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SMART ATTENDANCE MANAGEMENT SYSTEM WITH FACIAL RECOGNITION, PHYSICAL PRESENCE VERIFICATION, AND CENTRALIZED DATABASE INTEGRATION

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Abstract

The developed Smart Attendance Management System, hereinafter referred to as 'the System', addresses a limitation faced in Facial Recognition Systems (FRS), which often fails to authenticate physical presence during attendance marking. The system attempts to solve this problem by designing a solution that authenticates physical presence while attendance is being marked. The solution uses physiological signals, specifically the blinking of eyes, to indicate physical presence. The system marks attendance by first matching the images stored in its database with input images. Upon successful matches, the system looks for physical presence authentication. Attendance is marked successfully upon verification of physical presence. The attendance is recorded in a database for administrative reference. The designed system uses visual representations to interact with users during the entire process of attendance marking for both successful and unsuccessful marks. The system offers reliable attendance tracking by combining eye blinking detection with face recognition algorithms to provide a foolproof attendance management system.

INTRODUCTION

Facial recognition technology has gained significant importance in recent times, thanks to its wide range of applications, ranging from security applications to identity verification. In educational settings, the use of the Facial Recognition System (FRS) for attendance management has become an area of interest. The use of face recognition technology eliminates the need for manual processes such as paper-based attendance marking, offering a more effective approach to attendance tracking [1].

The face recognition-based attendance systems rely on several factors. Firstly, these systems address and solve the limitations of traditional attendance processes, which are often not effective i.e. time-consuming, and are inclined to various forms of manipulation.

By using machine learning algorithms such as OpenCV, HAAR Cascade, etc., the FRS results in a higher degree of accuracy, effectiveness in identifying individuals, and a fast mechanism [2].

Secondly, the resources required to design and develop these systems are easily available, such as cameras and computing resources. The integration of face recognition algorithms with the mentioned resources has solved a real-time problem of attendance tracking, making sure accurate attendance is marked [2].

Lastly, the digital transformation alone has the most impact on the current deployed solutions. This transformation alone is sufficient to slowly and gradually adapt new solutions in every area of the human race.

The adoption of deep learning models; Convolutional Neural Networks (CNNs), Deep CNN architectures, such as VGGNet, ResNet, `and FaceNet, have fast paced the adoption of computer vision technology as these models now can extract facial features, compare the patterns and identify almost as well as humans do [3].

The paper offers to track eyes and pupils, with a focus on analyzing and calculating attention time. However, it is observed that the system has a limitation that is an assurance of physical presence, as it relies only on visual elements to determine the attention period [4].

The paper proposed a methodology to recognize faces using recognition algorithms, but lacks discussion on the issue of physical presence, which results in unreliability of the solution being proposed, especially in education settings [5]. The research could have benefited from a solution which not only recognizes faces based on facial features but also from a mechanism that authenticates physical presence.

This research work aims to provide an in-depth analysis of the design and development of the system. The paper includes the system's design, development, and performance evaluation. Moreover, it will highlight the system's contributions to accurate attendance marking while assuring physical presence. Lastly, this paper will discuss how administrative efforts can be reduced in educational institutions.

The later sections of this paper will discuss a comprehensive system description, outlining the methodology and techniques used in developing the system. Simulations and results will be discussed in Section 3, and Section 4 will conclude the paper.

2.0 METHODOLOGY

This research project aims to develop a solution that not only marks attendance by matching facial features but also ensures that students are physically present while attendance is being marked. This methodology has two main components: facial features recognition for identification and physiological signals for verifying physical presence.

