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Design of an Access Control System Based on Face Recognition

Qiong Wu, Qiang Wang, Yuhao Zhang, Bin Jiang, Yongcheng Cao and Fang Liu

Department of Computer Science and Electrical Engineering
Heilongjiang Oriental College Harbin, China
E-mail: 282977435@qq.com

Abstract. This paper studies design of an access control system based on face recognition for the major purpose of programming face recognition and access systems for embedded equipment. The access control system studied in this paper has functions regarding security, access control, personnel management, travel logs and time management. In this paper, face recognition algorithms are theoretically analyzed and derived. Based on face recognition algorithms, access control systems, particularly including face recognition algorithms, image processing and software, are designed and realized. Overall systematic debugging practices prove that aforementioned algorithms and software designs are correct and effective.

1. Introduction

Since the ancient times, people have used various door locks for protecting their properties or other articles, in order that people couldn't enter their rooms without permission. This simple measure has been taken for quite a long period. In general, door locks are always inseparable from keys, and a key is needed for each lock. As a result, more and more areas shall be locked. Under this situation, people have to carry many keys. However, it is inconvenient to take numerous keys at the same time. In addition, keys are easily lost and stolen. All these phenomena are rather unsafe. With the rapid development of today's sciences and technologies, traditional door locks can no longer accommodate people's needs for security [1].To thoroughly reverse this situation, different smart door control systems have been developed. These developments have been performed based on technologies of electronics, machinery, optics, biology, computers and communications. Mart door control systems are superior products of a new era.

2. Image Processing and Face Recognition Algorithms

2.1. Image Processing

The main purpose of image preprocessing is to eliminate irrelevant information and other information with insignificant impacts from images, recover useful information, retain or highlight primary information, increase detectability of related information, and simplify data to the greatest extent, in order to extrct, separate, match and recognize image features more reliably. A range of interfaces available from Open Cv are helpful for image processing [3].

The filtration process is performed for two purposes: On one hand, features of objects are extracted for image recognition; on the other hand, noises mixed at the time of image digitalization are eliminated [4], so as to satisfy requirements for computer processing. However, there are two requirements for filtration. Firstly, important information such as image contours and images can't be destroyed; secondly, images are clear and highly visible, or else it will deviate from original purposes of filtration [5]. as shown in Fig 1:

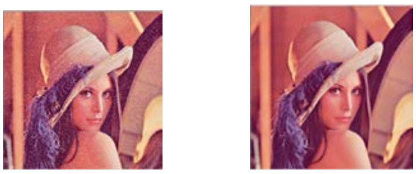


Figure 1. Results of Median Filtering

As shown in the figure, median filters blurred images and destroyed their details[6]. Therefore, different filtering results will be gained by adjusting the median filters, namely parameters of thee medianBlur (srcImage, dstImage, ksize).

By adjusting value of ksize, different results can be gained[7]. In case of varying aperture, the filter results are as shown in Fig 2:

Figure 2. Median Filtering Results for Different Aperture

2.2. Traditional PCA-based Face Recognition Algorithms

To apply the PCA-based algorithm is applied in face recognition, all faces are represented in low-dimension linear spaces, and faces are separable within the space. When the algorithm is used, a new group of orthogonal bases is obtained from the high-dimensional image space after linear transformation. These orthogonal bases are chosen and ranked in an order of priority, while some higher-rank orthogonal bases are retained to generate a low dimensional space for human faces, and dimensionality of human faces. is reduced to obtain a characteristic subspace[8].

The steps are as follows:

1. Face images are preprocessed.
2. The images are read and saved in a database of human faces, trained to obtain characteristic subspaces.
3. Trained and tested images are projected into characteristic subspaces obtained at the preceding step.
4. Judgments are made according to certain rules.

Images of human faces are preprocessed, denoised via median filtering. They are converted into H*W pixels through size transformation and by converting grayscale images.

3. Software Programming

Programs of this system are designed based on VMware10.01, Ubuntu12.04 Linux, OpenCv2.4.9 and CMake (compiling tool). The basic functions of this system include personnel management, time management, face recognition and travel records. Generally, there are three basic requirements for an access control system: who can enter, how and when to enter.

