

Face Recognition Technology Based on Partial Facial Features

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In the past two decades, many face recognition methods have been proposed. Among them, most researchers use the entire face as the basis for recognition. The basic technical route is to extract and compare the general features of the entire face. However, in actual scenes, human faces may be blocked by obstacles. Therefore, how to realize face recognition by using some of the facial features that can be obtained? In addition, this partial face recognition technology is mostly based on the acquisition of key points of the face to recognize the whole face. This review intends to summarize the full face and partial face recognition methods based on key points of the face.

Keywords: Face Recognition; Partial Facial Features; Information Extraction; Point-to-Point Comparison; Human Being

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THE basic concept of face recognition refers to judging whether there is a face in the input face image or video; if there is a face, the position and size of each face and the location information of each main facial organ are further given; And based on this information, further extract the identity features contained in each face, and compare it with the faces in the known face database, so as to identify the identity of each face. The face recognition process can be divided into three stages: face detection (to determine whether there is a face in the input image), facial feature extraction (to detect the location and shape of the main organs of each face), and face recognition (compare the results of facial feature extraction with the faces in the bank).

In the past two decades, a large number of face recognition methods have been proposed. Under some controllable conditions, these methods have achieved very good application effects on some public databases. Most of these methods use the entire face as a recognition object. In the previous few years, researchers used Local Binary Pattern (LBP), Gabor-PCA filters, convolutional neural network (CNN), histogram of gradients (HOG) to

extract facial features. However, the reality is that human faces are very easy to be occluded. At this time, this method of face recognition based on global features will no longer be effective. Therefore, recognizing part of the face will become the key to face recognition. Part of the face is shown in **Figure 1**. Therefore, we urgently need some methods to solve the problem of partial face recognition, and these methods have a good extension to the moderate change of the face. Part of face recognition can be better applied to actual scenes and has important application value.

Some face recognition has important academic and practical application value. Human faces are a class of natural structural targets with relatively complex details and changes. The challenges of recognition of such targets are: (i) changes in external light or expression changes. (ii) In a real environment, there may be occlusion by glasses, beards, makeup or masks or other objects. (iii) Object occlusion makes it difficult to detect human faces in complex environments.

History of Face Recognition



Figure 1. Some Partially Blocked Face Samples.

A. Partially occluded face samples in the LFW database. B. Face samples partially occluded by the AR database.

The research on face recognition originated from the work of Sir Francis Galton (1822-1911) at the end of the 19th century (1). By the 1990s, it began to develop rapidly as an independent subject.

The development of face recognition research is roughly divided into three stages: The first stage is represented by Allen and Parke (2, 3). Mainly study the facial features required for face recognition. The researchers realized a high-quality face grayscale model with a computer. The feature of this stage of work is that the recognition process all depends on the operator.

The second stage is the human-computer interactive recognition stage, in which the geometric feature parameters are used to represent the front image of the face, represented by Harmon and Lesk (4, 5), and the facial features of the face are represented by multi-dimensional feature vectors, and a design based on this feature is designed The identification system of the law. As represented by Kaya and Kobayashi (6), statistical recognition methods are used, and the Euclidean distance is used to represent facial features. Neither of these two types of methods can get rid of human intervention.

The third stage is the real automatic recognition of machines. Over the past ten years, with the development of high-speed and high-performance computers, there have been major breakthroughs in facial pattern recognition methods. A variety of automatic machine recognition systems have been proposed. Face recognition technology has entered a practical stage.

Classification of Face Recognition Research

Methods

Early research on face recognition has two main directions: one is the method based on the geometric features of the face. The idea of this method is to first detect the position and size of the main parts of the face such as eyes, nose, mouth, and then use the overall geometric distribution relationship of these parts and the mutual parameter ratio to recognize the face. It ignores local subtle features and is more suitable for rough classification. The main representatives are the Brunelli and Poggio groups of MIT (7).

The second is a method based on template matching, which mainly uses the autocorrelation of computer template and image gray to realize the recognition function. The main representative is Yuille of Harvard and Smith-Kettlewell Eye Research Center. Berto made a more comprehensive comparison of these two types of methods in 1993 and concluded that the template matching method is better than the geometric feature method.

The current research also has two main directions: First, research methods based on feature analysis. That is, the relative ratio of the reference points of the face and other shape parameters or category parameters describing the facial features of the face are combined to form the recognition feature vector. Second, the research method based on the whole. It considers the overall attributes of the pattern, including the Eigenface method (Eigenface) and improved Fisher face method (8), elastic map matching method, hidden Markov model method, neural network method, etc. In recent years, the research trend is to combine the overall recognition of human face with feature analysis.

