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Intelligent Community Access Method based on Face Recognition under Epidemic Conditions of COVID-19

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Abstract

The epidemic of COVID-19 is sweeping across the globe, its spread is very rapid and wide with its continuous deterioration. Efficient community access is an effective way to control the spread of the epidemic. This article describes a way using face recognition technology to effectively prevent epidemics in community buildings under the outbreak, and we propose a novel face recognition access control system based on principal component analysis technology. We evaluate the proposed face recognition access control system, experimental results show the satisfied performance.

Keywords

Face recognition, epidemic prevention, building intelligence, principal component analysis.

1. Introduction

The epidemic of COVID-19 spread very fast, spread between people, a wide range of, with its continuous deterioration, people in the community buildings for face recognition technology all the continuous improvement, the technology is also widely used in the meantime. Face recognition technology is a biometric technology based on human facial feature information. Use the camera or camera to capture images or video streams containing faces, and automatically detect and track faces in the image, which in turn gives the location, size and location of each face organ, and based on this information, further extract the identity characteristics contained in each person's face, and compare it with known faces, thus identifying each face of a series of related technologies. Face recognition technology Face recognition is now widely used in work clocking, payment, access control, security and other areas.[7]

At present, the mainstream face recognition research mainly contains two aspects, one is based on the overall research method, it takes into account the overall properties of the pattern, including the feature face method, SVD decomposition method, hidden Markov model method, face and other density line analysis and matching method, elastic map matching method and neural network method. The second method is feature-based analysis, where the relative ratio of the face reference point and other shape parameters or category parameters that describe the face's facial features form an identification feature vector. Recognition based on the overall face not only retains the topological relationship between face parts, but also retains the information of various parts themselves, while part-based recognition is to design the recognition algorithm by extracting local contour information

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and grayscale information in the face. Face recognition system is generally divided into four main steps: Face detection;Face alignment; Feature extraction; Feature matching.

Face detection in life is mainly used for the first processing of face recognition, the ability to accurately calibrate the position and size of the face in the image Its pattern characteristics are very rich, such as color features, structure, etc. Face detection is about picking out the useful information, removing the useless information, and finally taking advantage of these characteristics. [8]

With the continuous development of face recognition system technology, the application of more and more wide range of fields, many have been applied in smart campus, smart office, smart home, smart buildings, smart community management and other fields, of which, the application in the construction of smart community, should be the most common scenario.

The current intelligent access control system to card class, fingerprint device or digital password unlock mainly, these identification methods require people to operate at close range, when the user's hands are occupied appears extremely inconvenient, but also bring card or password loss, forget, copy and theft of hidden dangers, at the same time for property management cannot confirm whether the user is a resident of the community. In the smart community, the use of face recognition system, with non-replicable, can free the hands of people in and out, bring more convenient access management, but also more efficient and safer. Face recognition system only needs the community owners to enter information into the system in advance, after each time in and out of the community do not have to bring a card, walk to the gate on the automatic opening, the user experience will be very good.[9]

In contrast, the non-replicable face recognition technology makes people face recognition access control machine more security and stability, is the first choice for community building safety, through the video control system can identify unidentified people sneaking into the community, timely warning, to ensure community security. Traditional access control methods have been eliminated, and face recognition access is gradually becoming the standard of the "smart community". [10]

