Multi-face Synchronous Recognition Method for Civil Aviation Security Inspection Based on Deep Migration Learning

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Abstract. There is a large flow of people in the civil aviation security inspection process, and the traditional face recognition method is inefficient in synchronously recognizing multiple faces. To this end, a synchronous recognition method of multiple faces in civil aviation security check based on deep transfer learning is designed. Collect multiple face image data, and perform face image feature processing. Using deep transfer learning to build a multi-face synchronous recognition model for civil aviation security inspection, and then realize the multi-face synchronous recognition of civil aviation security inspection. The comparison experiment is used to verify that the face synchronization recognition effect of the new method is better, which is of great promotion value.

Keywords: Deep migration learning · Civil aviation security check · Multiple faces · Synchronous recognition method

1 Introduction

Identity authentication technology is playing a very important role in modern society. Especially with the rapid development of the Internet, information security has become more and more important. Identity authentication is widely used in finance, security, justice, network transmission and other application fields [1]. Currently, the most widely used methods of identity authentication mainly include logos (represented by keys, chest cards, employee cards, identity cards, etc.), specific knowledge (such as passwords, passwords, passwords, etc.) and the combination of logos and specific knowledge (such as bank cards passwords, access cards + passwords, etc.) [2]. Identification numbers, magnetic cards, IC cards and other technologies have been widely used. Although these technologies are technically mature and can be protected by information encryption and other strategies, the essence of these technologies is to add additional distinguishing information to the individual, which is easy to be lost, forged or stolen, and it is difficult to distinguish who is the real user and who is the impostor of the system. Today, with the rapid development of the information superhighway and the expanding influence of cyberspace on human beings, the reliability and methods of traditional authentication

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methods are challenged in the fields of electronic commerce, human-computer interaction, public security and network transmission, and the innovation of these technologies also put forward higher requirements for authentication methods and methods [3, 4].

Compared with fingerprint, iris and other biometrics, face recognition has many advantages, such as direct, friendly, convenient, stealthy, non-invasive, interactive and so on. Users have no any psychological barriers, and through the facial expression and posture analysis, they can get some information that other recognition systems can not get. As a result, academia and industry have focused on face recognition over the past 30 years [5]. Some scholars have used improved convolutional neural networks to recognize faces. On the basis of improving the CNN network, the ensemble learning strategy based on voting method is used to convexly combine the results of all individual learners into the final result to achieve more face recognition. However, the performance of this method in face recognition needs to be improved. There are also scholars who use the local ternary mode to extract low-resolution facial features, divide them into several blocks, and count the feature histograms of each sub-block. Face recognition is achieved by measuring the similarity of the histograms of the training set and the test set by the chi-square distance. However, the recognition of face details in this method needs to be optimized.

Face is a kind of highly non-rigid target, and there are a lot of details that reflect individual differences. First of all, the extremely complex face structure makes the face imaging itself a difficult problem, and the movement of facial muscles makes the face become a non-rigid object. Due to the influence of race, human face has different skin color models, contour models, but this difference in the same race is also different [6]. In a word, face recognition is a complex technology involving many subjects such as pattern recognition, computer vision, image processing, physiology and cognition. In order to improve the effectiveness of civil aviation security, this paper fuses the depth transfer learning with the multi-face synchronous recognition method.

2 Multi-face Image Preprocessing for Civil Aviation Security Inspection

2.1 Collect Multiple Face Image Data

The first step in face recognition is to collect face images. The quality of the collected face images directly affects the success or failure of subsequent face matching [7]. There are two types of image acquisition today: offline scanning and live scanning. In vivo scanning refers to the direct acquisition of human faces. In recent years, there have been many technological innovations in the sensors used in vivo scanning. The main types of sensors are optical sensors, silicon crystal sensors and ultrasonic sensors. Offline scanning, such as collecting the faces of criminals at the crime scene, collecting face and facial information, etc.

