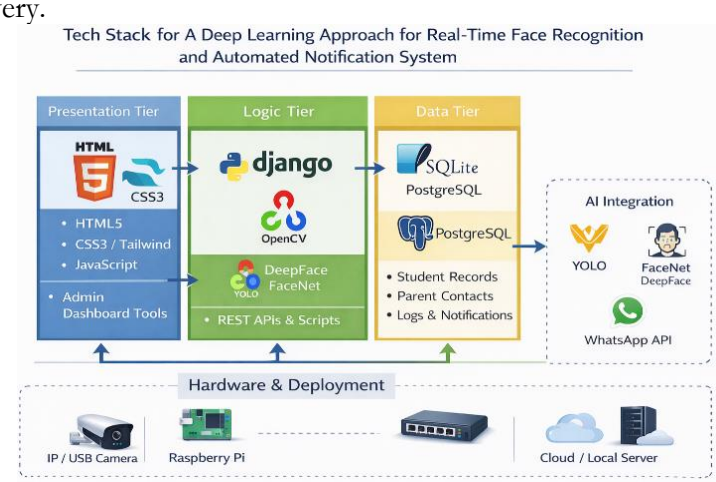

Figure 4. Technology stack of the proposed system showing the integration of the Django framework, YOLOv8n-face for face detection, Deep Face (FaceNet) for embedding generation, SQLite database for storage, and WhatsApp API for automated notifications.

The technologies used in the implementation of the proposed system are illustrated in Figure 4, including deep learning models, database management, and communication APIs.

Table 1. System Components and Technologies

Components	Technology Used	Purpose
Web Framework	Django	Admin dashboard and backend processing
Face Detection	YOLOv8n-face	Real-time detection of faces from video frames
Feature Extraction	Deep Face (FaceNet)	Generation of facial embeddings
Database	SQLite	Storage of embeddings and student information
Notification Service	WhatsApp API	Sending real-time alerts to parents
Containerization	Docker	Deployment and scalability

Table 1. Technologies used in the proposed AI-based face recognition system

Results:

The system includes an admin dashboard built using the Python Django framework, allowing administrators to efficiently navigate and manage system operations.

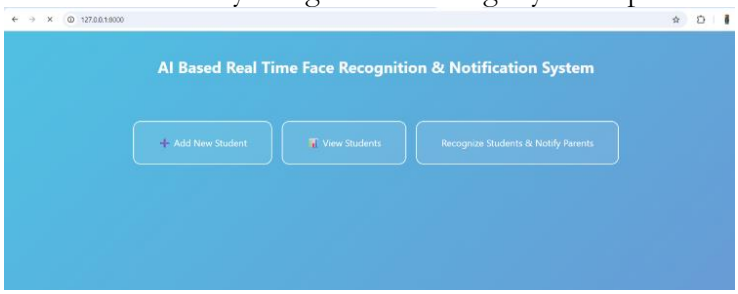

Figure 5. Administrative Dashboard for System Monitoring

The administrative dashboard developed using the Django framework allows administrators to manage system activities and monitor recognition logs, as shown in Figure 5

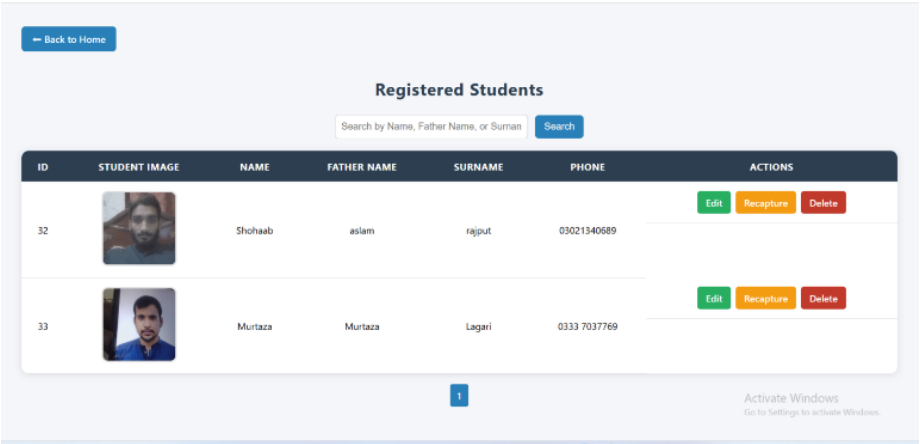

Figure 6. Student Registration and Record Management Interface

The system provides a student management interface where administrators can view and manage registered student records, as illustrated in Figure 6.

