Infrared Image Face Recognition Method Based on Signal Interference Technology

Zongren Chen(✉) and Wenda Xie

Computer Engineering Technical College (Artificial Intelligence College), Guangdong Polytechnic of Science and Technology, Zhuhai 519090, China
chenzongren210@sina.com

Abstract. Infrared imaging has the advantages of strong anti-interference, independent of visible light source, anti camouflage and anti fraud. Therefore, an infrared image face recognition method based on signal interference technology is proposed. Based on the in-depth analysis of the characteristics of infrared face image, the characteristics of infrared image face recognition are studied, and a new infrared image statistical face recognition method is proposed. The experimental results show that the recognition method studied in this paper is feasible both theoretically and experimentally, and has good recognition ability. The infrared image face recognition method can solve the difficult problem of face recognition under the change of lighting conditions and face camouflage.

Keywords: Signal interference technology · Infrared image · Face recognition · Anti interference · Visible light source

1 Introduction

Face recognition technology has received more and more attention in the field of computer vision and pattern recognition, and has gradually become a hot topic. At present, most face images are taken under visible light conditions, but in visible light environment, the illumination conditions are changeable and complex, and the performance of face recognition is affected by the environmental illumination changes. Therefore, overcoming the influence of illumination changes has become an important problem in the field of face recognition [1]. Due to the robustness of NIR imaging to illumination changes, NIR imaging technology solves this problem to some extent. In the application of near infrared face recognition, the face images required for registration and detection are taken under the condition of near infrared illumination, while in practical application, a large number of face images are taken under the condition of visible light, such as ID card photos. So it becomes a problem to realize the cross registration and verification of visible light face image and near-infrared face image. Because of the different imaging methods, there are many apparent differences between visible light image and near-infrared image of the same person [2]. However, from the perspective of human cognition, they should be recognized as the same person, which means that there is some

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correlation between the visible image and the near-infrared image of the same person. This paper will introduce the improvement of the performance of the visible light and near-infrared face recognition algorithm from two aspects. In recent years, the infrared image face recognition is a hotspot of biometrics research, which has a wide range of application value and challenge. Theoretically speaking, infrared image face recognition can solve the difficult problem of face recognition in the case of changing illumination conditions and face camouflage. But at the same time, it should also be seen that the current research on infrared image face recognition is not mature enough, and the mechanism of many factors affecting the performance of infrared image face recognition is not very clear. In addition, infrared image face recognition also has its disadvantages [3]. Therefore, when carrying out the research work of infrared image face recognition, it is necessary to deeply analyze the characteristics of infrared face image and the related factors that affect the performance of infrared image face recognition, so as to explore and study the effective ways and methods to improve the performance of infrared image face recognition.

2 Infrared Image Face Recognition Based on Signal Interference Technology

2.1 Face Feature Extraction from Infrared Image

Face detection is to find out all the regions containing faces in a given image. Visible face detection methods mainly use local feature detection methods, such as detecting eye position. However, the effect of this kind of method in infrared face detection is not very good, because the infrared face image is fuzzy compared with the visible image [4]. Because human skin has high emissivity, and the emissivity is not affected by race and skin color, face detection based on global features is often used in infrared face recognition. The automatic face recognition system includes two main technical links, as shown in Fig. 1: one is face detection and location, that is, find the face from the input image and segment the face from the background; the other is feature extraction and recognition of the planned image.

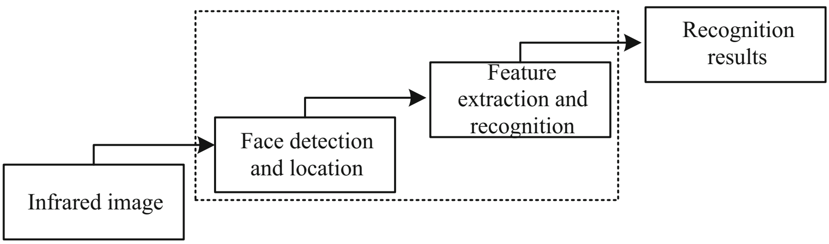


Fig. 1. Feature extraction steps of the planned image

The geometric preprocessing of infrared face image mainly refers to whether the relative positions of the key parts of the face in each infrared face image are the same.

