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AI-BASED ATTENDANCE MANAGEMENT SYSTEM USING IMAGE PROCESSING TECHNIQUES DURING COVID-19 PANDEMIC

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Abstract. *Attendance monitoring or tracking is the process of recording when individuals start and finish their working hours. While a physical recording kept in a register can be used for this, several businesses choose to use trustworthy digital staff attendance monitoring systems. Monitoring attendance is a critical administrative activity in all educational institutions as well as different organizations. A well-structured system will allow institutions to flourish at a faster rate. It assists students as well as administrators in every manner to make significant development in participation, consequently saving time and effort. In today's world, student or employee attendance is critical for performance evaluation and quality control. Most institutions use the traditional ways of calling names or signing on paperwork, which is both time-consuming as well as vulnerable. It becomes even more dangerous in critical situations, as the world is currently witnessing with the COVID-19 outbreak. Researchers must work together to develop more rigorous systems for accountability, openness, and integrity as soon as possible. The global epidemic COVID-19 has taught us new ways of living in all aspects of life. Citizens across the world must now learn social distance. During the COVID-19 outbreak, a smart attendance management system based on artificial intelligence (AI) and image processing is required to adapt to the problems posed by the COVID-19 disease outbreak. This paper describes an autonomous artificial intelligence (AI) as well as image processing-based attendance management system for efficiency and data reliability. This approach is intended to increase participants' involvement time, interact with educators on a regular basis, prevent proxy attendance, and provide complete information for future reference.*
Keywords: Attendance monitoring, COVID-19, AI, Image processing, Face recognition

1. **Introduction.** Every organization has an attendance management system (AMS), which monitors employee attendance to successfully conduct its business. Two primary methods of maintaining employee attendance exist: automated attendance management system (AAMS) and manual attendance management system (MAMS). The MAMS process involves the use of pen and paper, which can consume a lot of resources and waste time. The method can also be abused by employees signing on behalf of others, while HR employees responsible for managing it could also make mistakes. On the other hand, the AAMS process is automatic and can monitor employee attendance through biometric

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processes [1-3]. Companies all over the world still use biometric time attendance systems. The biometric time attendance system (BTAS) is still perceived as the most sophisticated and effective real-time employee data gathering system. Fingerprints or IDs are used in the traditional attendance system in many countries. However, the biometric attendance system is associated with several disputes such as that it is costly, time-consuming, makes errors, insecure, presents difficulty in scanning, escalates the transmission of infections, and presents potential loss of data. For instance, when COVID-19 started spreading across the world, many companies and government agencies began to suspend the extensively used fingerprint biometric attendance system. During this period, ensuring that critical services continued to operate while keeping everyone safe has been the biggest challenge in most places. This challenge is being mitigated by smart computerized attendance management systems. One of the most promising developments in this area is facial recognition, with many businesses showing a willingness to incorporate it into their processes, especially as they attempt to stop the spread of COVID-19 [4,5].

There are several challenges in existing attendance monitoring systems. One of the main challenges is that these systems are mostly manual and based on registers. Where electronic systems are implemented, this is usually done in silos, making them challenging to monitor or for information to be shared. Sometimes card-based systems are used. However, these can easily be misused where colleagues can hand over cards to each other. If one considers that employees can work in different locations at different times, fragmented systems will not be suitable for collecting information across different locations. Consequently, the system could report that such employees are absent when they are at work. This shows that fragmented systems make it difficult to compile and monitor attendance data. When manual systems make it difficult to monitor staff attendance, service delivery may be impacted, and those who need services may face considerable delays waiting for officials to attend to them [6]. To deal with the challenges mentioned above, biometric attendance systems have been developed. The advantage of biometric systems is that they reduce human involvement and the potential for mistakes [7]. Consequently, more convenient biometric attendance systems are required to deal with the mentioned challenges.

