IoT-Integrated Smart Attendance and Attention Monitoring System For Primary and Secondary School Classroom Management

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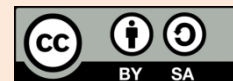
ABSTRACT

The monitoring of student attendance is a crucial aspect of the assessment of academic performance. The conventional methods for monitoring student attendance have inherent limitations in terms of both time efficiency and accuracy. Consequently, there is a clear need for a more expedient and precise attendance system. The objective of this research is to present the design of a real-time attendance recording and monitoring system for students from elementary school to senior high school, which will be implemented using the concept of the Internet of Things (IoT). The proposed system employs biometric technology in the form of face recognition. The methodology commences with the capture of images of students who leave the classroom during the instructional period via an active camera positioned on the classroom door. The system employs a Convolutional Neural Network (CNN) algorithm and a powerful computer vision tool, OpenCV, to perform real-time face recognition. Teachers will be informed of student absences and returns, as well as at the 15th and 30th minutes. An absence exceeding 30 minutes is classified as truancy. The integration of sophisticated technologies, such as machine learning and image processing, not only enhances the precision of attendance records but also equips educators with an efficient and automated system for streamlining classroom attendance management. This not only optimizes the learning environment but also facilitates more advanced and efficient pedagogical practices.

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1. INTRODUCTION

Class attendance is a method of recording student attendance [1]. The monitoring of student attendance is a crucial aspect of the assessment of academic performance. During the school day, students are required to be present on campus. As E. Mulyasa posits, the objective of student attendance at school is to

cultivate talents and potential, facilitate communication with teachers and classmates, comprehend messages delivered by teachers, and foster a democratic attitude. In the event that a student is absent from school, it is the responsibility of the student to provide a valid reason for their absence and to inform their parents or guardians of their whereabouts [2]. Consequently, it is imperative that teachers or homeroom teachers be able to record precise and accurate data, as this is essential for the analysis of student performance in learning. The ease of information and the validity of information are fundamental requirements for the preparation of attendance reports [3].

Two methods for verifying student attendance exist: manual and automated. In the manual attendance process, the teacher will take attendance by providing a paper containing a list of names, which are then signed by the students to record their attendance [1]. In addition to the use of manual signatures, another method employed is the calling of the student's name one by one, which allows for the recording of student attendance. In contrast to the manual method, the implementation of manual attendance necessitates the utilisation of tools to facilitate the attendance process. In conjunction with the advancement of technology, numerous methodologies have emerged to enhance the efficacy of the attendance process. One potential solution is the implementation of an Internet of Things (IoT)-based attendance system. For instance, in academic institutions, attendance is automatically recorded using radio frequency identification (RFID) cards [4].

The concept of the Internet of Things (IoT) emerged as a consequence of the pivotal role that internet technology plays in supporting daily activities [5]. The Internet of Things (IoT) is a network device that is embedded with electronics, software, sensors, transceivers, and other similar devices. Its purpose is to facilitate interactions, exchanges, and the analysis of information between users. The implementation of computerized attendance recording can be achieved through the utilization of the concept of the Internet of Things (IoT).

A number of previous studies have addressed the potential for the Internet of Things (IoT) to automate human work. One such study is that conducted by Naseri et al. in 2023 [6]. The research presents a methodology for the creation of a mask detection system on the human face. The primary objective of this research is to develop a system for detecting individuals wearing masks during the ongoing pandemic caused by the novel coronavirus (Covid-19). The research demonstrates that IoT offers an effective solution for monitoring health services related to medical monitoring through sensors. Additionally, Nguyen-Tat conducted further research in 2024 [7]. The research presents a methodology for the development of an attendance recording system that employs computer vision and facial recognition techniques. This research develops a reliable and efficient attendance management system that employs the most advanced IoT technology for tracking and monitoring attendance. The research yielded a cost-effective, efficient, and adaptable attendance tracking and management system with the potential to revolutionize attendance management practices.

From the advanced background presented, it is evident that the Internet of Things (IoT) has the capability to automate certain tasks that would otherwise require human input. Upon completion of the literature review, several studies were identified that address the development of attendance systems for various educational institutions. However, these studies primarily address automation in the context of higher education, with no discussion of research at the elementary school level to high school. Consequently, the objective of this research is to analyse potential solutions that could be employed to facilitate the attendance process at the elementary, middle, and high school levels by implementing the Internet of Things (IoT).

2. LITERATURE REVIEW

A comprehensive literature review was conducted to analyze the results of previous studies related to the implementation of the Internet of Things. A number of studies were reviewed in order to ascertain the potential of the proposed Internet of Things to be used to create an attendance system at the elementary school level, which is equivalent to high school. The research is the latest research within the last 10 years.

In 2020, Banu J conducted research on the Smart Classroom [8]. The research presents a discussion of the potential for the Internet of Things (IoT) to facilitate the integration of cloud-based technologies into the learning process at the university level. The Internet of Things (IoT) is employed to monitor student attendance, issue notifications to enhance focus on academic pursuits, and assist in locating misplaced personal belongings. The use of digital payment devices facilitates transactions in a variety of settings, including cafeterias and administrative offices. The data obtained from the sensor modules is then processed and transmitted to the cloud storage facility by the software modules. This article delineates the efficacy of restructuring educational and learning methodologies with conventional Internet of Things (IoT) and cloud infrastructure.