For the original infrared face image without any processing, the position of the face part in the image is offset. When the face recognition method based on overall gray statistics is adopted, it will affect the correct recognition of the face [5]. Therefore, the input infrared face images should be corrected so that the infrared face images in different cases are unified to the same pixel size, and the key parts of the face should be consistent as far as possible. For the extraction of face features, a pyramid recognition method based on signal interference is proposed. Using this method combined with signal interference sub pattern, face can be recognized efficiently [6]. The specific process of extracting signal interference sub mode features is shown in Fig. 2.

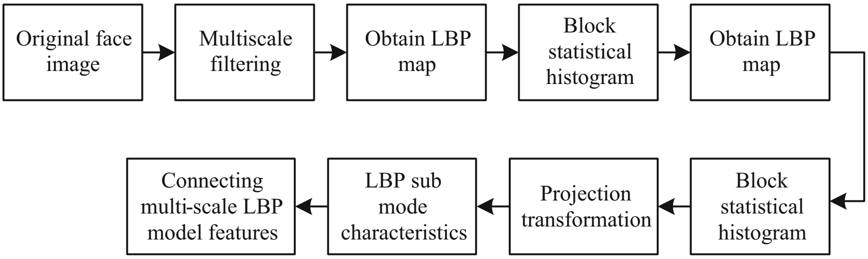


Fig. 2. Flow chart of infrared image feature extraction

The specific extraction steps of sub pattern features can be obtained from Fig. 2: select a filter with strong de drying effect to carefully filter and decompose the face image to remove redundant impurities, and build a low-dimensional image with multi-scale space on this basis; The signal interference operator is used to calculate the dimension of different scale images, so as to obtain the characteristic spectrum data; By dividing different characteristic spectra, the module area with non repetitive attribute can be obtained and the histogram data inside the area can be counted; The operator histograms of different regions are mapped by projection, and the sub module features of different regions can be obtained after transformation; By splicing the sub module features of all regions, a multi-scale sub module sequence can be obtained, which can be used as a feature vector for face recognition. When constructing face recognition image and signal interference map, it is necessary to select the image division level and decomposition area size according to the actual situation of different people [7].

2.2 Infrared Image Face Feature Recognition Algorithm

Different faces have different facial features, but their spatial macro structure is consistent, that is, eyebrows, eyes, nose, mouth and so on have similar distribution. From the local view of human face, the structure of each local feature is also similar. For this rule of face structure, Wiskott 2 A special shape label graph is used to represent the face. The nodes of this label graph are located in the meaningful positions on the face image for recognition. These positions are called the feature points of the face. In the vertical direction of the face, the distance from the hairline to the eyebrow arch, the eyebrow arch to the nose and the nose to the chin is generally the same, while in the horizontal direction of the face, the distance from the outer corners of both eyes to the ears is the same. The distribution map of various organs of the face is shown in Fig. 3.

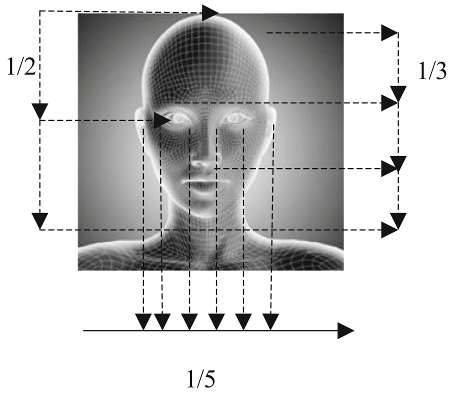


Fig. 3. Distribution of various organs of human face

It can be seen from Fig. 3 that the width of eyebrows is twice the width of both eyes, the nose is located from the center of eyebrows to 1/2 of the bottom of chin, the length from nose root to chin is half of the length of face, the septum of nose is connected with people, the bottom of nose is flush with ears, and the height of ears can be determined by the highest point of eyebrows [8]. The length of the tissue around the mouth is 2/3 of that from the nose to the chin. The distance between the two eyes is consistent with the width of the mouth. The two horizontal lines printed on the upper part of the eyebrow and the bottom of the nose run through the whole ear. According to the response characteristics of two-dimensional Gabor signal interference, it can be seen that the transformation coefficient reflects the change of image gray level, The parts with obvious gray change on the image are easier to locate the feature points than those with gentle gray change. Therefore, the selection of feature points should first consider these parts, such as eyebrows, eyes, nose, mouth and face contour, but ensure that all feature points can cover the face area of the image relatively evenly. By matching with the face moving picture, we can get the label graph representation GM of the training image and the label graph representation g of the image to be recognized, calculate the average value of the similarity between the label graph G of the image to be recognized and the label graph GM of all training images, and use the nearest neighbor rule to maximize the similarity. The training image is the recognized face image. The similarity between label graph G and label graph GM is defined as:

