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Dr. Yehia El-Mashad, Hesham A. Ali: A new approach for smart attendance system based on improved video facial recognition technology for smart university

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Abstract: Since entering the information age, there have been considerable developments in the methods of managing the various learning processes, so there is no need to rely on a large amount of human resources to collect and analyze data. Many technologies have emerged that are capable of analyzing different types of data and providing interdependence and movement to data effectively. So, it can be said that digital transformation has played a decisive role in developing management systems in smart universities. Attendance systems through facial recognition may be considered the most important operation in the smart university.

The main objective of this paper is to introduce the attendance system through a new methodology for detecting and identifying faces through video cameras based on artificial intelligence techniques to predict the face and match it with what is in the database. By developing a robust attendance system using video facial recognition technology, the proposed methodology in this paper aims to improve the accuracy, efficiency, and safety of attendance tracking in smart universities. To achieve the proposed goal, this paper will focus on developing a facial recognition algorithm that can accurately identify individuals under varying lighting conditions and facial expressions. The proposed system can provide real-time attendance information, allowing for timely interventions and support for students who may need it. Moreover, the use of video facial recognition technology can help reduce the workload for teachers and administrators. The proposed algorithm is tested, and the experimental results prove that, due to minimal error, better classification accuracy and high confidence value are achieved.

Keyword: Smart university, attendance system, Facial recognition, smart system

1. Introduction

One well-known organization that employs many technologies, initiatives, which utilizes various sorts of sensor devices, cameras, internet of things (IoT), and intelligent strategies is smart university. These methods help to competently construct active, safe, and smart universities. Smart universities cover a range of topics, including data collection from people and gadgets, traffic analysis, information analysis, and energy management.

Face recognition is one of the key components that has been incorporated with the university projects among the many smart university initiatives. In addition, the face recognition technique aids in maximizing the investigation process, preserving university safety, and enhancing smart university activities. In recent years, facial recognition technology has grown in popularity across a range of applications, including social networking, marketing, and security. Attendance monitoring in educational institutions, businesses, and other settings is one of the most promising applications of this technology. In order to improve efficiency and accuracy in tracking attendance, the goal of this study is to design an attendance system employing facial recognition technology.

The current attendance tracking systems used in many smart universities rely on manual methods, such as taking attendance sheets and calling out names. This process is often time-consuming and prone to errors, leading to inaccurate attendance records and wasted time. Moreover, in the post-COVID-19 era, the need for contactless attendance tracking has increased, making facial recognition technology an ideal solution.

In the suggested method, a camera will be utilized to snap a photo of the pupil or worker. This picture will then be examined by a face recognition algorithm to identify the person. By comparing the captured image to the photos that are already saved in the database, the algorithm will detect the presence of the identified person. The system will also generate reports on attendance information and alert the appropriate authorities when a student is absent.

The method described in this work will call for the development of a robust facial recognition algorithm that can correctly identify individuals in a variety of lighting and facial expression scenarios. Given that face recognition technology has sparked worries about bias and privacy violations, the system's design will also need to guarantee data privacy and security.

The proposed attendance system has several advantages over traditional attendance tracking methods. It will eliminate the need for manual attendance taking, reduce the risk of errors and fraudulent attendance records, and save time and effort for both teachers and students or employees. Additionally, the system can be easily integrated with existing school or workplace management systems, providing a seamless attendance tracking experience.

2.Basic and Related work

Thanks to the creation of innovative technology-based teaching and learning methodologies, new technologies are now possible that enable universities to be more active and involved within a team of workers. The Smart Collaborative technology serves as a roadmap for using technology for collaborative learning and handling the potentially conflicting obligations of autonomous collaborative learning. It emphasizes how important it is for universities to offer their own meanings and use effective communication strategies as they work together creatively and make use of interactive technologies. Figure1 illustrates the many technologies and requirements that could be used in a smart university.

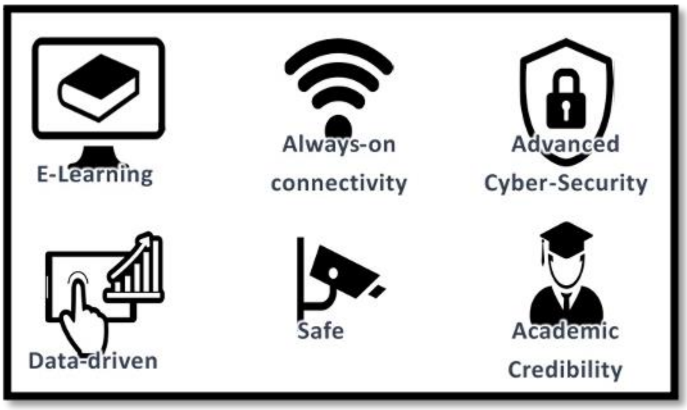

Figure 1 *Technologies and requirements that could be used in a smart university*

This strategy uses collaboration to particularly control the learning environment at a smart institution, offering chances for thoughtful conversation. The university creates an integrated environment for the learner through transit systems and technology tools, which improves his participation, cooperation, and regularity. Modern data processing technologies are necessary for this new generation of engagement in order to deliver intelligent services that are accessible and capable of adjusting to the learner's profile. To achieve this, it encourages the development of an environment conducive to training and research that supports learner-centeredness. Taking into account the educational, pedagogical and logistical factors in order to share knowledge intelligently. Figure 2 illustrates the most common IT architecture with layer and tier views. These layers provide the necessary technology for smart universities to function as a whole, as well as a range of services provided to improve their quality of student life.