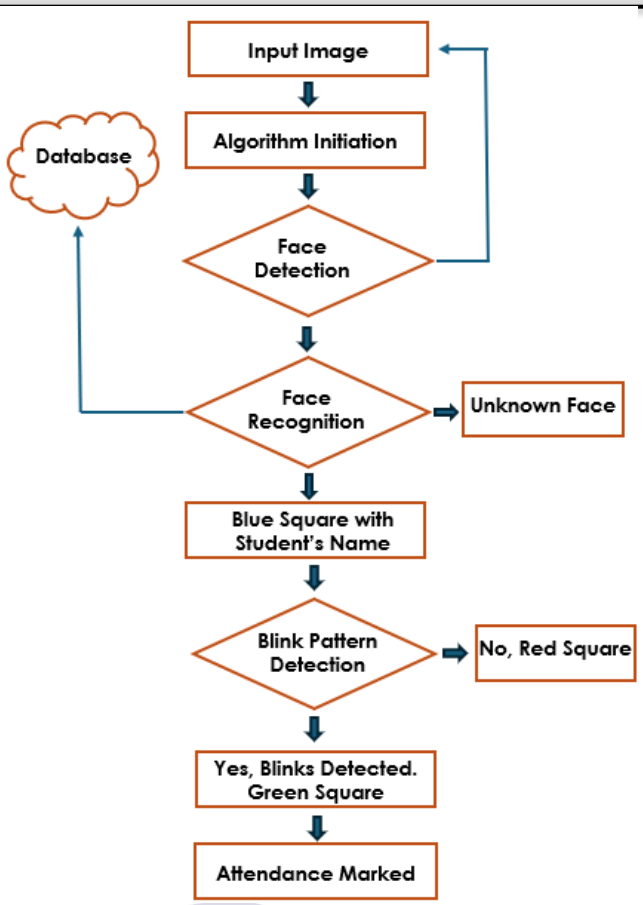

Figure 1 Flow process of the system

The system uses a database hosted on a php server to store attendance records. This makes it easy for administrators to add or delete records for both new and current students, resulting in reduced efforts for managing the records.

To add a new student's details, administrators can easily insert the details such as the student's name, ID number, and other additional information as shown in Figure 10. The system adds this information into the database, making the new student part of the attendance marking process. The workflow is shown in Figure 1.

2.1 FACE DETECTION

The System utilizes a pre-trained model for detecting faces. The model is built on HAAR-like features. These features include edge, line, and centre-surround characteristics of a face, to differentiate between faces within images or video frames. The HAAR cascade algorithm uses a cascade of classifiers to assess multiple levels of image regions to filter out non-face areas. This approach allows fast and accurate face detection [6].

2.2 FACE RECOGNITION

For face recognition, the system utilizes Python 3, along with OpenCV, DLIB and Face_Recognition libraries. The utilization of multiple algorithms lowers the false positives. The algorithms load pre-saved images of students and encode their facial features. The Face_Recognition library processes these images, extracting facial encodings which are required for recognition. The system uses a face encoding function, which converts the images into a numerical representation, to generate unique encodings for each image [2].

A set total of 68 facial landmarks, numbered from 0 to 67, is extracted that includes eye regions, nose, mouth, eyebrows, and jawline. These landmarks

capture unique features and spatial relationships within a face, making each face a distinctive one.

During the real-time recognition process, the algorithms capture video frames using OpenCV. The captured frames are converted into RGB format to comply with Face_Recognition library. The algorithms then detect faces within the RGB frames using the face-locations function. Subsequently, face encodings are applied to encode the detected faces.

To identify students, the systems compare the face encodings of the detected faces with the pre-saved encodings. This comparison is performed using the compare-faces function from the Face_Recognition library. If a match is found, the system displays a blue square around the recognized face. However, if a match is not found, the system labels the face as an 'unknown student' and displays a red square box as shown in Figures 2 and 3.

Table 1 Facial Landmarks (FL)

Landmarks	Range
Jawline	0 – 16
Right Eyebrow	17 – 21
Left Eyebrow	22 – 26
Nose	27 – 35
Right Eye	36 – 41
Left Eye	42 – 47
Mouth & Lips	48 – 68