$$S_G\left(G', G^M\right) = \frac{1}{N}\sum_n S_a\left(J_n^l, J_n^M\right) \tag{1}$$

The coarser the position of the feature set is, the more similar the position of the feature set corresponding to the actual sample is to the position of the feature set [9], and the position of the feature set corresponding to the image is formed. The grid structure composed of all edges of the label graph describes the geometric characteristics of the face. For different face images, the shape and size of the grid structure change accordingly. Through signal interference matching, the nodes of the label graph of all face images are unified to the selected corresponding feature points. Therefore, signal interference matching has become a method of locating face feature points. In terms of image processing and analysis theory, any image can be regarded as an element of high-dimensional space. Using statistical model to describe and analyze the target image has become a research hotspot in recent years [10]. By manually locating the eye coordinates, you can judge whether the two eyes in the infrared face image are on the same horizontal line. If they are not on the same horizontal line, rotate and transform the infrared face image to make the two eyes transform to the same horizontal line, so that the infrared face image can be zoomed and cropped next. The rotation transformation formula is as follows:

$$[x, y, 1] = [u, v, 1]\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{2}$$

Formula (2) rotates the point on the u, v plane by degrees counterclockwise relative to the coordinate origin. Among them, angle 8 is the included angle between the connecting line of two eyes and the horizontal line, u, v represents the pixel coordinates in the image before rotation, and x, y represents the pixel coordinate transformation in the image after rotation, which can transform the inclined infrared face image into the face image with two eyes on the same horizontal line, and then carry out the geometric transformation in the following steps. Although the two eyes of the rotated infrared face image r are on the same horizontal line, the distance between the two eyes is different. Therefore, all infrared face images need to be transformed into images with the same size through zoom transformation. The zoom in and zoom out transformation first calculates the zoom in and zoom out ratio in the length and width of the original image and the standard image, and sets it as a, b respectively. When r > 1 (i = x or y), the image in this direction is enlarged; When r < 1, the image is reduced. The scaling transformation formula can be expressed as:

$$[a, b, 1] = [x, y, 1][u, v, 1]\begin{bmatrix} r_x & 0 & 0 \\ 0 & r_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{3}$$

The algorithm uses r for zoom transformation. In the actual infrared face image zoom transformation, the scaling ratio in the horizontal and vertical directions is the same, which is the ratio of the distance between the two eyes of the standard infrared face image and the distance between the two eyes of the original infrared face image. According to the above rotation and zoom transformation, all infrared face images can be transformed into images with two eyes on the same horizontal line and the distance between two eyes is the same. Histogram equalization method is used to preprocess the gray level of infrared face image. The gray histogram of an image is a discrete function about the gray value of the image. It describes the number of pixels with the gray value in the image. Its abscissa represents the gray level of the pixel, and its ordinate is the frequency of the gray level (the number of pixels). Histogram equalization, also known as gray-scale equalization, aims to convert the input image into an output image (that is, the histogram of the output image is flat) network with the same number of pixels on each gray level through point operation. Through histogram equalization, the histogram distribution of a given image is changed into a uniformly distributed histogram, which increases the contrast of the image. For the image with small contrast, the distribution of gray histogram is concentrated in a small range. After histogram equalization, the probability of all gray levels of the image is the same. At this time, the entropy of the image is the largest and the amount of information contained in the image is the largest. Gray histogram is an important statistical feature of image and is considered to be the approximation of image gray probability density function. The probability of occurrence of gray level R in a gray image is:

$$p_r(r_k) = \frac{n_k[x, y, 1]}{[a, b, 1] - n} \tag{4}$$

In formula (4), n_k represents the total number of possible gray levels in the image, and n represents the total number of pixels in the image, that is, the number of pixels with gray level r. $p_r(r_k)$ represents the probability of occurrence of the kth gray level of the original image.