There are many requirements for biometric including sensor module for taking readings, signal processing module for features extraction, database for storing extracted features, and decision-making module to compare database reading with the new readings [8]. To identify an employee, the biometric attendance system uses fingerprints, hair, ears, nose, or iris. Another feature used by biometric techniques is face recognition [9-12]. Regarding the iris biometric method, the image of the iris or eyeball of an individual is taken and stored in a database. Attendance is established when the iris of the person captured matches that which is in the database. This method can be time-consuming and difficult to implement [13]. Another biometric method is fingerprint identification [14]. This method records each person's fingerprints on a database. When an employee places their thumb on a fingerprint sensor, the system records their attendance. Even though this method presents several benefits, individuals are still expected to stand in a queue to have their fingerprints matched, which can be time-consuming [2]. The fingerprint method also presents the risk of disease transmission because different users (some who may be carrying dangerous bacteria, viruses, or fungi) must meet the same surface [15]. This is a particularly significant risk during the time of COVID-19, which is primarily spread by droplets and contaminated surfaces or hands [17].

Cognizant of the dangers associated with the spread of COVID-19 [16], several scholars have been involved in efforts to explore alternative and more efficient methods to replace the traditional fingerprint biometric techniques. These alternative methods include the face recognition attendance monitoring system [17-20]. The face recognition method involves taking an image of each employee's face and storing it in a database. When an

individual stands in front of the camera, the camera captures their image, and the system compares it to the images in the database and enters the employee as present at work. Apart from providing accurate results, this method also requires less time. It also improves the level of security and reduces the risk of fraud. The face recognition method can be used in several sectors, including corporate offices, higher institutions of learning, retail, advertising, banking, and healthcare [2]. Generally, face recognition systems consist of three methods: holistic methods, feature-based methods, and hybrid methods [21].

Both theoretically and in practical application, face recognition has made a substantial breakthrough. This has attracted a lot of attention from pattern recognition scholars. Nonetheless, in the presence of occlusion, face recognition is one of the most challenging, especially when dealing with people wearing hats, sunglasses, hairstyles, or masks. Such occlusions can considerably interfere with the correct recognition of human faces. Therefore, face recognition systems should be able to solve the occlusion challenge [22]. Masked face recognition occlusion presents a distinct kind of occlusion face recognition, which introduces unique challenges because the nose and the mouth are concealed by the mask. This reduces the number of useful features that can be used by the system to detect the individual behind the mask. This is the reason why conventional face recognition systems have struggled during the COVID-19 pandemic [22]. Recent efforts have focused on dealing with the challenge of mask occlusion in face recognition. Some of the technologies that researchers are turning to are AI and deep learning-based techniques [23]. This technology has generated prospects for the development and improvement of methods based on deep learning. As a result of these efforts, face surveillance and recognition operations have been retrofitted with novel screening software making it possible to identify individuals even when the system has less information to work with.

The smart attendance management system is intended to address the shortcomings of traditional manual solutions. Researchers employed the face recognition technique to track attendance of students and improve the system. The system functions admirably in a variety of stances and variations. Researchers used the notion of facial recognition to create a system that detects and recognizes the presence of a certain person by detecting and recognizing the face. These techniques work well with a variety of facial expressions, bright lights, and postures. There is potential for development because current systems do not always recognize every participant's face. Researchers designed the tool accessible so that it could be used even while the sessions were running without disrupting the class. This approach also must be enhanced because it sometimes ignores individuals from a maximum range. Researchers also have certain processing limitations; therefore, working with a machine with higher processing capabilities may result in even enhanced efficiency of this platform.

The predominant goal of this research is to investigate novel opportunities using image processing and AI tools with the smart attendance management system during the COVID-19 pandemic. Thus, the research will design and develop a smart, automated system that can determine who is in attendance using an AI-based face recognition model (i.e., a deep learning algorithm). This paper will present the steps that will be followed in designing and developing this system. It will start by presenting some common algorithms employed in the past to apply systems of facial recognition together and detect temperate with datasets used in building and evaluating such algorithms. This study proposes a database with a user-friendly web interface to allow administrators to access the attendance database and managers to monitor employee attendance.