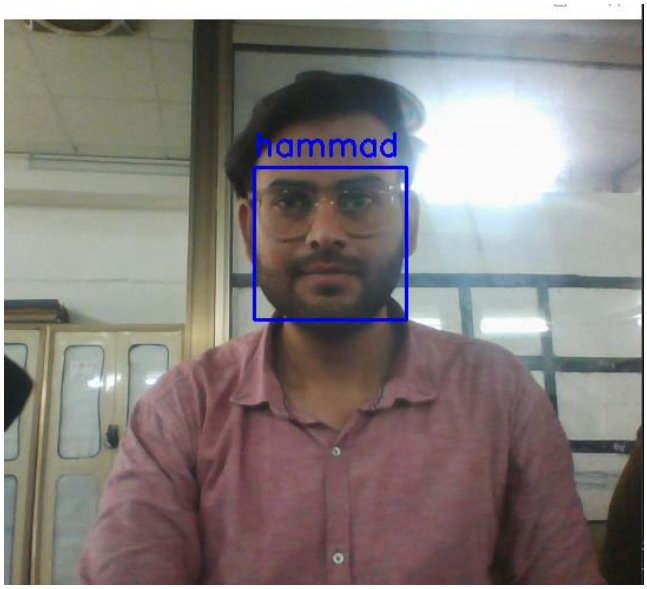

Figure 2 System recognizing student's face

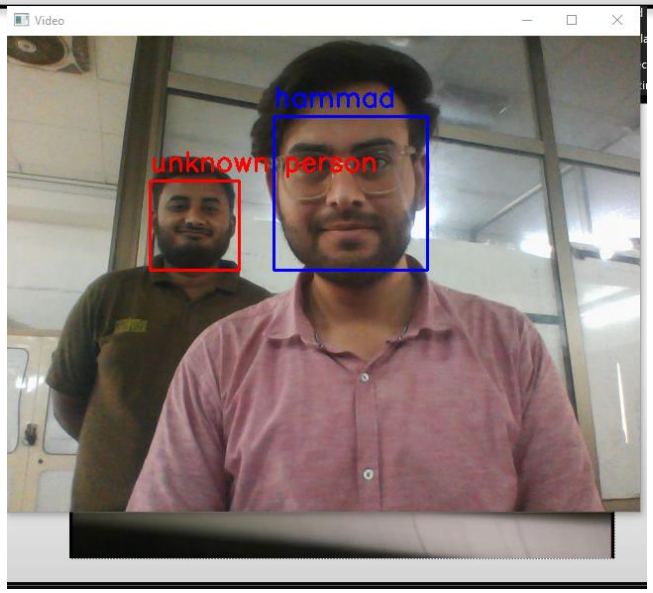

Figure 3 System labelling known and unknown student faces

2.3 EYES & BLINK PATTERN RECOGNITION

The verification of physical presence is accomplished via a physiological signal, i.e. eye blinking. The system uses shape predictors to detect eye regions, this region is determined using the indices. The indices for the right eye are from 36 to 41, and for the left eye, the indices are from 42 to 48. A red square appears around the eyes when the eye regions are detected to check for blinking patterns, as shown in Figure 4.

Figure 4 System detecting eye blinking patterns

The systems use a blink detection mechanism called an average eye ratio threshold. By comparing the calculated average eye ratio with a predefined threshold value of 0.19, the system determines whether eyes are closed or partially closed, indicating blink patterns. When the set threshold meets the set ratio, the blink frames counter increments to track the number of frames with closed eyes.

Table 2 Eye region indices

Parameters	Value
Left Eye Indices	36 – 42 (FL)
Right Eye Indices	17 – 21 (FL)
Threshold	0.19 (19%)

2.4 ATTENDANCE MARKING & STORAGE

Finally, upon successful verification of physical presence, the system proceeds to mark the attendance of students as shown in Figure 5.

Moreover, Figures 6 – 10 depict the working of the system along with the database. Additionally, this important event triggers the recording and storage of attendance information in the database, as shown in Figure 11.

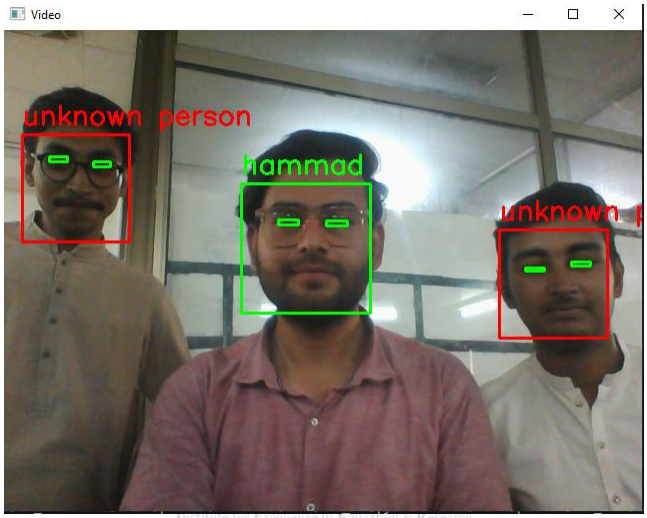

Figure 6 Visual representation of known and unknown faces with blinking pattern detection