2.3 Realization of Face Recognition in Infrared Image

If the unique face code can be extracted from each face, it can be recognized directly without matching and comparing with each face in the database. On the basis of observing the difference of each person's symmetrical waveform, we can consider using the coding method, which extracts the one-dimensional bar code from the symmetrical waveform. The conversion from symmetrical waveform to bar code seems easy, but it is not. The conversion process requires complex calculation. After 1-dimensional bar code, you can also try 2-dimensional bar code. The method is to establish a database first. In this database, the face is divided into many small units and each small unit is encoded. Calculate the face edge azimuth field T_{global} and the sample edge azimuth field $\{T_{global,n}|n = 1, 2, ..., N\}$ for comparative analysis. The distance between the calculated azimuth fields is $d_{global,n} = D(T_{global}, T_{global,n})$. The similarity between the samples given by set $\{d_{global,n}|n = 1, 2, ..., N\}$ and the overall structure is detected.When recognizing a face image, first segment the face, compare each segmented block with the content in the database, find the most matching block, and then assign it with the code of the block in the database, so as to form a two-dimensional bar code. This method looks promising, but it needs an optimized database containing a large number of face images. The local motion feature points of human body with pseudo feature points removed are processed by windowing method. After appropriate windowing, multiple pieces of information are extracted from one of the window feature points to form a feature vector to characterize human motion behavior. If people are at rest, the acceleration remains unchanged; If people are in motion, the acceleration changes constantly. Therefore, different accelerations are used to distinguish the static and dynamic behavior of the human body. According to the calibrated data, reconstruct the face 3D image. The specific steps are shown in Fig. 4.

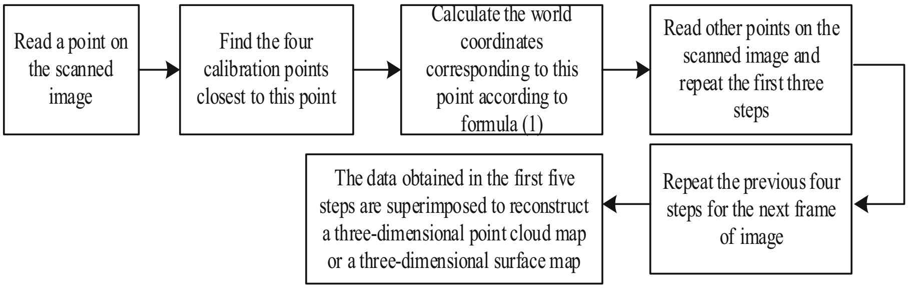


Fig. 4. 3D face image reconstruction process

According to the process shown in Fig. 4, the three-dimensional image of human face can be obtained to provide support for detailed feature location. The face image is an image composed of high-dimensional data, which is unevenly distributed in the high-dimensional space. From the perspective of pattern recognition, the intra class variance of multi-scale LBP sub pattern is large, mainly due to the relatively clear face image, The detailed information contained in it can not distinguish individual characteristics. However, the inter category variance of multi-scale LBP sub model is small, which is helpful to distinguish the different characteristics of the same individual. From the perspective of pattern recognition, the more detailed the details, the greater the intra class variance of multi-scale LBP sub patterns, the greater the probability of sample dispersion, and the fuzziness between categories. At this time, the recognition effect is the worst. In order to obtain face image information, the module needs to be more compact, so as to reduce the intra class variance. At this time, dimension reduction measures need to be taken, Extract more important features with recognition degree. To judge whether the result is valid or not according to the selected features, the category criterion should have different attributes, that is, the distance of the average value vector of different category features is the largest, and the sum of the variance of the average value vector of the same category features is the smallest. Therefore, this method is better for face recognition.