2. Our Method

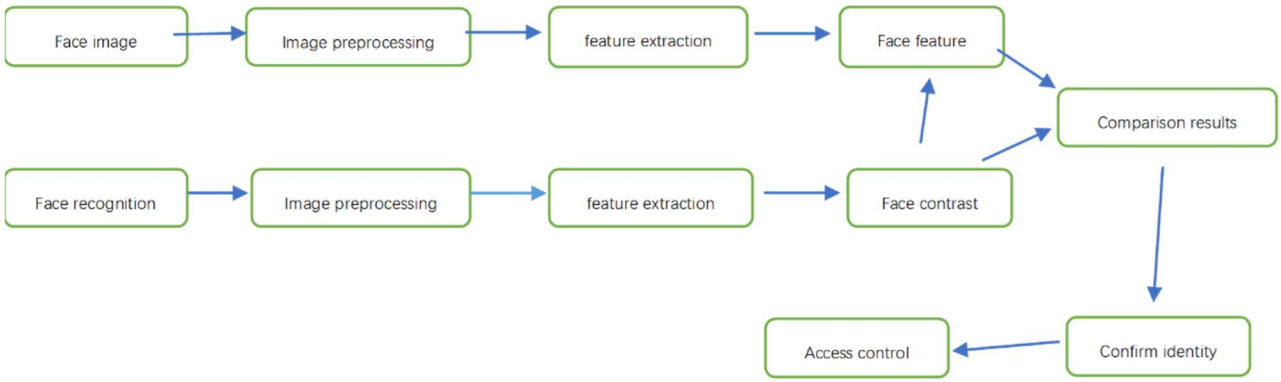

Figure. 1 The main technological process of our method

From the perspective of face recognition process, it is necessary to obtain face image information first. A series of acquisition devices are used to complete a large number of image acquisition for the target population and input into the computer information database. Because it is necessary to consider the definition of the image, the objective environment at the time of shooting, such as shooting, light intensity and other factors, these effects should be eliminated as much as possible through preprocessing. Compared with human eyes relying on physical and structural features for face memory and recognition, computers need to extract mathematical features in visual processing, and obtain feature data through covariance matrix calculation, sample average statistics and other operations. Therefore, machine learning needs a large number of data samples. If PCA algorithm is used to extract the main information and reconstruct the original high-dimensional vector, it can provide support for face recognition. In the feature matching stage, the features extracted from the

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obtained image need to be compared with the face feature samples in the database to realize matching analysis, and finally make the face recognized effectively.

2.1 Face recognition based on PCA

As one of the biometrics technologies, face recognition is based on the information of human facial features. It collects image sequences containing human faces through the camera and carries out an examination in the corresponding image. It is widely used in authentication and video retrieval in many fields.[11] Because of the high-dimensional and sparse distribution of human face images, it is difficult for computers and other intelligent devices to process face recognition data, which requires a lot of calculations. Texture feature extraction of face image is the basic stage of face image recognition, and to fully understand this stage is important to improve the efficiency and correctness of face image recognition successfully.[2]

There is a large amount of burdensome information in a face image which will not affect the operation and realization of face recognition, but will seriously slow down its speed and accuracy.[12] In order to reflect only the main information of the image, the eigenvectors corresponding to the multi-dimensional eigenvalues are chosen to replace the original vectors by calculating the contribution rate of the eigenvalues. The aim is to reduce the computation time of feature extraction without affecting the accuracy of recognition.[2]

Principal component analysis (PCA) is mainly used to extract important texture features of face images in face image recognition. The initial idea of this algorithm is to reduce unnecessary computation by removing the parts which are not related to the human face in the image.[1] In order to achieve pure face region segmentation, use the function to filter the image for the purpose of getting the position of the face, and use the convolution operation to obtain the feature vectors for the purpose of establishing the face geometric model. After completing the image pre-processing process, first use the PCA model to extract the feature vectors of the face image in order to select the main feature vectors among them, and then complete the high-precision recognition of the features based on the calculated similarity measure.

In the next step, PCA improves the speed of recognition by reducing the dimension of high-dimensional raw data. Take the face image and convert it into an original matrix by column. By taking the cross product of the original matrix with the linear transformation matrix, a new matrix with less computation is obtained, which only records the main features of the face image.[13]

Procedure:

1). non-capitalized x is the element selected by column from the face image. $X_1, X_2, X_3, \cdots X_N$ form the original matrix X.

