Design of an IOT System based on Face Recognition Technology using ESP32-CAM

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Summary
In this paper, we will present the realization of a facial recognition system using the ESP32-CAM board controlled by an Arduino board. The goal is to monitor a remote location in real time via a camera that is integrated into the ESP32 IOT board. The acquired images will be recorded on a memory card and at the same time transmitted to a pc (a web server). The development of this remote monitoring system is to create an alternative between security, reception, and transmission of information to act accordingly.The simulation results of our proposed application of the facial recognition domain are very efficient and satisfying in real time.

Keywords:
Authentication, ESP32-CAM, face recognition, Camera, Security.

1. Introduction

Face recognition is a popular biometric technology, it is widely used in authentication, access control and video surveillance applications, there are several global, local and hybrid face recognition methods [1], [2].
Face recognition is a popular biometric technology, it is widely used in authentication, access control and video surveillance applications, there are several global, local and hybrid methods of recognition of faces. In recent times and with the advancement of technology, the passwords and keys used in all areas of security and access control have become easily falsifiable and breachable [3], [4]. Therefore, researchers from different fields have focused their work on keys and passwords that are impossible to falsify and above all effective. to remedy these problems, we will use the field of biometrics which is characterized by a high level of security and control. And among all the biometric technologies that exist, facial recognition is one of the most widely used and adapted technologies in the field of real-time facial recognition. It makes it possible to exploit a lot of information relating to a person's faces [5].
The fields of use of facial recognition are very wide. We can cite some areas which are: unlocking phones, checks at airports and borders, finding missing people, reducing crime in shops, health, monitoring the presence of employees or students [6].

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In this paper, the proposed system using facial recognition. The proposed method consists of a camera sensor ESP32 for continuously monitoring the face of a person. The faces of the authorized persons are stored in the SD card of the ESP32-Cam [3], [4]. Whenever a person stands in front of the door the esp32 cam recognizes the face of the person by comparing the authorized faces of authorized persons in the database. The “AI-Thinker” algorithm is used in detecting and recognizing the face of a person.
The organization of the article is presented as follows. In Section II, architecture of the face recognition system is presented. In Section III, represents the real-time simulation of the surveillance system using an ESP32-CAM IP camera. Finally, a conclusion and a future work are given in Section IV.

2. Architecture of the face recognition system

Face recognition is a popular biometric technology, it is widely used in authentication, access control and video surveillance applications, there are several global, local and hybrid face recognition methods [7], [8].
A face recognition system must be able to identify the faces present in an image automatically. The system can operate in authentication or identification mode. There is another type of face recognition by checking against a watch list which is compared to a short list of suspects.
The system is broken down into three modules, learning, identification, and authentication [9], [10]:
- The identification module allows face detection in the image captured by the acquisition system. Then, the image signatures will be extracted and classified by those which contain a face; thus, it provides the authentication module with an image signature containing a face book

In authentication mode, based on the comparison between the signature classification result and the model created by the learning phase, the system makes the final decision: unknown person or known person with his identity.

The hardware part of the facial recognition system is illustrated by Fig.1.

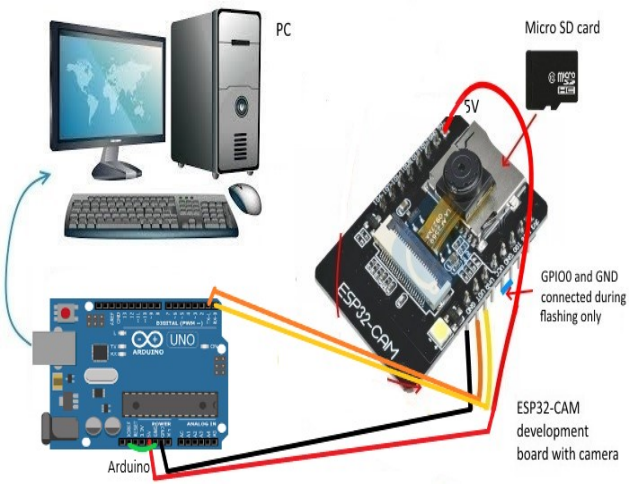

Fig. 1. Block diagram of the face recognition system

The below Fig.1 shows the complete circuit diagram of face detection

- IP Network Camera: ESP32-Cam

It is a very small integrated module of an OV2640 camera and an ESP3-S processor, allowing to create IP camera projects for video streaming with different resolutions and visualized in real time through a wifi network in a way direct. It contains three GND power pins of 3.3V or 5V [11].

