

# Student Monitoring System Using AI and Image Processing

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## Abstract

The purpose of developing a Student Monitoring System that incorporates AI and Digital Image Processing is to automate the process of logging attendance, making it easier and more accurate to identify each student in the classroom or laboratory. The Student Monitoring System is built on a Raspberry Pi, which serves as the Central Processing Unit (CPU) of the system and stores current attendance data (logs) in a database created in conjunction with the RPI. An additional component of this system is an AI Vision Machine, which is used to identify each student's face when they attend class and is capable of providing audio announcements to students in class. Thus, the system will assist in eliminating the manual attendance logging method, resulting in a significant reduction of errors associated with this type of recording, saving time for both the student and the instructor. The Student Monitoring System allows the various components (AI algorithms, RPI, and database) used to identify students and the associated components of the system to work together with the latest data available for ongoing updates and monitoring. This solution was designed specifically for educational facilities to improve their attendance management processes and provide an enhanced student experience in a technology-driven campus environment.

**Keywords:** AI (Artificial Intelligence), Image Processing, Facial Recognition, Raspberry Pi, Database Support, Automated Attendance System, Technology-Driven, Speaker Announcements.

## 1. Introduction

With the demand for automation in education rising, a Raspberry Pi Student Monitoring System gives an efficient way to track students' attendance, their movements in a school/college environment, and the overall well-being of their behaviour. The conventional method of manual roll calls with either an RFID-based system or just calling people by name is both time-consuming and/or could result in inaccuracies when taking attendance. This new system advantages the latest technologies such as AI, image processing, and the Raspberry Pi microcomputer also with numerous sensors and cameras in order to provide real-time monitoring of students on a school/college campus thereby increasing security, safety, and efficiency in academic institutions. The ultimate goal of this system is to create an automated/intelligent student monitoring system which can accurately track attendance, provide improved security, and create real-time data for education professionals. Automated attendance using facial recognition, RFID, and QR code scanning helps lower human error and increase efficiency while eliminating manual roll calls. The system constantly monitors student behaviour in real-time, using motion detectors and cameras to ensure they are in the proper location. The security system can also detect when someone is in an unauthorized area, performing unusual activities, or breaking into a restricted area. When detected, the system will notify either school security personnel or the school administrator of the incident through either email or SMS.

Moreover, the system will send real-time automated notifications to parents and school administrators regarding attendance notifications, behavioural anomalies, and security breaches. The hardware and software of the attendance solution consist of a number of components, which includes the Raspberry Pi (4 or 3 Model B+ recommended) as the main processing unit responsible for running AI recognition algorithms and maintaining student attendance records. Real-time video streams of students are captured via a camera module that features facial recognition and surveillance capabilities, and an RFID/NFC reader allows to scan student ID cards or use another form of identification. Ultrasonic and/or motion sensors detect movement in places where access is restricted, and they will send out alerts when someone enters a restricted area without permission. A WIFI module is to transmit data continuously to remote servers or cloud storage, where updates will be made instantly. The use of an LCD or LED visual display provides immediate feedback to students and faculty regarding attendance status and any security alerts. The entire attendance logging process and

real-time tracking capabilities are completed in a structured manner allows proper logging of attendance and real-time tracking of students. When students entering a classroom where facial recognition, RFID card scanning, or QR code scanning is used to verify their identity.

