Computer Vision Based Automated Attendance System Using Face Recognition

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Abstract

Face recognition technology has gained substantial attention owing to its diverse applications. One of the applications includes a face recognition-based attendance system which stands out the most among all the existing attendance systems because of its heightened security and time-saving capabilities. A face recognition system is the process of recognizing an individual based only on their facial traits. This paper proposes a real-time face recognition attendance system that validates the real-time monitoring of the process. OpenCV has been used to create a Haar cascade classifier, which is used to recognize faces. The face recognition algorithm Local Binary Pattern Histogram (LBPH) has been chosen in this system due to its robustness and better applicability in the real world. This proposed method can identify the faces of individuals effectively from various angles. The results prove the validation of the work through the monitoring of students' attendance.

Keywords
Smart, Recognition, Attendance, Computer, OpenCV

Introduction
The evolution in automation has led to the replacement of traditional attendance systems with Automated Attendance systems. Managing attendance records in educational institutions is a crucial factor for evaluating student performance. Every educational institution employs its own attendance tracking mechanisms. The conventional paper-based attendance management method is deemed inefficient due to the unnecessary consumption of a significant amount of lecture hours. Also, the manual attendance system is prone to proxy attendance. Moreover, the process of monitoring attendance remains a weighty and inconvenient task for faculty

members as they are required to generate attendance reports as well. The automated attendance system addresses these challenges by saving time and enhancing security. Keeping this in mind, researchers have been working on various attendance systems like biometric-based, Radiofrequency card-based, QR Code-based, face recognition-based systems, etc. Various commonly employed biometric techniques, such as iris recognition, voice identification, fingerprint identification, and DNA recognition, are utilized for identity verification as well. Fingerprint verification and identification, in particular, has been used as a popular means of ensuring the authenticity of an individual due to the uniqueness of fingerprints, making it a preferred choice wherever security is a concern. One drawback of using a fingerprint verification and identification system for attendance tracking is the potential for hygiene concerns. Since individuals need to physically touch the fingerprint scanner, there is a risk of spreading germs and infections, especially in environments with a high volume of users. Additionally, factors such as dirt, moisture, or injuries to the fingers can affect the system's accuracy, leading to potential authentication issues. QR code-based attendance system has been explored by some researchers. However, the system is quite dependent on external factors such as adequate lighting and the quality of the camera. If the lighting conditions are poor or if the camera resolution is low, the system may struggle to accurately capture and decode QR codes, leading to potential errors in attendance tracking.

An alternative proposed by another author is the NFC-based attendance system which involves long queues during the attendance system. RFID-based attendance tracking systems are also another popular method for attendance management. However, it also has the potential for unauthorized data access and privacy concerns. Since RFID technology relies on radio frequency signals to transmit information, there is a risk that someone with the appropriate equipment could intercept and access the data, compromising the confidentiality of attendance records. RFID cards or tags can be easily misplaced, lost, or even duplicated, leading to inaccuracies in attendance tracking. Unauthorized individuals may use someone else's RFID card, leading to false attendance records and potentially undermining the reliability of the system. Considering all the disadvantageous effects of different types of attendance tracking systems, this work aims to establish a robust face recognition-based attendance system with a minimized false-positive rate in detecting unknown individuals. The subsequent sections of this paper are structured as follows: Section 2 highlights the literature survey, section 3 details the system setup, and Section 4 presents the experimental results and discussion. Finally, Section 5 concludes the paper. Thus, to overcome or decrease all these problems we need a robust method of attendance monitoring and marking which may cover all the limitations of manual attendance marking and also can save plenty of time Thus, to overcome or decrease all these problems we need a robust method of attendance monitoring and marking which may cover all the limitations of manual attendance marking and also can save plenty of time Thus, to overcome or decrease all these problems we need a robust method of attendance monitoring and marking which may cover all the limitations of manual attendance marking and also
can save plenty of time.

