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Application Design of the Iris Recognition Technology in the Access Control Management System

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Abstract. This design is a method of implementing the iris-recognition-based access control management system, including the identity collection device, database server, infrared range finder, iris recognition device, and access controller. The identity collection device collects the target personnel's identity signals on site and outputs iris information. When a target person attempts to enter a door, the infrared range finder needs to work with the identity collection device to start the iris recognition device. The identity collection device will promptly and accurately collect the iris information, and then send the extracted iris information to the database server. The database server compares the received iris information with that previously stored in the database and quickly determines whether the iris information is legal based on the comparison results. If it is legal, the access controller sends a signal to the electric control lock to open the door and the person can enter the door. Otherwise, the person cannot enter the door. This design integrates the infrared sensing technology, human-computer interaction technology, data transmission technology, and communication technology. It utilizes the iris recognition algorithm in the iris recognition technology to improve the precision of recognition. Therefore, this design can efficiently identify and authenticate personal identity. In addition, this design features high reliability, low cost, small volume, complete functionality, and strong scalability on information collection.

1. Introduction

In the field of biometrics recognition, in addition to the application of fingerprint recognition and face recognition, people have applied the iris recognition technology to the access control management system that demands higher security. Iris is a visual characteristic of a human eye, which generally does not change after birth. It is unique for each person and features strong stability. The application of iris recognition in the field of access control will undoubtedly and significantly enhance the security performance of access control.

The iris-based access control management system fully realizes the automatic management of personnel who attempt to pass the access control system by using the data stored on the iris recognition device for comparison and using the computer as the backend processing tool. [1]

2. System Working Principle

The iris-recognition-based access control system is used to identify people by checking their iris. First of all, iris information is registered for each internal staff member, and their authorities are divided

according to their positions and departments. When a target person attempts to enter a door, the person needs to place his or her left and right eyes (the right eye is preferred) close to the identity collection device. The identity collection device will promptly and accurately collect the iris information, and then send the extracted iris information to the database server. The database server compares the received iris information with that previously stored in the database and quickly determines whether the iris information is legal based on the comparison results. Then, the system determines whether the person has authority to access the door based on the preset authority of the person. If it is legal, the access controller sends a signal to the electric control lock to open the door and the person can enter the door. Otherwise, the person cannot enter the door. [2]

3. System Architecture

The iris-recognition-based access control system consists of the identity collection device, database server, infrared range finder, iris recognition device and access controller. The identity collection device is connected to the database server by using a cable to recognize the identity of target personnel. The database server is connected to the iris recognition device by using a cable to store standard iris images of personnel. The infrared range finder is connected to the iris recognition device by using a cable to measure the distance between the target person's eyes and the iris recognition device. The iris recognition device is connected to the access controller by using a cable to automatically control whether the target person is permitted to pass the door after the iris image of the target person is compared. Figure 1 shows the architecture of the iris-recognition-based access control system.

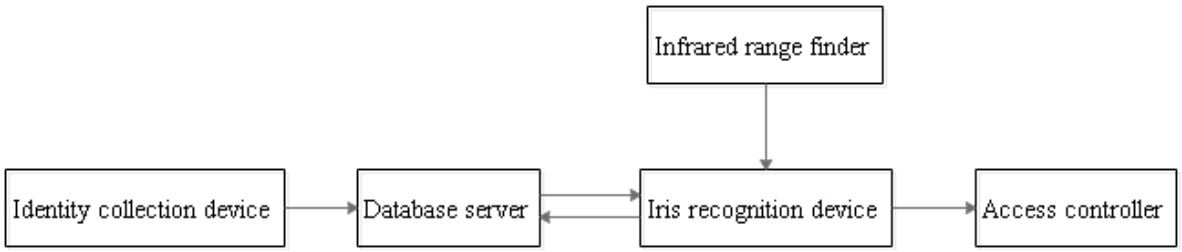

Figure 1. System architecture

The identity collection device is a non-contact smart card recognition device with the IC card function. The model chosen here is ACR122U-A9 NFC card reader. ACR122 is a smart card reader developed on the radio frequency of 13.56 MHz, which complies with the ISO/IEC18092 (NFC) standards.