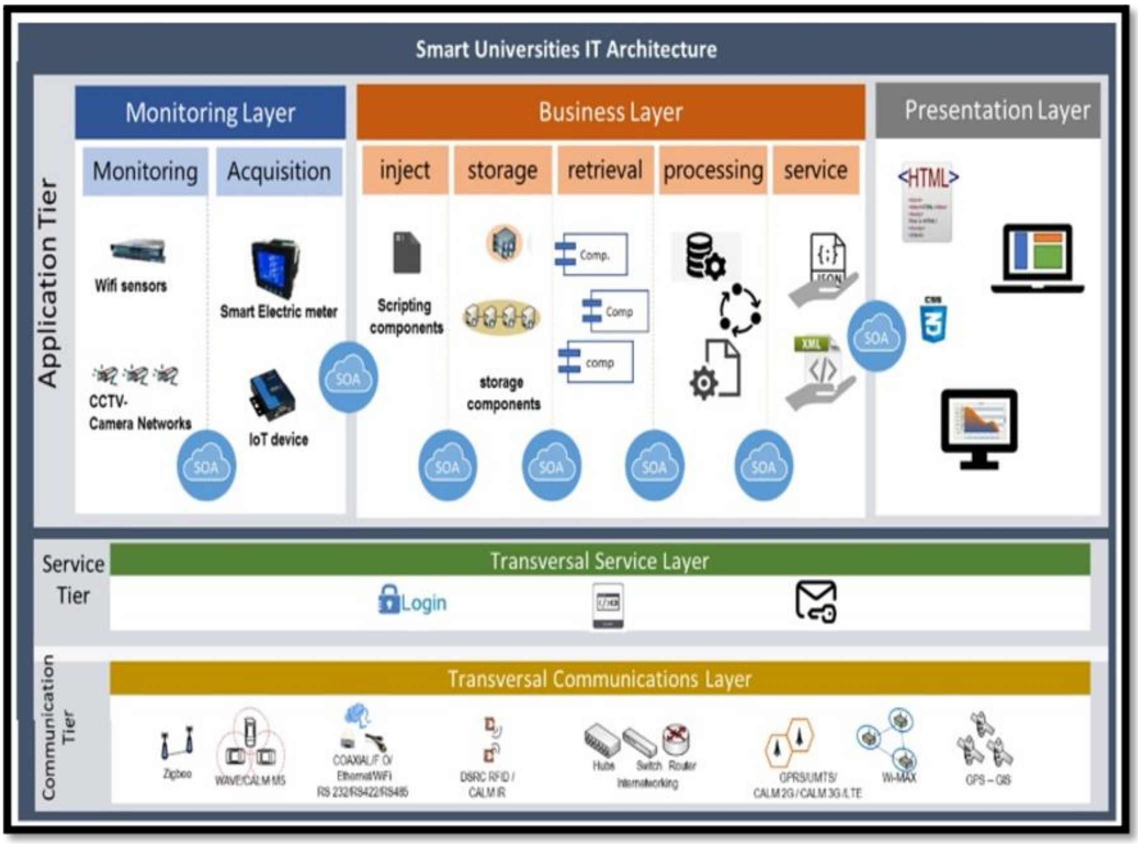

Figure 2 *General framework of the IT architecture of the Smart university.*

The specificity of the service-oriented concept makes the integrating of the learning and management process and its application possible for the university to be proactive, scalable, and innovative. The smart university adopts technology and innovates intelligent environments characterized by collaboration, adaptation, and personalization and can imply innovative and pertinent strategies to improve academic environments. The smart learner's profile, behavior, and comments are considered while designing services by Smart University. Figure 3 shows a modern, technologically integrated smart university. Additionally, it delivers a smart university system that is powered by smart technology and augmented with proactive services in response to the demands of a smart environment. computing. In addition, it responds to the requirements of a smart environment and provides a smart university system driven by smart technology and enhanced with proactive-services. computing

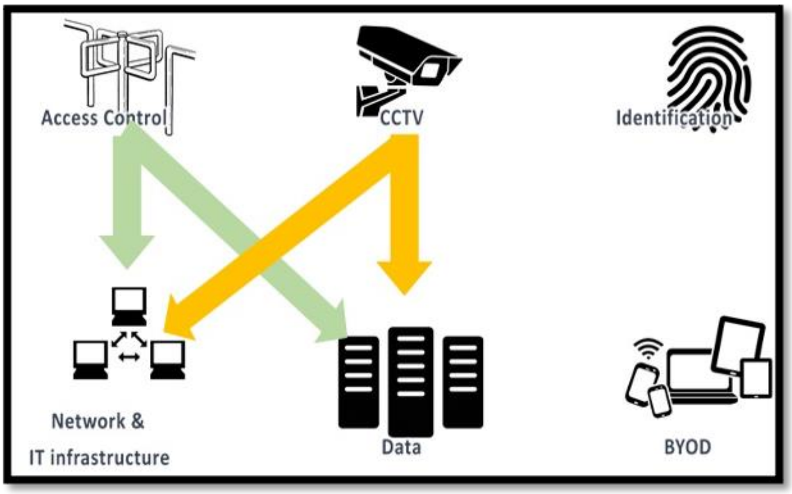

Figure 3 *The smart university of today with technology integration*

2.1 Different technologies for attendance systems

The growth of information technology and Internet of Things technologies has accelerated the digitization of education. One of the areas of focus and investigation in colleges and universities now concerns the growth of educational management using information technology. Student attendance in class is a crucial component of coll-ege education management, which must design techniques and processes to evaluate the efficacy and logic of everyday instruction using actual, scientific data [1].

Attendance systems include student attendance and teacher attendance. It can provide crucial fundamental data for teaching reform and not only represent students' learning behaviors but also the sincerity and efficacy of teachers' classroom instruction. The methods and technologies used to track class attendance are closely tied to the data collection process. Manual attendance is the fundamental component of the traditional classroom attendance system. Such attendance systems are not only susceptible to errors and omissions but also dynamically grasp the attendance status of pupils. Additionally, it must repeatedly test the attendance data, which uses many resources [2]. At the same time, manual attendance records are generally recorded, sorted, and kept by teachers, so it is not easy for students to understand their attendance. Therefore, the traditional classroom attendance method cannot meet the needs of students and teachers or the requirements for the development of information technology in colleges and universities [3].

A smart university is defined by its smart role in sharing knowledge and developing citizens' emotional, func-tional, and intellectual capabilities. This archetype is strived by a series of smart concepts that enhance the quality of training to meet requirements recommended by a generation of learners who prefer interactive and proactive systems, as well as to overcome the limits faced when using the existing solution (e-learning, MOOCs ...) and offer to modernize training for new educational models. The main ones are smart education, smart learning, smart pedagogy, and smart classroom; they are new opportunities for modernizing the learning process and creating an innovative educational model principally based on smart service. Table 1 depicts a comparison between the diffe-rent technologies of Face recognition

FaceMark: A Facial Recognition-Based Attendance System for Large Lectures: This project, conducted by researchers at the University of California, San Diego, developed a facial recognition-based attendance system that can identify students in large lecture classes. The system uses a webcam to capture facial images and a deep learning algorithm to accurately recognize individuals.

Face-Attendance: A Cloud-Based Attendance System Using Facial Recognition: This project, conducted by researchers at the University of Pretoria in South Africa, developed a cloud-based attendance system that uses facial recognition technology to track attendance. The system uses a mobile app to capture facial images and a cloud-based server to process the data.