Common Face Recognition Methods

Eigenface Method and Fisher Face Method

Principal Component Analysis (PCA), a face recognition method proposed by Turk and Pentland in 1991, is currently one of the most popular recognition methods. The principal component analysis method is based on the K-L transform, which is the optimal orthogonal transform for image compression. K-L transformation is performed according to the statistical characteristics of the image to eliminate the correlation between the components of the original vector. For each face image, string the gray values of all pixels into a high-dimensional vector in the order from top to bottom and from left to right, and then reduce the dimensionality of the high-dimensional vector by PCA. Simply put, the PCA method is to treat the image area containing the human face as a random vector, and use KL to obtain its orthogonal KL base. The base corresponding to the larger feature value has a shape similar to that of the human face. This is called the Eigenface method.

Although the Eigenface method can effectively represent human face information, it cannot effectively identify and distinguish human faces. Many researchers have proposed to use other linear spaces instead of Eigenface spaces to achieve better recognition results. Among them, the Linear Discriminate Analysis (LDA) method (also called the Fisher face method) uses the category attribution information, which selects the orthogonal vector scattered within the class as the feature face space, thereby suppressing the irrelevant information between the images. The difference emphasizes the difference between different faces, and at the same time weakens the changes of the same face due to illumination, viewing angle and expression, and obtains a better recognition effect than characteristic faces.

Elastic Graph Matching Method

Elastic graph matching method is a method based on dynamic link structure. This method uses grids as a template to change the comparison between images into comparisons between grids. Establish an attribute topological map for the face in a two-dimensional space, and place the topological map on the face. Each node contains a feature vector, which records the distribution information of the face near the vertex. The topological connection relationship between the nodes is geometric. The distance is marked to form a face description based on a two-dimensional topological map, and then the elastic pattern matching technology is applied to match the face in the library with the elastic map of the face to be recognized, and find the most similar face image. Experiments show that the recognition performance of the elastic map matching method is better than that of the Eigenface method, but the amount of calculation and storage are relatively large, and the recognition speed is slow.

Hidden Markov Model Method

Hidden Markov Model (HMM) is a set of statistical models used to describe the statistical characteristics of signals. It uses Markov chains to simulate changes in signal statistical characteristics. This change is described indirectly through observation sequences. Therefore, Markov the Kofu process is a double stochastic process. Hidden Markov model is based on statistical model and does not require complex facial image feature extrac-

tion. The advantage is that it has good robustness to changes in pose and environment, and the recognition rate is high. The disadvantage is the complexity of implementation.

Neural Network Method

The face recognition method based on neural network is a relatively active research direction in recent years. Usually need to consider two factors: which parameters of the image are selected as input; which neural network to choose. Currently, there are two main input strategies. The first one uses the extracted feature vector as the input vector; the second one uses the image pixels directly into the neural network. The neural network method has unique advantages over other types of methods in face recognition. It avoids complex feature extraction, and can obtain implicit expressions of the laws and rules of face recognition that are difficult to achieve by other methods through the learning process. However, due to the huge amount of original gray-scale image data, the number of neurons is usually large, and the training time is long and slow.

The Broad Application Prospects and Challenges of Face Recognition

Biometrics and future identification methods will include fingerprints, faces, iris, palm prints, retina, infrared temperature spectrum, handwriting, gait, voice prints, etc. Compared with other recognition methods, face recognition has the advantages of non-contact collection, concealed operation, convenience and speed. It's easier for people to accept. Therefore, face recognition will be widely used in future life.

The Technical Challenges of Face Recognition The Challenge of Face Change

The face image of the same person has undergone tremendous changes due to changes in expression, mental state, health, posture, plastic surgery, age changes, accidental injury, makeup, glasses, hats, hair and beards.

Challenges from the External Environment

The lighting environment conditions, the camera equipment, the distance and angle between the person and the camera equipment, and the image storage quality will also cause major changes in the face image.

Full Face Recognition

The method of extracting face based on global LBP, CNN, and HOG, etc. is not the focus of this article. We mainly introduce the high-dimensional face feature extraction method based on key points (9). Facts have proved that the application effect of this method is very good. The key of high-dimensional feature extraction is to locate the key points of the face, and then correct the inclined face. Then the position of the key points to calibrate the face is the key. By mainly calibrating the eyes, nose, mouth and other key points of the face, using the method introduced by Belhumeur et al. (10) and Cao et al. (11) to align the face. The meaning of high dimensionality is to extract multiple key points and multi-scale features, as shown in **Figure 2**.