Literature Survey

Researchers have been developing diverse attendance systems, including those based on biometrics, Radiofrequency cards, QR codes, and face recognition technology over the years. Masalha and Hirzallah (2014) proposed a QR code-based attendance system for digitizing the attendance record which was capable of reducing attendance-taking time by up to 90%. This system provided students with a QR code that they could scan with a smartphone application to confirm their attendance and thus save time. It also prevents unauthorized attendance registration with multi-factor authentication, which uses "Something you know", "Something you have", and "Something you are" to verify the student's identity. Dey et al. (2014) proposed a speech biometric-based attendance system that verifies the identity of a person using human characteristics or traits to restrict access to an intended service. Speech biometrics is commonly termed speaker verification (SV). The state-of-the-art text-independent SV systems are based on the total variance i-vectors derived from the GMM mean supervectors for modeling speakers. Some researchers developed RFID RFID-based attendance tracking system which captured students' attendance in a semi-automated way where the students are required to flash their student card at the RFID reader upon entering the classroom. This system promotes a more organized and systematic student attendance recording, prevents data loss, and allows the data to be available and accessible to lecturers or other academic staff. It also helps to automatically compute the percentage of attendance for each student. Mohamed and Raghu (2012) proposed a fingerprint-based attendance system that is used in corporate environments to store and verify fingerprints and can be ported to academic environments with modifications. The concept of a fingerprint attendance system using RFID technology has been proposed by Kassem et al. (2010) and Sarker et al. (2016). Rao and Satoa (2013) proposed an employee attendance management system using fingerprint recognition. During, every check-in and check-out time, employees needed to scan their fingerprints to record attendance. Minutiae-based matching combined with alignment-based greedy matching was used to recognize scanned fingerprint in the proposed attendance system. The proposed system is inappropriate for course attendance system in the case of a huge number of enrolled students as it will cause a long and time-consuming queue. Another approach by Mohandes (2016) suggested NFC based system. In this approach, students bring their NFC-enabled phones close to the Lecturer's NFC phone upon entering the classroom. However, this method may result in long queues during the attendance process. Moreover, the risk of fraudulent attendance exists, as student cards with barcodes, QR codes, or RFID and NFC-enabled phones can be easily transferred between students. Additionally, not all smartphones come equipped with NFC systems. Consequently, considering the current state of automated attendance systems, it is evident that face recognition stands out as the most effective approach for accurately identifying students in an attendance system.

Rastogi et al. (2022) conducted Algorithmic Analysis on an Automatic Attendance System employing Facial Recognition. Their system demonstrated enhanced speed and accuracy in detecting and recognizing human faces through images or videos captured by surveillance cameras. The video frames were converted into images for seamless searching within the attendance database. Sultan et al. (2022) proposed a Real-Time Face Recognition Based Attendance System tailored for university classrooms. This system efficiently identifies all present students, records matching features with the database, and accommodates face recognition from various angles. Additionally, it can be implemented for robust surveillance setups based on face recognition principles. Anshari et al. (2021) conducted a systematic review focusing on face recognition for identification and verification in attendance systems. The aim was to provide researchers with insights into face recognition implementation, verification processes, and critical success factors for attendance systems. Alburaiki et al. (2021) introduced a Mobile-Based Attendance System utilizing Face Recognition and Location Detection through Machine Learning.

This system enables lecturers to generate attendance and students to submit it by scanning their faces using a mobile phone camera and providing their location. The proposed system integrates automatic face detection and analysis, face recognition API with machine learning algorithms, and maps API. Testing involving over 30 students showed high accuracy in recognizing faces, even in challenging environmental conditions. Khan and Usman (2020) proposed a Real-Time Automatic Attendance System for face recognition using Face API and OpenCV, implemented through smartphones. The system efficiently counts and detects attendance in real-time. Bussa et al. (2020) presented a Smart Attendance System utilizing OpenCV and facial recognition. This model incorporates a camera, face detection algorithm, face encoding and identification, attendance marking in a spreadsheet, and PDF conversion. The training database is created using the faces of authorized students, and LBPH algorithm extracts features. Winarno et al. (2019) introduced another Face Recognition-Based Attendance System using the CNN-PCA method and real-time cameras. This hybrid feature extraction method aims for increased accuracy. The system exhibits effective and efficient data processing, ensuring reliable and powerful real-time identification of human faces.

This work focuses on developing a face recognition-based attendance tracking method using OpenCV. Face detection in this system is implemented using the robust Haar cascade method, while face recognition utilizes the LBPH algorithm, known for its resilience against monotonic grayscale transformations. Notably, this system detects and stores images of any unidentified person in the class, even if their information is not present in the database.

