Research and implementation of Access Control System based on RFID and FNN-Face Recognition

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***Abstract*—With the development of face recognition and the wide use of RFID technology , the reliability and efficiency of identity verification is improved. The paper introduces an intelligence access control system, which consists of face detection based on skin model, RFID card processing and face recognition based on FNN. This system can be used in many fields, such as safety check in public activities, access control in uptown and work attendance check. There is a very important practical value.**

Keywords-FNN; RFID; access control system; face detection; face recognition

I. INTRODUCTION

Access control system which is also called gateway access automation management system, has the function of access control and Security guard against theft. The common access control systems are password access control system, non-contact IC card access control system, biological recognition access control system and so on, which related to the fields of electronic, machinery, computer, communication, biological technology and so on. The foreign brand of this system are mainly HID, NexWatch, NewTek in America, DDS in Israel and so on. The domestic production enterprises are MeLucky, SHENZHEN DAS, REFORMER in Hangzhou and so on. The development of domestic market is far behind abroad. With some large activities such as ShangHai World Expo held in China, and the general improvement of peoples' security consciousness, there will be important practical significance and wide application prospects to develop the access control systems which have independent intellectual property rights.

The development trends of access control system are safety and intelligent. This paper discusses an intelligent access control system which combines the RFID technology and biological technology (face recognition). First the overall framework of system and its subsystems are introduced. Then the technologies of RFID, face detection and recognition are explained. Finally the system is completed and tested.

II. FRAME OF THE SYSTEM

A. Overall framework of the system

The work process of system can be described as below: when a person wants to enter the access control system, he used the RFID card to swiping card by non-touch way. The system reads the information in the card and meanwhile the video camera is started to take photos of the person. Then the face can be detected in a short time. The identity information in the card is compared to the information from the database and the corresponding face data will be obtained. If the identity information and the face data are all matched to the information from the database, the person will be passed. Else he can't enter. The manager can do the manage work such as query the records.

According to the demand, the system should contain four subsystems[1,2]: information acquisition subsystem, data processing subsystem, information storage subsystem and information management subsystem. The other peripheral hardware equipment such as door machine and electromagnetic lock are also included. The overall framework is showed in Figure 1.

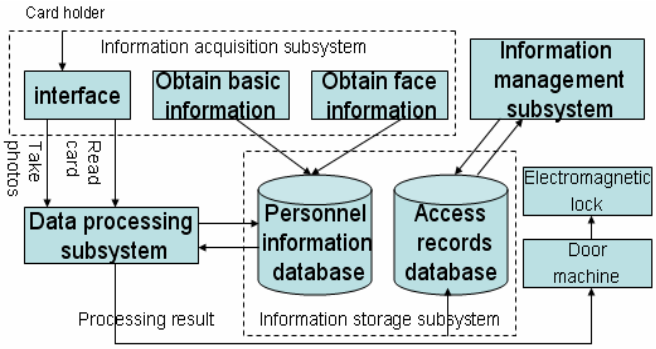

Figure 1. Framework of access control system

B. Subsystem structure

1)Information acquisition subsystem

This subsystem is responsible for two works. One is original information collection, which puts the basic information in the issued RFID card into the database and fetches the face image of the card holder. The other is to obtain the information in card and the face information of the cardhoder after the system starts in order to compare them to the information from the database. The hardwares of the subsystem are camera, RFID card and the RFID reading device.

2)Data processing subsystem

This subsystem is the core part which involves the RFID card information processing, face detection, face recognition and communication with the information storage subsystem. Its processing flow is showed in Figure 2.

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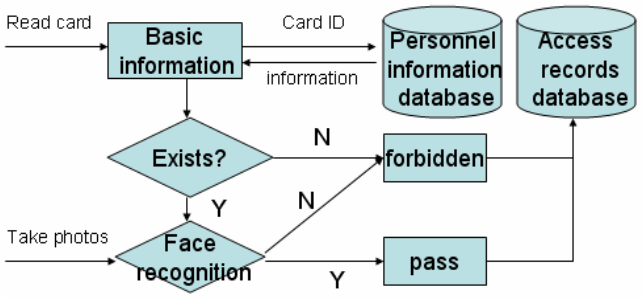

Figure 2. Processing flow of the data processing subsystem

3)Information storage subsystem

Two databases are involved in this subsystem: personnel information database and access records database. Personnel information database need the data input through the information acquisition subsystem and the information includes the basic information of the card holder and his face information. Access records database stores the logs of the system which are easy to the manager to query.

4)Information management subsystem

The main function of this subsystem is to query data. Managers can query the access records accoding to the time, the name of users, the ID number or the state of access.