2). Taking the cross product of the original matrix X and the linear transformation matrix B to form a new matrix Y, where each element y contains information of row and column. The specific process is shown in Formula 6.

$$\mathrm{Y} = BX = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ \cdots \\ B_K \end{bmatrix} \begin{bmatrix} X_1 X_2 X_3 \cdots X_N \end{bmatrix} = \begin{bmatrix} B_1 \cdot X_1 & B_1 \cdot X_2 & B_1 \cdot X_3 & \cdots & B_1 \cdot X_N \\ B_2 \cdot X_1 & B_2 \cdot X_2 & B_2 \cdot X_3 & \cdots & B_2 \cdot X_N \\ B_3 \cdot X_1 & B_3 \cdot X_2 & B_3 \cdot X_3 & \cdots & B_3 \cdot X_N \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ B_K \cdot X_1 & B_K \cdot X_2 & B_K \cdot X_3 & \cdots & B_K \cdot X_N \end{bmatrix} \tag{1}$$

3). Compare the new matrix Y, which contains the main features, with the matrix generated from the face image which needs to be recognized in the system, and it leads us to get quick access to the result. [1]

In the process of sample classification, it is also assumed that the sample has n features. By calculating the sample average value and dispersion matrix SW, the projection direction can be selected and the sample can be projected to one-dimensional space y. The spatial boundary points can be found and

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classified according to the association between projection points and boundary points. For example, when the mean vector of each sample is Mi, the dispersion matrix between sample classes satisfies:

$$S_b = (m_1 - m_2)(m_1 - m_2)^T \tag{2}$$

If you want to keep a large distance in the projected one-dimensional space, you need to make the sample mean difference (m1-m2) large to maximize the distance between classes. At the same time, minimizing the distance between classes can keep each sample close. To obtain the vector w *, it is necessary to complete the construction of the classification criterion function to obtain:

$$J_F(\mathrm{W})=\frac{W^T S_b W}{W^T S_w W} \tag{3}$$

Since w * = Sw - 1 (m1-m2), projection of all samples can obtain:

$$y = (W^*)^T X \tag{4}$$

and dispersion matrix of each sample in one-dimensional space can be obtained. For a given original variable x, y is obtained by projection in w *, and the classification can be completed according to the size ratio of y to Y0. When calculating the covariance of sample data, the obtained matrix Σ=(Sij)p × P (I, j = 1,2,..., P), and complete the eigenvalue λ I and the corresponding orthogonalized unit eigenvector AI are analyzed. According to the contribution rate of principal components, the screening of important principal components can be completed. The product of the average eigenvalue of the principal component FI and the original variable XJ coefficient is the principal component load, which can reflect the correlation degree between it and the original index, and obtain:

$$l_{ij} = \sqrt{\lambda_i} a_{ij} \tag{5}$$

By analyzing the scores of different principal components, the sample feature evaluation can be completed, and the following results are obtained:

$$F_i = a_{i1} y_1 + a_{i2} y_2 + \cdots a_{ip} y_p \tag{6}$$

2.2 Control mode of access control system

The common methods of access control include radio-frequency card, fingerprint, face recognition, etc. The opening and closing of the door are managed by the electronic door lock system, with the addition of a buzzer as an alarm device. First enter all personnel information into the system, and then compare the information stored in an individual's RF card, fingerprint, face, etc. with the information stored in the system when he or she tries to get access to the protected area. If the two information matches, the electronic door lock system will automatically open the door while recording the entry. If the match fails, the system will activate the buzzer to alarm.[3]

When a person enters or leaves a protected area, the signal generated by the access control system, which is typically the information stored in a radio-frequency card, will be displayed on the monitor. The signal is compared with the information within the system. The gate will be opened if the two information matches, and vice versa.[4]

At present, the PLC system is mostly applied to the management of people in and out of a protected area. Its high degree of intelligence makes it easy to operate in the real world. Users can utilize the system to monitor the entry and exit of people and save the records of all entries and exits to reach the purpose of helping a protected area to achieve unsupervised management.[3]

Main functions of the PLC system:

1). Recognize a person's identity by using the information stored in his or her radio-frequency card as he or she enters or exits the protected area.

2). Manage the inlet and outlet gates of the protected area by controlling the motor. The forward rotation of the motor causes the gate to rise and the reverse rotation causes the gate to fall.