The rest of the paper is organized as follows. Section 2 discusses the recent related works done by different authors. Further, Section 3 presents the predominant goal of this research is to investigate novel opportunities. Furthermore, Section 4 discusses the proposed system, and Section 5 presents the methodology and implementation. Finally, Section 6 concludes the work.

2. **Related Works.** In the past few years, researchers have been paying added attention to the use of face recognition techniques [7]. Nonetheless, most of the available automatic attendance systems have been developed for educational institutions. In Saudi Arabia, only a few studies have been done in the area. For example, Bhattacharya et al. [24] proposed a system to address the issues that current systems with manual attendance confront. The same investigation looks at how real-time face recognition as well as recognition might help with classroom attendance management.

The study describes an automated attendance system consisting of cameras installed in the classroom to capture images. It is also able to detect multiple faces. Several technologies are involved in the system, including attendance marking, comparison/recognition, SVM classifier, face detection and eye detection, HOG features, face database creation of students. However, there are certain weaknesses noted with the system proposed by the paper. For instance, the system is sensitive to lighting. This is a drawback that could be dealt with by designing the system to use algorithms that are not sensitive to lighting or through the employment of sophisticated high-resolution cameras [24].

Kumar et al. [25] developed an attendance method for people wearing masks in a related study. The system detects whether people are wearing masks as well as will only mark them as present if they are. The system is divided into two components. The first is the user component camera, which takes an individual's front image to identify and recognize the location of the eyelashes, eyebrows, and eyes. The second component is a software component that recognizes whether a person is wearing a mask as well as the position of the eyes and brows. The system's recognition as well as detection are aided by the MobileNet deep neural network and picture processing algorithms.

A study by Jeong et al. [26] proposed an IoT-based automatic attendance system (IAAS). This is an attendance checking system based on face recognition technology. The system collects image data of students using a capturing device such as a tablet PC or smartphone and then processes it using a face recognition system. The study combines specific features of existing face recognition techniques. The detection was made possible through VGG16 and GoogLeNet, while recognition was facilitated through MTCNN face detection technologies. Each model was tested with the same sample data, concluding that the performance of GoogLeNet was better in comparison to others. Using the vggface2 dataset, the IAAS system trains face verification models. The system can check and provide details about who was in class and send the data to the attendance database system via an email notification. Results indicate that the detection accuracy of MTCNN was about 0.988.

To deal with the challenges of prevailing manual systems, Salman et al. [27] proposed a three-step system. As part of their study, these scholars developed a system database that used a Raspberry Pi-connected camera. The data used was inputted into the system using user ID and image. The system employed Haar Cascades classifier for detecting the faces of students based on their stored images. The face recognition is accomplished through the local binary patterns histogram (LBPH) algorithm. To train the system, the local binary patterns histogram (LBPH) algorithm is used. The training involved 300 negative and positive images belonging to 30 students. The flash web framework of python was used to develop a cloud server. HTML was employed for developing a user-friendly web application for the class attendance system to be accessed. When the system recognizes the face of a student, that student is reported as a present, while those not recognized by the system are recorded as absent. The attendance data collected by the system is then exported into Excel format before being uploaded to the cloud server. An email is then sent to teachers and students, providing them with the attendance data for a specific period.

In another study, Filali et al. [28] compared four approaches based on a machine learning technology. This technology permits the machine to progress through a learning process and to accomplish tasks that would be more complicated to accomplish using more traditional algorithmic means. These four methods are Haar-AdaBoost, LBP-AdaBoost, GF-SVM, and GFNN. The initial two methods – Haar-AdaBoost and LBP-AdaBoost – are based on the Boosting algorithm. This algorithm is used for both choosing and learning a strong classifier with cascade classification. On the other hand, to extract the characteristics, the last two methods – GF-SVM, GF-NN – employ the Gabor filter.