OpenCV: OpenCV is an open-source computer vision library that can be used to develop facial recognition-based attendance systems. It provides various tools and algorithms for image processing, pattern recognition, and machine learning.

Amazon Rekognition: Amazon Rekognition is a cloud-based facial recognition service that can be used to develop attendance tracking systems. It provides a pre- trained deep learning model that can accurately recognize faces and can be customized for specific use cases.

FaceID: FaceID is a commercial facial recognition-based attendance system developed by the company Bio-Enable. The system uses a high-resolution camera to capture facial images, which are then processed by a deep learning algorithm to identify individuals. The systemalso provides real-time attendance reports and can be integrated with other systems such as payroll and HR management.

Face Recognition Attendance System: This project is a facial recognition-based attendance system developed by researchers at the University of Lahore in Pakistan. The system uses a webcam to capture facial images and a deep learning algorithm to accurately recognize individuals. The system also includes a dashboard for real-time attendance monitoring and reporting.

Microsoft Azure Face API: Microsoft Azure Face API is a cloud-based facial recognition service that can be used to develop attendance tracking systems. It provides a pre-trained deep learning model that can accurately recognize faces and can be customized for specific use cases. The service also includes tools for face detection, face verification, and face grouping.

Kairos: Kairos is a facial recognition API that can be used to develop attendance tracking systems. It provides a pre-trained deep learning model that can accurately recognize faces and can be customized for specific use cases. The API also includes tools for face detection, face recognition, and face analysis.

In conclusion, several related works, research/projects, and tools are similar to Attendance Using Facial Recognition Technology. These projects and tools use facial recognition technology to develop attendance tracking systems, with many using deep learning algorithms to accurately recognize individuals in real-time. These systems can significantly improve the efficiency and accuracy of attendance tracking while also addressing the need for contactless attendance tracking. However, concerns about data privacy and security must be addressed to ensure the safe and secure use of the technology in attendance tracking systems.

Table 1 *Comparison between the different technologies of Face recognition*

Technology	Key Features	Usage	Data Privacy	Contactless Operation
FaceMark	Uses deep learning algorithm for real-time recognition; captures facial images using webcam	Large lecture classes	Data is encrypted and stored securely	Yes
Face-Attendance	Cloud-based system; uses mobile app to capture facial images	Schools, universities, and workplaces	Data is stored in the cloud; controlled through user authentication	Yes
OpenCV	Open-source computer vision library with tools for image processing, pattern recognition, and ML	Various applications	Dependent on how the tool is implemented	Dependent on how the tool is implemented
Amazon Rekognition	Cloud-based facial recognition service with pre- trained deep learning model	Various applications	Data is encrypted and stored securely	Dependent on how the tool is implemented

FaceID	Commercial facial recognition-based attendance system with high-resolution camera	Schools, universities, and workplaces	Data is stored securely and only accessible by authorized personnel	Yes
Face Recognition Attendance System	Uses deep learning algorithm for real-time recognition; captures facial images using webcam	Schools and universities	Data is encrypted and stored securely	Yes
Microsoft Azure Face API	Cloud-based facial recognition service with pre- trained deep learning model	Various ap plications	Data is encrypted and stored securely	Kairos

2.2 Different Methodology for attendance systems

Attendance system (according to the various required devices and techniques) can be categorized into four categories: (1) biometric fingerprint verification, [1,2,3] (2) RFID-based technology [4,5,6] (3) QR code-based technology, [7,8] and (4) facial recognition [9,10,11], as shown in Table 1.

The system reads the RFID card and compares it to the dataset stored in the microcontroller using the Arduino, real-time clock (RTC) module, LCDs, and web-based applications [1,2]. However, the author failed to explain of how to log and retrieve data from a server or cloud, and the microcontroller (from the 8051 generations) had a finite amount of storage space. As a result, it was unable to extensively monitor student attendance. Additionally, the authors in [3] presented a new anti-collision protocol by combining dynamically-framed slotted ALOHA (DFSA) and basic-framed slotted ALOHA (BFSA) approaches to eliminate RFID tag collisions using a Java library. The ESP8266 module, a low-cost Wi-Fi device with a full TCP/IP stack and functionality, was used to create a low-cost event attendance system in [4]. They also suggested using the system server to give data analytics.

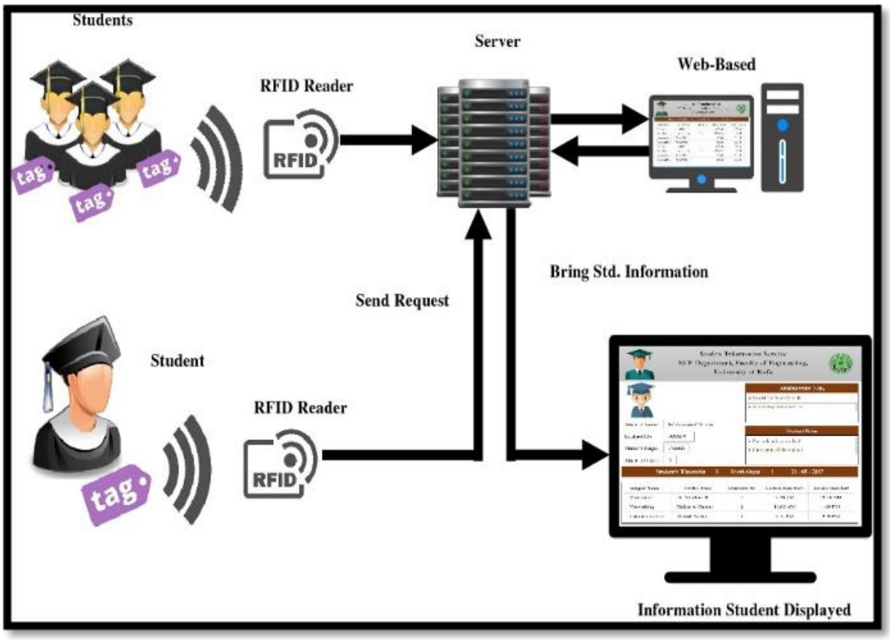

Figure 4 *Architecture of the RFID-based attendance*

Fingerprints have distinct qualities that are personal to each individual and, barring an accident, do not alter throughout a lifetime [5]. Therefore, the best/fastest method for an attendance system is a fingerprint system. Figure 4 depicts the Architecture of the fingerprint-based attendance. In [5], the authors merged an Arduino Wemos D1

R2 and fingerprint scanner; the system could connect to a database via Wi-Fi. It is possible to use this method in sizable databases. In contrast, the attendance system in [6] controls fingerprint devices and student attendance through a PC or server. The ZKTeco U260-C fingerprint reader,.NET C# web service, Oracle database, and fuzzy-based attendance system were proposed and used to lower the daily mistake rate [7]. In order to maximize the likelihood of error-free attendance logging, the attendance system could also incorporate a Wi-Fi module to create an access point (in the event of no coverage) [13].