Optical Sensor: Optical Sensor is based on the principle of total reflection of light, light pressure on the face of the glass surface, CCD acquisition of reflected light to draw the face image, the amount of reflected light depends on the face pressed on the glass surface of the ridge and valley line depth and skin and grease between the glass [8]. Silicon crystal sensors are small in size and low in power consumption, but are easily affected by static electricity, are easily damaged, and cost more than optical sensors. Ultrasonic sensor: Ultrasonic sensor is considered to be a very good way of face imaging technology, and its process is very similar to the laser in optical scanning. In an ultrasound scan, the dirt and oil accumulated on the skin have little effect on the obtained image, so such an image can be truly reflected. The face images collected by the three sensors are shown in Fig. 1.

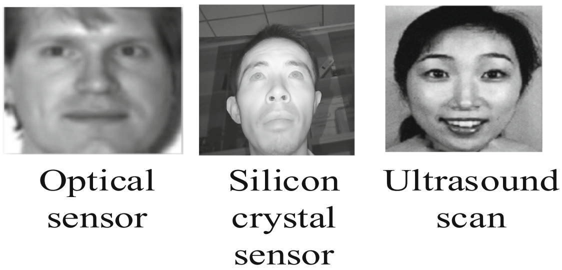


Fig. 1. Images captured by three sensors

2.2 Face Image Feature Processing

The process of face recognition is actually the process of face feature comparison, so the quality of face feature extraction determines the success or failure of the whole recognition system. Feature extraction includes three questions: what feature to extract, what method to extract feature, and whether the extracted feature can represent the true feature of the face [9]. Feature extraction is the core algorithm in the whole face recognition and identification process. The traditional feature extraction algorithm extracts and processes as many singular points and detail points as possible, because singular points are mainly used for rough classification in face database, and detail points are used for distinguishing different types of faces. In the face recognition process, we must first classify a face according to its macroscopic characteristics, and then match it with the corresponding face in the face database by using the detail feature parameters. Face feature extraction is an important premise to ensure the matching performance of automatic face recognition system. Face classification and matching are all based on face feature information. At present, most of the popular automatic face recognition systems are based on minutiae. This method simulates artificial face matching, determines the position of detail features in the face image, and then determines whether the face matches by comparing the correlations of features. Detail feature is the mutation of facial ridge, and its distribution and proportion are not the same in the face image. Endpoint and bifurcation are the most common detail features. Therefore, in most automatic face recognition systems, only endpoint and bifurcation points are used as detail features, and the pattern matching or point pattern matching is generally used.

Face image processing is a very important step in the whole automatic face recognition system. All kinds of noises usually accompany the face images acquired. Part of it is caused by the picker, such as the stains on the picker, the parameter setting of the picker is not appropriate, and the other part is caused by facial features. The first kind of noise is relatively fixed error and is easy to recover. The second kind of noise is closely related to the individual face features, so it is difficult to restore them. Therefore, face image preprocessing is a key step in the face recognition process. It is unavoidable to be disturbed in the process of collecting face images. Under the present condition, it is impossible to ensure the quality of the captured face images. The aim of face image preprocessing is to remove all kinds of noises in the face image, eliminate the deformation of the face image and restore the clear and complete face feature structure. The processing flow is shown in Fig. 2.

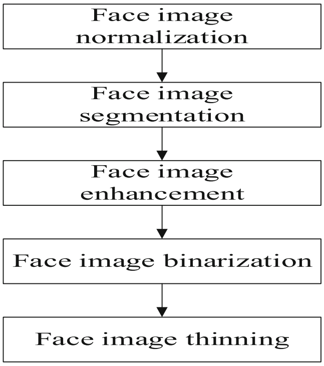


Fig. 2. Face image feature processing flow

As shown in Fig. 2, preprocessing is to process the low-quality face images with certain algorithms, so as to make the texture structure clearer and ensure the reliability of feature extraction. The accuracy and stability of feature extraction are directly affected by the processing results, which determines the performance of automatic face recognition. In general, face image recognition includes image normalization, segmentation, enhancement, binarization, thinning and so on.