Chintalapati and Raghunadh [29] described distinct methods for applying a system for monitoring attendance using face recognition. The process consists of two primary parts. The initial part is the face detection method, while the second is the face recognition technique. The Viola-Jones face detection algorithm can be used to implement face detection. This involves four primary parts: Haar-features, integral image, AdaBoost algorithm, and cascade feature. LBP (local binary patterns) can be used to implement the recognition. LBP assists in converting the image so that it is in a format (i.e., binary format) that can be understood by the machine. Before an image is detected and recognized, it needs to be converted into a greyscale so that it can be simpler to distribute. The face detection technique must first capture the image and place it in the student dataset so that faces can later be detected from these images. The face recognition technique captures the images from the classroom and then attempts to recognize them by comparing them to faces detected earlier.

Another study conducted with the aim of solving the weaknesses of the traditional manual attendance systems was proposed by Rathod et al. [30]. These scholars explain how real-life face identification and detection can be valuable when monitoring student attendance. The system illustrated by the Rathod et al.'s [30] report is an automated attendance arrangement that involves a classroom-fixed camera that captures images, followed by the detection of multiple faces. Their system consists of several technologies like attendance marking, comparison/recognition, SVM classifier, eye and face detection, HOG features, face database creation of students. One of this system's drawbacks is that it may be sensitive to light. The system suggested in this study may deal with this weakness by employing algorithms that are not likely to be sensitive to lighting and by the use of advanced high-resolution cameras.

Various techniques for implementing an attendance monitoring system using face recognition are described by Arif et al. [31]. They divide the process into two primary parts. The initial part involves face detection, and the second one is face recognition. The algorithm for face detection is the Viola-Jones, and it has four primary components: cascade feature, AdaBoost algorithm, integral image, and Haar-features. Local binary patterns (LBPs) are used for face recognition. LBP ensures that the image is converted to greyscale so that it is easier to circulate. Initially, the face detection technique captures the image, which it saves as part of the dataset, and later detects faces from the captured images. These detected faces are stored for further reference. The face recognition method captures the images from the classroom and then attempts to recognize them by comparing them with the face detected earlier.

Alghamdi et al. [32] developed an intelligent attendance system for Imam Abdulrahman Bin Faisal University (IAU), a Saudi Arabian university, employing face detection. Cameras were installed in the classroom as part of the system. A machine learning technique is utilized to recognize and capture the photos. This is proceeded by a verification of the photographs entered with those in the IAU repository. When a student enters the classroom, the system identifies them as present. Even though the proposed system could reduce errors and save effort and time, it was built for facial recognition without a mask and is best suited for educational institutions.

Alghamdi [33] designed a smart mobile application for monitoring student attendance at Taif University. The aim was to ensure that the system did not require any effort from the lecturer to use any time allocated to the lecture. The system was designed for mobile applications based on RFID technology. To determine whether a student was present, the system used the ID student's ID card. Lecturers that want to check which students were in attendance during their lecture will use their own mobile phones as opposed to the use of manual methods to register attendance. Rather, student attendance is recorded when the student comes within a certain range of the reader a lecturer would make available to students. When a student ID is not detected by the system, it means that the student was not in attendance.

3. **Problem Statement.** Many attendance systems in use now lack information-sharing abilities and efficiency. These are the limitations that this research attempts to overcome and further improve. The research is expected to have an impact and contribute. For instance, using contactless AI-supported thermal cameras, this system can speedily identify employees and detect their body temperature, indicating whether an employee is showing signs of COVID-19, making it possible for an authorized contact to determine the next action. This will ensure that workspaces are enjoyable and safe amidst the COVID-19 pandemic, ensuring the spread of the virus is restricted. This will minimize workflow disruptions by having a way to monitor staff attendance without using the traditional fingerprint recognition methods. The system that will be developed in this study will be connected to any smart hardware devices, ensuring that it can be accessed by authorized individuals from anywhere if they have an Internet connection so that they can monitor employee behavior, boost organizational productivity, and easily trace contacts. Because employees entering a workplace can do so in large numbers at the same time, the system will be able to determine their temperatures and determine whether they are all wearing masks, using infra-red thermal imaging technology. Knowing that there is an accurate system monitoring attendance could make workers want to arrive at work on time. This will also ensure that fraudulent activities such as employees signing in on behalf of their friends are minimized.