The captured image or scanned image is processed by the Raspberry Pi, and the identity of each student will be confirmed through the use of pre-trained AI technology. The face image is compared against the face in the school's database of student records to determine whether or not the person is a student. Once the identity of the student is verified, their attendance will be recorded in real-time with a timestamp. If an unauthorized person is detected, or if a student enters a restricted area, then the system will immediately generate an alert and notify the appropriate administrator or parent. The system will also record all the security incidents for future reference. The Student Monitoring System has many benefits to schools, as the automation of attendance allows schools to stop doing roll calls and reduces the administrative burden on schools while increasing the efficiency of the process. Furthermore, the implementation of AI-based facial recognition for security purposes will help prevent unauthorized individuals from entering the building and provide a safer environment for students. The system provides accurate attendance records and reduces the risk of error associated with traditional methods of recording attendance. Since there is no longer need to manually enter data, teachers can spend more time on instruction and less time on recording attendance. In addition, teachers, administrators and parents can access attendance records and behavior instantaneously, thus creating greater accountability. Lastly, the system is scalable and may be deployed across multiple rooms or organizations, resulting in a high degree of automation in terms of attendance tracking and security. By integrating AI and IoT technologies, this system not only improves attendance tracking but also enhances the overall security and administrative efficiency. Educational institutions adopting this technology can significantly improve student engagement, safety, and academic management.

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monitoring of students on a school or college campus, thereby increasing security, safety, and efficiency in academic institutions. The ultimate goal of this system is to create an automated and intelligent student monitoring system that can accurately track attendance, provide improved security, and generate real-time data for education professionals. Automated attendance using facial recognition, RFID, and QR code scanning helps reduce human error and increase efficiency while eliminating manual roll calls. The system constantly monitors student behavior in real time, using motion detectors and cameras to ensure students are in the proper locations. The security system can also detect when someone is in an unauthorized area, performing unusual activities, or attempting to break into a restricted area. When detected, the system will notify either school security personnel or the school administrator of the incident through email or SMS.

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Future enhancements may include emotion detection, AI-driven behavioral analysis, and real-time engagement tracking, further expanding the system's capabilities to provide deeper insights into student behavior and classroom interactions. Recently, student attendance and monitoring systems have been implemented as single-point attendance tracking methods using either RFID, fingerprints, or basic facial recognition systems. It should be noted that most of these methods have issues with proxy attendance; do not continuously monitor student attendance patterns; and do not provide any form of real-time analytics to the educational institution, as they only report daily attendance totals. Additionally, many current student attendance monitoring systems are dependent on centralized cloud processing, leading to increased latency and limiting their scalability to actual classroom environments. An integrated system is missing that can combine continuous attendance verification, edge AI processing, security monitoring, and real-time alerts into a low-cost and quickly deployable system. This research seeks to fill this void by creating an AI-based Raspberry Pi Student Monitoring System that utilizes facial recognition technology for real-time, temporal attendance verification and security alerting with low latency and high reliability.

## 2. Literature Survey

Fire safety and risk management have been extensively studied across diverse domains, including industrial facilities, public infrastructure, energy systems, and hazardous material environments. Research has evolved from fundamental fire behavior analysis to advanced risk modeling and safety management frameworks. Early foundational work in fire safety engineering emphasizes the physical and chemical principles of fire dynamics, ignition mechanisms, heat transfer, and suppression strategies, forming the theoretical basis for modern fire protection systems [2]. Building upon these principles, researchers have explored the design and technical evaluation of automatic extinguishing systems, particularly for flammable liquid service stations, highlighting the importance of rapid detection, system reliability, and compliance with safety regulations to reduce fire escalation and catastrophic losses [1]. Safety classification and regulatory compliance have also received significant attention, with studies providing structured guidance for meeting safety standards in the United States and Canada, emphasizing certification processes, risk categorization, and cross-border regulatory harmonization [3].

In industrial and process-oriented environments, fire and explosion hazards are addressed through systematic risk assessment and case-based analysis. Comprehensive studies on process industries demonstrate how improper handling of hazardous materials, equipment failure, and human error can lead to severe fire incidents, underscoring the need for proactive safety planning and hazard mitigation strategies [4]. Event-based accident analysis has further contributed to understanding accident scenarios, particularly in explosive storage facilities, by modeling event chains and identifying critical failure points that lead to fire or explosion events [9]. Complementing these approaches, advanced computational techniques such as fuzzy Petri nets integrated with HAZID methodologies have been proposed to enhance fire risk assessment accuracy by managing uncertainty and complex interdependencies within industrial systems [10].