One of the most common methods employed in the construction of an automated attendance system is the use of Radio Frequency Identification (RFID) technology. A study conducted by Wardana et al. in 2024 demonstrated the efficacy of RFID technology in the creation of an automatic attendance system [9]. The system is constructed using four RFID cards, which have been categorised according to the results of the needs analysis. These categories are as follows: male, female, child and guest. Over a period of three months, the utilization of the tool resulted in a 40% increase in the efficiency of recording congregation attendance in

comparison to the previous manual method. Furthermore, the technology has reduced the incidence of recording errors by 25%, thereby enhancing the accuracy of the data available to church administrators. Additionally, the congregation expressed positive sentiments regarding the new recording device. Eighty-five percent of respondents indicated satisfaction with its ease of use, while 90% reported that it facilitated increased participation in church activities. The utilization of this technology not only enhances the operational efficacy of the church but also offers a more favorable experience for the congregation.

The utilization of fingerprint biometric technology can serve as a solution for the accurate and reliable recording of student attendance, thereby reducing the occurrence of errors or fraud, such as manipulation or forgery, in the attendance recording process. An Internet of Things (IoT) based system utilizing fingerprint sensor technology on the Message Queue Telemetry Transport (MTTQ) protocol is employed to assist in the recording of attendance at SMK Perhotelan 45 Mataram, which continues to utilize conventional procedures. The system records attendance for 10 respondents over a total period of 11,241 seconds, with an average time of 1,124.1 seconds [10].

Other biometric technologies that could be employed in the attendance recording system include face recognition, as explored by Alqudah et al. [11]. This approach employs a convolutional neural network (CNN) model for feature extraction and the K-Nearest Neighbor (KNN) algorithm for face recognition. The system achieved 98% accuracy in attendance recording by utilising a camera positioned at a height of 2.4 metres and a distance of 2 metres from the front row of students. This configuration enables the camera to capture the front image of the student. This level of accuracy is achieved by requiring only five images per student, captured from five different angles during the enrollment process.

From the aforementioned considerations, it is imperative to develop a contactless attendance tracking system that is resilient to spoofing, capable of accurately identifying faces, and capable of accurately recording attendance. The incorporation of technology has rendered obsolete traditional systems that are both time-consuming and susceptible to favoritism [12]. This evidence demonstrates that the integration of the Internet of Things can significantly enhance the accuracy of attendance data collection.

3. PROPOSED SYSTEM

The proposed Internet of Things (IoT)-based Smart Attendance and Attention Monitoring system is a student attendance recording system that employs face recognition technology. The system comprises a camera positioned in proximity to the classroom entrance and integrated with a smartphone. The system can be operated via a smartphone application, which allows the user to set the system to either active or inactive mode. In addition to recording attendance at the commencement of the lesson, the system is also capable of monitoring student attendance throughout the duration of the class.

Facial recognition technology constitutes a subcategory of computer vision. The functioning of face recognition systems is contingent upon the deployment of sophisticated deep learning algorithms, which are meticulously trained on expansive data sets with the objective of accurately identifying intricate facial patterns and traits [13]. One of the algorithms most frequently utilized in the domain of computer vision research is the convolutional neural network. The Convolutional Neural Network (CNN) algorithm has been demonstrated to possess robust and dependable face recognition capabilities, enabling the model to discern the minutest nuances in facial characteristics, thereby rendering it an optimal choice for incorporation into the proposed system [14]–[16].

In developing a face recognition system, this research will utilize a key component in the field of computer vision: OpenCV (Open Source Computer Vision Library). OpenCV provides a comprehensive set of tools and features for object identification, machine learning, image and video processing, and other applications [17], [18]. The utilization of OpenCV enables the real-time identification of individuals, thereby facilitating its integration into the proposed system. OpenCV functions by emulating the processes of the human visual system. Upon observation of an object, the captured image is conveyed to the computer's central processing unit (CPU) for analysis. This enables the computer to comprehend the visible object in a manner analogous to the human eye's ability to identify it. This enables computers to perform complex visual analysis and object recognition. Computer vision systems are designed to emulate the human visual perception process, which involves the analysis and interpretation of digital images to recognize and comprehend the objects within them [19].