4. **The Proposed System.** The flowchart for the proposed system is shown in Figure 1. The proposed system will apply to all employees and visitors wishing to enter the premises who must pass through a contactless temperature check. For this task, the proposed system will rely on Arduino Uno, fitted with either a thermal camera sensor (AMG88339, for example) or an infrared thermometer (such as MLX906148). The system also makes use of the ESP8266 Wi-Fi module to connect with Edge servers via Message Queuing Telemetry (MQTT) protocol. MQTT facilitates communication between machines, which in this case are the Raspberry Pi, Arduino, and Edge.

The proposed system starts with beginning of temperature sensors for collection of real-time temperature data in matched to environmental temperature estimates. This system is created without push button system to achieve the wireless monitoring of temperature. The normal body temperature ranges by 36.5°C to 37.5°C. The different body temperature measurement is dependent of various aspects, i.e., age, exertion, and place of body at which measurement was.

If the body temperature of the person standing before the proposed system is normal, the system will move to the next step of detecting and recognizing the face with or without a mask to record attendance. If the body temperature of the person is higher than normal, the system locks the entrance and sends an MQTT to the server with the value of the recorded temperature and where it was captured. Once the server receives the message, it passes it to a smart device application monitored by the security guards so that they can attend to the situation and ensure that the person does not enter the building. If such a

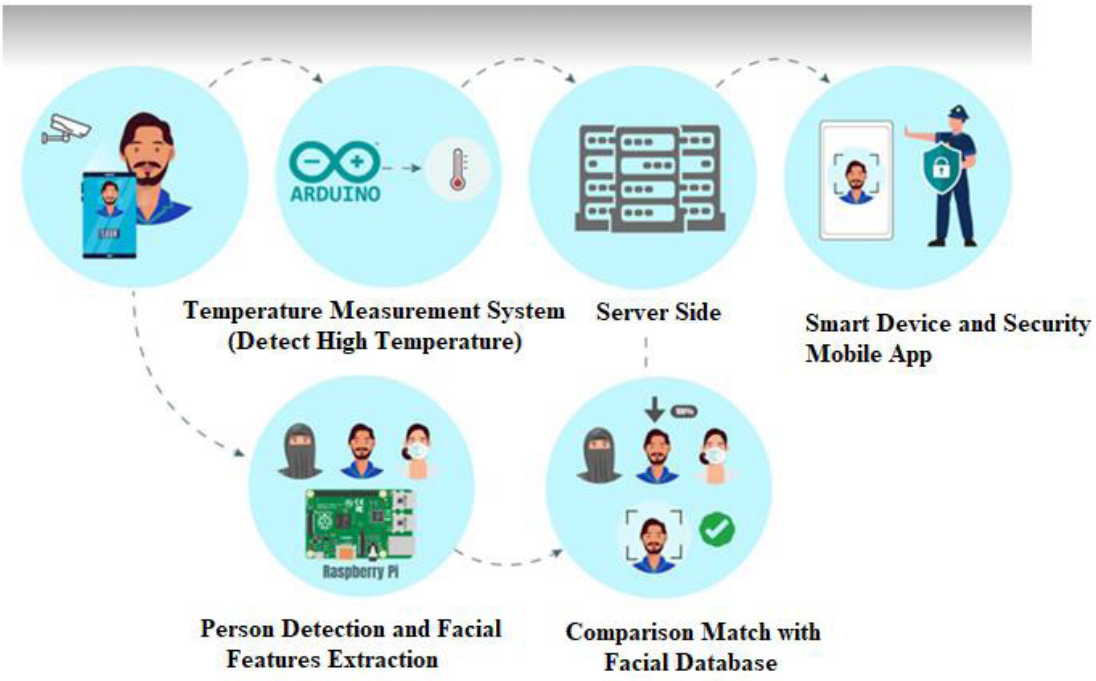

FIGURE 1. Proposed system

person is an employee, these details will be transmitted to the attendance database. This research proposes that the system automatically records attendance that has got through continuous observation. Continuous observation is useful in forecasting and improving attendance performance. The system monitors temperature and attendance by recording the face images and temperatures of the staff. Added to this, the system will also record the time when a specific individual entered and exited a building.

