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Effective Inexpensive and Robust Solution to Classroom Attendance Recording Using Face Detection Technology

Rushabh Gandhi[1*], Kritarth Jain[2], Nayan Mandliya[3], Hussein Motiwala[4], Rohini Nair[5]
[1,2,3,4]*Student, Department of Computer Engineering, K.J. Somaiya College of Engineering, Mumbai, India*
[5]*Associate Professor, Department of Computer Engineering, K.J. Somaiya College of Engineering, Mumbai, India*

***Abstract*: Traditional methods of documenting attendance, such as roll call and sign-in pages, have several inefficiencies, as highlighted in the paper. They demand considerable time and effort from instructors and are susceptible to human error. Furthermore, these methods are frequently susceptible to proxy attendance, which can result in inaccurate records and negatively affect students' grades. To address these issues, the paper proposes a low-cost solution that makes use of class photographs and face detection techniques to track attendance. The system can autonomously locate and identify students' features from class images, removing the need for instructors to manually input data. Students can then register their attendance by distinguishing themselves from the list of detected features using a web application that is fast, simple, and parallel. The paper emphasizes that the proposed solution has several advantages over conventional methods of recording attendance. It is substantially more effective and can reduce instructors' workload. It is more precise and trustworthy because it is not susceptible to human error or fraudulent activity. The paper also notes that the system can aid in the identification of students who may require additional support or attention, as their attendance patterns can be more readily monitored. In spite of these advantages, the paper acknowledges that the proposed system has certain limitations. The instructor must have access to the internet and a camera-equipped device. For optimal use of the proposed system, it is suggested that students have a dependable Internet connection. In the event that students experience internet connectivity issues, they can request assistance from their instructors to ensure that their attendance is precisely recorded.**

***Keywords*: cost effective, Smart attendance, face detection, user friendly interface, time efficient attendance, progressive web app.**

1. Introduction

Attendance tracking is an essential aspect of many educational institutions, as it is frequently used to monitor student engagement and classroom participation. Particularly, schools and universities with mandatory attendance policies rely on accurate attendance records to ensure that students are successfully completing course requirements. In addition, scholarship programs and other sources of funding may require regular attendance reports as a condition of continued support.

Numerous studies have investigated the relationship between student attendance and academic performance, with many discovering a positive correlation. For instance, a 2010 study discovered a positive correlation between attendance and academic achievement across a variety of subjects and educational levels [12]. Allen and Robbins (2008) found in another study that students with higher rates of attendance had higher GPAs than those with lower rates of attendance [13]. In a more recent study, Al Hazaa and colleagues (2020) discovered that attendance is a significant predictor of students' failure risk [14].

Most educational institutions still require regular attendance records as part of their standard operational procedures. Roll call and sign-in sheets have been the two traditional methods for recording attendance in the classroom. The instructor calls out each student's name and records their attendance in a register or on a computer during roll call. A sign-in page is a sheet of paper or electronic document that is circulated among students, who then sign or cross off their name to signify their presence in class.

Nevertheless, these conventional methods for documenting attendance have a number of drawbacks. First, they are inefficient in terms of time, particularly in large courses where roll-call can detract significantly from instruction. In addition to being time-consuming, sign-in sheets require students to locate their names and send them on to their companions. Second, both roll-call and sign-in sheets can be labor-intensive because staff members must manually enter attendance information into a database or spreadsheet for further processing. This can be particularly difficult for institutions with numerous sessions and students. Thirdly, both approaches are susceptible to human error, as attendance information may be lost, mis-recorded, or recorded on behalf of other pupils. Sign-in pages can be a distraction, diverting students' attention away from the lecture and diminishing their engagement with the learning process.

This paper proposes a novel solution for documenting student attendance using facial detection technology to address these issues. Specifically, computer vision techniques will be used to automatically detect and identify pupils' features, eliminating the need for manual data entry. To manage false

*Corresponding author: rushabhgandhi13@gmail.com

negatives and false positives from the face detection model, the system offers alternative measures, such as face cropping from images and the ability to add and eliminate attendances for the instructor. In addition to addressing issues such as human error and distraction, the proposed system will provide a streamlined and effective method for documenting attendance in the classroom. We have developed web applications for both students and instructors to interact with the system, making it readily available and intuitive. In this paper, we will describe the design and implementation of our proposed attendance recording system and assess its ability to improve the accuracy and efficacy of classroom attendance monitoring.