A fixed-size square area of interest around each key point is shown in **Figure 2(B)**. Extract features such as LBP, Gabor,

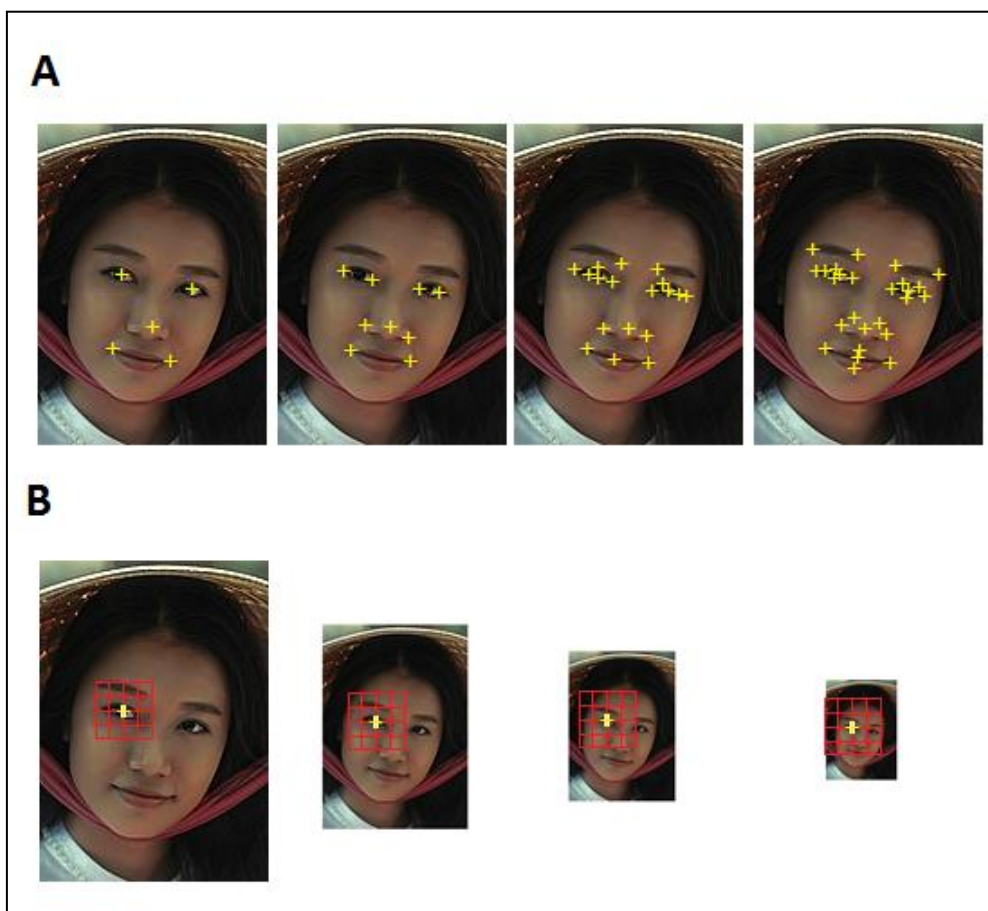


Figure 2. Key Point Positioning of Face Recognition.

A. Locate key points on the face. B. Multi-scale locating the region of interest of key points and dividing them into blocks.

SIFT, LE, HOG, etc. for each sub-region. The original face is reduced by a unit scale, and a fixed size frame is added at the same time, and then the corresponding features are extracted from the sub-regions, and the scales are sequentially reduced to extract the features. Of course, other key points also do the corresponding operations.

But such operations will cause dimensionality disasters, and it is not easy to store on the data. For an embedded system, a lot of storage space is needed, especially for some portable devices with relatively small storage space. Therefore, we need a sparse conversion matrix, and the storage space required for the sparse matrix is small (9). This is to use risk minimization to obtain a sparse transformation matrix B . **Figure 3** is the process of feature extraction and feature dimensionality reduction.

The reduced-dimensional features in the training sample can be based on PCA, using X as input and Y as output, with the following loss function.

$$\min_{B, R} \|R^T Y - B^T X\|_2^2 + \lambda \|B\|_1$$

$$s. t \quad R^T R = I$$

λ is the regularization coefficient, the above formula can be used to solve B^T through the optimized algorithm, and the last saved feature is Y .