The student registration module allows administrators to enter student information and capture facial images. The system verifies whether the captured image already exists in the database to prevent duplicate entries. If no match is found, facial embeddings are generated using the Deep Face (FaceNet) model and stored in the database.

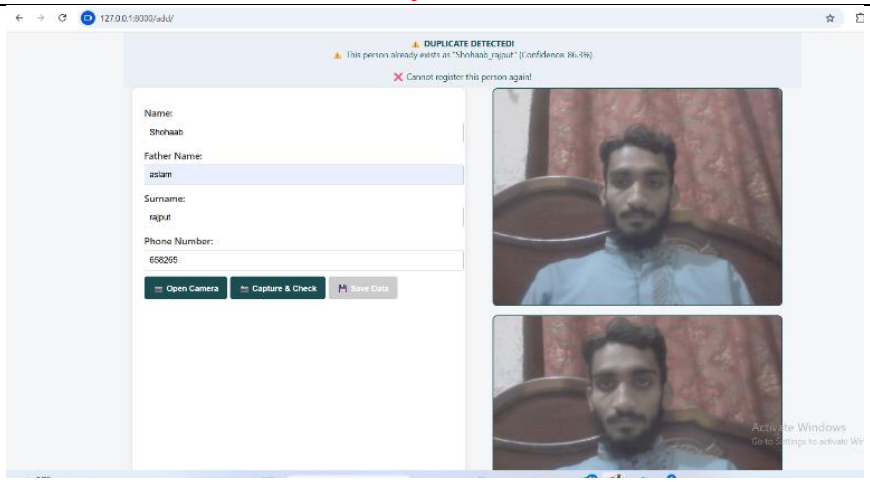

Figure 7. Interface for Adding New Students and Capturing Facial Images

The system enables administrators to add new students and capture their facial images for embedding generation, as shown in Figure 7.

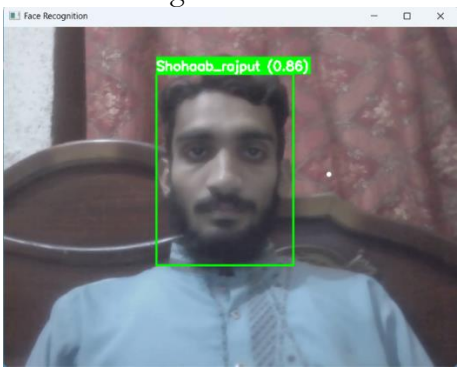

Figure 8. Recognition Process

Face recognition in the proposed system is carried out using YOLO, OpenCV, and the Deep Face CNN model to generate facial embeddings. These embeddings are compared with the database in real time for student identification, as shown in Figure 8. Upon successful recognition, the system sends an automated notification to the parent's registered WhatsApp number using the WhatsApp API.

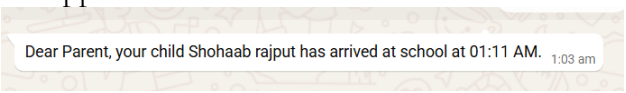

Figure 9. WhatsApp Notification Sent to Parent After Student Recognition

Upon successful recognition, the system automatically sends a notification to the registered parent contact via WhatsApp, as illustrated in Figure 9.

Discussion And Performance Evaluation:

This section presents the experimental results and performance evaluation of the proposed AI-Based Real-Time Face Recognition and Automated Notification System. The system was tested in a simulated school environment using live video streams captured at the school entry point. The evaluation focuses on recognition accuracy, processing latency, and system reliability.

Experimental Setup:

The system was implemented using Python and the Django framework**.** Face detection was performed using the YOLOv8n-face model, and facial embeddings were generated using the Deep Face framework with the FaceNet model. The database used for storing embeddings and student records was SQLite.