3.1. Reading of Configuration Files and Assignments to Parameters

According to the analysis results, many parameters such as total number of people in the training database, each person's name, port number and IP address of IPV4 necessary for networking as well as image resolution (width+height), match ratio, start/end time of authorized transit time, number of each person' face images in the training database, and the sole identification number of the access controller used for remote control are initially assigned in the running process of the program. In this design, above parameters are included in configuration files and read during running. It is unnecessary to re-translate or alter source codes. The program operations can be impacted by altering content of the configuration files anytime. On this part, the flowchart is shown in Fig 3 as follows:

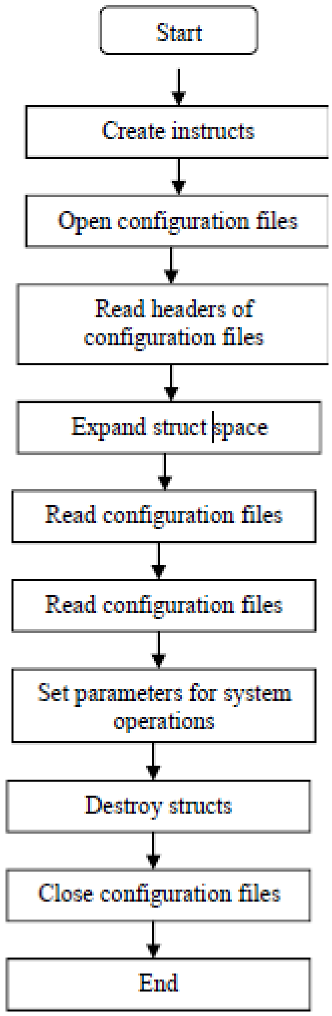


Figure 3. Flowchart of the Module of Configuration Files

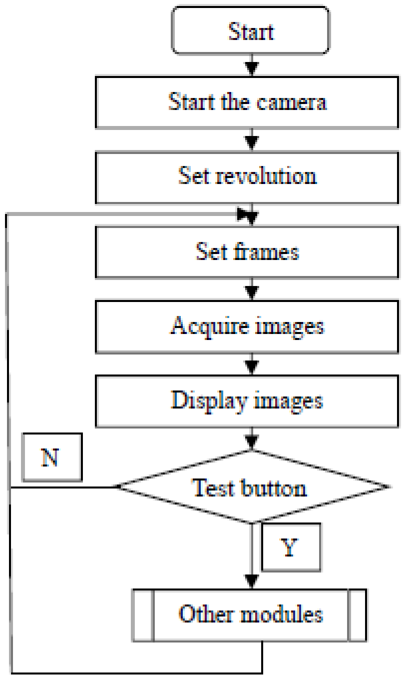


Figure 4. Flowchart of Camera Operation

3.2. Camera Operation

In this design, USB cameras are used. They are easy to use and cheap. They are called through related interfaces of OpenCv2.4.9. Most USB cameras available in markets mostly use USB2.0 interfaces. For these cameras, signal transmission and power supply share the same wires. Unstable power supply or too low voltage causes mutual interference, as a result of which cameras of controllers don't work. Under this circumstance, select timeout errors in program operation. On this part, the flowchart is shown in Fig 4 as follows:

3.3. Module of Mode Detection

In the course of mode detection, durations and working state are tested. To test the working state, STATE is set as a global variable in the system. There are three states, namely STATE_NORMAL, STATE_CLOSE and STATE_OPEN. These states mean normal working, normal close and normalopen states respectively. When the system is working normally, subsequent tests are performed; if it is normal close, it will deny all accesses and show that access is banned at the current time, while the access will be kept normal close; provided that the system is normal open, all accesses are allowed and all people are permitted to access, while the access is normal open.