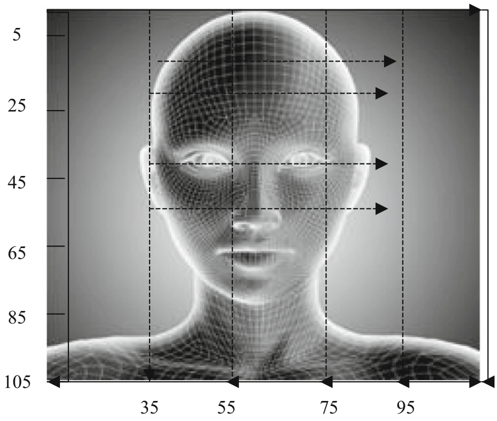
3 Analysis of Experimental Results

In order to verify the rationality of the design of face recognition technology based on signal interference, the data in the standard face database are used to verify the rationality of the technology. Firstly, the traditional PCA + LDA method is compared with the method in this paper. Because the outer face image is fuzzy and its edge features are not obvious, it is difficult to locate the feature points in the signal interference matching; The operation error of manual point selection in the process of constructing face moving map. Face recognition sampling is carried out in the sports wonderful cases section of the measurement website. The specific experimental environment is shown in Table 1:

Table 1. Configuration of simulation experiment environment parameters

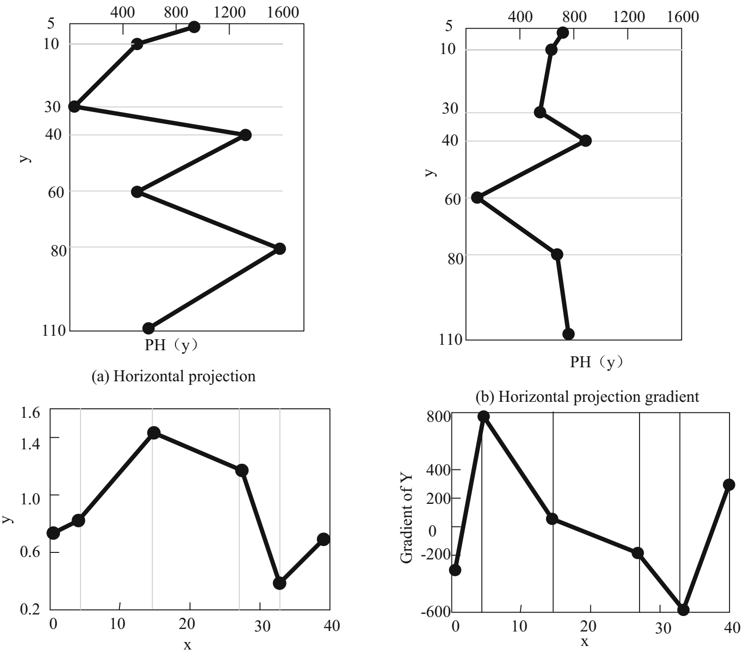
Name	Parameter content
Development environment CPU, Inter Pentium 4	3000 MHz
Memory	1.5 G
Visual image sampling sample set	800
Spectrum bandwidth distribution	5 kHz–14 kHz
Interval	0.25 ms
Sampling frequency	24 kHz

According to Table 1, in MATLAB software, the original face images (as shown in Fig. 5) and scanned images in the face database without laser scanning are projected horizontally and vertically respectively, and the face features are located according to the horizontal and vertical projection curves and integral projection gradient curves. The results are shown in Fig. 6.



(a) Original face image

Fig. 5. Original face image



(a) Horizontal projection

(b) Horizontal projection gradient

(c) Vertical projection

(d) Vertical projection gradient

Fig. 6. Horizontal and vertical projection curves and integral projection gradient curves

It can be seen from Fig. 6 that at the boundaries on both sides of the face, the sum of gray values decreases rapidly, forming an obvious peak phenomenon. In the rising process of the vertical integral projection curve, the maximum point is the left boundary of the face, and the falling will follow the right boundary of the minimum point of the gradient value. The maximum ascending gradient of the vertical integral projection curve of the left face is the coordinate position of the left eye, while the maximum ascending gradient of the vertical integral projection curve of the right face is the coordinate position of the right eye. The infrared face image is preprocessed, and then the image in the training database is used to make the adult face beam structure. The registered image and the image to be recognized are matched with the face moving image respectively to obtain the signal interference of the registered image and the image to be recognized. Finally, the similarity between the image to be recognized and the registered image is calculated to realize the classification and recognition of infrared face image. The CMC curve corresponding to the experimental results is shown in Fig. 7:

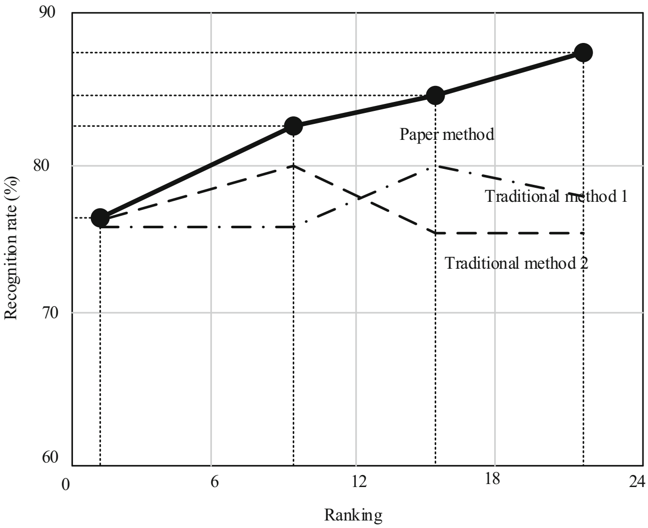


Fig. 7. Analysis of experimental results

It can be seen from Fig. 7 that the recognition rate ranked first is 81.25%. It can be seen that the face recognition method based on signal interference can realize the face recognition of infrared images. Further, the face images of 40 people are selected from the face database, with 10 images per person, including expression changes, posture changes and angle changes. The image size is selected as 90 × 110. In the experiment, each one, three and five images of the 40 people were used as training samples, and the remaining images were used as experimental test samples. The traditional recognition technology was compared with the recognition technology in this paper. The results are shown in Table 2.

Table 2. Experimental comparison results of different recognition technologies on face database

Training sample	Entry name	Traditional recognition technology	Paper recognition technology
Training sample 1	Recognition rate	0.73	0.83
	Characteristic dimension	397	597
Training samples 3	Recognition rate	0.83	0.95
	Characteristic dimension	498	712
Training samples 5	Recognition rate	0.91	0.98
	Characteristic dimension	1500	2827

Through the experimental comparison results in Table 2, it can be seen that the traditional recognition technology has low recognition efficiency, while the recognition technology based on signal interference has high recognition efficiency for face recognition.

To sum up, under the action of the method in this paper, the sum of the gray values at the boundaries on both sides of the face decreases rapidly, forming an obvious peaking phenomenon. During the rising process of the vertical integral projection curve, the maximum point is at the left boundary of the face, and the falling point will follow the right boundary of the minimum point of the gradient value. The maximum value of the ascending gradient of the vertical integral projection curve of the left face is the coordinate position of the left eye, and the maximum value of the ascending gradient of the vertical integral projection curve of the right face is the coordinate position of the right eye. Infrared image face recognition method based on signal interference technology can realize face recognition in infrared image, and has high recognition efficiency.

4 Conclusion

Face recognition technology has important theoretical value. After years of development, this technology has made great progress. Face recognition technology can obtain acceptable recognition ability in an ideal state, which has been demonstrated in several commercial face recognition systems and has been preliminarily applied. According to the subspace transformation feature structure, the signal interference sub pattern features are extracted, and the features are weighted by face feature matching. On this basis, the classification performance is analyzed. The practice shows that this technology is increasingly mature and has strong robustness and practicability. The experimental results show that this technology has high recognition efficiency.

For future work, we can conduct in-depth research, including:

(1) Infrared face image and visible face image have great complementarity. For example, visible face image is greatly affected by illumination, while infrared face image acquisition is independent of illumination conditions. Therefore, the fusion of infrared image face recognition and visible light image face recognition will be an important direction of face recognition research in the future.

(2) How to further study and analyze the statistical features of infrared face images on the basis of in-depth research on the imaging mechanism of infrared images and the characteristics of infrared face images, so as to obtain the most useful features for face recognition, understand the essential differences between them and the face features of visible light images, and effectively fuse them with the face features of visible light images at the feature layer, How to improve the performance of face recognition system in various practical applications is a topic that needs to be studied in depth.

(3) Because face recognition has a wide range of application value, in order to realize the application of infrared image face recognition in various practical situations, we must achieve the real-time performance of face recognition algorithm and the

automation of face recognition system. Therefore, one of the next research directions of face recognition is how to quickly and effectively express the features of the face itself and carry out face recognition, including the recognition of large-scale face databases, with as few constraints as possible.

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