2. Literature Review

Monitoring systems for attendance are an important component of educational institutions because they enable teachers to record student attendance in a manner that is both efficient and accurate. Over the course of the years, a number of different kinds of technologies, including fingerprint identification systems, facial recognition systems, RFID and NFC-based systems, QR code-based systems, and location-based systems, have been put into place to speed up the process of collecting attendance. However, given that each system has its own set of benefits and drawbacks, it is important to evaluate which system is the most suitable for every particular educational establishment.

RFID and NFC-based solutions [4], [5] are employed extensively in a broad variety of educational establishments. Students are required to carry ID cards or badges that are equipped with RFID [6], [7] or NFC technology while using these systems. The expenditures associated with these systems' infrastructure are expensive despite the dependability and accuracy of the systems themselves. In addition, students are required to carry their student ID cards or badges at all times, and the procedure of replacing them may be time-consuming if they are misplaced. In addition, there is a restriction that only allows one student to check in at a time, which results in longer wait times during peak hours.

Another form of method for tracking attendance is a fingerprint recognition system [8], which is becoming more commonplace. Students are need to register their biometric information in these systems, which is a procedure that may be time consuming. In addition, the process of student registration could take longer if the student in question has a finger injury. The infrastructure costs and maintenance needs of these systems are much greater than those of other systems, despite the fact that they are accurate.

The use of face recognition software in educational institutions to keep track of students' attendance is becoming more common. Nevertheless, these systems either do not have a high level of accuracy or have a slow processing speed [2], [3]. Students are required to confirm their identities in certain attendance tracking systems before their attendance can be marked. This may be a time-consuming procedure [1]. In addition, there is a possibility that these systems may make erroneous detections, which would lead to attendance records that are incorrect. In addition, in order to record their attendance, all of the students in the classroom need to have access to the Internet.

Additionally, attendance tracking systems that use QR codes have been deployed in certain organizations. In order to register their attendance, these systems need students to utilize the phones they were provided with to scan a QR code that was presented on the screen. The fact that every student has to scan the QR code on their own consumes a lot of time, despite the fact that this system is basic and doesn't cost too much money to put into place.

In the event that the attendance system is based on QR codes, [9], [10] it is feasible for students to send an image of their QR code to absent classmates who are also absent. This might lead to an erroneous attendance record as well as inconsistencies across the system.

In response to this problem, certain attendance systems that are based on QR codes have included extra safety precautions in order to avoid fraudulent behavior. For instance, the QR code may be made to become invalid after a certain length of time has passed, or it could be restricted to a single use for each student. On the other hand, if the attendance is registered inside the allotted amount of time, then no one will be able to identify it.

In order to keep track of where students are located inside the school building, location-based attendance systems make use of GPS technology [10]. When students enter a classroom that is equipped with GPS sensors and are within a specific range of that classroom, these systems will automatically record their attendance. However, the accuracy of these systems cannot be guaranteed since some students may be out of range of the sensors or may leave the classroom while the teacher is speaking. In addition, it is possible that these systems are not suited for use in lecture halls or auditoriums that are of a significant size.

Faced with the constraints of current methods for monitoring attendance, the suggested system combines face identification with a low-cost solution that leverages class pictures to track attendance. This allows the system to circumvent the restrictions of existing systems. This reduces the need for teachers to manually enter data by finding and recognizing students' facial characteristics in class photos. This is done by locating and identifying the students' faces. Using a brisk, straight-forward, and parallel web application, students are able to register their attendance by identifying themselves from a list of identified attributes and registering their attendance. This approach is more effective and has the potential to lessen the burden of the teachers. Because it cannot be affected by things like dishonesty or mistakes made by humans, it may also be relied upon to be more accurate.

The installation of attendance tracking systems is an essential component of educational establishments. There are many different kinds of systems, and each has its own set of benefits as well as drawbacks. The attendance tracking system that has been developed, which makes use of facial detection as well as images of the class, is an effective solution that lessens the workload of teachers while also being more accurate and dependable.

