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Robust Facial Recognition System

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Abstract: Access control and security are two areas where facial recognition technology is being used more and more. A robust facial recognition system that can recognize faces with a mask is a needed upgrade from its predecessor which can only scan faces without masks. This is due to the current pandemic where most places require their employees to wear masks when attending to work. This especially complicates the attendance clock process when the employees would have to remove their masks to have their faces scanned. This can ultimately increase the transmission risks which can endanger the entire workplace. With this system installed on the premises, employees can easily scan their faces to clock in their attendance without having to remove their masks which can also reduce any crowding. In this work, the ESP32 camera module, Arduino IDE, and Python were used to create the facial recognition safety system with a mask. Any visitors or staff are photographed and recorded on video by the system, which then uses machine learning algorithms to identify them using facial recognition and logs their information in an Excel spreadsheet. In a fully functioning system, the system will be able to scan and recognize an individual's face when they are standing in front of the camera with average accuracy, precision, sensitivity, and specificity scores are given 76.92, 85.26, 83.51, and 57.57 respectively. If the individual has already been registered in the system, then the system will be able to detect the individual and their log-in or clock-in details will be recorded in the attendance sheet. This makes the system can be implemented in any facility since it is simple to operate, affordable and has a compact footprint.

Keywords: ESP32 Camera Module, Python, Excel, Masks

1. Introduction

In Wuhan, China, in December 2019, a main atypical (viral) pneumonia outbreak that was new and alarmingly contagious surfaced. Later research revealed that the newly discovered illness, known as coronavirus disease 2019 (COVID-19), was brought on by the previously unidentified zoonotic coronavirus known as acute respiratory illness coronavirus 2 (SARS-CoV-2) (Wu, 2020). Salivary or nasal secretions are one of the ways that COVID-19 is spread. Since the SARS-CoV-2 virus is very

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contagious, this can be a concern in crowded places, especially when an infected individual coughs or sneezes.

On a regular day, employees or individuals have to queue up to wait for their turn to clock in their attendance. To stop the spread of the COVID-19 virus, rigorous health and safety regulations at workplaces require individuals to wear face masks and maintain social distancing. However, these effort goes in vain when the individuals or employees make a crowd when attempting to clock in for their work. During this process, health and safety measures are breached when the individuals remove their masks or even stand close to each other without following social distancing. The current attendance system is inefficient as it is time-consuming and inevitably raises the chance of the disease spreading. The robust facial recognition system uses technology that recognizes faces by scanning faces one by one when entering a building with a face mask on. The proposed system can be developed using artificial intelligence that emphasizes the safety and health of individuals and is built on machine learning [1]-[5].

In previous works, there have been two different technologies that were developed for a similar use but not as robust as this work. The first work was developed by Warot Moungsoy back in 2022 titled “Face Recognition Under Mask-Wearing Based on Residual Inception Networks” [6]. This was a work suggested as a method to identify human faces while wearing a mask. The bottom third of a person's face is hidden and cannot be used in the learning process for facial recognition. The suggested approach is therefore intended to identify individuals based on any accessible facial traits, which may change subject to whether a face mask has been put on or not. By altering the current facial recognition model, the suggested approach, which depends on the FaceNet framework, aims to increase the effectiveness of both scenarios with and without the use of a mask. Then, on top of the original face images, masked-face photos are derived to aid in learning recognition. On top of real face shots, fake masked-face images are created to aid in learning face recognition. The suggested tactic is tested under several experimental conditions. The result shows an astonishing accuracy of 99.2% in a scenario with mask-covered faces.

Finally, the second work was developed in 2021 by H. N Vu, M. H. Nguyen & C. Pham. Their work was called “Masked Face Recognition with Convolutional Neural Networks and Local Binary Patterns”[7]. The phrase "occluded face recognition" describes a group of methods in which the system has to identify a person whose face is hidden. Face blockage is undoubtedly a challenging challenge to address since the obstructed parts of the subject's face can vary in their position, size, and shape. In occluded face recognition, occluded face datasets are typically used for testing whereas occlusion-free face databases are often used for training. The occluded face database is a collection of real or fake occlusions. Occlusion recovery-based recognition of faces, occlusion conscious facial identification, as well as occlusion robust feature extraction, were the three categories into which the work categorized occlusion-related face recognition systems. The author's method for representing a hidden face was to utilize a continuous function from their training dataset. The sparse representation was enhanced by the author's combination of prior knowledge about pixel distribution. Based on customized scores and error photographs, the authors suggested a technique to mimic adjective block occlusion. The pipeline of the suggested technique consists of facial embedding, LBP-aware facial detection, and face detection.