To improve safety, it is optional to configure a SAM card slot in ACR122. Ensure that the SAM card slot complies with the ISO7816-3 standards. In addition, the ACS can also provide the ACR122 module for easy integration into large devices, such as POS terminals, access control devices and advertising machines. In the infrared range finder, there is a frosted glass ring plate on the first round table of the inner wall of the shell. Two infrared emitters and two light-emitting diodes are installed symmetrically on the second round table of the inner wall of the outer shell. The lower end of the shell is connected with a CCD camera. The infrared range finder is equipped with red and green LED lights. When the distance between the target person's eye and the iris recognition device is within the range of 25 to 35 cm, the green LED light is on, and the iris recognition device is working. When the distance is not within the range of 25 to 35 cm, the red LED light is on, and the iris recognition device is not working. The upper end of the device shell can be buckled onto the eyes of the target person. Under the illumination of the infrared emitter and light-emitting diode, the iris images are collected by the CCD camera and stored in the database server.

The management platform of the iris-recognition-based access control management system is installed on the database server. The management platform provides various functions such as user management, data storage, and access control management.

The iris recognition device consists of the infrared camera, positioning processing module, feature coding module, and feature comparison module. It is the core component of the iris-recognition-based access control management system. [3]

The access controller adopts the main control and sub-control structure, and the chip can use the ARM 32-bit CoreTile boards.

4. Design of Positioning Processing Module in the Iris Recognition Device

The workflow of the iris recognition device is shown in Figure 2.

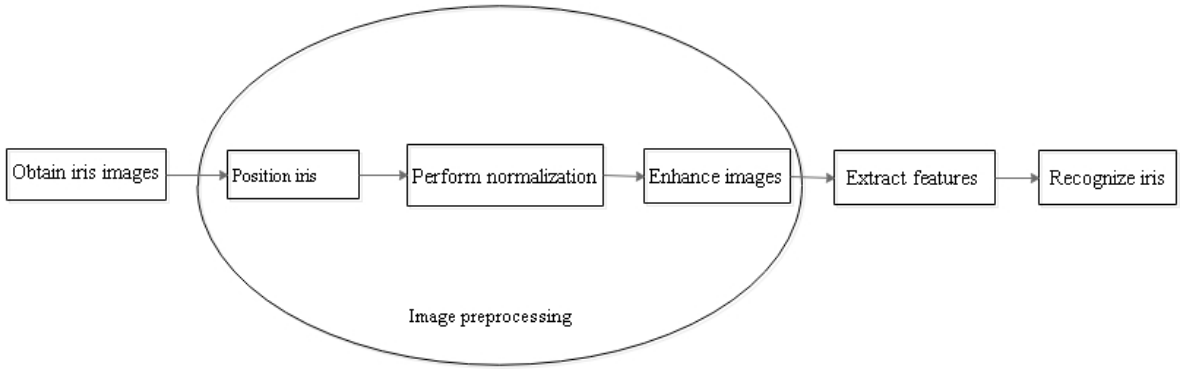

Figure 2. Workflow of the iris recognition device

The iris recognition device obtains iris images from the iris collection device, and then position, normalize and enhance the iris images through the process of image preprocessing. The processed iris images are then sent to the iris feature extraction module to extract the relevant characteristics. Then, the iris recognition device matches the iris characteristics and the iris data previously stored in the database server and obtains the final result.

The iris recognition device mainly includes infrared camera, positioning processing module, feature coding module, and feature comparison module, among which the design of the positioning processing module is particularly important. This is because the accuracy of positioning directly affects the subsequent feature extraction and recognition rate. The inaccuracy of positioning may further lead to the failure of the recognition algorithm.

The inner iris is adjacent to the pupil, and the outer iris is adjacent to the sclera. There is a clear boundary between the iris and the pupil, and the gray-level gradient between them changes significantly. Therefore, the inner edge of the iris can be positioned accurately. The outer edge of the iris is connected with the sclera, but the gray-level gradient between them is not obvious, so it cannot be directly processed. However, a larger gray-level gradient can be formed through the contrast enhancement for the outer edge of the iris.

The positioning processing module is designed to quickly and accurately position iris images. Based on the analysis of the characteristics of iris images and with reference to a few articles about fast iris positioning, this paper proposes a fast positioning algorithm, that is, enhancing iris edge contrast before positioning while suppressing the effect of the iris texture. During the process of iris positioning, use a simple thresholding and the improved Hough transformation. [4]

4.1. Positioning of the Iris Internal Contour

The inner edge of the iris is the circular border between the iris and the pupil, which is much darker than the rest of the image and occupies a different gray-level range. Therefore, as long as an appropriate grayscale threshold is selected, the binary image of the pupil can be easily and quickly obtained. Then you can find out the edge points of the pupil in the binary image and estimate the circular parameters of the pupil edge by using the least square method. In this way, you can accurately position the inner edge of the iris.