3. Methodology

A. Dataset

Selecting a suitable dataset is the initial stage of building a face detection model. The Wider Face dataset is selected because it is a comprehensive and well-established dataset for face detection. It contains over 32,000 images containing over 393,000 labeled features, making it an excellent resource for training and evaluating face detection algorithms. Additionally, the dataset is preprocessed to remove irrelevant images and objects that are not faces along with resizing and normalizing the images to make the dataset uniform.

Fig. 1. Shuo Yang WIDER face dataset

B. Face Detection

The system employs the YOLOv4 face detection model. YOLOv4 is the abbreviation for You Only Look Once version 4. It is a cutting-edge object detection algorithm with high precision and efficiency. The architecture of YOLOv4 is based on the Darknet framework, which is a framework for object detection that uses deep neural networks.

The architecture of YOLOv4 consists of a backbone network, a neck network, and a detection head. The backbone network consists of a succession of convolutional layers that extract image features. The neck network combines the characteristics of the backbone network and renders them compatible with the detection head. The detection head is composed of convolutional layers that forecast the bounding boxes and class probabilities of the image's objects.

YOLOv4 has several enhancements over previous versions. It employs a spatial pyramid aggregating module that aids in the detection of objects at various scales. It also employs a cross-stage partial network that enhances the model's precision. In addition, data augmentation techniques such as random cropping and rotating are employed to enhance the model's robustness.

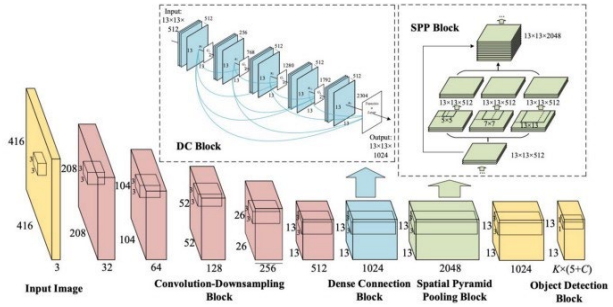

Fig. 2. YOLOv4 architecture

C. System Flow

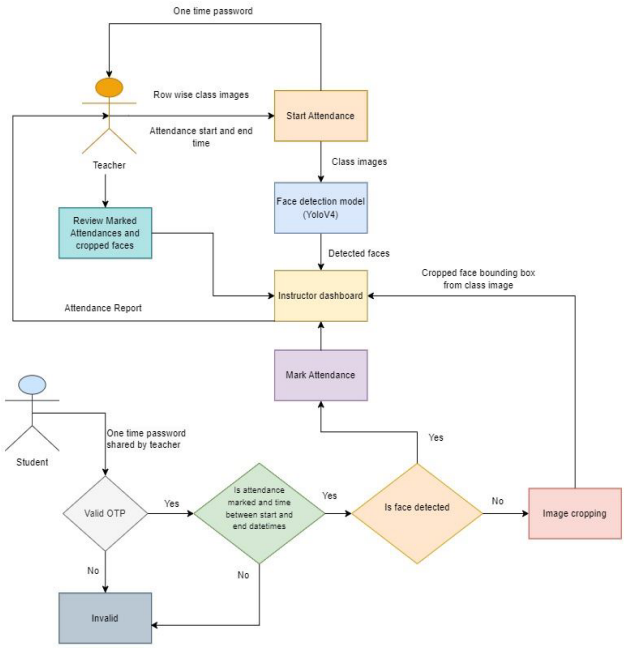

Fig. 3. System flow diagram

1. The instructor logs into the attendance system and navigates to the desired course.
2. The instructor captures images of each row of pupils in the classroom using a smartphone or tablet and enters the attendance start and end datetimes.
3. Images are uploaded to the system's backend and stored using the file names in the database. The file name has a specified secret convention to avoid any conflicts.
4. The backend system employs face detection algorithms to detect and identify each unique face within the uploaded images.
5. The system generates an OTP, class images with detected faces surrounded by numbered bounding frames, and a numbered catalog of cropped faces from these images.
6. The instructor then shares the OTP to all present students so they can begin recording their attendance.
7. Students use their own devices to navigate to the correct course in the attendance system and input the one-time password (OTP) provided by the instructor to begin recording their attendance.
8. Students then identify their face from the displayed list of faces by locating their position in the class photo and matching their face from the list using the provided bounding box number.
9. The pupil may only indicate attendance once and only between the start and end dates and timings. In order to prevent mis-clicks, the students can also view a catalog of previously marked features alongside the names of their classmates who marked them.
10. If a student's face is not detected, they can locate it in the uploaded images and outline it with a rectangle.