III. KEY TECHNOLOGYS

A. RFID Data Read

RFID mainly consists of RFID card and the reading device, which is showed in Figure 3. They are dormant most of the time. When the reading device is waked up by the triggered signals, the RFID card will be waked up by the coded message send by the LF launch circuit on the reading device. Wireless two-way communication is used to transfer data in order to reduce the power consumption of the system. The triggered signals wake up the LF launch module of the reading device by the capacitive near detectors[3]. The workflow diagram is showed in Figure 4.

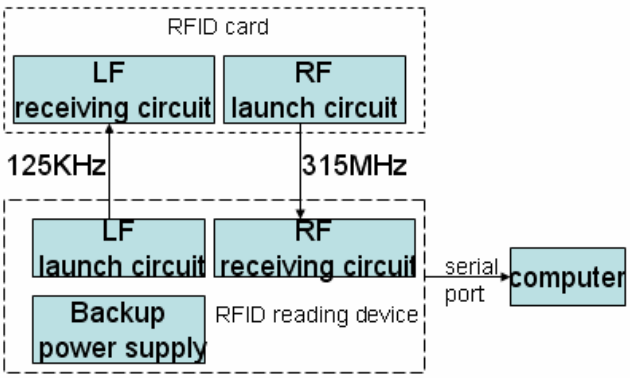

Figure 3. The RFID hardware

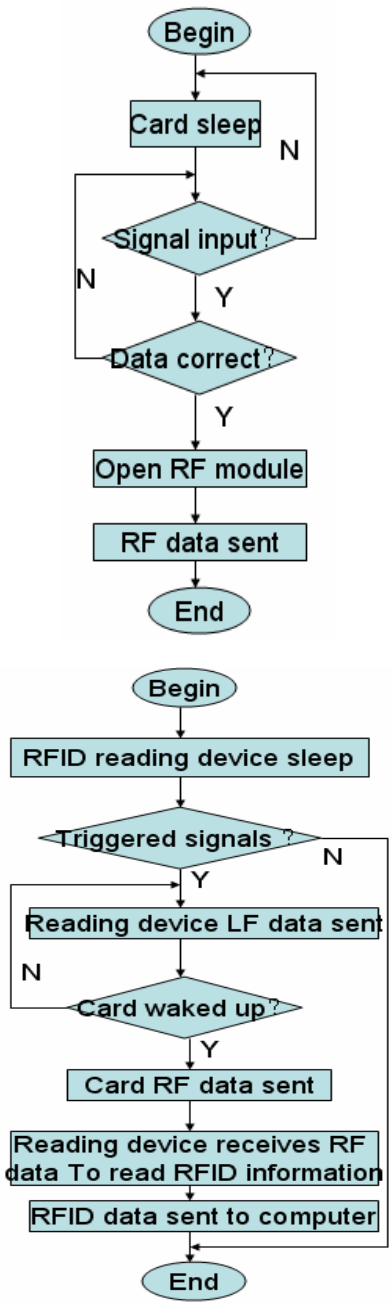

Figure 4. Process of sending and receiving RFID information

B. Face Detection

The face detection module can detect the face quickly by those steps as below[4].

First step is light compensation, which can eliminate the colour deviation by adjust RGB according to the grayscale average.

The second step is to turn the RGB color space into the YcbCr color space. Then we analysis the distribution of the skin color pixels, and the mathmathematical model will be built by polynomial curve fitting. The model can judge

whether a pixel is a skin color point and the color image will be turned into a binary image. Most of the background can be removed.

The third step is morphology processing. Then the sigle pixel which doesn't connect or the area which is not the face region obviously can be seen in the so-called skin area, and they must be removed by the scan algorithm. After this step, the face can be detected.

C. Face Recognition

The module of face recognition is the core of biological recognition. It fetches the face features information of Corresponding identity from the database according to the basic information passed by RFID card. The features information is extracted from five facial attitude images. The FNN is trained by the information, than the face features which are collected from the swiping card people are used as the input of the FNN to recognize. If the recognition passed, it means the Identity confirmed. Else it means the identity is false.

1)Features Extraction

A face image with m×n size can be changed into one dimensional row vector , is the average vector. If $X=[x_1-\mu, x_2-\mu, ...x_i-\mu]^T$, than $s_t=XX^T$. The $s_t=W\wedge W^T$ can be diagonalized, and we make the orthonomalization to every row vector of W signed as $[\omega_1,\omega_2,...,\omega_t]^T$. The face vector P_i is projected to the subspace W, and the first K eigenvectors will be fetched out. We project the face vector to the K eigenvectors, and a set of projective coordinate coefficients can be obtained. Then the LDA method[5] can extracts the face features data.