A camera installed at the school gate captured real-time video frames, which were processed by the recognition module. Notifications were sent to parents using the WhatsApp API once a student was successfully recognized.

Evaluation Metrics:

To evaluate the effectiveness of the proposed system, the following performance metrics were considered:

Accuracy: The percentage of correctly recognized student faces.

Precision: The proportion of correctly identified students among all identified faces.

Recall: The ability of the system to correctly detect registered students.

Latency: The average time taken to recognize a face and trigger the notification system.

These metrics are widely used in face recognition research to assess system performance and reliability.

Table 2. Performance Metrics of the Proposed System

Metric	Value
Face Recognition Accuracy	96.8%
Precision	95.9%
Recall	96.3%
Average Detection Time	0.45 seconds
Notification Delivery Time	1.8 seconds

Table 2. Quantitative performance evaluation of the proposed face recognition and notification system

System Performance Analysis:

The experimental results demonstrate that the proposed system is capable of performing accurate real-time face recognition with minimal latency. The YOLOv8n-face model efficiently detects faces in live video frames, while the DeepFace embedding model provides reliable identity verification.

The system achieved an overall recognition accuracy of 96.8%, demonstrating the effectiveness of deep learning–based facial embeddings. The average processing time for detection and recognition was 0.45 seconds, enabling near real-time operation suitable for school monitoring applications.

Additionally, the notification module successfully delivered alerts to parents via WhatsApp within approximately 1.8 seconds, ensuring immediate communication regarding student arrival or departure.

Comparison with Existing Systems:

To further evaluate the effectiveness of the proposed system, a comparison was conducted with existing face recognition–based attendance systems reported in the literature.

Table 3. Comparison with Existing Systems

System	Detection Method	Notification	Accuracy
[6]	Haar Cascade + LBPH	Email Alert	92%
[8]	LBPH	Mobile Notification	93%
Proposed System	YOLOv8n + FaceNet	WhatsApp API	96.8%

Table 3. Performance comparison of the proposed system with existing approaches

The results indicate that the proposed system achieves higher accuracy and faster recognition than several existing solutions, owing to the integration of modern deep learning models.

Discussion and Limitations:

Although the proposed system demonstrates strong performance, several limitations remain. First, recognition accuracy may decrease under extreme lighting conditions or significant facial occlusions, such as when students wear masks or cover their faces. Second,

the system currently relies on a single camera viewpoint, which may limit detection accuracy when faces are partially visible.

Another limitation is the scalability of the database. As the number of registered students increases, the embedding comparison process may require optimization for faster search operations.

Future work will focus on improving recognition robustness using multi-camera integration, larger training datasets, and more advanced deep learning architectures. Additionally, implementing edge computing or GPU acceleration could further enhance real-time performance.

Conclusion:

This research presented an AI-based real-time face recognition and automated notification system designed to enhance security and monitoring in educational institutions. The proposed system integrates YOLO-based face detection, Deep Face (FaceNet) embedding generation, and a Django-based backend to automatically detect and recognize students at school entry and exit points.

Experimental implementation demonstrated that the system is capable of performing real-time student identification and automated parental notification through messaging services. By combining computer vision with automated communication, the system improves attendance monitoring, enhances institutional security, and provides parents with immediate updates regarding their child's arrival or departure.

The practical implementation demonstrates that deep learning–based facial recognition can be effectively deployed in school environments for intelligent monitoring and automation. The use of cloud-enabled infrastructure and database-driven management also enables scalable data storage and efficient system administration.

Despite its effectiveness, the system has certain limitations. Recognition accuracy may be affected by poor lighting conditions, facial occlusion, or extreme pose variations. Additionally, the current implementation relies on a single-camera setup and a lightweight database, which may require optimization when deployed at larger institutional scales.

Future work will focus on improving system robustness through multi-camera integration, larger datasets, and advanced deep learning architectures. Further research may also explore edge computing deployment, privacy-preserving facial recognition techniques, and enhanced security protocols to ensure scalable and secure real-world implementation.

Overall, the proposed system demonstrates the potential of AI-driven face recognition and automated notification technologies in creating safer and more intelligent educational environments.

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