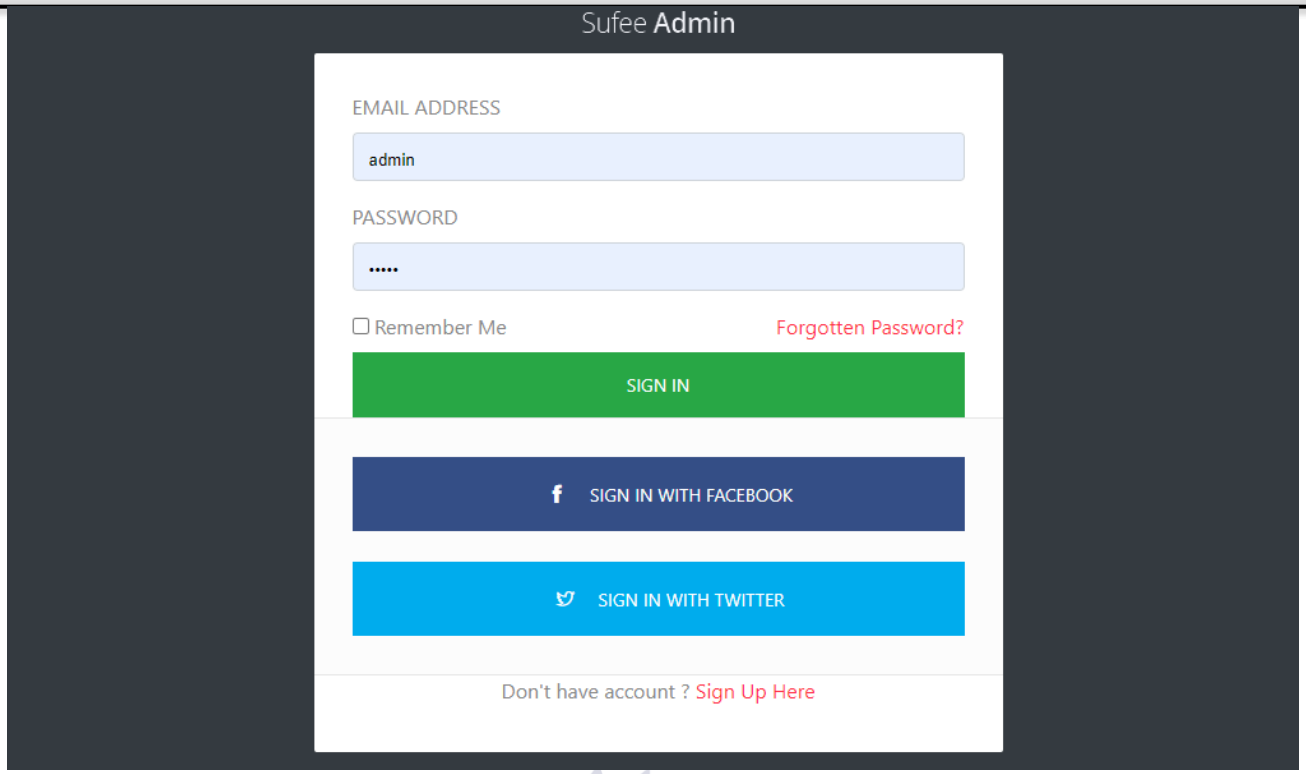

Figure 7 Admin login page for database

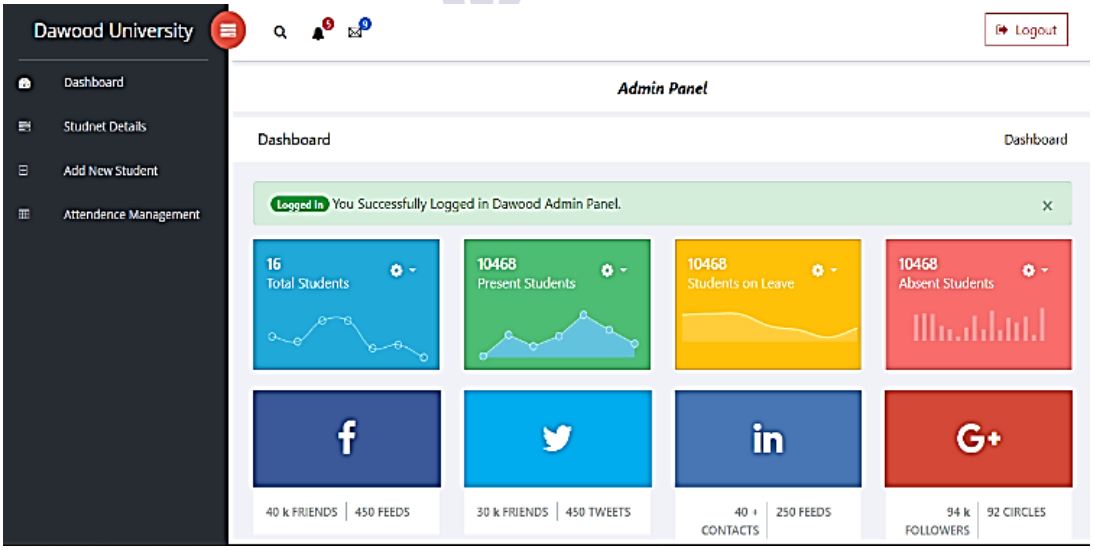

Figure 8 Database Dashboard

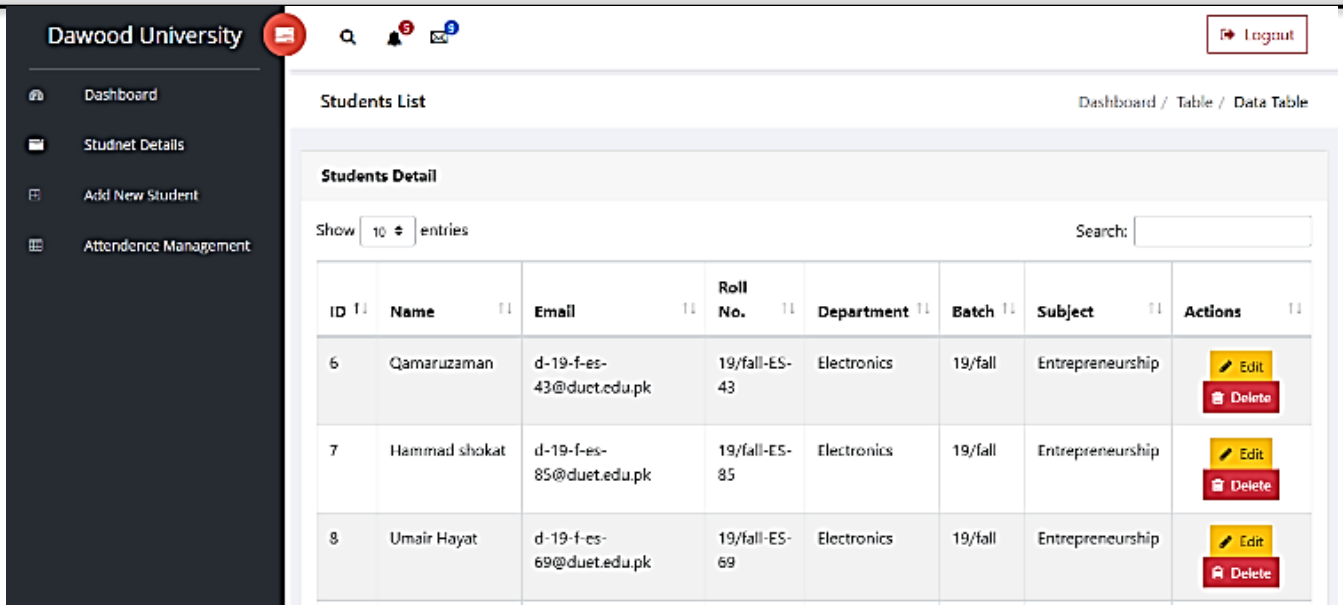

Figure 9 Student's attendance records

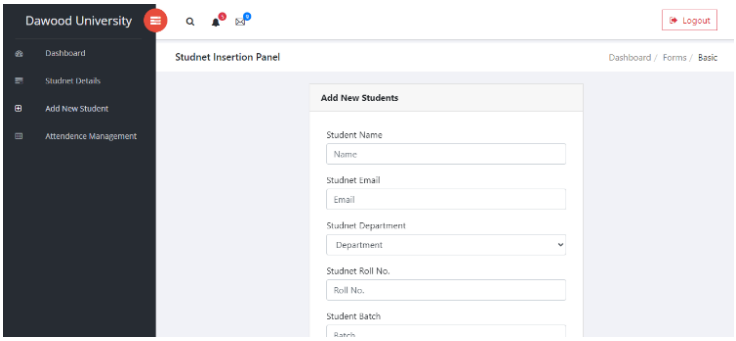

Figure 10 Record modification page

Figure 11 Attendance status

3.0 RESULTS & DISCUSSION

The utilized face recognition algorithms in the developed solution demonstrated high precision and high accuracy in detecting and recognizing faces by effectively distinguishing and labelling students as either 'name-of-the-student' or 'unknown student'.

The addition of blinking patterns as a physiological signal for authenticating physical presence added a sense of security, linking blink events to actual presence, making it a more reliable solution. The autonomous storage of attendance records concludes an end-to-end attendance management solution. The use of multiple techniques effectively resulted in an advanced attendance management solution. Overall, the system contributes to the advancement of how attendance is marked and recorded.

4.0 CONCLUSION

The developed solution addressed and solved a major problem faced in current facial recognition-based attendance systems utilizing eye blinking detection as an authenticator for physical presence during the attendance marking process. The system, on the basis of results, is reliable for educational settings. For future research, it is recommended to utilize more than one physiological signal for authenticating physical presence and use algorithms that work well in low-light conditions.

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