A high-brightness LED can be ordered for night shots, for example. In this case, it is possible to connect a photoresistor on the board. Indeed, it also integrates some GPIO ports to assemble different sensors and actuators.
The ESP32-CAM module also has an SD card reader which can be used to save images when an event is detected [12], [13].

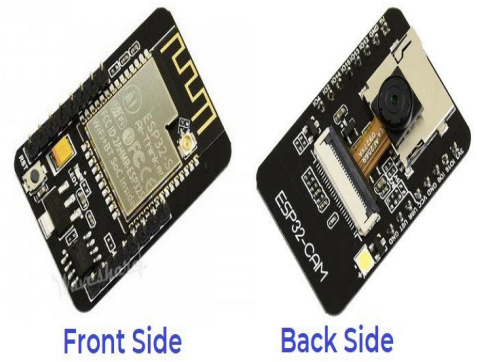

Fig. 2. : Front and back side of the ESP32CAM board

We use this camera because of [11], [14], [15]:

- Its speed of data transfers,
- Storage capacity;
- May contain other additional functions;
- Efficient transmission without data loss or noise intrusion.
- effective reception of transmitted signals (such as images; sensor responses).

Very responsive to a reception and execution via an order.
- The ESP-32CAM can be used in various IOT applications. It is suitable for smart home appliances, industrial wireless controls, wireless monitoring, QR wireless identification, wireless positioning system signals and other IOT applications. It is an ideal solution for IOT applications [11], [12], [14].
Fig.3. shows the internal composition of the ESP32-CAM board [11].

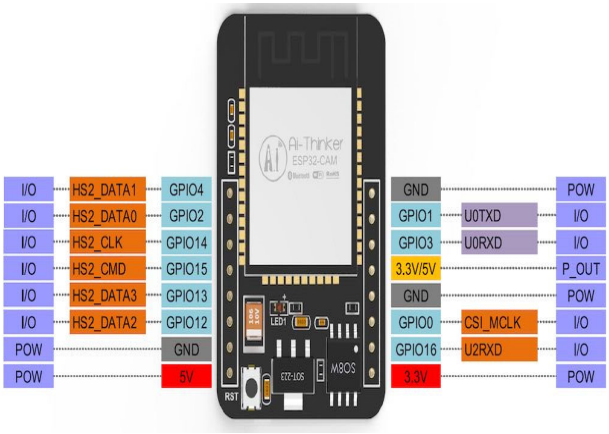

Fig. 3. : Internal composition of the ESP32-CAM board

- **Communication card**

To ensure the uploading of an operating program of such an application to the ESP32-CAM card, there are several cards such as FTDI, ARDUINO, MODULE TTL.
We chose the ARDUINO board as a converter compatible with the control board because it can play both a control board and a converter, Fig.4.

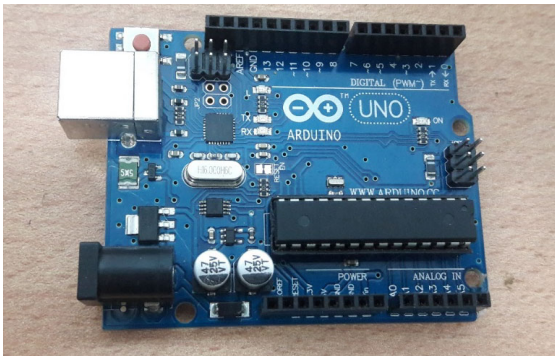

Fig. 4. : Arduino Uno board

The advantages of the Arduino UNO card are:
- Simpler and more economical.
- Ease of use.
- Easily accessible.

3. Simulation Results

In this part, we will access the ESP32-CAM board via a local network. The router acts as an access point and the ESP32-CAM board is configured as a station. We connect to a local network to control and access the ESP32-CAM web server. The network access procedure that the ESP32-Cam module is integrated with WiFi connectivity allowing it to send videos in real time, the module consists mainly of a microprocessor which behaves like an Arduino, for this reason we can program it through the Arduino software.