System Set Up

This system comprises of two main elements: a camera functioning as an imaging device and a computer responsible for processing and executing the program. PyCharm serves as the platform for program execution. The block diagram in Figure 1 illustrates the configuration of the real-time face recognition attendance system. Firstly, a camera is connected to the system, ensuring it is properly configured and has a clear view of the individuals whose faces need to be recognized. Then, the OpenCV library is imported into the system. OpenCV is a powerful open-source computer vision library that provides various tools for image and video processing. Haar Cascade Classifier is created which is trained to identify specific features in the images of a student, and in this case, it is trained to recognize faces. The real-time video or frames are captured using the camera continuously from the video feed. The Haar Cascade Classifier is applied to each captured frame to detect faces in real time. The classifier will identify regions in the frame that match the characteristics of a human face. Once a face is detected, a face recognition algorithm namely Local Binary to identify the person. This step involves comparing facial features with the pre-existing database. If the identified face corresponds to a known student, their attendance is logged. Thus, a database of registered individuals is maintained and their attendance records are updated based on the recognized faces.

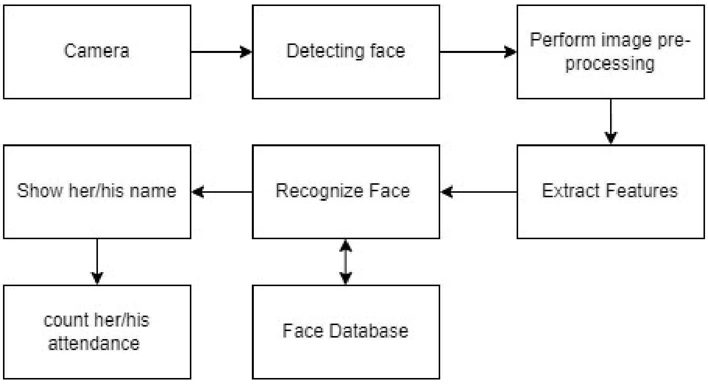


Figure 1. Block Diagram of Realtime Face Recognition Attendance System.

Sketchup has been used to show the 3D view of the camera which is shown in Figure 2. This web camera has Built-in 6 white LED and Built-in microphone.

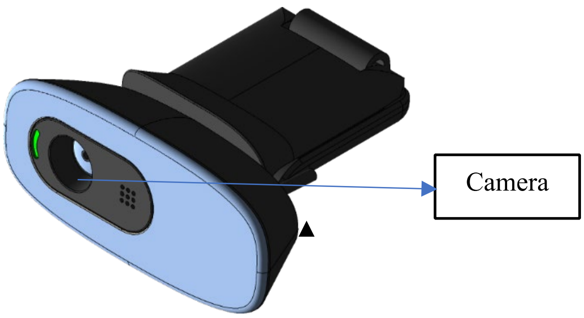


Figure 2. 3D View of the Camera Used

The following Figure depicts the flowchart of a face recognition-based attendance system. Initially, the system is activated by executing the code through PyCharm. The camera is activated to identify faces. Upon detecting a person in front of the camera, the system begins face recognition. If the detected face matches any of the trained faces, the person's name is displayed on the PC monitor, and their attendance count is incremented. If the detected face is not recognized and does not match with the trained images, the PC monitor indicates that the face is unidentified.