3). Display and continually update the number of people who can be accommodated by the protected area. Since the number of people entering and leaving the protected area can be calculated using the number of rotations of the motor, the system is able to provide a new number of remaining living

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space for each change in the total number of people. In the epidemic, it is necessary to control the number of people entering and leaving the protected area in order to prevent the spread of the virus.[4] [5]

Taking a vehicle into a garage as an example, the prerequisite is to install a screen at the inlet gate that displays the number of remaining parking spaces. The system uses its license plate recognition function to detect a vehicle when the vehicle starts to enter or leave the garage. If the recognition succeeds, the inlet or outlet gate will be controlled to rise. When the vehicle is overall into the garage, the inlet gate is controlled to drop and the number of remaining parking spaces is reduced by one in the system. And when the vehicle is overall out of the garage, the outlet gate is controlled to drop and the number of remaining parking spaces is increased by one in the system. When the number of parking spaces left reaches zero, the system automatically recognizes that the garage is full and closes the inlet gate to prevent more vehicles from entering. The system will also record all incoming and outgoing vehicle information for future inquires.[5]

2.3 Access control system process

The design of the access controller defaults that the initial state of the door lock is closed. The facial images of visitors are collected through the driverless camera and transmitted to the server. Run the face recognition algorithm on the server to judge whether the face identity matches the database. If the face image at this time determines that there is corresponding face data in the access control face database through the recognition algorithm, it indicates that the information is safe. The computer sends the door opening command to the access controller, and the access control is opened. On the contrary, the door lock remains closed at all times. The execution of various commands of the access control controller is mainly controlled by the computer on the server. When there is a face image to be recognized in the access control face database, the server sends a matching success signal to the access control controller. At this time, the sent command sets the gpod port of the access controller s3c2440a to 0, and opens the door lock through driving so that visitors can pass through; If there is no recognized face image in the access control face database, the gpod port of the access control controller is set to 1, the door lock remains closed and visitors are not allowed to enter and exit

The circuit diagram of the access controller is shown in Figure 2.

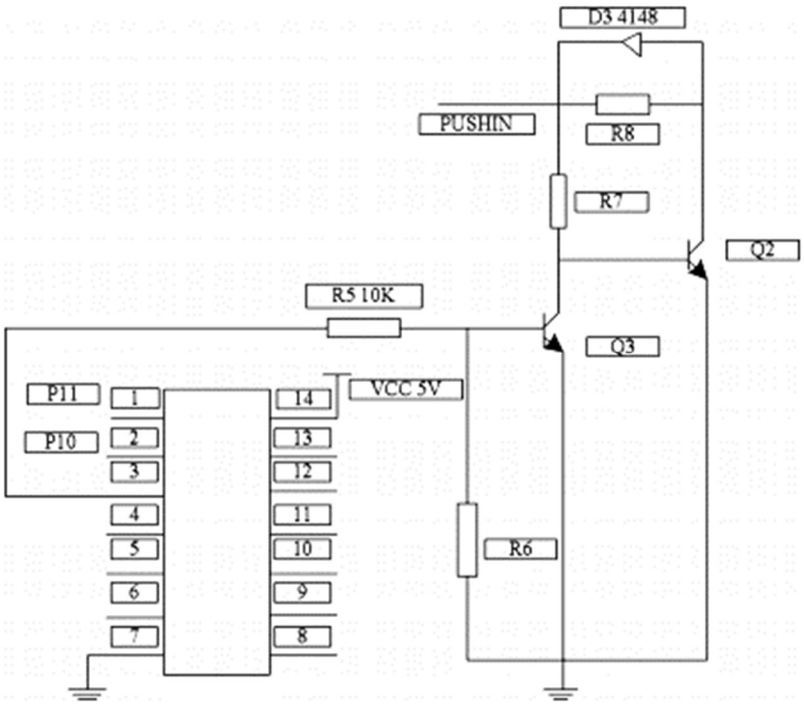

Figure 2. Access control automatic control circuit

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In the above process, three bit variables are used as identifiers to represent the status of the current door lock, namely lock_ c, lock_ O and lock_ a. The meaning represented by the value of identification is shown in Table 1.