3.4. Module of Logs

For an access control system, it is fairly necessary to keep travel logs. In important occasions, people stepping in and out shall be registered as proofs for future query. the flowchart is shown in Fig 5 as follows:

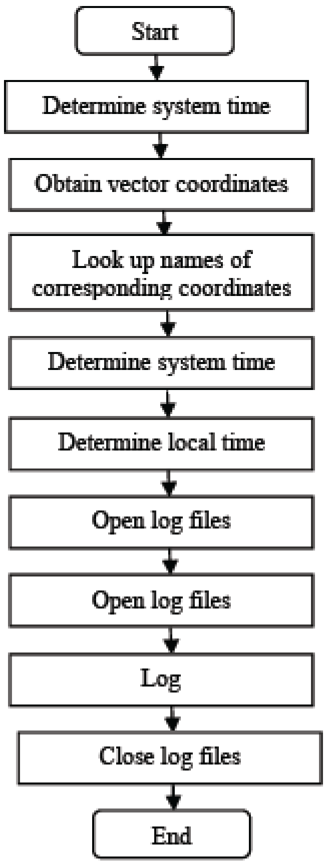


Figure 5. Flowchart of the Module of Mode Detection

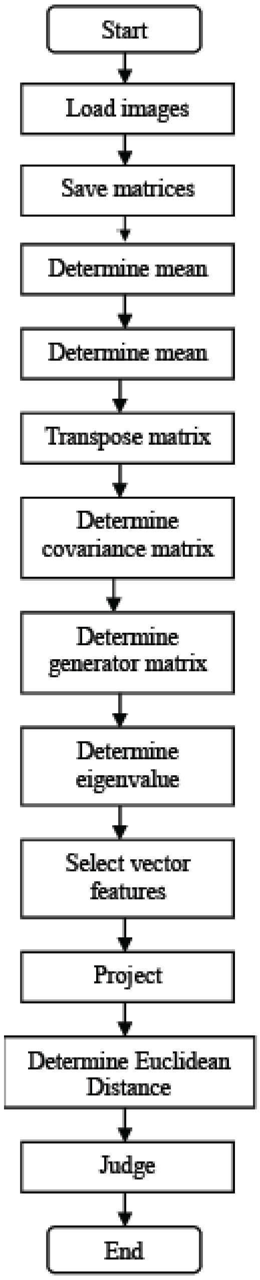


Figure 6. Module of Face Recognition

3.5. Face Recognition

Programmed design for face recognition involves many functions, including matrix multiplication, matrix transposition, mean calculation, covariance matrix, eigenvalue determination, feature vectors, projection and recognition. The specific algorithms have been introduced in the foregoing section. The flowchart is shown in Fig 6.

3.6. Server Design

The Linux server of this design is useful for received files uploaded at clients, indicating states of doors to clients and reading standard inputs. All these functions can be realized at the same time by setting unobstructed socks and unobstructed reading modes.

The server serves clients through a thread pool, and preliminary requests are made for thread resources, in order not to make repeated requests for resources and cause poor efficiency. The thread pool makes synchronization possible between threads by its mutex and cond. Function pointers are utilized to have the thread pool widely used and highly scalable.

4. Overall Debugging

4.1. Reading Configuration Files and Setting Running Parameters

Parameters shall be written in a configuration file altogether. After it is read, the configuration file shall be closed. Parameters shall be assigned to corresponding variables. Some running results are shown in Fig 7.

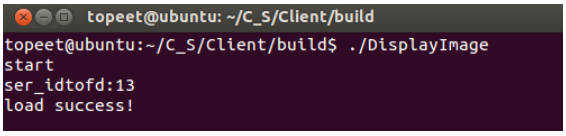
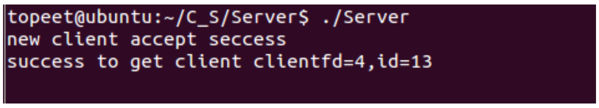


Figure 7. Running Results of the Module of Configuration Files

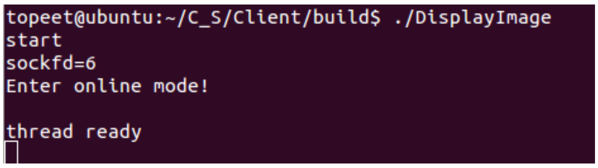
4.2. Network Connection

Through the last step, the IP address of the server and corresponding port number are identified. The networking sockets are determined in accordance with parameters. Try connecting network and set operation mode of the system based on return results.