2. Materials and Methods

The proposed work involves the implementation of both hardware and software for the development phase. The hardware used for the development is an ESP32 Camera Module which is used as an input and a YP-05 FTDI USB to TTL UART is used to connect the ESP32 Camera Module to a computer. Additionally, the software used in this project are Open CV, Arduino IDE, and Python IDLE.

Figure 1 shows the flow of the system’s operation. First, the ESP32 camera is turned on as part of the development and design process. Because no technique is accessible before taking a picture, it is always the first step in the process. The person`s or employee`s masked photos would be kept inside a picture folder with their name underlined. All of this is related to the registration process, which is the first stage in the Facial Recognition Safety System. Next, manually install the libraries required for facial recognition using Command Prompt (CMD). The OpenCV library is then used to generate the 27-face detection Python code. From this point on, the face detection and recognition stages of the second phase will start. The training data set of faces would be loaded to recognize the person or employee`s face. The ESP32 camera took photographs of both the person and the employee to compare to the originally loaded training set after it started streaming video. The following step is recognizing the face. Utilizing CNN from the Dlib package will contrast the recognized faces with the training set. When the pattern matches the training set, the system transmits information from the ESP32 camera to Microsoft Office Excel, which instantaneously displays the attendance list in the Excel file of the person or employee`s name.