Status serial number	lock_c	lock_o	lock_a	EXPLAIN
1	0	1	0	Access control closed
2	1	0	0	The access control is waiting to be opened, and the door is opened after a delay
3	0	0	0	The door closing signal has been sent, and it is not confirmed whether the access control is closed
4	0	0	1	If the door closing signal has been sent out but the door is not closed, an alarm will be given

Figure 3 Door lock status table

Under normal conditions, after initializing the access controller, the default door lock is closed under normal conditions. When the camera scans the visitor's face image, face recognition starts. After the face recognition algorithm is completed, it is judged that there is a face image in the access control database. The program enters the door opening process, drives the relay to open the door, sets the same line delay, closes the door lock after the delay, and saves it in the database after a few minutes. The storage format is "personnel ID (32-bit binary) - access direction" (1 byte) - access time (7-Bit BCD code). So as to realize the face recognition access control system under the epidemic situation, and has the two functions of face recognition, opening the door and recording the access.

3. Experimental Results

3.1 Algorithm implementation

In the implementation of the algorithm, when the length and width of the two-dimensional face image are m and N respectively, it can be regarded as Mn column vector, which needs to calculate the m * n value of the image first. Transpose operation is realized according to rows, image gray value extraction can be realized according to columns, and one-dimensional vector matrix t is obtained. By preprocessing the graph, the average value of one-dimensional column vector can be obtained. Matrix A can be obtained by using the array to reduce the average value of each column. Using a to realize sample training, the dimension can reach M × N × P. The covariance matrix C can be obtained by multiplying with transpose, and the dimension is (MN) 2. Due to the high dimension, PCA algorithm is also used to reduce the dimension. C = AAT can be used to realize the construction of matrix L, and L = AAT ∈ RM can be obtained × m. By calculating the eigenvalue and vector, the value exceeding 100 can be selected as the eigenvalue of C, and then the eigenvector is calculated again to generate the eigenface image. In the face recognition stage, the image is extracted from the database

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through sample training. After obtaining the feature database, the sample test can be carried out. For the face to be recognized, the extracted features are compared with the sample distance in the database, and the image with the smallest distance is regarded as the result, so as to complete face recognition. In order to determine the implementation effect of the algorithm, MATLAB software is also used for programming, and 400 face images are obtained from face 94 Essex face database. When the proportion of sample images exceeds 65%, the remaining 35% image data is used for face recognition test after sample training. It can be found that the face recognition rate can reach more than 92%, which can meet the application requirements of face recognition technology