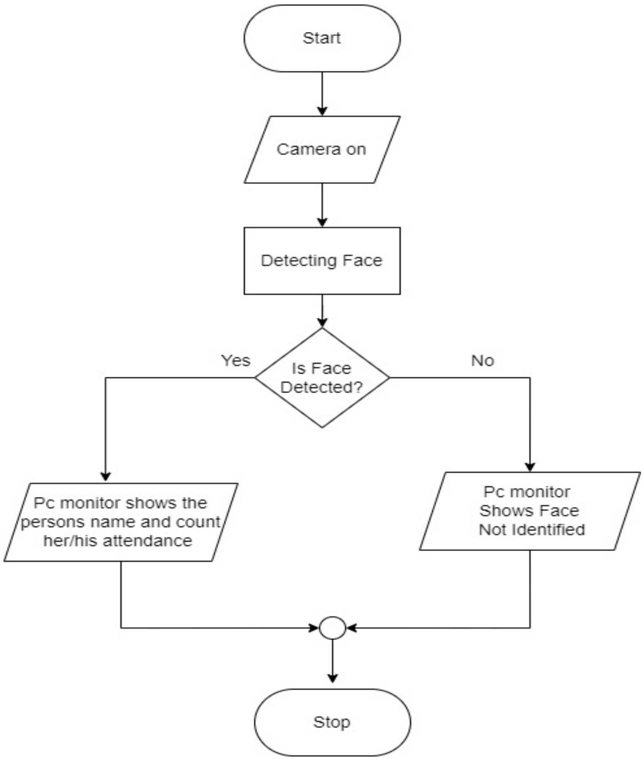


Figure 3. Flow Chart of Realtime Face Recognition System Attendance System.

Among the face recognition algorithms like Local Binary Pattern Histogram (LBPH), Eigenfaces, and Fisher faces, the proposed system uses LBPH algorithm which focuses on local texture patterns, making it robust to variations in lighting conditions, facial expressions, and small changes in appearance. Also, LBPH is known for its robustness to changes in lighting conditions, making it suitable for real-world applications where lighting can vary. Eigenfaces and Fisher faces, being global methods, might be more sensitive to variations in the entire face, making them potentially less robust in certain scenarios. Moreover, LBPH captures local patterns effectively through its histogram representation and unlike others it is less sensitive to facial expression, making it suitable for recognizing faces with distinct textures.

LBPH-based Real-Time Face Recognition system works based on Local Binary Patterns Histogram (LBPH) algorithm to address the human face recognition in real-time. The four essential components of most face recognition systems are the input acquisition module, feature extraction module, classification module, and training classifier database module. Firstly, the input image is preprocessed to enhance its quality and reduce noise. The LBP operator is applied to the preprocessed image. For each pixel in the image, LBP compares the intensity of the pixel with its neighboring pixels. If the intensity is greater than or equal to the center pixel, a binary '1' is assigned; otherwise, a '0' is assigned. This process is repeated for each pixel, creating a binary pattern. The binary patterns generated for each pixel are used to construct a histogram. The histogram represents the distribution of these patterns in the image. Each bin in the histogram corresponds to a unique binary pattern. The image is divided into local regions, and LBP histograms are computed for each region. This local information helps capture texture details in different parts of the face. The histograms from all local regions are concatenated to create a feature vector that represents the face. This feature vector captures the spatial distribution of texture patterns in the face. During the recognition phase, the feature vector of the input face is compared with the feature vectors of faces stored in the database.

A threshold is applied to the computed distances to determine whether the input face is a match with any face in the database. If the distance is below a certain threshold, the system recognizes the face; otherwise, it is considered unknown. Based on the thresholding results, the system decides whether the input face corresponds to a known individual. If it does, the recognition system retrieves the associated identity; otherwise, it classifies the face as unknown. This entire process is carried out in real-time as video frames are continuously captured. For each frame, the LBPH algorithm is applied, and the face recognition decision is made. If a face is recognized, the database is updated in real-time to reflect the latest attendance or recognition information.

Result & Discussion

In this system, OpenCV is employed to generate a Haar cascade classifier, designed for facial recognition. The AdaBoost technique is implemented using this Haar cascade classifier to identify various facial features. The process begins by reading and converting the target image to grayscale. Subsequently, the Haar cascade classifier is loaded to ascertain the presence of a human face. Upon identification, it analyzes the facial features and delineates a rectangular frame around the detected face. If no face is detected, the system proceeds to the next image for evaluation. The Local Binary Pattern (LBP) operator is utilized to represent a pixel's contrast information relative to its neighboring pixels. The original LBP operator is defined in a 3x3 window, where the grey value of each of the 8 surrounding pixels is compared to the median pixel value, which serves as the window's threshold. If the neighboring pixel value is greater than or equal to the median pixel value, the pixel position is marked as 1; otherwise, it is marked as 0. This operation is defined by the equation below and is illustrated in Figure 4.