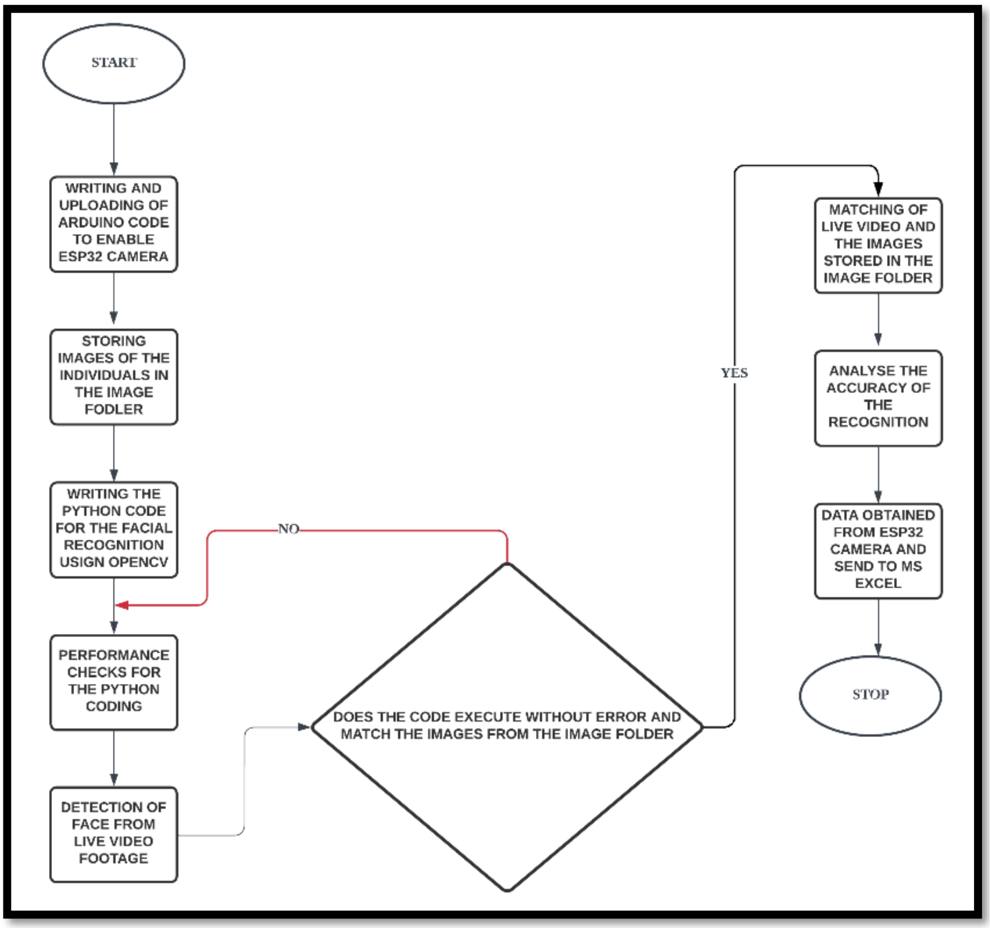


Figure 1: Flow of the system

Figure 2 shows the block diagram of the Robust Facial Recognition System. The diagram shows that the ESP32 camera is used as the input, the ESP32 board is the processing unit, and finally for the output, the laptop displays, and MS Excel.

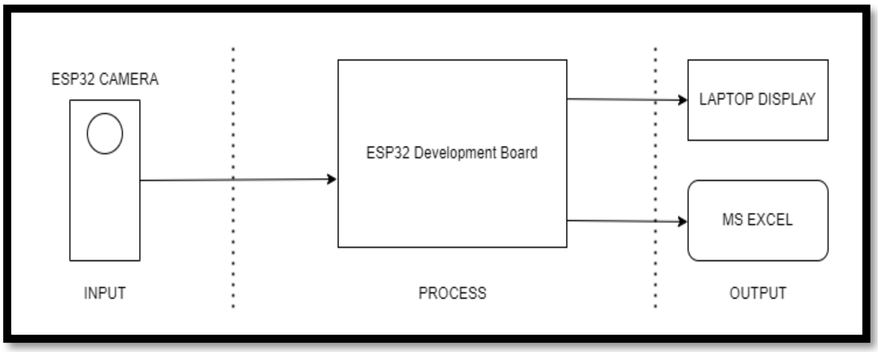
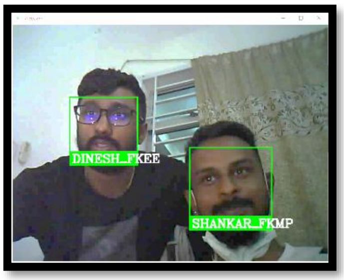


Figure 2: Block diagram of the system

This study recruited six subjects aged between 21 to 25 years all with different facial features for evaluation of the system performance. The subjects were instructed to position their face direction in front of the camera (i.e. esp32 camera module) to scan their faces with the developed device. In order or the system to detect the individuals face accurately, they first have to upload a picture of themselves with a mask. This picture is saved in a special folder which acts as the dataset. So, when the specific individual scans their face, the system will refer to the folder to make sure that this individual is an authorized person and only then it detects their face.

In an event there is a person who is not authorized, meaning they have not uploaded their picture into the dataset folder, the system will not be able to recognize their face. Additionally, if two authorized people scan their faces at the same time, the system will still be able to recognize these individuals apart as long as they are authorized. Furthermore, authorized people can also scan their faces without wearing a mask hence this has proven the robustness of the system. Table 1 shows the images to prove the robustness of the system.

Table 1: Proof of images for the robustness of the system

Situation 1	Situation 2
	
The system does not detect and recognize the face of an unauthorized person.	The system can detect and recognize two authorized simultaneously. The system is also able to recognize the faces of the individuals even when not wearing a mask.

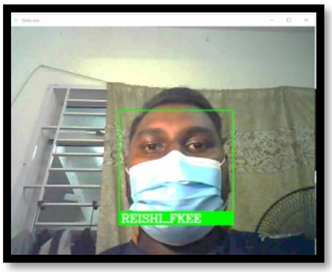
3. Results and Discussion

The proposed system was able to precisely identify the faces of several persons in various lighting situations, and the data was delivered to a Microsoft Excel spreadsheet with accuracy. The outcomes of simulations performed on both software and hardware are carried out and examined. The precision of the facial recognition system with the mask was high because the facial recognition system has a low rate of false positives.