The parameters of the iris inner contour can be obtained by the parameter fitting of separated pupils. It is assumed that the iris is a circle. The parameter form of the circle is shown in equation 4-1.

$$(x—x_c)^2+(y—y_c)^2=r^2 \tag{4-1}$$

Where, (x_c, y_c) is the center of the circle, and r is the radius. Suppose there are N points at the edge of the pupil. They are (x_0, y_0) (x_1, y_1) (x_2, y_2) ... (x_n, y_n). Use equation 4-2 to calculate the center and radius of the pupil:

$$AX=B \tag{4-2}$$

Where,

$$X=\begin{bmatrix} 2x_c \\ 2y_c \\ r^2-x_c^2-y_c^2 \end{bmatrix},\quad A=\begin{bmatrix} x_0 & y_0 & 1 \\ x_1 & y_1 & 1 \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ x_n & y_n & 1 \end{bmatrix},\quad B=\begin{bmatrix} x_0^2+ & y_0^2 \\ x_1^2+ & y_1^2 \\ & \cdot \\ & \cdot \\ & \cdot \\ x_n^2+ & y_n^2 \end{bmatrix},\qquad n > 5$$

Equation 4-3 is to use the least square method to calculate the circular parameters at the pupil edge:

$$X_{LS}=(A^TA)^{-1}A^TB \tag{4-3}$$

4.2. Positioning of the Outer Edge of the Iris

On the basis of accurate positioning of the inner iris edge, the upper and lower eyelid parts in the image are removed according to the inner edge radius and the center of pupil. According to the scope of the outer radius, the edge points that are too far from the center of the pupil in the horizontal direction are removed, and those that are less than the radius of the inner iris edge at the center of the pupil are also removed.

In order to improve the signal-to-noise ratio of the image at the edge, it is necessary to preprocess the collected image before detecting the outer edge. The preprocessing process involves suppressing noise, reducing the contrast in the iris region, and enhancing the edge contour of the iris region for accurate positioning. The specific method is to shrink the image size to 40%. By extracting vertical edge gradient information from the shrunk image, the system removes some useless edge points. Hough circle detection is conducted within the radius of the outer circle to accurately position the outer edge.

The method of neighborhood averaging and grayscale stretching is used in preprocessing. Neighborhood averaging smoothes the image, eliminates and suppresses the isolated points and line noise in the image, reduces the contrast in the iris region, and enhances the outer edge of the iris. [5]

The solution matrix of circle parameters in Hough circle detection is shown in equation 4-4.

$$When\ det(A)\neq 0,\ X=A^{-1}B \tag{4-4}$$

Where,

$$A=\begin{bmatrix} x_0 & y_0 & 1 \\ x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \\ x_4 & y_4 & 1 \end{bmatrix},\quad B=\begin{bmatrix} x_0^2+ & y_0^2 \\ x_1^2+ & y_1^2 \\ x_2^2+ & y_2^2 \\ x_3^2+ & y_3^2 \\ y_4^2+ & y_4^2 \end{bmatrix}$$

(x_0, y_0) (x_1, y_1) (x_2, y_2) (x_3, y_3) (x_4, y_4) are the five points randomly selected at the edge of the pupil. [6]

5. Implementation Process and Steps of the Iris-Recognition-based Access Control Management System

The contactless smart card recognition device collects the iris samples of the target personnel and stores them in the database server. The database server management platform manages user information and conducts system maintenance and update.

Figure 3 shows the flow chart of implementing the iris-recognition-based access control management system.