Partial Face Recognition

Different from the above-mentioned full face recognition, some features cannot be extracted due to the lack of information of some faces. Before performing face recognition, it is necessary to know which part of the face is missing, and the extent and scope of the missing. Although this is a difficult problem, Weng et al. (12) use SIFT key point location information and texture information to recognize faces. The key is how to correct the face. Through the continuous affine transformation of the image, the distance between the key point operators of the whole face and the part of the face and the distance between the texture features reach the global minimum, thus completing the image correction.

Finally, compare the part of the face to be recognized with the face in the data. The disadvantages of this method are as

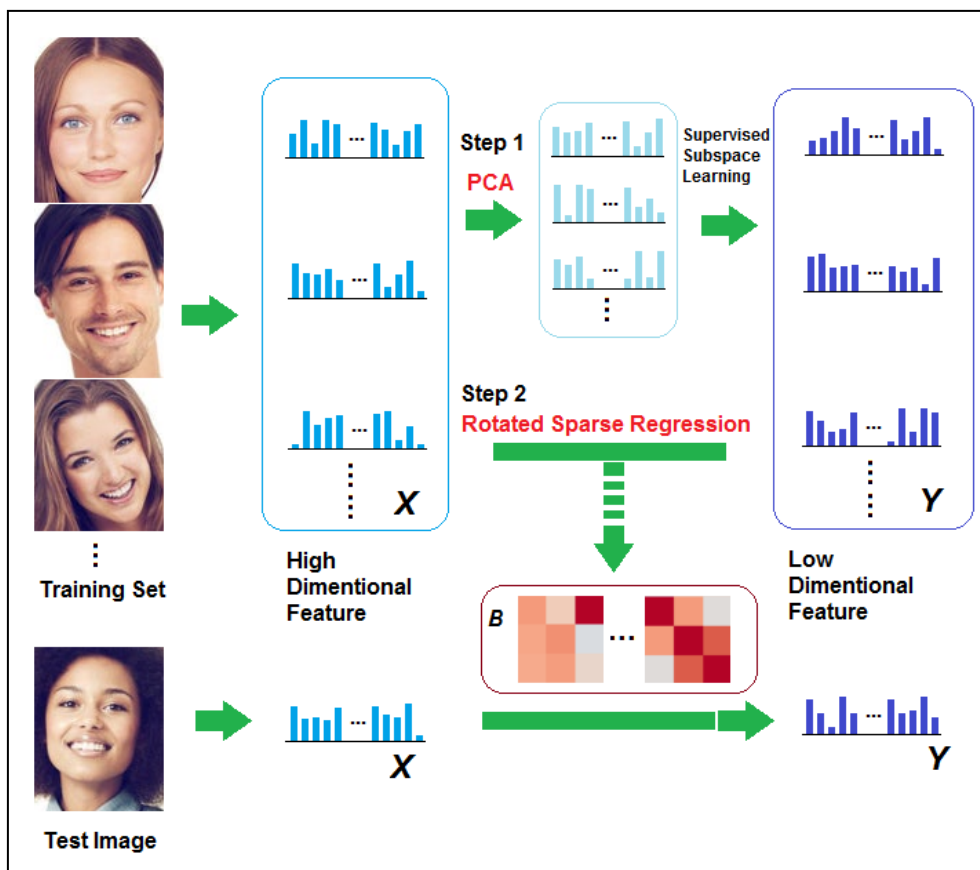


Figure 3. Diagram of Feature Extraction and Dimensionality Reduction.

X, the original concatenated feature, *Y*, the feature after dimensionality reduction. *B*, sparse conversion matrix.

follows: First: each iteration requires a long time, resulting in a relatively low efficiency of face recognition. Second: The experiment is done on the face image that has been cut; the most critical part of the face detection will become the key to face recognition in the actual scene.

Liao (13) proposed a face recognition method that does not require face alignment. This method uses some key areas as recognition objects. The key part is divided into sub-blocks. After the Gabor filter is used to extract features in several directions, PCA is used to reduce the dimensionality, and then these features are formed into a dictionary with sparse coding, and finally the key parts are matched to these faces.

Questions we need to solve: First: If the key parts are se-

verely occluded, these key features will not be extracted and the face cannot be recognized. Second: Some face detection is still a problem.

Conclusion

The existing methods use key points or key positions for face recognition, and have achieved some good results, but if these key points or key positions are occluded, these algorithms may not be robust. What we need to do is when doing face detection, we need to know which parts of the face are occluded and which parts are not occluded, and extract the features of the unoccluded parts and compare them with the database. The key is that we can only extract local features.

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