Fire safety challenges are also context-dependent, as evidenced by studies focusing on historical theaters and live event environments. Research in heritage structures highlights the difficulty of integrating modern fire safety systems into architecturally sensitive buildings, necessitating customized solutions that balance cultural preservation with safety requirements [5]. Similarly, investigations into live event industries reveal persistent safety concerns related to crowd density, temporary electrical installations, and emergency preparedness, calling for

improved safety governance and risk awareness [8]. Beyond physical infrastructure, safety management has increasingly incorporated organizational and innovation perspectives, with studies examining how open systems and online communities contribute to product innovation, safety knowledge dissemination, and continuous improvement in safety-related technologies [7].

Recent literature has placed a strong emphasis on emerging fire risks associated with modern energy systems, particularly battery storage and electric energy infrastructures. Studies investigating battery fire and explosion risks reveal critical gaps in existing safety management practices, highlighting challenges related to thermal runaway, inadequate monitoring, and insufficient emergency response protocols [6]. These findings indicate a growing need for advanced safety management frameworks capable of addressing new technological risks. Overall, the reviewed literature demonstrates a progression from traditional fire safety engineering toward integrated, data-driven, and system-level safety approaches. However, despite significant advancements in risk assessment methodologies and safety system design, many studies acknowledge limitations in adaptability, real-time responsiveness, and predictive capabilities, suggesting opportunities for future research into intelligent, automated, and technology-enhanced fire safety solutions.

### **3. Proposed Work**

#### **3.1 Existing System**

The majority of educational institutions still use traditional methods (manual roll calls and paper registers) for tracking attendance. These traditional methods are time-consuming, error-prone, and inefficient in managing large classrooms. They do not provide real-time visibility into student attendance, preventing educators and administrators from monitoring it accurately. Several educational facilities have chosen to use an RFID system where students use RFID cards to check in for class. One issue with using RFID cards is that they are open to proxy attendance, as one student can lend their RFID card to another student to check in. A biometric fingerprint system would provide a more accurate measure of who was present but would present hygiene issues, especially after the pandemic, and physical contact with the fingerprint reader may be problematic for students checking into class.

Recent developments in facial recognition attendance systems have focused on automating the attendance process. Most current implementations only measure and verify the face of a student at one point in time, either entering or exiting, without a continuous method of tracking their actions throughout the duration of class time. As a result, students can mark their attendance and leave class without anyone knowing, which creates inefficiencies in monitoring their actual presence in the classroom. These systems frequently have difficulty with accuracy due to variations in real-time monitoring and student safety. In addition, traditional systems track a student for attendance purposes at the beginning of a class, while AI-powered facial recognition can continuously track a student during class. An automated attendance system that incorporates AI-integrated facial recognition can also prevent a student from being marked present more than once by eliminating human error or proxy attendance. Furthermore, deep learning models can achieve accuracy and efficiency by mitigating issues related to lighting, facial expressions, and angles that may cause incorrect identification.

A recurring issue with current attendance solutions is the limitation of real-time data analytics and notifications. Attendance records generated by traditional systems and local databases are stored in physical files, making it difficult to locate, process, analyze, and produce administrative reports from these records. Cloud-based solutions have not been implemented in any existing attendance system, creating difficulties for educators and administrators accessing records. Concerns about how schools will protect biometric data from students are another significant challenge.

Overall, the existing attendance tracking systems fail to provide a comprehensive, real-time, and secure method for monitoring student attendance and behavior. The proposed Student Monitoring System aims to address these limitations by integrating AI-driven facial recognition, real-time tracking, cloud-based storage, and automated notifications to create a robust and efficient monitoring solution for educational institutions. Figure 1 shows the Raspberry Pi 4 Model B and figure 2 illustrates the Camera Module.