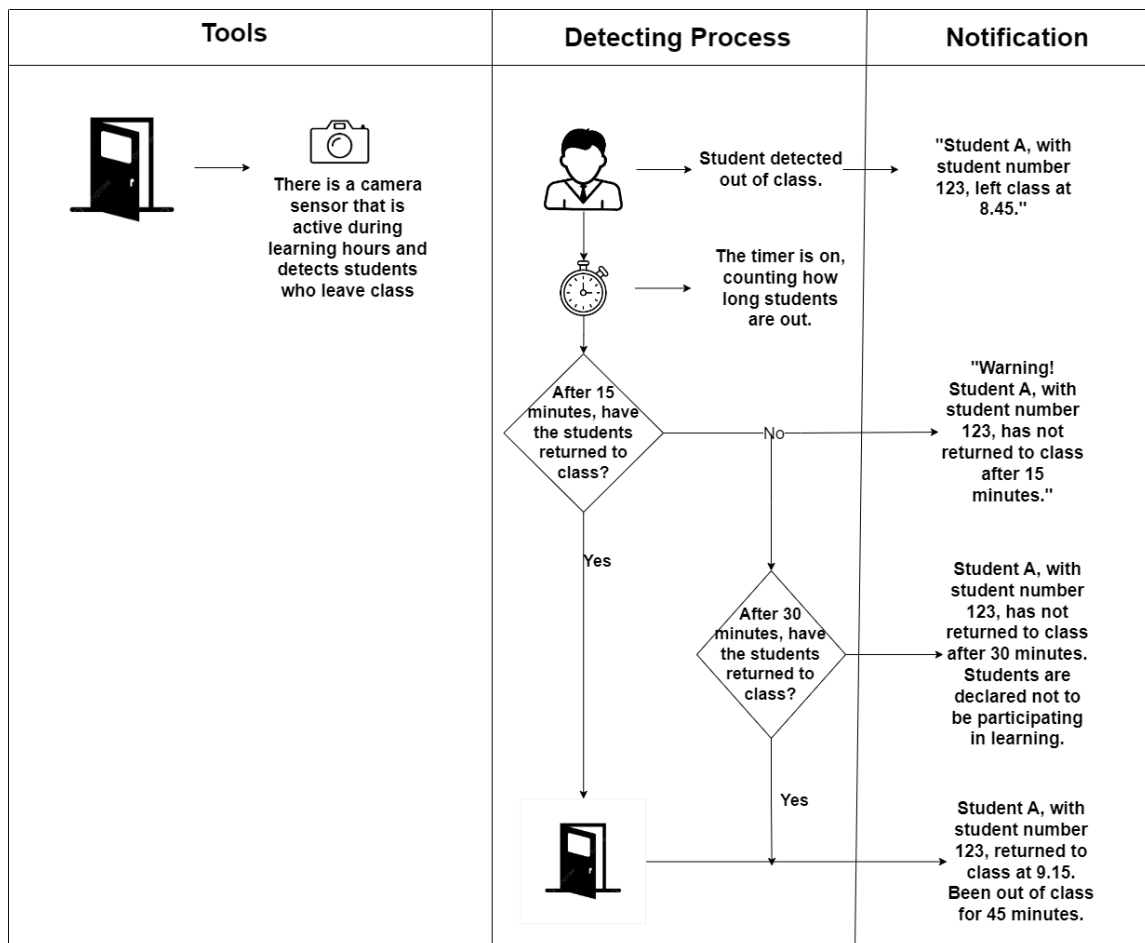Figure 1 illustrates the operational principles of the smart attendance and attention monitoring system.

Figure 1. The operational principles of the system.

3.1. Tools

The system employs the use of a camera that is activated during the course of the lesson. The camera will take photographic records of students who leave the classroom before the conclusion of the lesson. The camera is linked to a system that is capable of performing face recognition in real time.

3.2. The detection process and subsequent notification

Upon activation of the system, the camera will be activated to enable the detection of students who leave during the lesson. Prior to this, data regarding face information, name, and student ID have been inputted and learned by the face recognition system. In the event that a student is detected leaving the classroom, the teacher will receive an alert containing the student's name and ID number via telegram. The timer will then be activated, and the length of time the student remains absent will be calculated. This calculation will be based on the number of students who have left the classroom and will be conducted separately for each student. The objective is to ensure that the exit times of each student can be calculated with precision and accuracy. Upon the departure of a student, a warning notification will be sent a maximum of two times. This notification will be sent every 15 minutes. When the exit time reaches 30 minutes, the student will be considered absent from class. Conversely, if the student has returned, a notification will also be sent with details of the length of time the student was out.

The implementation of this system is anticipated to facilitate the identification of students who frequently skip class, thereby enabling educators to gain a more comprehensive understanding of each student's individual circumstances. This, in turn, will allow for more targeted disciplinary actions to be taken, as needed. The implementation of this system has the potential to enhance the efficacy of student supervision and alleviate the administrative burden on teachers, particularly in regard to class management.

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4. CONCLUSION

The proposed Internet of Things (IoT)-based Smart Attendance and Attention Monitoring system employs a combination of facial recognition technology and smartphone integration to record student attendance and supervise them during class. The utilization of a Convolutional Neural Network (CNN) algorithm and OpenCV library enables this system to detect students' faces in real-time, subsequently providing attendance or absence notifications to teachers via the Telegram app. Cameras positioned outside the classroom and managed via a smartphone application facilitate effective monitoring. In the event that a student leaves the classroom, the system is able to detect and record this occurrence, and automatically generate a notification if the absence exceeds 30 minutes. The implementation of this system is anticipated to result in enhanced efficiency in student supervision, thereby reducing the need for teachers to perform ancillary duties and allowing them to dedicate more time to the learning process. Furthermore, the system facilitates the identification of truant students, thereby enabling the school to take more expedient and appropriate action.

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