3.2 Experimental Evaluation

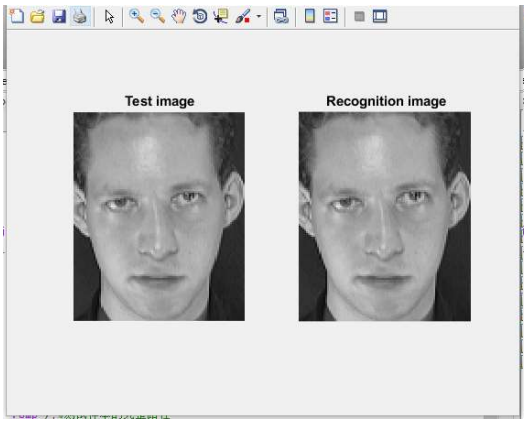

Figure4 No. 1 face sample

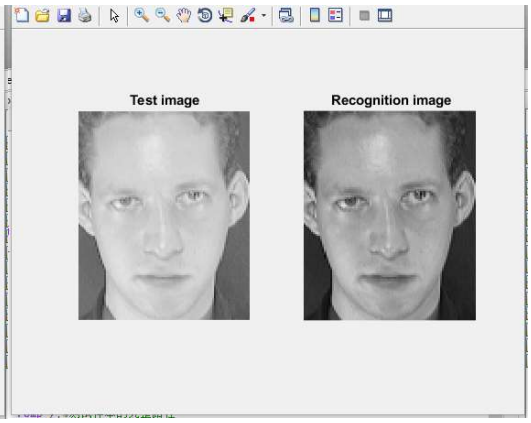

Figure5 No. 2 face sample

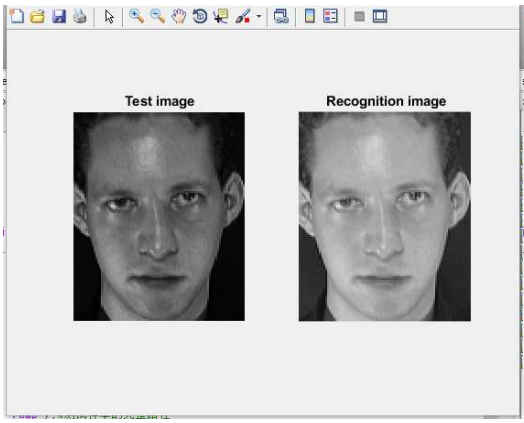

Figure6 No. 3 face sample

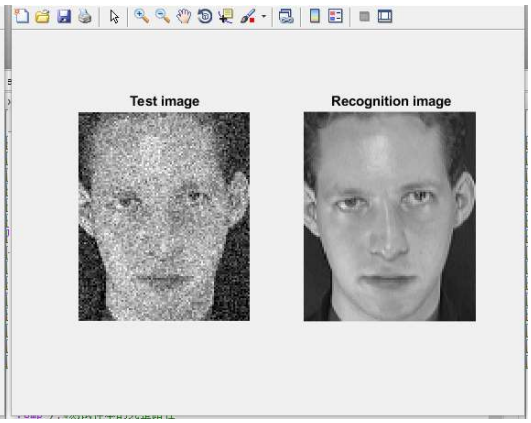

Figure7 No. 4 face sample

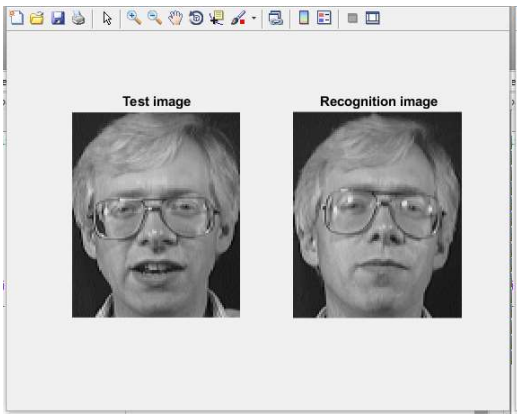

Figure8 No. 5 face sample

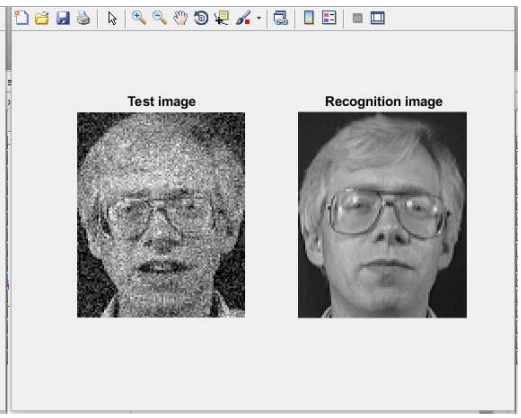

Figure9 No. 6 face sample

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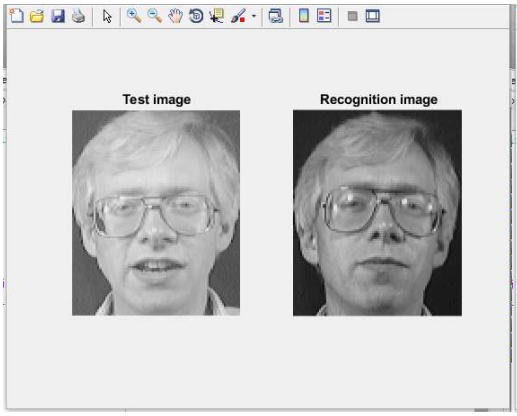

