

Design and Implementation of Intelligent Access Control System based on FaceNet

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Abstract

This paper designs a face recognition intelligent access control system based on deep learning FaceNet network to meet the security needs of dormitory apartments, office buildings and other places. The system mainly uses the Keras deep learning framework to write the face recognition server program based on the FaceNet algorithm, compares and connects with the door lock control program, the microcontroller and the steering gear, and realizes the door lock control, face registration, access rights management, etc.

Keywords

Face Recognition; Facenet; Access Control System.

1. Introduction

In the past half century, the global economy has developed rapidly, and people's requirements for material culture have been continuously improved. The access control system is an important line of defense for people to protect their lives and property, so it is widely used in residential quarters, institutions, office buildings, student dormitories and other places. Most of the traditional access control systems are card-swiping methods, which contain too many unreliable factors, such as loss, theft, and need to be properly kept by human beings, and the operation is very unfriendly to some disabled people, which cannot meet the increasing demand for security protection. growing demand. The face recognition access control system has the following advantages: 1. The collection method is convenient: you only need to stand three or four seconds before the camera is static to collect and recognize the face image; 2. There is no contact with the recognition equipment: during the recognition process, the body does not need to be in contact with the device, there is no invasiveness, and it is more friendly and convenient for most users; 3, the cost of the acquisition device is low. The intelligent access control system designed in this paper is to apply image acquisition, image transmission, feature extraction and other technologies to the monitoring and management of the access control system.

2. Overall System Framework

The overall design structure of the access control system designed in this paper is shown in Figure 1. In this paper, the single-chip microcomputer is used as the access control control center, and the PC is used as the algorithm execution unit.

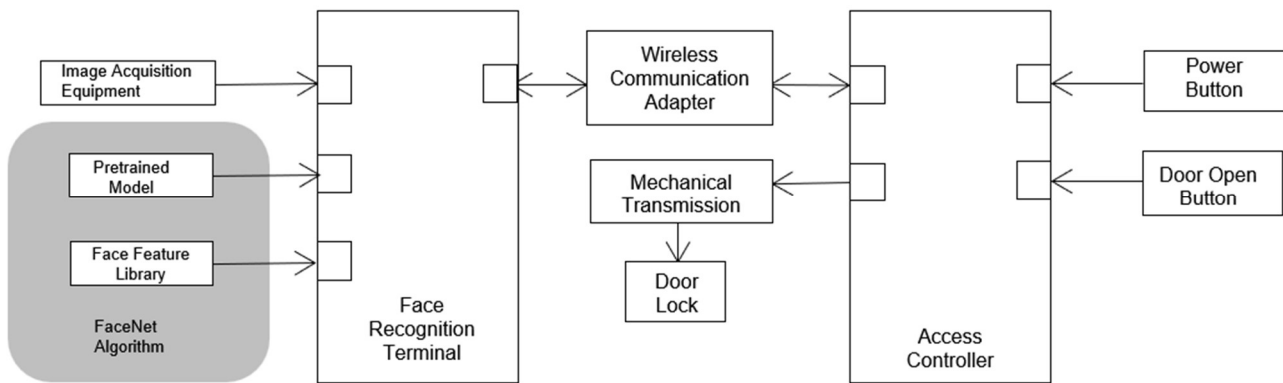


Figure 1. Overall structure diagram of intelligent access control system

The hardware system of the system mainly uses Raspberry Pi microcontroller and PC as the control core, and at the same time, the camera, steering gear, buttons and other auxiliary devices are used to form the whole system. The structure of its control core system is shown in Figure 2:

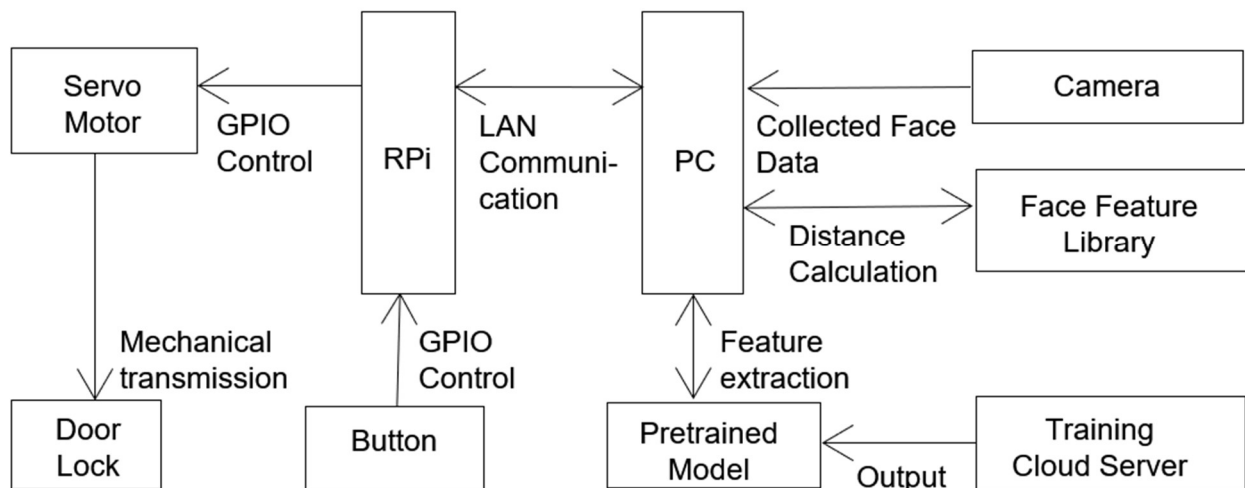


Figure 2. Core structure diagram of intelligent access control system

After the system is powered on, it starts to initialize. When someone tries to enter the access control, the camera collects the face, the system starts to process and recognize the face image, and finally outputs the recognition result by comparing the face feature vector Euclidean distance. The main program flow Figure 3. The distance threshold determines the safety and efficiency of the system. If the distance threshold is too large, the false rejection rate of the system will increase and the system efficiency will decrease. Conversely, if the distance threshold is too small, the false acceptance rate of the system will increase and the system security will decrease.

2.1 Hardware System Composition and Description of Main Components

The hardware system that meets the design requirements of simple structure, low cost and operational reliability is composed of image acquisition equipment, PC, Raspberry Pi, steering gear, and a router supporting LAN communication. The PC stores the trained FaceNet model. Since FaceNet supports end-to-end feature extraction, a network with strong feature extraction capability can be trained on a large-scale face database in advance, and then the newly entered face can be directly extracted using the trained network. eigenvectors of . When someone approaches, the PC reads the input image matrix from the image acquisition device, and calculates the Euclidean distance with the entered face feature vector to verify the face.

The Raspberry Pi (using the PigPIO service) is connected to the servo to realize access control. The Raspberry Pi is connected to the PC through the wireless LAN, and the control information is obtained through the face recognition return value of the PC. If the characteristics match, the access control system opens the door. If the features do not match, reacquire the image. The selection of Euclidean distance threshold determines the security and efficiency of the system.

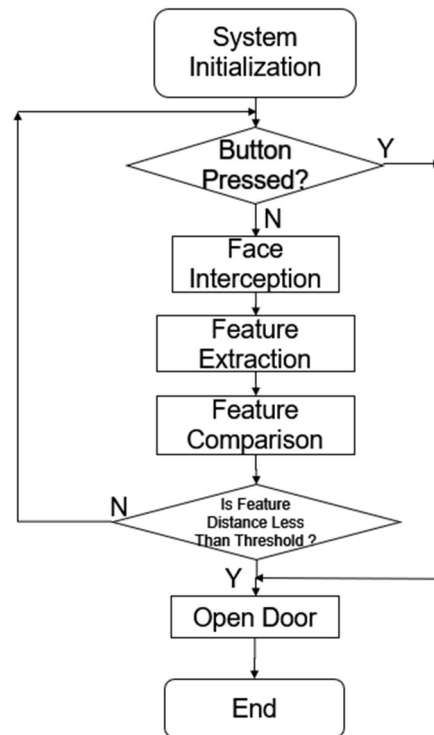


Figure 3. Main program flow char

The steering gear is mainly composed of a steering plate, an upper casing, a gear set, a middle casing, a motor, a control circuit/wire, and a lower casing. The steering gear can realize rotation control at any angle according to the command, and it has fewer leads than the stepper motor. Its working principle is as follows: 1. The control circuit receives the PWM control signal from the signal line, and drives the DC motor to rotate; 2. The reduction gear group slows down the speed of the DC motor, so that the output torque of the DC motor reaches the corresponding multiple and then transmits it to the output rudder plate ;3. The position feedback potentiometer rotates with the output shaft of the steering gear, and the rotation angle of the steering shaft can be measured; 4. The control circuit judges the rotation angle of the steering gear according to the potentiometer, and then feedback controls the steering gear to turn to the target angle or maintain the target. angle.