$$s(x) = \begin{cases} 1, & x \geq 0 \\ 0, & x < 0 \end{cases}$$

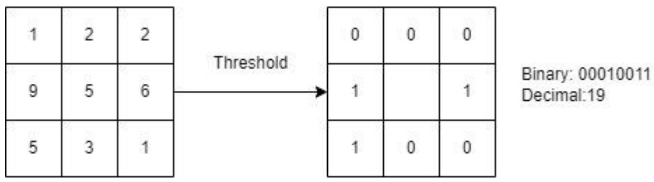


Figure 4. Original LBP Operator

The process involves comparing 8 positions within the 3x3 neighborhood to generate 8-bit binary numbers. In this approach, the Local Binary Pattern (LBP) values of the central pixel points within the window are obtained by converting them into decimal integers, providing insights into the texture characteristics of the region. The Local Binary Pattern Histogram (LBPH) method utilizes an improved circular LBP operator. The computation of the Local Binary Pattern Histogram (LBPH) for a particular pixel in an image is expressed through the following equation

$$LBPH = \Sigma_{p=0}^{p-1} S(g_p - g_C) 2^p$$

Where, p is the number of neighboring pixels considered in the Local Binary Pattern (LBP) computation
g_p represents the intensity value of the p-th neighboring pixel
g_c represents the intensity value of the central pixel (the pixel for which the LBP is being computed
$S(x)$is a function that returns 0 if $x < 0$ and 1 if $x > 0$
This function essentially converts the result of the pixel intensity comparison into a binary value (0 or 1)

The Local Binary Pattern (LBP) is computed by comparing the intensity value of the central pixel with the intensity values of its neighboring pixels. If a neighboring pixel's intensity is greater than or equal to the central pixel's intensity, it is assigned a binary value of 1; otherwise, it is assigned a binary value of 0. This process is repeated for each neighboring pixel, resulting in a binary code. The expression $S(g_P - g_C)2^P$ computes the contribution of each bit in the binary code. If g_P is greater than or equal to g_C, then the term 2^P is included in the sum; otherwise, it contributes 0. So, the entire expression represents the summation of the contributions of each bit in the binary code, forming the Local Binary Pattern for the central pixel. This LBP is then used for texture analysis in face recognition.

The Local Binary Pattern algorithm captures the local spatial arrangement of a facial image by utilizing the LBP operator in extracting local features. The LBP operator is quantified as the count of binary patterns formed by pixel intensity ratios within a vicinity of eight pixels surrounding the central pixel. The system recognizes a face in an input picture through camera and captures the grey scale image in the face detection stage. This is depicted in the equation below.

$$LBP(x_{c,} y_c) = \sum_{n=0}^{7} S(i_n - i_c)\, 2^n$$

Where (xc, yc) shows eight surrounding pixels information.
i_c is the intensity of the central pixel
i_n is the intensity of the n th neighboring pixel
$S(x)$ is a step function that returns 0 if $x < 0$ and returns 1 if $x > 0$

This formula represents the computation of the Local Binary Pattern for a pixel in an image. It compares the intensity of the central pixel with the intensities of its neighboring pixels. If the intensity of a neighboring pixel is greater than or equal to the intensity of the central pixel, it contributes a 1 to the binary code; otherwise, it contributes a 0. The binary code is then represented as a decimal number using the 2^nweights, and the sum is taken over all neighbors.

The developed face recognition system has been tested on a number of university students whose faces were trained earlier. The Figure 5 shows that the developed system successfully recognizes the trained faces while Figure 6 depicts that the system doesn't recognize unknown face or untrained faces. Figure 7 illustrates the attendance sheet of 10 students.