Face image segmentation can not only reduce the processing time of redundant information, but also improve the accuracy of its subsequent processing algorithm. So far, many methods have been proposed for face image segmentation, which can be divided into two categories: gray-based method and direction-based method. The method based on gray level is to select an appropriate threshold to segment the foreground and background of human face on the statistical feature distribution of gray level. The direction based method mainly considers the consistency of the face texture direction. Firstly, the face region and background region are distinguished according to the direction of the texture on the face. In the face region with directional guidance, this method can identify the face region more accurately. But for the regions with discontinuous ripples and single gray level, and the regions around the center and triangle, the effect of this method is not ideal. Both methods have their own advantages and get good results. For the common face images with clear texture and uniform background, both methods can segment the face images accurately.

But the two methods also have some limitations: the gray-scale method is often too wet or too dry for the face image segmentation results are not accurate, and the direction based method for the face image of perspiration and other noise processing power is not strong. Using the local gray mean, local standard deviation and local consistency as features, the face image is segmented by line classification. Among them, local consistency characterizes the consistency of local image texture orientation, but these features are not enough to identify the fuzzy region. That is to say, the current method is not ideal for the poor quality image processing, so we need to propose a low-quality image segmentation method according to the actual needs.

At present, the face image enhancement methods are mainly based on the texture characteristics of the face lines, including direction continuity, distance approximation and so on. Firstly, a separation filter group is designed according to different grain directions and grain widths. Then different filters are used to filter the images and a group of filtered images are obtained. Finally, different filtered images are reconstructed using local texture orientation to reconstruct filtered images. When the number of filter banks is very large, the algorithm is very good, but the processing time is long, which will cause the performance of the algorithm to decline, reduce the number of filter banks and shorten the processing time, but the enhancement effect is not very ideal.

In order to enhance the face image, a filter is designed based on the pre-estimated local ridge direction and width, and then the filter and local face direction are coincided to achieve face image filtering. Therefore, if the actual grain width exceeds a predetermined range, this method will fail. Poor image quality can enhance the image quality, but it leads to a large number of false endpoints or bifurcation points. Feature extraction is to extract the required features from the input image. It is responsible for expressing in numeric form such features as the line orientation, line breakpoints, and intersections of a face image, which can fully represent the uniqueness of the face. In order to compare the accuracy, feature extraction algorithm is required to extract as many effective features as possible, while filtering out false features caused by various reasons.

2.3 Construction of Multiple Face Simultaneous Recognition Model for Civil Aviation Security Screening Based on Deep Transfer Learning

Global optimization Deep belief networks with multiple hidden layers are often difficult to deal with, and in order to achieve better optimization performance, greedy algorithms can be used here, that is, optimization layer by layer, learning only two adjacent RBM model parameters at a time, and by so greedy learning layer by layer to obtain the global DBNs. As for why learning greedily is effective for learning DBNs. The DRN obtained by DRN can be fine-tuned according to the final criteria of interest, that is, a DBNs network is stratified, unsupervised learning is performed on each layer, and the whole network is fine-tuned by supervised learning. Each module of a deep belief network consists of a number of nodes (often hundreds or thousands). The RBM model is shown in Fig. 3.

During the calculation, each layer learns the RBM parameters of this layer through the learning method of RBM, according to the input data (usually the output of the next layer), including the connection weights and the hidden layer node values. As the lowest input, it usually comes from observation variables, i. e. the original training data