3.1 Results

Table 2 shows the outcome of the system. The green box highlighting the specific region on the face is the area of significance. This is the region where the system and its coded algorithms conducts the facial recognition protocol to identify the exact individual scanning their faces. These individuals have already submitted their pictures to be included in the dataset which enables the system to recognize their faces when scanning them later.

Table 2: The outcome of the system

No.	Employee Name_Faculty	Image
1	DHIVA_FKEE	
2	DINESH_FKEE	
3	HEMA_FKEE	
4	REISHI_FKEE	
5	SHANKAR_FKEE	
6	NAVHIN (UNREGISTERED PERSONNEL)	

3.2 Discussion

The results of all five volunteers' effective facial recognition are shown in Table 2. The volunteer's name will be included in the attendance database in an exact folder as the image_folder along with the time of a successful data entry.

After the execution of the Python code using Python IDLE, the system will show the data input of the volunteers whose faces were correctly recognized by the ESP32 camera. The file is utilized by the Python script to hold the names of the people whose faces were identified in the photographs together with the time when they were identified. The script added new rows to the database with the name of the individual and the current time each time a face is recognized in the image, signaling that the volunteers have attended work on that particular day. At the start of the script, a new file is generated if it does not already exist or removed and recreated if it already does.

3.3 The system performance evaluation

Precision, specificity, sensitivity, and accuracy are the metrics used to assess a facial recognition system's performance. The precision is defined as the percentage of true positive results between all positive results. High precision indicates that the system detects faces with a small percentage of false positives and is effective at correctly identifying those faces. The sensitivity is the percentage of true positive outcomes between all actual positive results (that is, all faces in the dataset). High sensitivity indicates that the algorithm has a small percentage of false negatives as well as is effective at detecting faces in the dataset. When compared to all negative results, or all faces the system misses, specificity represents the percentage of real negative results or accurately rejected faces. High specificity indicates that the system accurately rejects faces that it is unable to recognize and has a small percentage of false negatives. The amount of true positive and true negative results among every outcome is measured by accuracy. High accuracy indicates that the system produces few false positives and negatives. Table 3 and Table 4 respectively show the distribution of results for the facial recognition and the performance of the system.

Table 3: Distribution of results for the facial recognition

Volunteers	No. of samples from each volunteer	True Positive	True Negative	False Positive	False Negative
DHIVA_FKEE	20	15	0	2	4
DINESH_FKEE	20	15	0	3	3
HEMA_FKEE	20	18	0	3	4
REISHI_FKEE	20	16	0	2	2
SHANKAR_FKEE	20	17	0	3	3
NAVHIN	20	0	19	1	0
Total	120	81	19	14	16

Table 4: The performance of the facial recognition system

Performance metric	Total
Precision	85.26%
Sensitivity	83.51%
Specificity	57.57%
Accuracy	76.92%

4. Conclusion

The accuracy of the ESP32 camera can be calculated based on the overall accuracy, precision, sensitivity, specificity and of the facial recognition system with a mask experimental setup. The ESP 32 camera has an 85.26% precision. As a result of this, the ESP32 camera is capable of correctly identifying the faces it detects. Following that, the ESP32 camera has a sensitivity of 83.51%. A highly accurate system detects most or all of the faces in an image, whereas a low-sensitivity system misses some of them. According to this outcome, the ESP32 camera is reasonably good at recognizing most faces. Following that, the ESP32 camera has a specificity of 57.57%. As a result, the ESP32 camera is only partially effective at rejecting faces that it does not detect. Following that, the ESP32 camera's accuracy is 76.92%. Based on this result, the ESP32 camera is a suitable device for a robust facial recognition system. On the other hand, the camera has some lighting issues. One of the most common problems is that the environment's lighting is insufficient for the camera's ability to recognize clear images of faces. This could be due to an inadequate ambient light or the subject being positioned in a manner that their entire face is in shadowy areas. Furthermore, while the ESP32 is an effective microcontroller capable of powering a facial recognition system with a mask, its efficiency might be limited when compared with other, more powerful devices. This is because facial recognition systems necessitate an enormous amount of computation power and memory to analyze pictures to generate accurate identifications. It's additionally essential to remember that factors like illumination, the quality of the image, and the variety of the data set used for training will all have an impact on the system's performance.

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