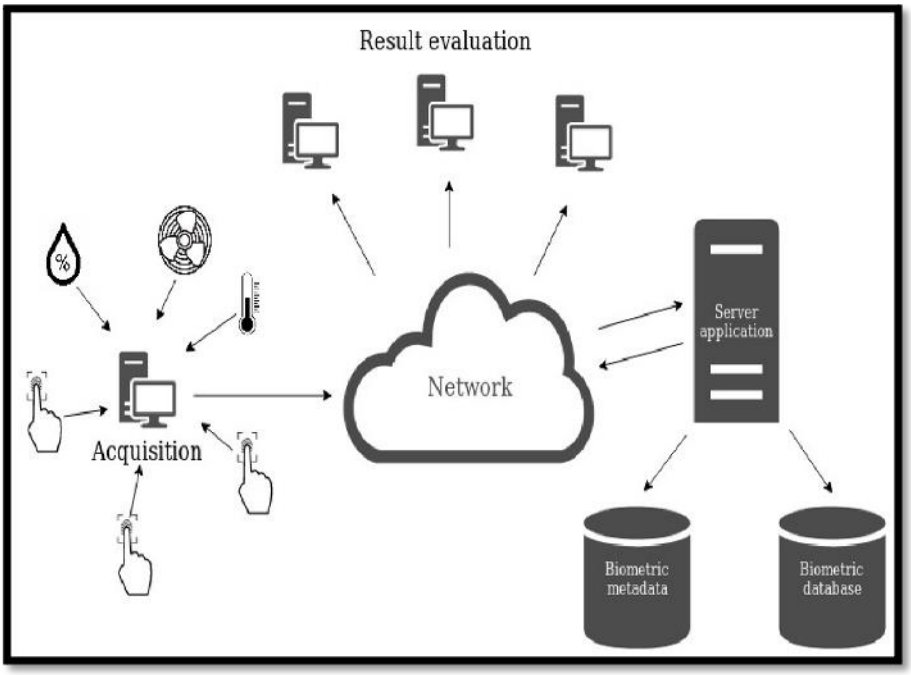

Figure 5 *Architecture of the fingerprint based attendance*

For easier reading and larger storage capacities, as shown in Figure 6, the QR code-based attendance system was created [8,9,10,,11]. The data are displayed in both horizontal and vertical components in the QR picture [11]. To prevent erroneous registrations, the creators of [8.11] created a QR code-based attendance system by incorporating the global positioning system (GPS). Users' identities can be confirmed and kept when used in conjunction with the server [,10]. In the presence of a false student, the facial photos must be retained.

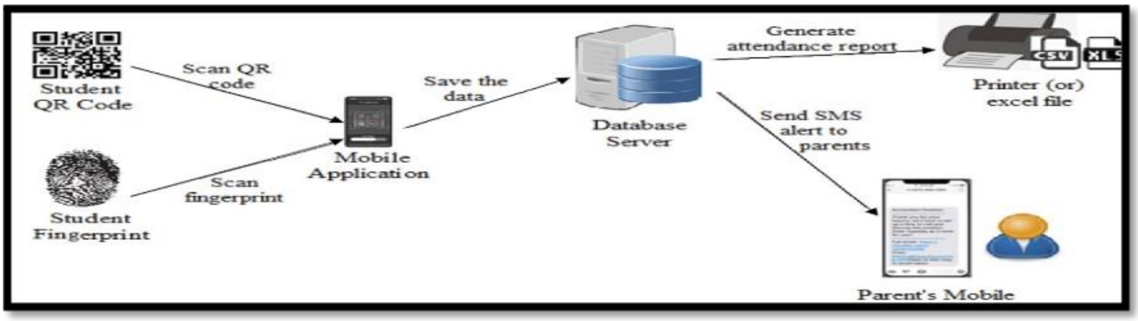

Figure 6 *Architecture of the QR based attendance*

Based on pattern recognition and computer vision advancements, a facial recognition-based attendance system is regarded as an efficient biometric verification method [12], which is explained in Figure 7. Numerous strategies have been identified, including the eigenvalue face method [16], deep metric learning [14], a pre-trained Haar cascade model [15], and HOG [13]. An attendance system that uses facial recognition works in the following steps: (1) take the picture, (2) find the face, (3) identify it in the database, and (4) record the attendance. Deep learning and machine learning methods for facial recognition are complex and require much CPU computation. Therefore, unique technology, such as computers, laptops, and phones, is needed to deploy this system.