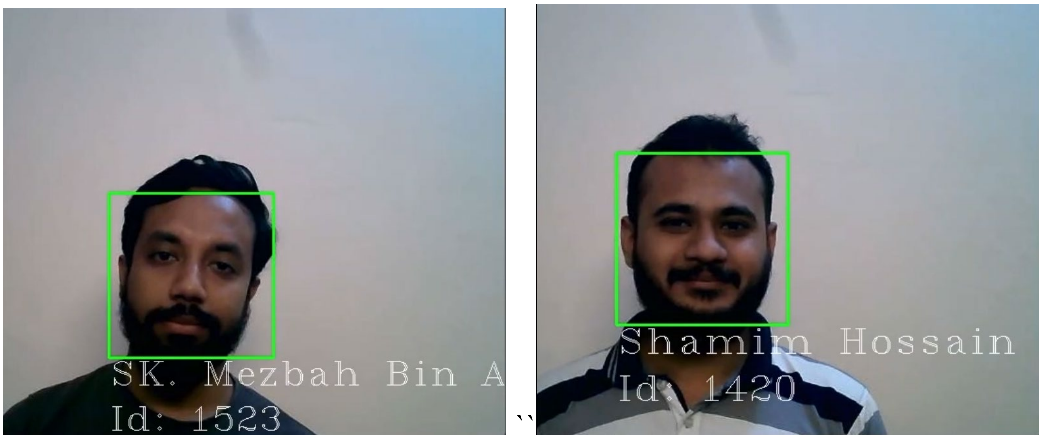
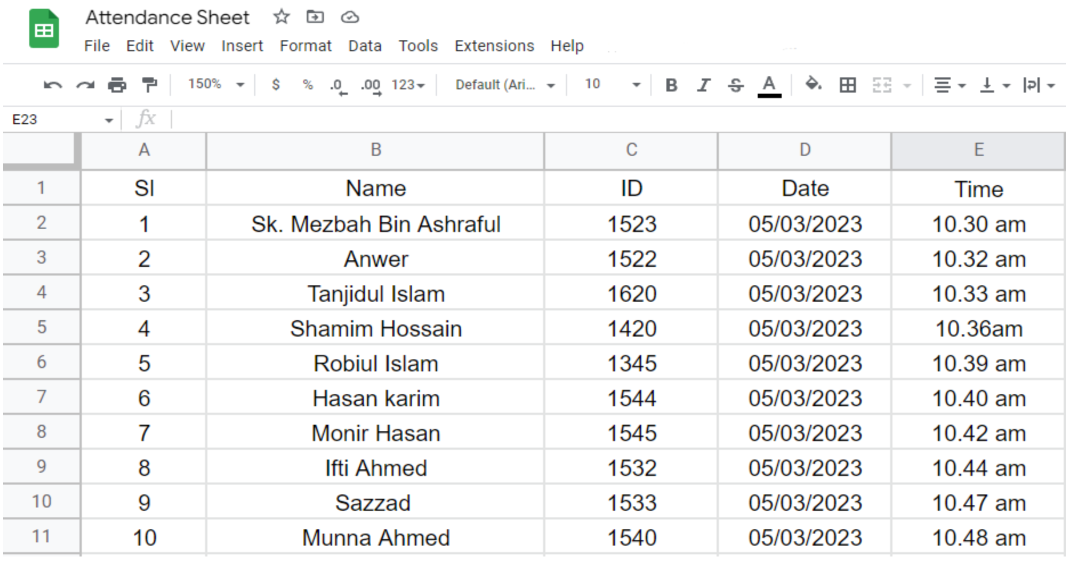


Figure 5. Known Faces recognized

Figure 6. Unknown Faces Unrecognized



Sl	Name	ID	Date	Time
1	Sk. Mezbah Bin Ashraful	1523	05/03/2023	10.30 am
2	Anwer	1522	05/03/2023	10.32 am
3	Tanjidul Islam	1620	05/03/2023	10.33 am
4	Shamim Hossain	1420	05/03/2023	10.36am
5	Robiul Islam	1345	05/03/2023	10.39 am
6	Hasan karim	1544	05/03/2023	10.40 am
7	Monir Hasan	1545	05/03/2023	10.42 am
8	Ifti Ahmed	1532	05/03/2023	10.44 am
9	Sazzad	1533	05/03/2023	10.47 am
10	Munna Ahmed	1540	05/03/2023	10.48 am

Figure 7. Attendance Sheet

Table 1 illustrates the confusion matrix for this system. A confusion matrix is a technique for summarizing the performance of a classification algorithm. It is used in machine learning and pattern recognition to evaluate the performance of a classification algorithm. In the context of face recognition, a confusion matrix helps assess how well the system is able to correctly classify individuals into different classes (faces of different people).