This can be done only once if the pupil has not yet marked attendance.

11. The teacher will receive a notification regarding the student's impending attendance and will examine the images of the bounding box drawn by the student.
12. The teacher authorizes the student's attendance if he or she has a valid visage.
13. If a student is unable to mark his or her attendance, he or she may report to the teacher, who can mark attendance by inputting the students' roll numbers. Teachers can also remove attendance records if they receive complaints or suspect misbehavior.
14. For future reference, attendance data is stored securely in the backend system.

4. Results

The proposed attendance system offers a significant enhancement in time efficiency over conventional attendance recording methods, which typically involve instructors manually taking roll-call or signing-in documents. This procedure is not only time-consuming, but it also disrupts the flow of class, causing instructors to lose valuable teaching time. In contrast, the proposed system makes use of facial recognition technology and class photographs to take attendance swiftly and without interruption, thereby saving time. The system is designed to accommodate large classes without increasing attendance-taking time, making it suitable for use in schools and universities.

The attendance process takes only a few seconds per pupil on average, with the system identifying their face in the list of profiles using bounding box numbers from the original photograph of the class. This results in substantial time savings, and since all pupils can record their attendance at the same time, the entire attendance procedure can be completed in minutes. This system is more efficient than NFC, QR code, and RFID-based attendance methods because the instructor can rapidly add, remove, and review undetected faces. While the proposed system may not be as quick as face recognition systems, it is more accurate and lightweight, managing false positives and negatives of the face detection model without the complexity of face recognition techniques.

Traditional methods of documenting attendance can be laborious and time-consuming, adding to instructors' workloads. Using a mobile application, instructors can swiftly and easily take attendance under the proposed system, which significantly reduces their workload. The system updates attendance records automatically, removing the need for instructors to manually enter data into a spreadsheet or database. Although the teacher's participation in the attendance proctoring process is marginally greater than in NFC, RFID, and face recognition systems, the extra effort precludes the possibility of fake or proxy attendances caused by both student and system errors. The proposed system reduces instructors' attendance recording efforts significantly compared to conventional methods.

Utilizing a progressive web application accessible on every student's portable device and extant classroom technology such as a camera or webcam on the teacher's end, the proposed attendance system is cost-effective. The implementation cost is minimal, and the system is designed to be readily scalable, making it suitable for use in classrooms of all sizes. This makes the proposed system a cost-effective alternative to other, more costly options. Additionally, the system does not require any additional hardware, such as NFC, RFID, Bluetooth, or retina scan-based systems, as it utilizes the pupils' and instructors' already existing portable devices.

The proposed attendance system is user-friendly and straightforward for instructors and students alike. The mobile application interface (PWA) is user-friendly, with features like facial detection for attendance recording. Additionally, the system is designed to integrate seamlessly with existing classroom technology, making it simple to install and utilize. There are several advantages to using a progressive web application (PWA) for the attendance management system. A PWA is a web application designed to function on any device or platform that supports a browser, regardless of operating system. Another advantage of a PWA is that it is simple to maintain and update. This means that any modifications or enhancements to the attendance system can be implemented rapidly and without requiring users to download and install updates. The system is more user-friendly than the current attendance system because it provides instructors with a comprehensive interface and allows students to effortlessly take attendance using their phones. In addition, students with attendance discrepancies can approach the teacher to have them corrected, making the process more open and accountable.

Traditional methods of documenting attendance are susceptible to errors, such as fictitious attendance and recording errors. The proposed attendance system substantially reduces the likelihood of attendance recording errors. Facial detection technology guarantees the accuracy of attendance records, eliminating the possibility of fraud. Additionally, the system employs a one-time password that is shared by the instructor with all pupils, making it difficult for anyone outside of the classroom to record attendance. In addition, all students are able to see who has designated their attendance for each detected face. This will further eradicate proxy attendance by preventing other students from marking their classmates' attendance in an unethical manner, thereby enhancing accountability. The instructor also has the central authority to add, remove, and authorize boxes of undetected student faces, which eliminates all proxy attendances. In addition, the system automatically updates records, eliminating the need for manual data entry and reducing the likelihood of transcription errors.