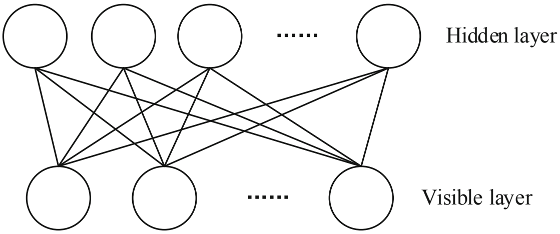


Fig. 3. Face image feature processing flow

of the object, such as the pixel gray of the image. That is, the visible layer (the training data) and the h form a typical RBM, making the RBM achieve energy balance. Then the output layer of the first RBM, the hidden layer, is used as the input of the second RBM, and the parameters are adjusted separately to make the current RBM structure energy tend to balance. Higher RBM's are trained in the same way until the top RBM is trained. This series of processes is called pre-training or pre-learning. After learning the RBM layer by layer, we adjust the whole network according to the maximum likelihood function using the original training data as the monitor data, which is called fine-tuning. That is the process of deep transfer learning [10]. In order to ensure the accuracy of face recognition and enhance the ability of multi-face recognition, this paper constructs a multi-face recognition model for civil aviation security screening based on deep transfer learning. The model is as follows:

$$P_i = \sum_{j \in C} P_{ij} \tag{1}$$

$$f(A) = \sum_{t=1}^{k} P_t \tag{2}$$

$$P_{ij} = \frac{\exp\left(-\|Ax_i - Ax_j\|^2\right)}{\sum_{t=1}^{k}\left(-\|Ax_i - Ax_t\|^2\right)} \tag{3}$$

$$P'_{ij} = \frac{\exp\left(-d_{ij}^2\right)}{\sum_{t=1}^{k} t\left(-d_{ij}^2\right)} \tag{4}$$

In formula (1–4), it is the construction rule of the model. Among them, P_i is the gradient of the random transformation of the face; P_{ij} is the learning efficiency between i and j; C is the identification label; $f(A)$ is the partial derivative function of the random data A; t is the learning time; x_i and x_j are training samples respectively; k is a constant; exp is the function definition formula; P'_{ij} is the learning efficiency between i and j in a specific area; d_{ij} is the Euclidean distance in the feature space; d_{ij} is defined, and its relevant rules are:

$$d_{ij} = \left\|F(x_i; W) - F\left(x_j; W\right)\right\| \tag{5}$$

In the formula (5), $F(x_i; W)$ is the multi-layer learning network of the weight vector W parameterized to x_i transition; $F(x_j; W)$ is the multi-layer learning network of the weight vector W parameterized to x_j transition. Let $j = k$, then:

$$P = c_i \sum_{k=1}^{t} kP_{ij} \tag{6}$$

In formula (6–7), P is the identification data point; c_i is the label data. It is concluded that the constraints in the model designed in this paper are as follows.

$$O_{NCA} = \sum_{t=1}^{N} tP_{ij} \tag{7}$$

$$\partial O_{NCA} = \partial F(x_j; W) \tag{8}$$

$$\frac{\partial O_{NCA}}{\partial W} = \frac{\partial O_{NCA}}{\partial F(x_j; W)} \tag{9}$$

In the Eq. (7–9), O_{NCA} is the objective function of NCA, NCA is the linear data point for deep learning, and ∂ is the partial derivative parameter. Under the model design, the simultaneous recognition of multiple faces can be performed.

3 Experiment and Analysis

In order to verify the effectiveness of the proposed method, the simulation platform is MATLAB 2019a, the traditional method is reference [5], and the face database is Yale B. The database, created by the University of Yale, contains more than 5,000 images of individuals photographed in a single light, from different poses and lighting conditions. The size of each picture is 640 × 480. Figure 4 shows some sample images of this database. The experimental process and results are shown below.

Fig. 4. Examples of some images of Yale B's face library

3.1 Experiment Procedure

First, analyze the passenger information table of civil aviation security check, as shown in Table 1 below.

As shown in Table 1, it is the passenger information table of civil aviation security check. According to the research on face recognition in the article, deep learning and face recognition are integrated, and the passenger information and face information are compared to ensure the safety of passengers and civil aviation.