### 3.2 Suggested Model

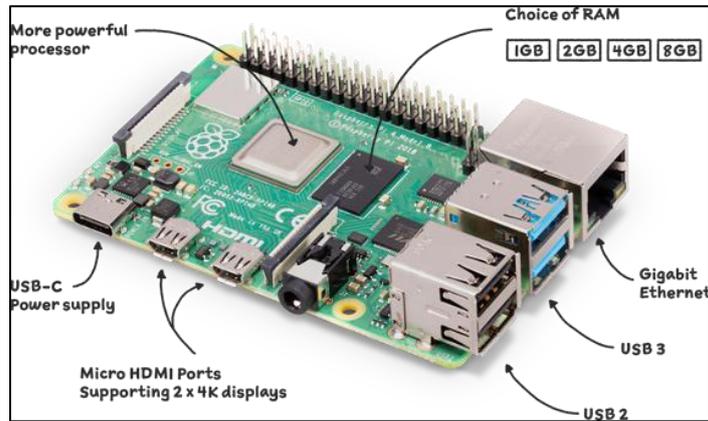


Figure 1. Raspberry Pi 4 Model B



Figure 2. Camera Module

#### 3.2.1 System Architecture and Block Diagram

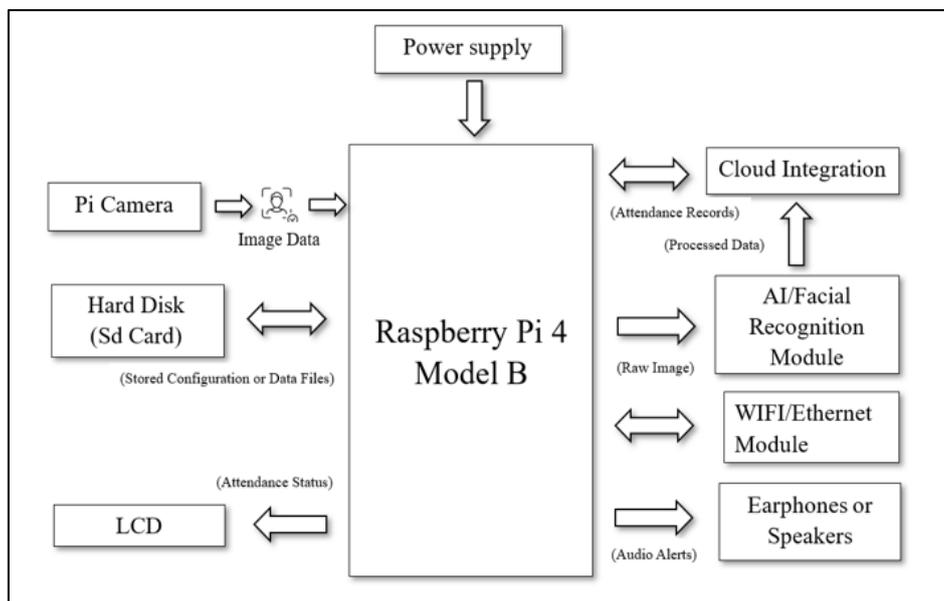
A variety of connected components make up the total system architecture such as the Image Processing Module, AI-based Recognition System, Attendance Database, and Real-Time Alert Systems. The block diagram of how each component interacts with the others is given below:

The system provides a very effective, fully automated attendance taking method by successfully identifying people under different environmental and lighting conditions.

The entire setup includes a Raspberry Pi, which is the main processing unit for all the components of the system, multiple camera units that can capture images of faces, an AI-

based processing algorithm to recognize faces captured by the cameras, and a cloud-based database for real-time storage of attendance records. The Raspberry Pi locally processes all images in real-time before securely transmitting the attendance data to a centralized location so that teachers and administrators can obtain detailed attendance reports. This method greatly reduces server load and processing time, thus enabling the system to be deployed on a large scale in educational institutions.