In conclusion, the proposed attendance system represents a substantial enhancement over conventional methods of recording attendance in terms of time efficiency, accuracy, cost-effectiveness, security, and adaptability. The system is designed to be intuitive and simple to use for both teachers and students, as well as highly secure and adaptable. By employing this system, institutions can optimize their processes for monitoring attendance, save time, and devote more resources to teaching and learning.

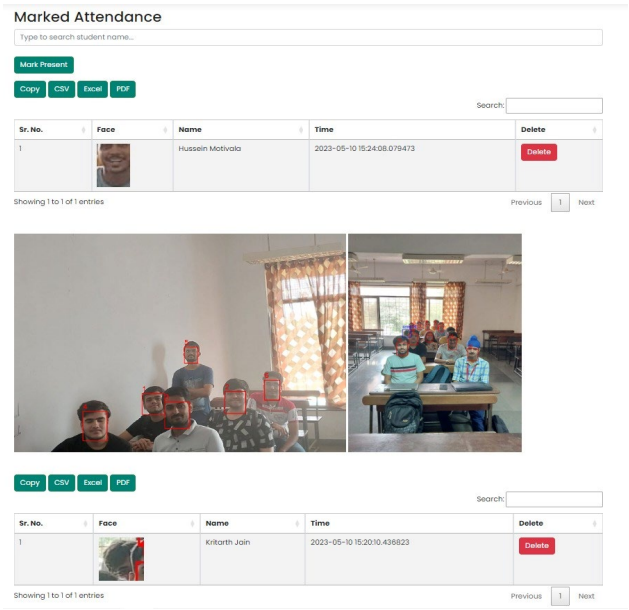

Fig. 4. Instructor's dashboard for attendance tracking

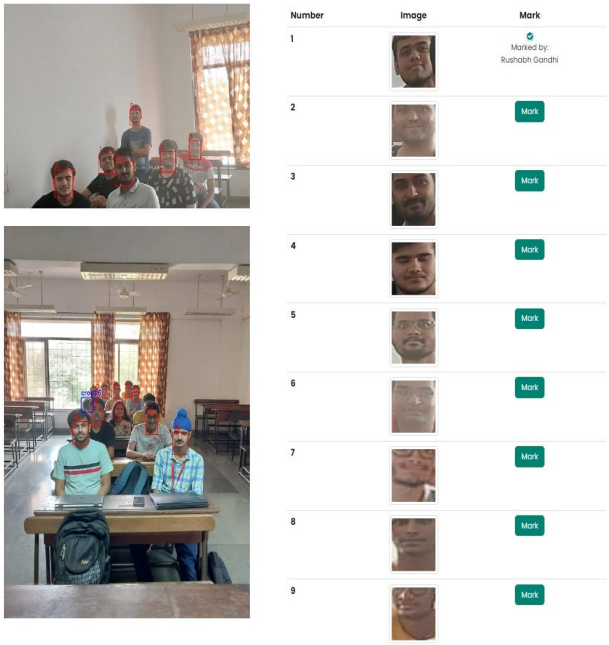

Fig. 5. Student Interface for marking attendance

5. Conclusion

Using face detection technology and a web application, this research paper proposed a low-cost solution for expediting classroom attendance recording. The proposed system offers several advantages over traditional methods of attendance recording, including increased efficiency, precision, and dependability. In addition, it can help instructors identify students who may require additional support or attention, enabling them to better meet their requirements.

This research paper's methodology involved the use of a larger face dataset for training the face detection model. The results demonstrated that the proposed system could accurately detect and identify pupils in class photographs, providing a dependable method for monitoring attendance.

While the proposed system has some limitations, such as requiring internet access and devices with cameras, it offers a promising alternative to conventional methods of attendance recording. Future research can further investigate this system's potential and resolve any outstanding issues.

This study emphasizes the potential of face detection technology and web applications for expediting classroom attendance registration, ultimately to the benefit of both teachers and students.

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