In case of successful networking, running results are as follows (Fig 8):



a) Server;



b) Clients.

Figure 8. Running Results on Networking

In case of failed networking, running results are as follows (Fig 9):

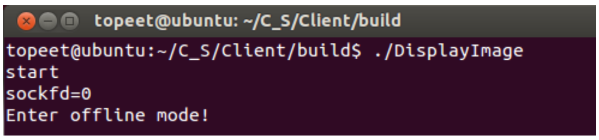


Figure 9. Running Results on Networking - Clients

4.3. Reading Face Databases and Face Modelling

Create corresponding matrix spaces and read the images of each face according to the grayscale images. Save grayscales of each image pixel inside matrices. Determine mean of matrices and calculate covariance matrices. Calculate eigenvalues and feature vectors. Then, project them into characteristic subspaces and generate egenfaces. The running results are shown in Fig 10.

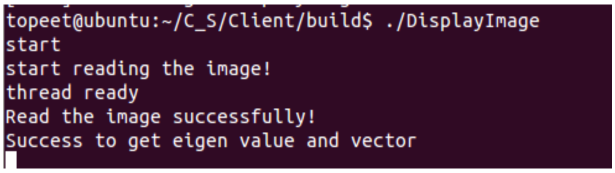


Figure 10. Running State of the Module for Face Modelling

When the module runs successfully, it will give a prompt that images have been read, while eigenvalues and feature vectors have been determined.

4.4. Opening Cameras and Setting Parameters
Set frames, window name and resolution for the camera. Start the camera. Set 33 frames for the camera and name the window as “capture”. The resolution is 640*480. After the camera is started, the running results are shown in Fig 11.

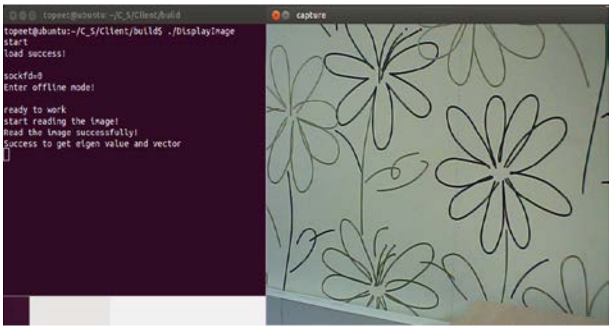
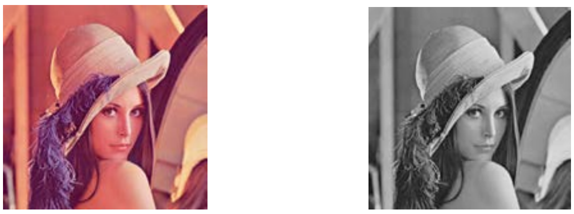


Figure 11. Operation State of Camera

4.5. Grayscale Conversion
The results of grayscale conversion are shown in Fig 12:



a) Raw Images for Grayscale Conversion b) Results of Grayscale Conversion

Figure 12. Grayscale Conversion

5. Conclusions

This access control system is designed based on face recognition technologies. The face recognition algorithm is used based on the traditional PCA algorithm, and the optimized algorithm is useful for general face recognition. By this algorithm, faces are recognized via grayscale conversion, filtering and denoising. However, it is impossible to guarantee the accuracy when there are very few samples in the training database.

The system designed in this paper is useful for identity recognition, travel recording, control and execution as well as remote control, log uploading and time management. Furthermore, travel records

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are locally kept. All logs are uploaded together every 24 hours, and local files are cleared. The server names and saves received logs pursuant to unified naming rules for the convenience of future checks. The test results suggest that the design scheme for access control system proposed in this paper is effective.

6. Acknowledgment
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7. References
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