To upload the program from the computer to the ESP32-Cam, a first step is to connect the module to a PC via a programmer. Hosted by a web server, the ESP32-Cam module can create its own Wifi network which allows it the autonomy to generate a connection and send videos to any location.
Fig.5. presents the wiring of the GPIOs of the ESP32-CAM board and the Arduino board.

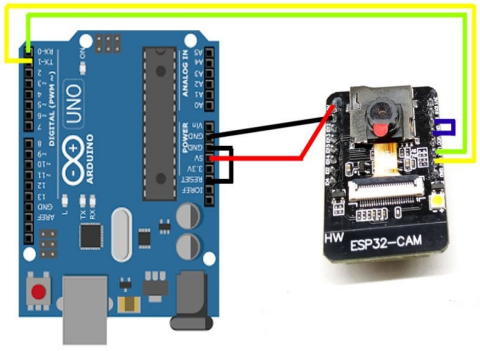

Fig. 5. : Connection between the ESP32CAM board and the Arduino board

Fig.6. presents the actual face recognition program upload montage.

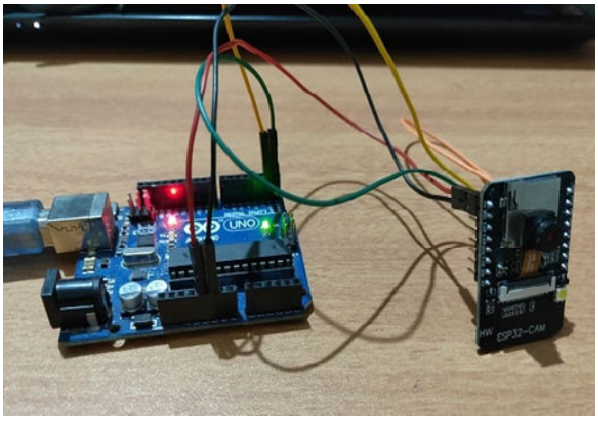

Fig. 6. : Face recognition program upload

The face recognition algorithm by ESP32-CAM is given as follows:

Step 1: Access via web browser

The serial monitor displays the IP address that will allow the opening of the camera according to the URL reserved in a web browser

```
Wifi connected '80'
Starting Web server on port:'80'
Starting  Stream server on port :'81'
Camera Ready ! Use 'http://192.168.1.157 to connect
```

Fig. 7. Affichage des données sur le moniteur série

Step 2: Camera opening

This step opens the camera. To ensure the proper functioning of our application. We need to update the URL variable in the code with the URL copied from the Arduino serial monitor to run our code, Fig.8.

```
WiFi connected
Starting web server on port: '80'
Starting stream server on port: '81'
Camera Ready! Use 'http://192.168.43.192' to connect
```

Fig. 8. L'URL executé dans Arduino

Copy the address given by Fig.8 and then paste it into the address bar of a web browser. The web browser needs to be on the same network as the ESP32-CAM is connected to.

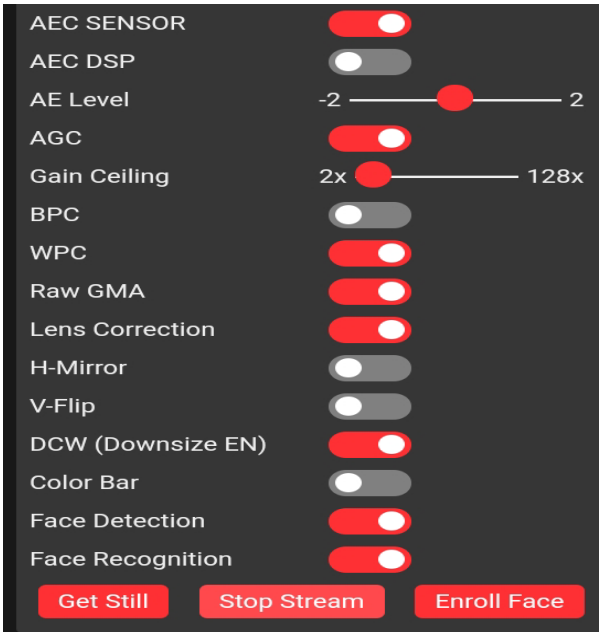

Fig. 9. : Camera feature

Fig. 10. : Example of registered database

Step 3: Creation of the database

In this step, we will create the database. For our case, this database is composed of a set of facial images, made up of 10 people by the face-taker.py script. Each of them presents 100 images recorded for different grimaces (neutral, angry, depressed, happy, etc.).
Fig.10. shows the states of people's faces

Step 4: Validation of the authentication phase

Each time the camera succeeds in detecting a face, an identification is made after a real-time comparison between the detected face and those registered in our database.
Once the comparison is made, the application can provide two results: the name of the person if the face is well selected in the database or an unknown person since his face does not exist in the database.
Figs.11 and 12, illustrate the proper functioning of the phenomenon of facial recognition by various examples with grimaces and different positions indicating the percentage of confirmation of the requested person.