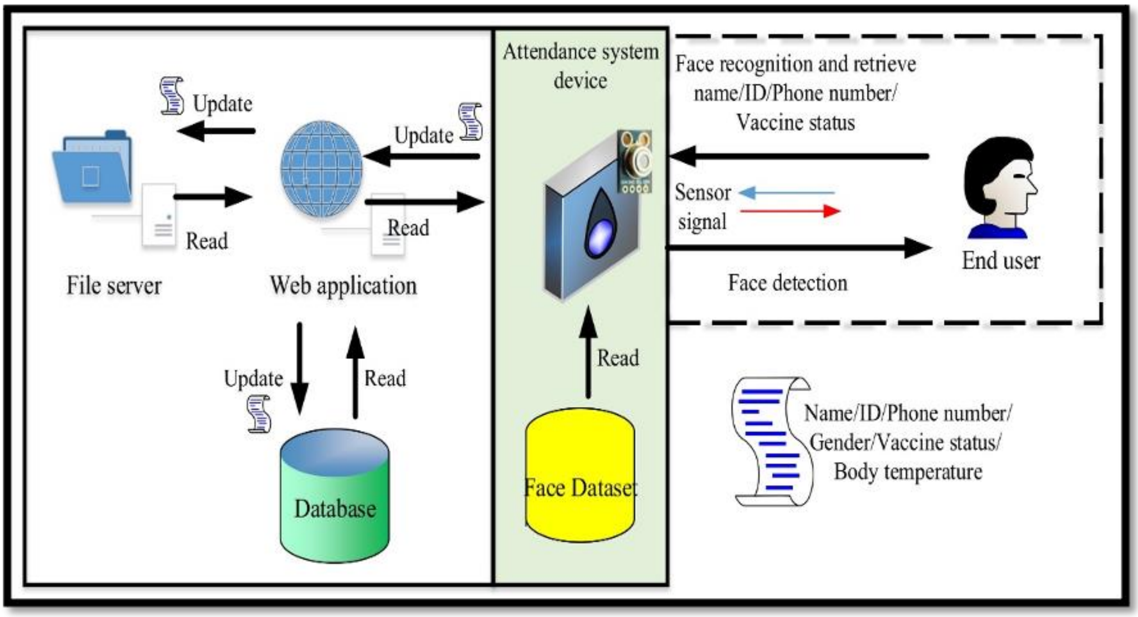

***Figure 7** Architecture of the Face recognition based attendance*

One of the most recent infiltration methods in facial recognition is video facial recognition technology. This method can be categorized into three groups: key frame-based, image-set matching-based, and temporal model-based. The temporal model -based methods pick up on the facial dynamics of the face throughout a movie [17,18,19]. It successfully clusters input frames using a manifold for recognized characters. Keyframe-based approaches anticipate each keyframes identification in a face track and then use probabilistic fusion or majority voting to choose the best match [20,21,22]. Face tracks can be modeled as image sets using approaches based on image-set matching, which calculates a distance between each face track based on a mutual subspace distance, where each face track is modeled in its own subspace [23,24]. Since a test face track can be generated from a portion of training faces belonging to the same class, the essential concept is to introduce sparsity. A simple modification of this method would estimate each frame separately and probabilistically merge the findings.

Table 2 *Comparison between the attendance system*

	Technology	Cost	Reliability	Social acceptability	Accuracy	Spoofing (Creating a fake biometric)	Behavior analysis
Attendance Systems	RFID Tag	Medium cost and Single-purpose	Very High	Very High	Very High	Very easy	Impossible
	Finger print	Medium cost and Single-purpose	Very High	High	High	Very easy	Impossible
	QR	Low cost and Single-purpose	High	High	Very High	Very easy	Impossible
	Face Recognition	Medium cost and Multi-purpose	Very High	Very High	High	Very difficult	Possible (dynamic)

2.3 Problem formulation and plan of solution

Traditional attendance tracking methods, such as manual attendance sheets or calling out names, are time-consuming, prone to errors, and require significant effort from teachers and administrators. Additionally, in the post-COVID-19 era, the need for contactless attendance tracking has increased, making manual methods even less practical. There is a need for a more efficient and accurate attendance tracking system that can operate without physical contact. The main objective of this study is to develop a facial recognition-based attendance system that can accurately track attendance in real-time without physical contact, improving the efficiency and accuracy of attendance tracking while also addressing the need for contactless attendance tracking.

The most significant complications to developing a face recognition-based attendance system include: (i) Accurately identifying people in a variety of lighting situations and facial expressions. (ii) Ensuring data security and privacy, including preventing unauthorized access to facial data and ensuring compliance with data protection laws. (iii) Creating a user-friendly system that is simple for teachers and students to utilize. (iv) Connecting the attendance system to already installed programmers, including grade books or learning management systems. (v) Creating a system that is scalable and affordable for use in big businesses or institutions.

The solution to these challenges is to develop a deep learning algorithm-based facial recognition-based attendance system that can recognize people in real-time regardless of illumination or facial expressions. The system should also have strong data protection measures, such as encryption and access limits, to guarantee the safe and secure use of facial data. With features like real-time attendance reporting and connectivity with current systems, the system should be made to be user-friendly and simple to use for both teachers and students. The technology should also be adaptable and affordable, enabling its usage in big businesses or institutions. A facial recognition-based attendance system can offer a more effective solution by resolving these problems and an accurate attendance tracking solution that is contactless and safe in the current pandemic.

3. The proposed architecture and Methodology

Figure 8 shows the proposed architectural design of the facial recognition technique for the university attendance record system. The framework is divided into three phases: the enrolment phase (storing authorized persons) and the sign-in/out phase (verification phase).

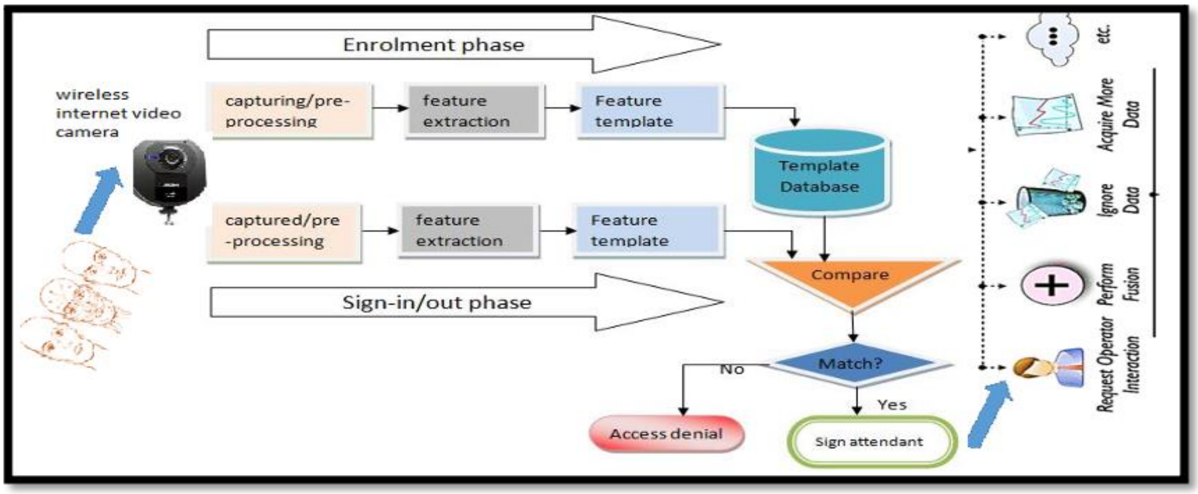

Figure 8 *The architectural design of our proposed facial recognition*

Details about the proposed architecture's different components are as follows: (1) Cameras: The first component of the architecture is the camera or cameras used to capture images of individuals entering and exiting the premises. These cameras should be strategically placed at key entry and exit points to ensure maximum coverage. (2) Facial recognition software: The second component is the facial recognition software, which analyzes the images captured by the cameras and identifies individuals based on their facial features. The software should be able to accurately match faces with a pre-existing database of authorized personnel. (3) Database: The third component is the database of authorized personnel, which contains images and other identifying information for individuals permitted to enter the premises. This database can be stored locally or in the cloud, depending on the specific implementation. (4) Integration: The fourth component involves integrating the facial recognition system with other systems and processes, such as HR systems, security systems, and access control systems. This integration ensures that attendance data is captured and processed in real-time and that authorized personnel are granted access to the appropriate areas of the premises. (5) Data analytics: The fifth component involves using data analytics tools to analyze attendance data captured by the facial recognition system. This can help organizations identify trends and patterns.