Table 1. Passenger information form for civil aviation security check

Name	Type	Comment
Id	NUMBER	Serial number
FlightNum	VARCHAR	Flight number
Name	VARCHAR	Name
Age	VARCHAR	Age
Photo	Blob	Picture

3.2 Experimental Results and Discussion

In the above environment, the method designed in this paper is compared with the traditional method to verify the recognition effect of the two methods. The results of partial face recognition are shown in Table 2.

Table 2. Experimental results

Number of experiments	References [5] Simultaneous recognition of the number of faces/piece	The face recognition method designed in this paper recognizes the number of faces at the same time/piece
1	25	50
2	30	55
3	35	60
4	40	65

As shown in Table 2, the traditional method can recognize up to 40 faces at the same time. Under the same conditions, the method designed in this paper can recognize up to 65 faces at the same time, and the recognition effect is better, which is in line with the research purpose of this paper.

On the basis of the above experimental environment, we conducted a comparative test again. The experimental indicator of this test is the face information recognition

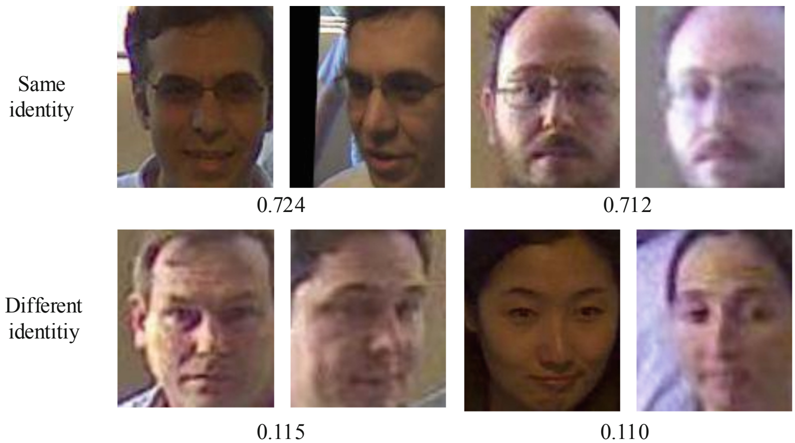
Table 3. Face information recognition time comparison

The number of experiments	Traditional method	The method of this paper
1	7.23	2.35
2	7.21	2.21
3	7.26	2.58
4	7.26	2.64
5	7.14	2.57
6	7.23	2.76
7	7.35	2.72
8	7.41	2.46
9	7.25	2.26
10	7.47	2.62

time. Randomly select 100 face images in the database, each group of 10, and conduct a total of 10 experiments. The experimental results are shown in Table 3.

It can be seen from Table 3 that the time for traditional methods to recognize face information is all higher than 7s, while the time for this method to recognize face information is all less than 3s. It can be seen that the method in this paper can realize the recognition of multiple face information in a relatively fast time, and improve the efficiency of civil aviation security inspection.

In order to further visually verify the effectiveness of the method in this paper, the effect of using the method in this paper to identify the face identity is shown in Fig. 5.



Multi-face recognition renderings

It can be seen from Fig. 5 that the similarity between face pairs with the same identity but different facial poses is high, while the similarity between face pairs with different identities and different facial poses is very low. It shows that the method in this paper can extract highly recognizable face features from the multi-pose face images in the surveillance scene.

4 Conclusion

With the continuous development of society, ensuring information security through identification has become a hot topic today, and face recognition technology has gradually become a hot area of research. Based on the actual civil aviation security inspection system, this paper studies the preprocessing of face images, image feature extraction and image matching, and finally applies the research to actual projects.

Through the research of this article, we have a deep understanding of the field of face recognition, and face recognition technology needs to be completed by many aspects of cooperation. The algorithm also needs to be improved in practical applications to achieve the best results. The processing of face images involves several steps to work together to ensure accuracy. This paper completes the experiment of face recognition by extracting local feature information and matching faces in polar coordinates. Finally, it is applied through the inspection of the aviation security inspection system, and focuses on ensuring the effect of facial synchronization recognition, providing convenient conditions for civil aviation security inspection.

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