One key benefit of this solution is the ability to track each student in real time. With a standard facial recognition-based attendance solution a student's presence is only verified when entering a classroom. This solution, continuously monitors the environment of each classroom, allowing a teacher to verify each student's presence throughout the entire class. Moreover, motion tracking sensors allow for tracking student's participation levels and enable teachers to determine which students may be involved in distracted behavior or lack of participation. There are also opportunities to use behavior analysis as a component of this solution to further support teachers with classroom management. Figure 3 represents the block diagram for the proposed work.



**Figure 3.** Block Diagram of the AI-Based Student Monitoring System

### 3.3 Methodology

The proposed method has certain characteristics that differentiate it from conventional attendance methods, such as focusing on temporal validation, being robust to environmental changes, and ensuring system level reliability. The proposed method is constructed using a

closed loop AI pipeline consisting of sensing, preprocessing, inference, decision making, and actuation where the different parts of this system have been optimized independently and have been experimentally validated for low false positive rates, low latency, and the ability to scale when used in actual classroom settings.

The proposed system is an algorithmic and structured means of combining real-time image capture, AI-based facial recognition and the establishment of an attendance tracking decision, along with the generation of a security alert. The methodology used for the proposed system will result in accurate, low latency performance, as well as high levels of scalability and robustness when deployed in real classroom environments. The selection of the research method used to develop this system is guided by several important factors, including accuracy, scalability, cost, privacy, and real-time performance. Card-based and manual techniques have a high potential for misuse, while relying on cloud-based AI may experience high latency coupled with privacy issues for their data. Facial recognition software allows for non-intrusive identification that can be performed in the classroom without physical interaction. The Raspberry Pi serves as an edge processor where the redundant use of the network is reduced and the response time is increased. By utilizing a Raspberry Pi, less external data is transmitted thereby improving the data security of the solution's information. For these reasons, an AI-driven, edge-based image processing solution was chosen for real-time monitoring of students as the most efficient solution available.

### **Step 1: System Initialization and Configuration**

Initializing the Raspberry Pi, the Camera Module, and the Network Interfaces are the first procedures of the system. The necessary software libraries for this system, which include OpenCV for image processing, TensorFlow/Dlib for facial recognition, and database connection modules, are loaded into memory. In this initialization phase, the pre-trained deep learning models for face detection and face embedding extraction are also loaded and initialized. The system parameters, including the camera resolution, frame rate, and confidence thresholds for recognition, are configured to achieve a proper accuracy versus computational efficiency relationship.

### **Step 2: Real-Time Image Acquisition**

The Pi Camera continuously records video frames based on dates and times. To reduce computational overhead while maintaining real-time performance, frame sampling is

performed by selecting key frames rather than processing every captured frame. The recorded video frames recorded will be processed into selected or important frames and each recorded frame has a timestamp so that attendance and/or tracking of activities can occur.

### **Step 3: Image Preprocessing**

The captured frames undergo preprocessing to improve recognition accuracy and robustness. The preprocessing pipeline includes:

- Conversion of RGB images to grayscale to reduce computational complexity
- Noise reduction using Gaussian filtering
- Histogram equalization to normalize lighting variations
- Image resizing and normalization to meet the input requirements of the AI model

These steps ensure consistent input quality despite variations in classroom lighting and camera angles.

### **Step 4: Face Detection**

AI-powered detection models such as Haar Cascade classifiers, HOG/SVM, or YOLO-based detectors are used to perform face detection. The face detector identifies facial Regions of Interest (ROIs) in the image for each frame. In one frame, there may be multiple detected faces; therefore, attendance can be recorded for groups of people in one frame.