4. Implementation and Experimental results analysis

Our proposal divides the attendance systems into two phases (enrollment phase and identification phase) as shown in Figure 9, detail and different modules that composed each of them is depicted in figure 10.

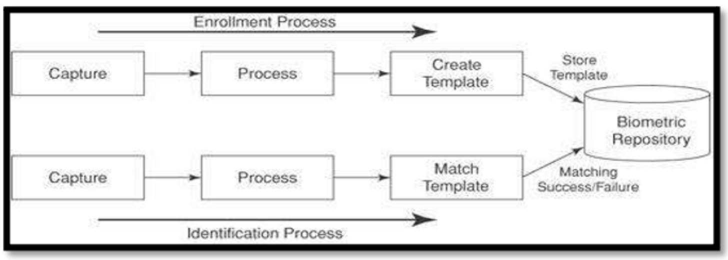

Figure 9 *Overview of the proposed framework*

The suggested method will use a video camera to capture a student's photo, which will then be examined by a face recognition algorithm to identify the person. By comparing the captured image to the pictures that are already saved in the database, the algorithm will detect the presence of the identified person. The system will also generate reports on attendance information and alert the appropriate authorities when a student is absent.

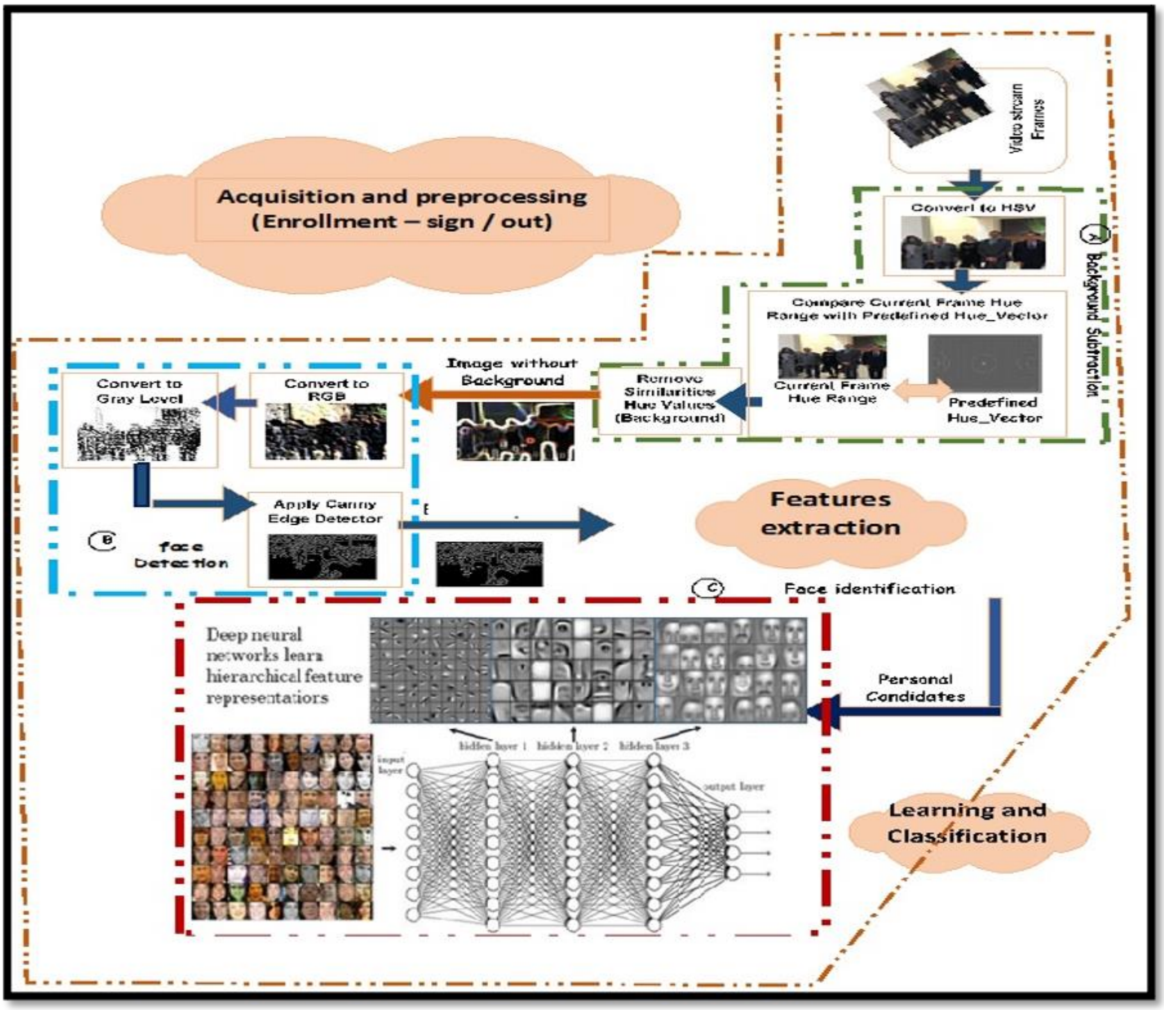

__Figure 10__ Detail of the proposed framework for attendance system based on video

4.1 Data acquisition and preprocessing

Opencv and Dlib together work in a great way to produce a powerful technique for processing and matching images, that is actually what we need to start, using Opencv to read the given images and preprocess them as well the given features, and Dlib to help detect face from the image object, until that we can work with the given faces to extract the most veluable points and store them on a 2D matrix for training using SVM (Support Vector Machine), CNN (Convolutional Neural Network), then we can make our training file base on the face and make a prediction on a new given feature.