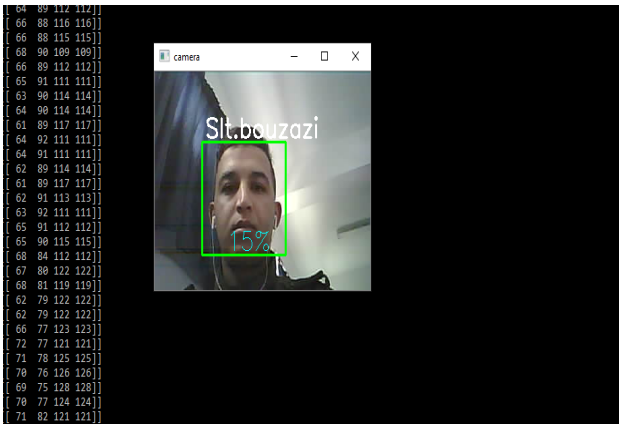

Fig. 11. : Example of recognized face

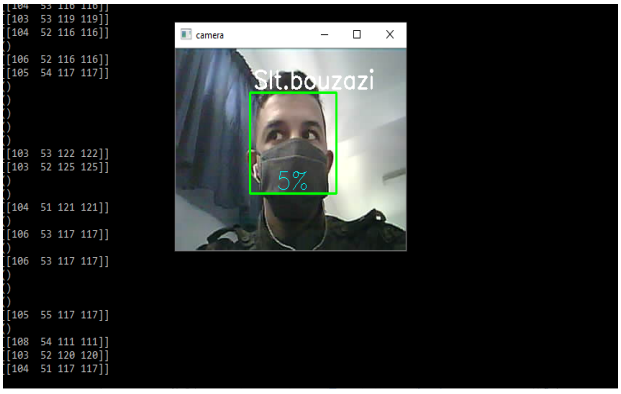

Fig. 12. Recognized face example

Fig.13 shows the validation of the presence system which is presented in the form of an Excel file, and which contains the name of the person, the date of identification, as well as the time of detection of the person.

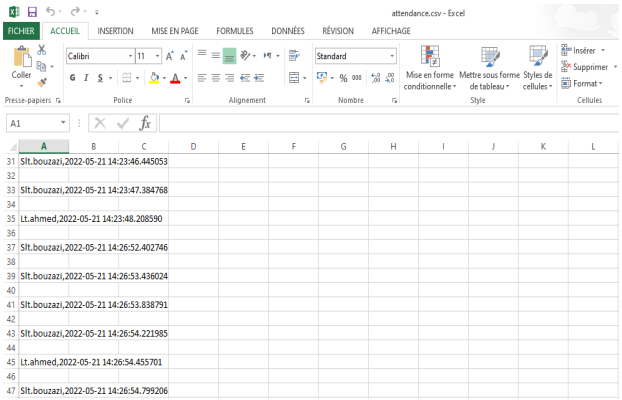

Fig. 13. Result saved in Excel

4. Conclusion

The objective of this paper is to design and implement an IOT facial recognition application using the ESP32-CAM board, which is able, in real time, to recognize faces. Given the quantity of potential software (security, social networks, etc.) that can be based on this application, it must meet the requirements of speed and robustness of the results. There are a variety of techniques devoted to face detection. Face tracking systems have developed a lot in recent years thanks to the improvement of hardware and the high industrial demand.

Among the perspectives, we can introduce Deep Learning technology as a new method of implementation that ensures more precise, faster, and configurable operation in the field. As well as the use of other recognition methods, and the combination with other biometric technology such as the fingerprint or the iris to finalize the multimodal application and make the system more reliable by reducing the sensitivity to lighting conditions by new standards.

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