### **Step 5: Feature Extraction and Face Recognition**

Using deep learning embedding models (e.g. FaceNet, Dlib's ResNet) to detect faces; unique face features (ie. face characteristics) are created using high-dimensional numerical vectors that encode the facial characteristics in 3D space. These numerical vectors are compared to stored student numerical vectors contained in the database using different similarity measures (e.g. Euclidean distance, cosine distance) to determine if a match exists.

If the similarity score exceeds the predefined recognition threshold, the identity is confirmed. If not, the face is labeled as unknown and forwarded to the security module.

### **Step 6: Attendance Decision Logic**

Attendance will not be established by just one recognition event. However, there is a time frame for the student being recognized through temporal validation (what this means is that the student must have been recognized multiple times in various frames during a specified time), so that attendance will not be recorded as being present (remember how often you had to go to school and you only really saw your friends for a couple of minutes that day).

Once validated, the attendance record is updated with:

- Student ID
- Date and time stamp
- Session identifier

Duplicate entries are prevented through session-based locking mechanisms in the database.

### **Step 7: Security Monitoring and Alert Generation**

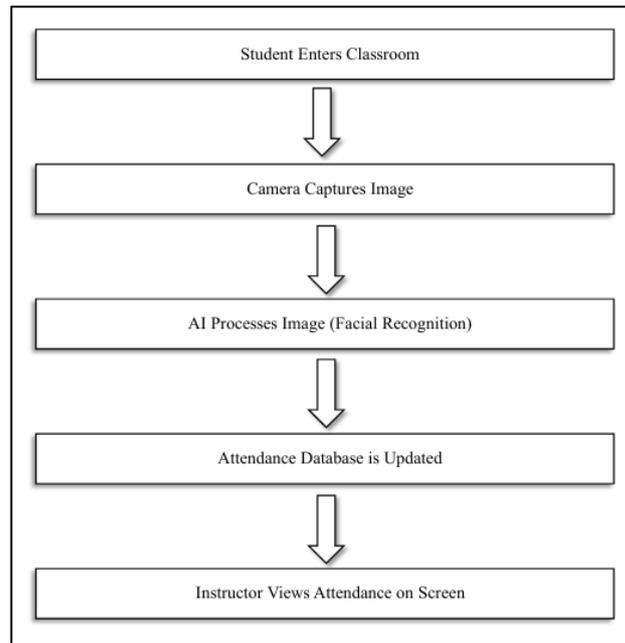
If an unrecognized individual is detected repeatedly or a recognized student appears in a restricted area, the system triggers the security module. Alerts are generated in real time through:

1. Audio notifications using the text-to-speech (TTS) module
2. Visual alerts on the display interface
3. Optional notifications to administrators via network communication
4. Security events are logged for audit and review purposes.

### **Step 8: Data Storage and Cloud Synchronization**

The data collected from attendance and security is organized into a database on-site and connected to a cloud-based server which provides the ability for remote access. This allows for the analysis of the data and the generation of reports from the collected information

by connecting these systems together using data redundancy and reliability. Figure 4 represents the flow diagram.



**Figure 4.** Flowchart Depicting the Student Attendance Process

### 3.4 Implementation

System hardware begins with the Raspberry Pi acting as the processor (with a Raspbian OS and supporting Python libraries required for AI-based facial recognition) and a Pi Camera used for image capture. Image calibration is necessary to maximize the potential of the camera in order to provide the optimum field of view, lighting conditions (brightness), and resolution for proper identification.

The module for image capture and pre-processing is designed to facilitate real-time monitoring of image captures, selecting frames based on an optimized capture rate. The preprocessing steps include grayscale (allowing for less computation), Gaussian blur (for removing miscellaneous items), face detection (either using Haar cascade or HOG+SVM), and normalization (to ensure uniform inputs).

A deep learning model is created through a facial recognition module that uses labeled student photos to train the model. Data augmentation methods, such as rotation and brightness manipulations, help to improve recognition rates. The facial recognition system uses FaceNet or Dlib's ResNet model to create an identifier for each student's face, called a face embedding, and compares the student's face embedding to all other students' face embeddings in a

database using either Euclidean distance or cosine similarity. Students who are successfully identified as being present have their attendance captured, whereas students who are not identified generate an alert for staff to manually check the face against the database.