4.2 Face detection and features extraction

For accurate training, the entered data is a video with a maximum runtime of two minutes per person, in which the frames are captured and compared to the data that were trained similarly. If the frame is recognized, it is then automatically recorded that it contains attended. As depicts in Fig. 10, we have to phases (enrollment (learning) and identification (testing)) a test video dataset is used to detect faces and track them across the frames. Table

3. Shows the Face detection accuracy of the proposed methodology. As shown in Figure 11: Face detection of the given frame, after face detection, it obtains facial features using 80 nodal points". Some of them are easily read by the scanner. (i) Distances between the eyes. (ii) Width of the nose.(iii) depth of eye socket , (iv) Chin. And more as depicted in Figure 12.

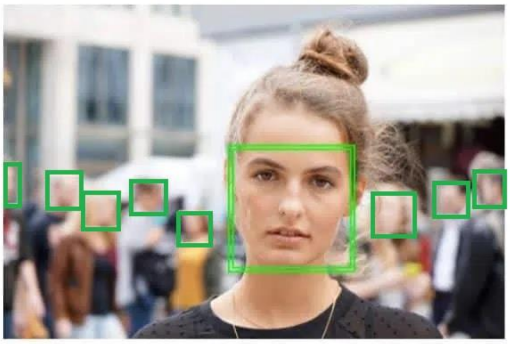

Figure 11 *Face detection of the given frame*

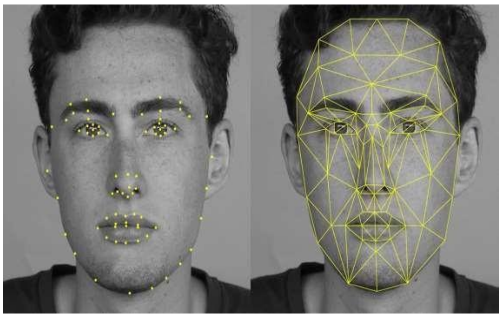

Figure 12 *Features extraction for a detected face*

Table 3 *Face detection accuracy*

No. of faces in an image	No.of faces detected	Accuracy (%)
5	5	100
10	9	90
15	12	80
20	19	95

For each detected face, the filters use edge detection and orientation values and extract, facial features from images. For face detection, in a video, a face detector is required to detect the location of the face in a frame Vision. After detecting faces in a single frame, to detect faces in successive frames, a step function is used. To perform face – tracking, a feature is needed to analyze the different facial movements in consecutive frames. We have to consider it does not vary when the object moves or when the background is affected by color or illumination changes. When the face's location is known, the tracker places a bounding box around the face. For each frame, the features obtained are optimized to reduce the dimensions of each feature vector. The optimized features are given as a test input to the algorithm. The training features are available from a gallery of still images. In all, our faces have "80 nodal points," as declared in Figure 13. Some of them are easily read by the scanner. Distances between the eyes. Width of the nose. Depth of eye socket, Chin, and many more.

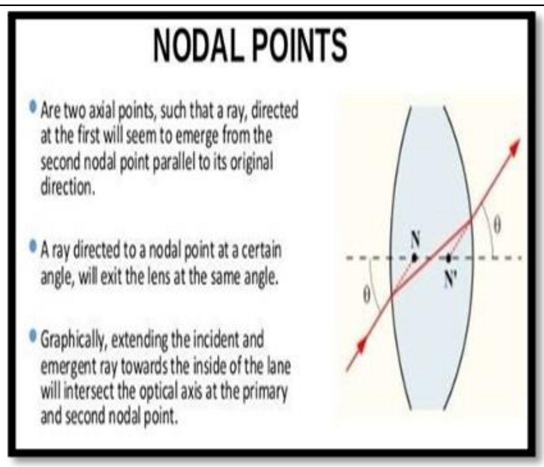

Figure 13 *80 nodal points" concepts*

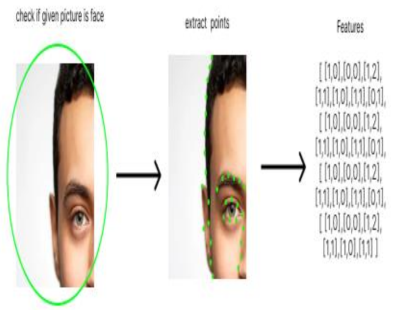

Figure 13 *Convert face features into 2D po-ints*

4.3 Data set and learning

Table 4 : Parameter settings used in the experiments. The Dataset used for the CNN model training system is yawn_eye_ dataset. Figure 14 depicts sample of these image. It is a free and open source dataset available on kaggle. The entire dataset has been divided into 2 parts which are used separately for training (75% of the dataset) and testing (25% of the dataset). Each part has 4 different feature values (yawn- non yawn- closed eyes-opened eyes) that will be taken into consideration while evaluating

Table 4 *Parameter settings used in the experiments*

Parameter	Value
Feature Vector Size	4096
Mini Batch Size	32
Training ratio	80%
Testing ratio	20%

Figure 14 *Sample of the Image within the used data set*

Three virtual machines were created with the same OS as the laptop, with one library respectively. Table 5 depicts the Specifications All experiments were executed on the CPU and under the same conditions, no other programs running in the background.

Table 5 *Specifications*

Specification	ASUS 550LN
Operating System	MS Windows Ver 10
CPU	Intel i5-4200U @ 1.6GHz
GPU	GeForce 840M
RAM	6GB DDR3 1600MHz
Storage	HDD 5400RPM

We have used two different approaches towards the solution (Deep Learning). First being the Deep learning model in which we built a Convolutional Neural Networks (CNN) with keras. A convolutional neural network is a special type of deep neural network which performs extremely well for image classification purposes.

A CNN basically consists of an input layer, an output layer and a hidden layer, A convolution operation is performed on these layers using a filter that performs 2D matrix multiplication on the layer and filter. It consists of multiple layers namely Convolutional layer, Fully connected layer, Input layer and output layer. Each layer has an activation function and an optimizer except the output layer.

The dataset contains 8,000 images divided into train and test data where images indicate different facial features of eye open and close pictures, mouth opening (yawn) and closing (non-yawn) and lastly head tilt feature. The images are converted to grayscale for the algorithm to easily identify the landmarks. Now we check if the aspect ratio value is less than 0.25 (0.25 was chosen as a base case / (threshold)). If it is less an alarm is sounded and user is warned. Figure 6 depicts Sample of the processed image the different process for each image (converting the input to gray scale, face detection. These datasets were characterized by various numbers of images, including males and females. The proposed algorithm was tested on different images in the first dataset, and the results demonstrated the effectiveness of the CNN algorithm in terms of achieving the optimal solution (i.e., the best accuracy) with reasonable accuracy, recall, precision, and specificity compared to the other algorithms. At the same time, the proposed CNN achieved the best accuracy reached 99.4%. The suggested algorithm results in higher accuracy (99.06%), higher precision (99.12%), higher recall (99.07%). Table 6 depicts sample of the results. Figure 15 depicts sample of the results.