This study will be achieved using an AI-based powered automatic attendance management system, equipped with camera technology that can identify faces and connect them to a specific ID, proper use of a mask over the face and mouth, and read the employees body temperature using contactless AI-assisted thermal cameras. The captured details will be transmitted to security and health professionals via a discreet messaging network so that they can deal with patients showing symptoms or are detected not to be wearing the appropriate personal protective equipment. The project will also cover database management and web-based development through a user-friendly user interface (UI). An organization that embraces this system can replace the traditional methods of managing employee attendance. It also has the capability to generate an attendance report for a specific time frame. The proposed new system framework reflects the following problems and restrictions stated in the previous sub-section as recommendations and will overcome those limitations of the existing attendance management system. It will be helpful for keeping the employer's attendance record for a long time in the database that makes it easy for the company to access the database. In addition, our proposed system will be responsible for a user-friendly user interface which will help to guide each user to use it accurately without any specific training.

5. **Methodology and System Design.** This section will discuss the methodology and system design. Body and face detection algorithms depend on the application of Haar feature cascades-based existing OpenCV implementation of Viola-Jones object detection framework [34]. This is a machine learning approach that involves the training of the cascade function using a substantial set of negative and positive images. Following the learning, this function is employed for the detection of objects in new images. OpenCV

comes with a detector and trainer. Nonetheless, OpenCV makes predefined classifiers available, making it able to detect common objects such as parts of the face and the body and the full face and body, both the front and back. For implementing the mask detection algorithm, the proposed system will depend on three OpenCV library classifiers.

I. Haarcascade_frontalface_default: Employed in the detection of the front side of the human face.
II. Haarcascade_mcs_mouth: Recognizes the mouth in a supplied image.
III. Haarcascade_mcs_nose: Detects the nose.

Thus, this research leverages the classifiers that already exist in the OpenCV library, as they were adequate for the needs of the implemented solution. The proposed system, as illustrated in Figure 1, has the following subsystems: measurement of temperature; detection of facemask and recognition of masked face; server-side; and smartphone application for security guards. The steps involved in the design system are described below and illustrated in Figure 2 as the following.

A. Creating the database

There will be three databases in the proposed system: attendance database, non-attendance database, and unknown databases. Once the face detection and recognition phase are accomplished, images are entered into the system as an input. In the attendance system, the inaugural step involves the development of the central database of faces. For this phase, all employees are involved, and the camera is used for capturing the front of the face. The captured images will then be saved in the database together with the registration ID. In creating the central database, the images of employees need to be added to the basic data so that the image entered the system and the image entered in the central database correspond. When the comparison of the images results in a match, the employee is then entered as present, and when they do not match, the system transmits this information to the administration so that an appropriate decision can be made regarding the attendance. Where the system is unable to obtain the employee information, it sends the case to the unknown database.

B. System for measuring temperature

The system measuring employee temperature is based on Arduino Uno and measures an individual's temperature using a contactless IR sensor. Specifically, this research uses the Arduino Uno microcontroller1 board with a contactless temperature sensor. On the other hand, the Raspberry Pi2 single-board computer has a camera that uses computer vision techniques for the other two scenarios. These devices have been selected because they are affordable and small in size.

C. Face detection

Before face detection, the images must be acquired. Preferably, a high-quality camera should be used for this task. This is because the high-quality camera is expected to produce more features when compared to a low-quality one. Face recognition starts with the localization of the human face in a specific image. This step aims to determine whether the input image contains a human face or not. Proper face detection can be impeded by the differences in facial expression or illumination. To facilitate the development and ensure that the face recognition system is more robust, pre-processing steps are required.