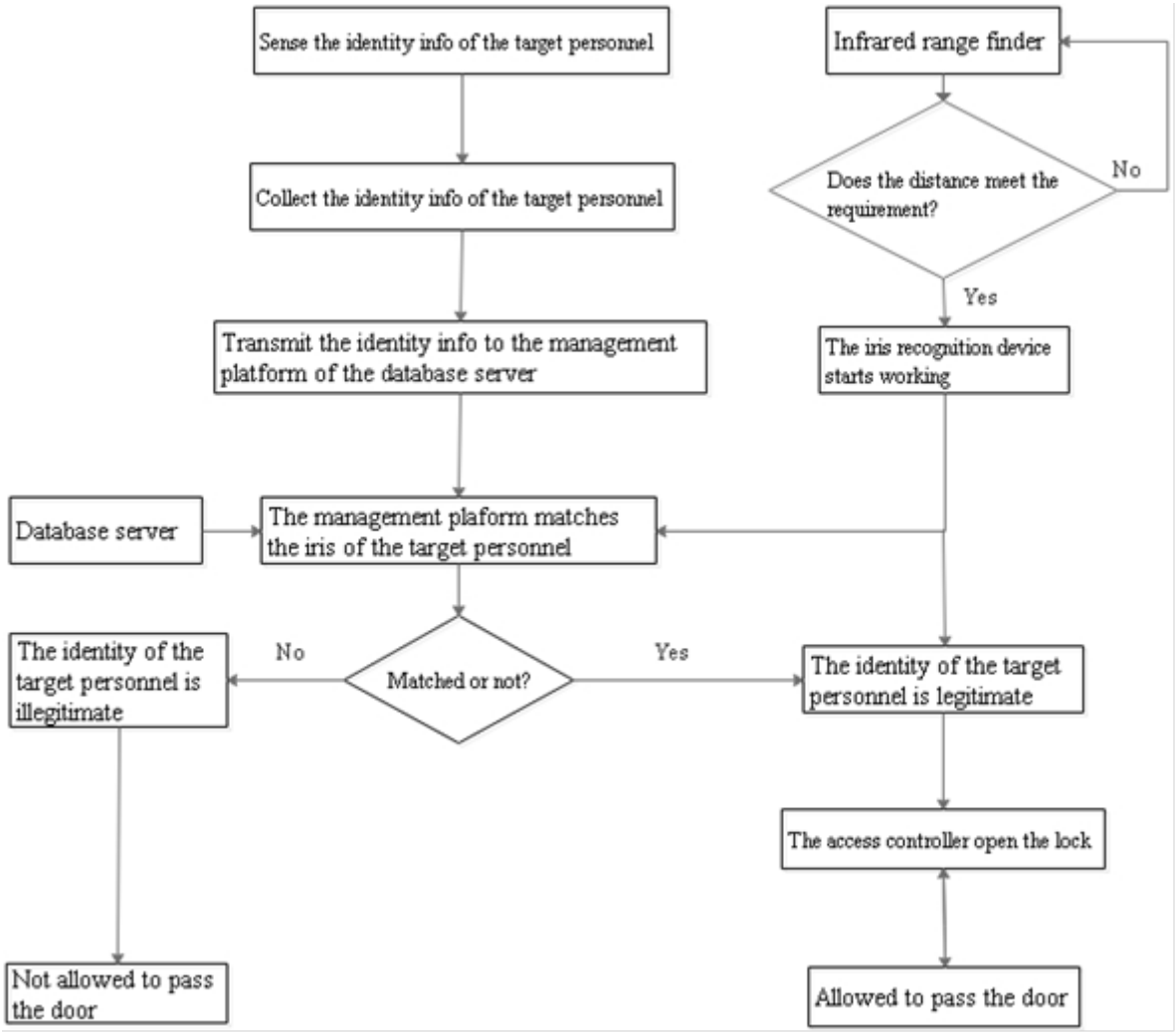

Figure 3. Flow chart of implementing the iris-recognition-based access control management system

The system is implemented in the following steps:

Step 1: The contactless smart card device detects in real time whether there is a target personnel at the access control. When sensing a visitor, the system is triggered to start.

Step 2: The contactless smart card device collects the identity information of the target personnel on site and transmits it to the access control management platform over the network;

Step 3: When the distance between the target personnel's eye and the infrared range finder is within the range of 25 to 35 cm, the green LED light is on and the iris recognition device starts to work.

Step 4: The management platform matches the iris information of the target personnel and compares it with the original iris samples of the target personnel stored in the database server;

Step 5: The management platform determines whether the iris identity of the target person collected on site matches the iris samples stored in the database server. If so, the target person's identity is

considered legitimate and you can jump to step 6. If not, the target person's identity is considered illegitimate and the access control is not opened.

Step 6: The management platform judges that the iris identity of the target person is legitimate, and the system then opens the access control through the access controller.

6. Summary

Iris recognition, as an key trend of biometrics recognition, is an important branch of artificial intelligence. Compared with the access control systems based on the existing technologies, the iris-recognition-based access control management system has a lot of advantages. Its design integrates the infrared sensing technology, human-computer interaction technology, data transmission technology, and communication technology. It utilizes the iris recognition algorithm in the iris recognition technology to improve the precision of recognition. Therefore, this design can efficiently identify and authenticate personal identity. In addition, this design features high reliability, low cost, small volume, complete functionality, and strong scalability on information collection.

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