Table 6 *Sample of the results*

Videos	Num. of Frame	Detection Rate (%)
1	387	99.3
2	313	99.7
3	394	98.6
4	474	99.6
5	368	97.2
6	352	98.6
7	290	97.0
8	310	99.5
9	663	97.3
10	418	98.7

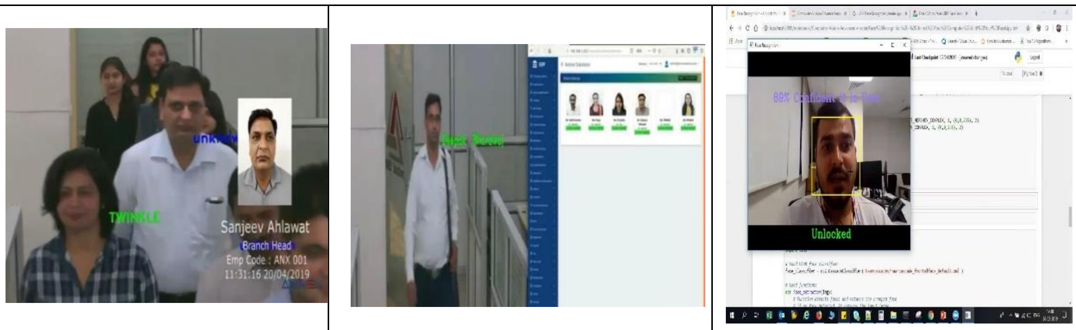

Figure 15 *Sample of the results*

Using the suggested techniques described in equations (1) and (2), we enhanced the quality of both our input face photographs and training images. Now, we use our techniques in conjunction with the LBP algorithm to extract more distinct and observable facial features in order to improve comparison certainty for more precise face identification.

Eq = H' (CF (x,y)) (1)

Where H' is the normalized cumulative distribution with a maximum value of 255 as in [25], Finally, in order to extract and compare features from our detected face photos, we utilised the LBP algorithm. A fixed 3 X 3 neighbourhood window is employed by the first LBP operator that has been written about.

$$\mathrm{LBPp,r}\,(X_c, Y_c) = \sum_{p=0}^{p-1} 2^p \mathrm{S}\,(i_p - i_c) \quad (2)$$

where (X_c, Y_c) is gray-level value of the center pixel with i_p and i_c being the intensity of the neighbor pixel and *p* the surrounding pixels in the circle neighborhood with a radius *r*, and S(X) is the sign function defined in

$$S\,(\mathrm{X}) = \begin{cases} 1 & if \quad x \geq 0 \\ 0 & if \quad x < 0 \end{cases}$$

it’s used to threshold the fixed 3 X 3 neighborhood as in [26].

Table 7 depicts the results of the performance assessment of the initial CNN method applied to our dataset, which was the dataset without any image processing. In our analysis, we used the following metrics: Unknown faces, false negatives, and false recognition. The facial recognition rate was determined as follows: Face Recognition Rate is calculated as follows: (Total Number of Faces - Total False Reorganizations)/(Total Number of Faces) * 100%.

Table 7 *Shows the performance evaluation of original LBP operator using.*

Total Faces	False Ne-	Unknown	False Recog-
355	18	1	32
357	6	3	24
363	27	0	37
417	7	4	49
371	10	5	35

Face Recognition Rate = 90.49%.

In Table 8, we show the performance evaluation of our improved face recognition method that was run on our dataset, which was processed using equation

$$G(x) = (1 - \alpha) f_0(x) + \alpha f_1(x)$$

with an alpha (α) value of 0.5. Using the same metrics and face recognition rate formula

Table 8 *The performance evaluation of improved LBP algorithm using dataset*

Total	False Negati-	Unknown	False Recogni-
764	1	5	1
773	0	8	0
765	0	13	0
760	0	9	1
762	2	4	0
768	0	3	1
767	0	8	1

Face Recognition Rate = 99%.

In addition, In Table 9 compares the face recognition accuracy of our proposed method in a controlled environment with the accuracy of three other different current methods.

Table 9 *Face recognition accuracy methods comparison.*

Methods	Accuracy (%)
LBP + SVM + PSO [26]	96.54
Original LBP [27]	89.3
DCP + LBP + SVM [28]	97.50
Proposed Method	99.0

The findings in Table 9 demonstrate that our approach, when compared to other approaches, demonstrates to be very robust to be implemented in a controlled real-life environment. The novelty of our approach is focused on the combination of the LBP algorithm with advanced image processing techniques, such as contrast adjustment, bilateral filter, histogram equalization, and image blending for both input images and training images, which is more of an incremental contribution to the LBP algorithm.

5. Conclusion

This paper proposed a deep learning method, the proposed CNN algorithm, which is based on a set of steps to process the face images to obtain the distinctive features of the face. These steps are divided into preprocessing, face detection, and feature extraction. The proposed method improves the solution by adjusting the parameters to search for the final optimal solution. In this study, the proposed algorithm was tested on three standard benchmark datasets to demonstrate the efficiency and effectiveness of the proposed CNN in solving the FR problem. These datasets were characterized by various numbers of images, including males and females. The proposed algorithm was tested on different images in the first dataset, and the results demonstrated the CNN algorithm's effectiveness in achieving the optimal solution (i.e., the best accuracy) with reasonable accuracy, recall, precision, and specificity compared to the other algorithms. At the same time, the proposed CNN achieved the best accuracy reached 99.4%. The suggested algorithm results in higher accuracy (99.06%), higher precision (99.12%), higher recall (99.07%), and higher specificity (99.10%) than the comparison algorithms.

Based on the experimental results and performance analysis of various test images (i.e., 30 images), the results showed that the proposed algorithm could be used to effectively locate an optimal solution within a reasonable time compared with other popular algorithms. In the future, we plan to improve this algorithm in two ways. The first is by comparing the proposed algorithm with different recent metaheuristic algorithms and testing the methods with the remaining instances from each dataset. The second is by applying the proposed algorithm to real-life FR problems in a specific domain.

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