In the present research, the face detection algorithm that will be employed is Viola-Jones algorithm. This algorithm consists of four phases: Haar feature selection, integral image, AdaBoost training and cascading [35]. The Haar feature prepares the similarities of the human face for the Haar feature selection. Two or three rectangles composed together represent the features. For instance, the human face would consist of similarities where usually, the part of the nose bridge will be brighter when compared to the eyes. In such a case, Haar features representing the white and dark areas are selected. Using this technique

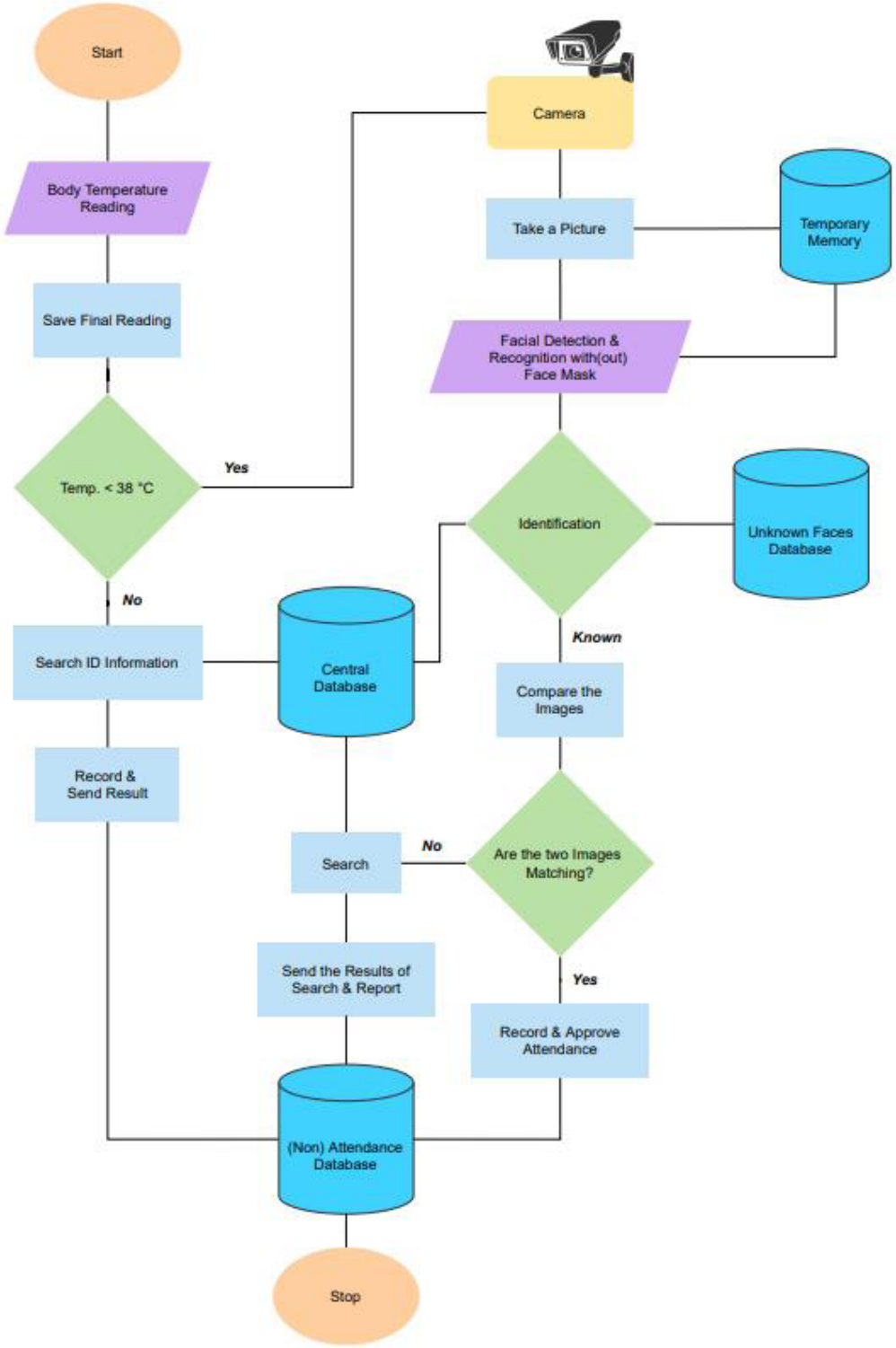

FIGURE 2. The steps involved in the proposed system

makes it easier to detect whether an image contains a face or not. Usually, this Haar pattern can be obtained in the eye part of the human face. The human nose-bridge is represented by the bright part, which is between the darker parts of the Haar figure. In this figure, the human eyes are represented by the darker part [36].

I. Face recognition

In this step, the features extracted from the background during the feature extraction phase are considered and compared with known faces saved in a precise database. Face

recognition will involve two broad applications: identification and verification. The identification step involves comparing a test face with a set of faces with the aim of determining the most likely match. In the verification phase, a test face is compared to a known face saved in the database so that the rejection or acceptance decision is made. This task can be effectively addressed through convolutional neural network (CNN) [37] correlation filters (CFs) [38-40] or k-nearest neighbor (K-NN) [41].

II. Features extraction

The primary function of the feature extraction step is to extract the features of the face images detected in the detection phase. In this step, a face with certain features of the vector is represented. These features of the vector are called "signature" and describe the face image's noticeable features such as the eyes, nose, or mouth so that the face can be identified using distance and size [42]. In the present research, feature extraction will be achieved using Haar wavelets, Fourier transforms [42-48], and local binary pattern (LBP) techniques [42]. COVID-19 is affecting the entire globe, and it is over time to consider applying machine learning in different areas [49,50]. Keeping a safe distance from people has become necessary these days. Circumstances like this can be dangerous if individuals have a manual attendance system. Acquiring a face recognition-based attendance system will not only allow users to record a person's attendance but will also keep users at a safe distance from people as individuals can work safely as