The image acquisition device selects a camera with moderate pixels, which can not only capture clearer images, but also prevent the system from freezing due to large sampling. This system chooses a 1920x1080 external camera.

2.2 GPIO Control based on Raspberry Pi

Generally, the steering gear has three control lines, which are yellow, red, and gray (black). The control signal of the steering gear is a pulse width modulation (PWM) signal with a frequency of 50Hz, in which the pulse width is from 0.5ms-2.5ms, and the corresponding position of the steering wheel is 0-180 degrees, which changes linearly. The Raspberry Pi kernel comes with a GPIO driver, and the GPIO Zero library can be used to remotely control the GPIO port on the Raspberry Pi through the network.

By controlling the duty cycle of the GPIO output pin, the direction of the 180-degree steering gear can be simply controlled to achieve the function of manipulating the steering gear to rotate at a certain angle. Software on any pin is supported in the GPIO Zero library Simple PWM control without having to spend time writing code that modulates the pin state for PWM pulses.

2.3 Remote GPIO Remote Control

The GPIO Zero library is installed on the console device. Choose to install it through the package manager or pip: pip install gpiozero pigpio, and set the Pin Factory to achieve this function as follows:

```
from gpiozero import Servo;
```

```
from gpiozero.pins.pigpio import PiGPIOFactory;
```

```
factory = PiGPIOFactory(host='192.168.1.3') # Fill in the IP address of the Raspberry Pi;
```

```
servo = Servo(17, pin_factory=factory)# Fill in the GPIO pin number, this article uses Pin17;
```

After completing the configuration, you can use Python operations such as servo.min() to control the steering gear.

3. Face Recognition Algorithm based on FaceNet

Deep learning is included in machine learning, which is mainly based on artificial neural networks, and is an algorithm for learning representations of data. In 1986, Geoffrey Hinton published the paper Learning Representations by Back-Propagating Errors [1], which elaborated the usefulness of the back-propagation algorithm in deep learning, which made the back-propagation algorithm popular. This is an important milestone in the development history of deep learning, which can be said to have played a decisive role in the development of deep learning. However, due to the limitations of the data set size and computer hardware at the time, early deep learning could only be used for small-sample tasks such as recognizing handwritten digit systems. However, with the development of computer hardware such as GPU and CPU, it is no longer an important factor limiting deep learning, so deep learning has shown great advantages in the field of face recognition. One of the representative achievements is the proposal of FaceNet. FaceNet is a new set of convolutional neural network face recognition models proposed by Google. It uses a deep convolutional network to learn the Euclidean embedding of each face image, so that the square of the L2 distance in the embedding space is related to the face Similarity is directly related.



Figure 4. The network structure of FaceNet

FaceNet can use two styles of deep convolutional neural networks, Zeiler&Fergus[2] and Inception[3]. In this paper, the Inception style network is used. Usually, in order to make the fitting effect of the artificial neural network better, we can further increase the depth of the network and the number of network parameters in each layer. However, this approach has two drawbacks: a) When the depth and width are proportional to the learned parameters, it is easy to cause overfitting; b) Increasing the size of the network uniformly will increase the amount of computation.

In order to solve the above problems, we can use the Inception network, which uses a sparse fully connected method to reduce the amount of parameter calculation and slow down the gradient disappearance phenomenon. Its specific structure is shown in the following figure:

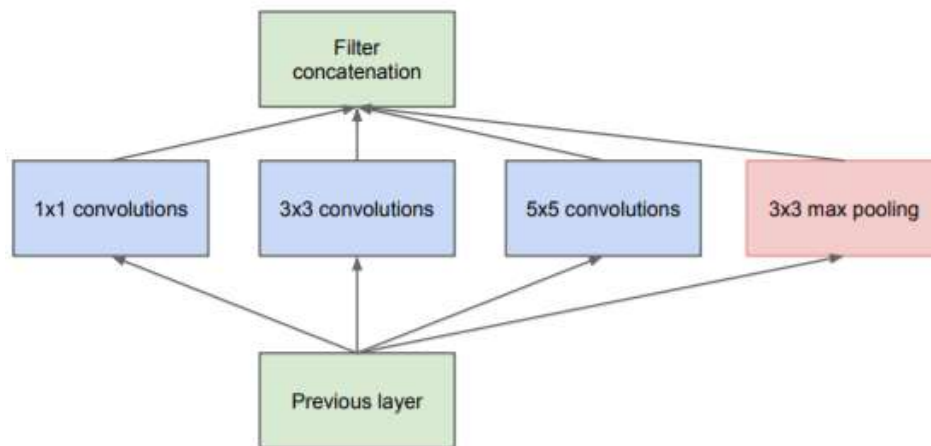


Figure 5. The structure of Inception layer (initial version)

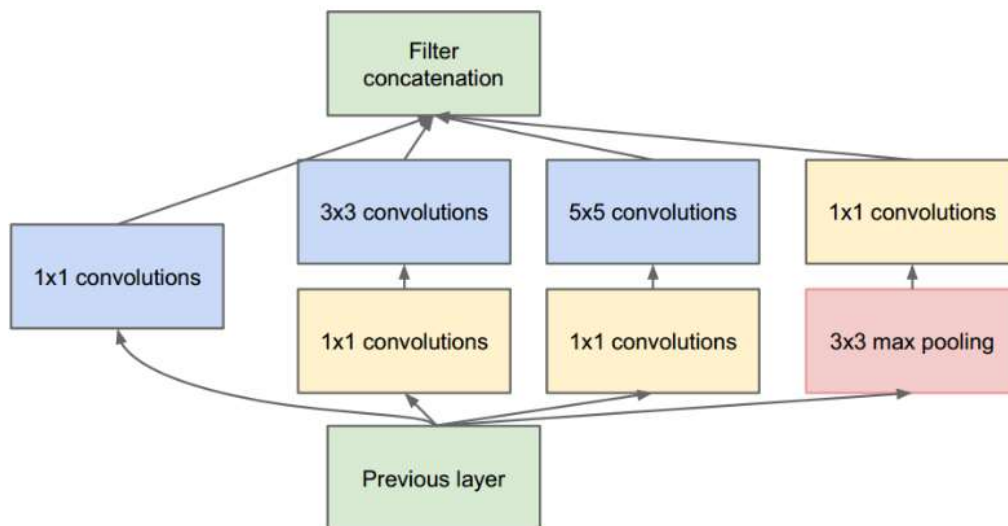


Figure 6. The structure of Inception layer (dimensionality reduction version)

Figure 5 contains four channels, which use convolution kernels of 1×1 , 3×3 , and 5×5 sizes respectively. Convolution kernels of different sizes represent receptive fields of different sizes, so features of different scales can be obtained. The reason why the Inception network also uses a 5×5 convolution kernel for feature extraction is because for some face images, the face features may be far apart. In order to obtain some features, we must use a relatively large volume accumulated nucleus. However, the 5×5 convolution kernel requires a lot of matrix calculations, and its efficiency is low. In order to solve this problem, the structure shown in Figure 6 appears, and the 1×1 convolution kernel is used to effectively reduce the dimension, which can greatly reduce the amount of calculation. In short, compared to traditional networks, Inception does not need to manually determine the size of the convolution kernel to add a pooling layer, which saves you a lot of time. At the same time, the author of the paper draws an important conclusion that we should use the Inception structure at the high level as much as possible, rather than the bottom layer.

FaceNet is an upgraded version of GoogleNet, which replaces the multi-dimensional vector output by the softmax classifier in its network structure with a fixed-length 128-dimensional feature vector output after L2 normalization. On the other hand, GoogleNet is an optimization of traditional CNN. On the basis of adding Inception structure, it eliminates the gradient disappearance of traditional CNN when the depth increases, the large amount of calculation and the need to manually select the network structure.

4. Conclusion

The main work of this paper is to use deep learning technology to realize a set of intelligent access control system based on face recognition. Compared with other biometric technologies, the face recognition technology designed in this paper has the characteristics of higher accuracy, more convenient acquisition process and uniqueness.

References

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