2)FNN

FNN is composed by five levels[6]. The first level is the input level. The second level is the obfuscation level. The third level is the fuzzy rules level (or called fuzzy reasoning level). The fourth level is the fuzzy output level. The fifth level is the ouput level.

The fuzzy rule[7] is expressed as below：

R^j:

$$If(x_1=a^j{}_1, x_2=a^j{}_2,...,x_n=a^j{}_n), \quad (1)$$
$$Then(y=\omega_j)$$

The x_i is the input vector, and the y is the output vector. $\overline{\omega}_{ik}$ is a real number consequent. $j=1,2,...,M; i=1,2,...,n$. The output of the fuzzy system is：

$$y^*=\sum_{j=1}^{M}\mu_j\omega_j \quad \mu_j=\mu_{A^j{}_1}(x_1)\times\mu_{A^j{}_2}(x_2)\times...\times\mu_{A^j{}_n}(x_n) \quad (2)$$

The study of the FNN system is revising the parameter of the membership function and the real number ω_j. This paper chooses the trigonometric membership function as below:

$$\mu_{A^j{}_i}(x_i)=1-2\left|x_i-a^j{}_i\right|/b^j{}_i \quad (3)$$

The $a^j{}_i$ is the centre of the triangle, and the $b^j{}_i$ is the width of it. Then the fuzzy reasoning output y can be computed according to the function (2)

If the expected output of the iutput vector $X=(x_1,x_2,...,x_n)^T$ is y^d, the purpose function is:

$$E=(y-y^d)^2/2 \quad (4)$$

We substitute the function (2) into (4):

$$E=\frac{1}{2}\left[\sum_{j=1}^{M}\prod_{i=1}^{n}\mu_{A^j{}_i}(x_i))\omega_j-y^d\right] \quad (5)$$

The study rules can be obtained by the gradient descent method:

$$\begin{aligned} a^j{}_i(t+1)&=a^j{}_i(t)-\eta_a\frac{\partial E}{\partial a^j{}_i}\\ b^j{}_i(t+1)&=b^j{}_i(t)-\eta_b\frac{\partial E}{\partial b^j{}_i}\\ \omega^j{}_i(t+1)&=\omega^j{}_i(t)-\eta_c\frac{\partial E}{\partial \omega^j{}_i}\end{aligned} \quad (6)$$

IV. SYSTEM COMPLETED AND TESTED

The system uses Pentium(R) Dual-Core CPU T4400, 2.20GHz, 2.20GHz processor,2.00GB RAM, Windows7 OS, development tools are Visual Studio C#.NET+SQL Server2000, the camera is Integrated Camera, the Video collection frame rate is 5f/s, RFID reading device is ZHIF100S, the biggest induction distance is 100cm。

The system mainly defines five classes: AccessControl、RfidControl 、 RfidResultSet 、 VideoControl 、 FaceRecognition and RecordSave. AccessControl is the master control class which controls the RFID information reading, video images fetching, face detection and recognition and information storage. RfidControl is the RFID reading class which includes the methods of BeginRead(), EndRead(), ReadCard(), HandleCard() and so on. It stores the information to the RfidResultSet class and meanwhile it fetches the face features information of corresponding card number from the database. VideoControl is video control class which includes the methods of start, pause, stop and image fetching. And the images will be passed to the FaceRecognition classe to detect and recognize face. FaceRecognition class includes every algorithm introduced above and it can recognize the face. Finally is the RecordSave class which stores the Real-time information to the database as log. The operation interface of system is showed in Figure5-7, including three test results: pass smoothly, identity information doesn't exist and the face information doesn't match.

Figure 5. Pass smoothly

Figure 6. Identity information doesn't exist

Figure 7. Face information doesn't match

After real test, some parameters of the system are listed as TABLE 1.

TABLE I. MAIN TEST PARAMETERS OF SYSTEM

Parameter	Value	Parameter	value
Analytical time of RFID card	≤3s	Test times	100
Time of face detection	≤80ms	Correct judgement times	92
Time of fadce recognition	≤300ms	Correct rate	92%

V. CONCLUSIONS

The access control system uses the structure of four level subsystems. First it read the identity information by the RFID technology. Second it fetches the face images by video capture, and compares them to the face information in the database, then the conclusion whether the face information matches the identity information comes out. The experiment results prove that the system's instantaneity and effectiveness is good enough. Also the application field of the system is wide.

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