well as still see who is entering and leaving. This implies that the overall smart attendance management system a far more secure, effective, and speedier method of recording attendance. The proposed smart attendance management system is relatively simple to use [51,52]. The reason for this is that data retrieval and storage are quick, and data is effectively handled [53,54]. Additionally, the suggested system includes a graphical user interface, which allows users to interact with the platform more easily.

6. **Conclusion.** The development and building of a smart attendance management system based on temperature detection and face detection could provide a safe environment for employers and visitors as possible. Using technologies like the attendance system proposed in this study will save the resources of companies that embrace it as the technology will take over many tasks that would otherwise have been done by humans. Using cloud management systems ensures an efficient system. Such technologies make it easy to identify, record, track, monitor, and analyze employee data in real time, saving resources, time, and staff energy. The solution can also be linked to existing HRMS systems to ensure minimal disruption in processes, guaranteeing business continuity. This system developed for this study will be used in many applications, including home protection, digital signage, ordering machines, point-of-sale, smart retail, access control, and security. Other areas that could benefit from the system include centric zones in real time, bar sound monitoring, monitoring levels of vehicles and pedestrians in a specific area to optimize walking and driving routes, and weather and intelligent adaptive lighting. The employment of this system, whether in educational institutions, corporate offices, or other organizations, reduces the reliance on traditional methods of monitoring attendance and makes it possible to access attendance reports whenever they are needed. The solution offered by this system, such as retina scanning and facial recognition, provides a more accurate security solution. The user-friendly aspect of this system makes it simple, which results in time savings, reduction of staff overhead, and ensures that there is adequate labor data to make effective decisions when managing an organization. Overall, this system is being designed to deal with the prevailing issues in the traditional systems of managing attendance during the COVID-19 pandemic. This proposed system can be used at gates in airports, hospitals, subways, schools, train and bus stations, shopping malls, companies, universities, and other crowded places. Finally, this study required further research to apply and validate the system model for these employers.

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