Figure10 No. 7 face sample

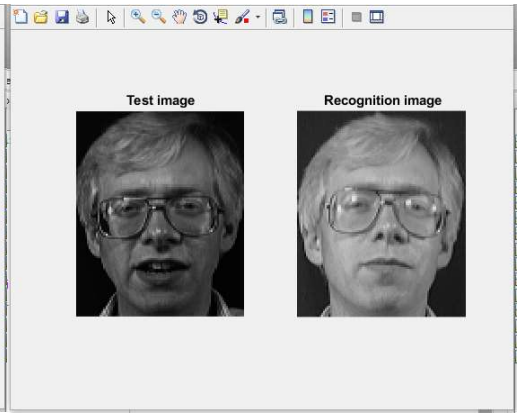

Figure11 No. 8 face sample

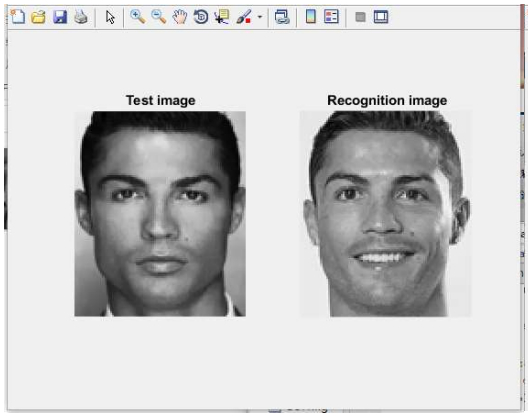

Figure12 No. 9 face sample

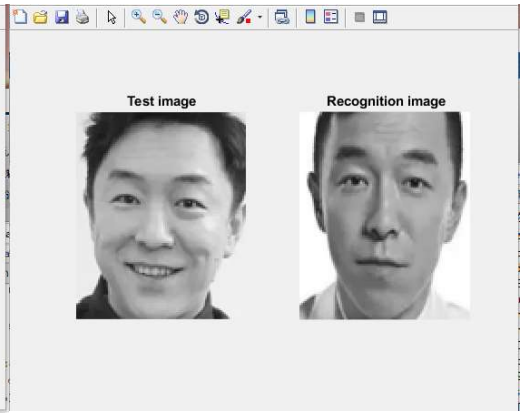

Figure13 No. 10 face sample

Based on the above theory, experimental research is carried out. It is realized in MATLAB, and the corresponding results are given. Method: a series of experiments are carried out in the laboratory. The database contains photos of 40 people. Each person has 10 photos and 400 photos in total. 92 per image × 112, each image has 256 gray-scale pixels. For some subjects, these images are taken. At different times, the light changes slightly, facial expression (open / close eyes, smile / no smile) and facial details (wear glasses / no glasses). All images were taken under a dark uniform background, and the subjects were in the upper right and front positions (some side movements were allowed). In our experiment, the image was not processed. We divide the whole database into two parts on average. One part is for training and the other part is for testing. Compared with using the improved method and not using the improved method, the recognition rate verifies the effectiveness of the improved method. Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, Figure10 and Figure 11 respectively prove that the algorithm can still have strong stability when the brightness and clarity of the picture are greatly different from the original image. Figure 12 and Figure 13 show that the program is also applicable when recognizing images outside the face database So we think we prove the effectiveness and stability of the method.

4. Conclusion

In an epidemic that can easily spread from person to person, it is important to identify the person who is willing to pass through the access control system quickly and accurately. Allowing an unidentified person into a protected area can cause incalculable security risks and property damage to people in the area. Through the combination of PCA in the access control system, the face recognition function is successfully brought to the inlet and outlet gate of the protected area, which makes the identity of the person entering and leaving can be recognized more directly.

PCA's perfect functionality of improving the accuracy and speed of face recognition leads it to be widely used in the field of identity recognition. Compared with other systems, it has the advantages of less sampling points, fast operation speed and higher degree of recognition. For places that need to ensure security, the use of the access control system plays a protective role for personnel. At the same time, its access records also provide convenience for future inquiries.

The PLC system achieves the unmanned management of the parking lot and enables its users to find the parking space for his or her vehicle more quickly under the difficulty of parking in cities. Compared with other systems, it has the advantage of saving human resources and saving time for its users.

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