Table 1. Confusion Matrix

N=20	Predicted: Trained faces	Predicted: Non-Trained faces	Total
Actual: Trained faces	8	2	10
Actual: Non-Trained faces	2	8	10
Total	10	10	

The suggested system uses cameras to take snapshots of students present in the classroom on two occasions: initially at the start and subsequently at the conclusion of the class. Following this, the system autonomously identifies and recognizes students in the images, facilitating the recording of their attendance. The results demonstrate the validation of the work through the monitoring of students' attendance. This work involves capturing the student's image, face detection through pre-processing, feature extraction, and person recognition. In the domain of face recognition, the proposed system employs the Local Binary Pattern Histogram (LBPH) algorithm and the Haar Cascade classifier. The LBP Algorithm utilizes a Histogram, thereby enhancing the precision of face recognition. It is seamlessly integrated with the Haar classifier, which harnesses machine learning algorithm. The Adaboost Learning algorithm selectively picks small features from extensive sets, thereby amplifying the efficiency of the recognition process. The Haar cascade method is chosen for face detection due to its robustness, while the LBPH algorithm is employed for face recognition.

Conclusion

The proposed automated attendance system applies the concept of Haar cascade and local binary pattern histogram algorithm for face recognition of students. Acquiring student images from the camera, preprocessing for face detection, extracting features, as well as recognizing individuals has offered an effective means for face recognition. The automated process not only reduces the workload on faculty members but also enhances the efficiency of the attendance tracking system. The findings affirm the validation of the work by monitoring students' attendance. The LBPH algorithm has been successfully implied due to its robustness to variations in lighting conditions and facial expressions, making it well-suited for real-time face recognition systems. Notably, the proposed system operates efficiently without necessitating high-end hardware specifications. This proposed system for attendance system allows face recognition in a controlled environment.

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Biographies

Abu Salman Shaikat is a graduate student pursuing his postgraduate studies in Engineering Science at the Bharti School of Engineering and Computer Science, located at Laurentian University in Canada. He has completed his Master of Engineering degree from the Asian Institute of Technology (AIT) in Mechatronics and his Bachelor of Science in Electrical and Electronic Engineering degree from Ahsanullah University of Science and Technology (AUST), Bangladesh. After completing his Master degree, he has worked at Bangkok Glass Public Company Limited, Thailand, as a production engineer as well. He has more than 20 publications in peer-reviewed international journals, conferences, and books. His research interest includes Computer Vision, IOT, Robotics, Automation, Control Theory and Artificial Intelligence.

Molla Rashied Hussein is an Assistant Professor at the Department of Computer Science and Engineering, University of Asia Pacific (UAP), Dhaka, Bangladesh. He has completed his Master of Engineering degree in Computer Engineering from Old Dominion University, Norfolk, Virginia, USA. He has 15 publications. His research areas include but are not limited to: Cybersecurity, Blockchain, Natural Language Processing, Machine Learning and Robotics.

Rumana Tasnim is currently working as an assistant professor in the Department of Mechatronics Engineering at the World University of Bangladesh. She achieved her M.Sc. degree in Electronics Engineering (MSEE) from the International Islamic University of Malaysia (IIUM) and her B.Sc. degree in Electrical and Electronic Engineering (EEE) from the International University of Business, Agriculture, and Technology, Bangladesh. She has more than 50 publications in peer-reviewed international journals, conferences, and books. She has reviewed a number of international journals throughout her academic career. She is the advisor of the IEOM Society WUB Chapter. Her research interests include smart sensing, instrumentation and measurement, automation, robotics, IOT, Computer Vision and renewable energy.

Ahmed Farhan is working as a Lecturer in the Department of Mechatronics Engineering at World University of Bangladesh (WUB). Previously, he also worked in this department from 2014 to 2016. He completed his Bachelor of Science (B.Sc.) in Electrical and Electronic Engineering at the renowned Islamic University of Technology (IUT) with the OIC scholarship. During his time at IUT, Mr. Farhan demonstrated exceptional dedication to his studies and a passion for learning that set him apart from his peers. After earning his B.Sc. degree, Mr. Farhan continued his educational journey by pursuing a Master of Engineering (M.Engg.) degree from the prestigious Harbin Engineering University (HEU) with the prestigious CSC scholarship. This decision displayed his commitment to furthering his knowledge and expertise in his chosen field. Throughout his academic career, Ahmed excelled in various subjects related to engineering and technology. His determination, intellectual curiosity, and strong work ethic made him stand out as a student who was destined for success. Mr. Farhan has published three international journal papers and one conference paper. His research interests are biomedical engineering and image processing.

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