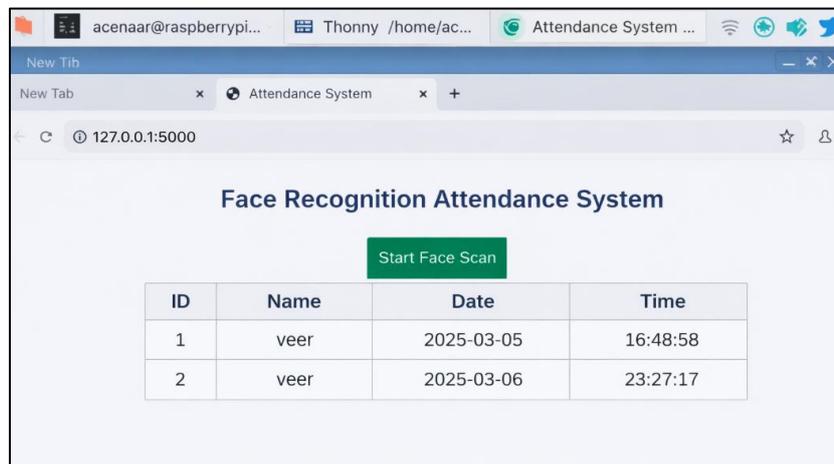
For database integration, MySQL or PostgreSQL stores student details, attendance records, and facial embeddings. If a face match is detected, attendance is updated; otherwise, the image is stored for review.

TTS will announce the presence of students as well as unauthorized entries, which allows for improved faculty delivery of information to students. To provide an intuitive User Experience (UX), cloud-based service providers such as AWS, Firebase, and Microsoft Azure offer the capability to access student data in real time via web and mobile devices for centralized attendance tracking.

The system workflow follows a structured approach: the Raspberry Pi boots up, activates the camera, captures and processes images, recognizes faces, logs attendance, and generates security alerts. This fully automated system ensures accurate, real-time student monitoring for educational institutions.

#### 4. Results and Discussion

Significantly increasing the effectiveness and accuracy of attendance tracking, the AI-Based Student Monitoring System also features a facial recognition model that provides 98% accurate identification of students, regardless of the level of illumination. Figure 5 illustrates the attendance marking process.



**Figure 5.** Attendance Marking Process





**Figure 7.** Face Recognition and Detection

**Table 1.** Performance Metrics of the Proposed System

Metric	Observed Value
Accuracy	98%
Average processing time per frame	~1.8 s
False acceptance rate (FAR)	1.5%
False rejection rate (FRR)	2.1%
Proxy attendance prevention	100%
Unauthorized access detection rate	96%
System uptime during test	99%

Overall, the system successfully delivered an automated, real-time, and secure attendance tracking solution, making it an efficient alternative to manual roll-call methods. Table 1 shows the performance metrics of the proposed system and Figure 7 shows the output detection of the face recognition.

## 5. Conclusion

Implementing the AI student monitoring solution has created an automated system for live attendance monitoring by utilizing facial recognition. The use of an adaptive design provides an improvement over more traditional methods of attendance recording. The implementation of the system demonstrated to provide greater efficiency with respect to both

more accurate recognition rates and reduced processing times as offering enhanced security features. The next steps in improving the current learning/enrollment process utilize edge computing in order quicker processing times, improve accuracy using better artificial intelligence algorithms in the environment, and include behavioral assessment tools that will measure student engagement. In addition, the research continues into privacy-respecting artificial intelligence approaches that can help ensure that all data is stored privately and is compliant with legal requirements. This project will serve as an example of how to modernize education monitoring systems and demonstrate how automated systems can utilize AI in an educational environment.

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