

# **Biometric Recognition Method and Apparatus, and Device and Storage Medium**

## **Cross-Reference to Related Application**

The present invention claims the priority of Chinese Patent Application 202111350756.5, filed on November 15, 2021, and entitled "Biometric Recognition Method and Apparatus, and Device and Storage Medium", the entire contents of which are herein incorporated by reference.

## **Technical Field**

The present invention relates to the technical field of information processing, and in particular to a biometric recognition method and apparatus, and a device and a storage medium.

## **Background**

A biometric recognition technology is closely combined with high-tech means such as optics, acoustics, biosensors and biometric principles by a computer, to perform personal identity recognition by using inherent physiological properties of a human body, such as a fingerprint, a human face, an iris, a finger vein, etc.

With the increasing requirements for the accuracy and reliability of social security and identity authentication, the limitations of single biometric recognition in terms of accuracy and reliability are increasingly prominent, and the requirements of product and technological development cannot be met. With the continuous maturity of the biometric recognition technology, the research and invention of a multi-modal biometric recognition technology make up for the limitations and deficiencies of a single biometric recognition technology, further reduce the false recognition rate of a biometric recognition system, and improve the identification precision.

Therefore, people are paying increasing attention to the multi-modal biometric recognition technology. The biometric identification operates on a 1: N comparison mode, and is generally applied to biometric searches such as attendance access control, personnel clustering, blacklist monitoring and the like, which have brought convenience to the lives and works of people. Nevertheless, in practical applications of 1: N comparison model, the problems of false identification, false alarm and under-reporting often occur, thereby bringing troubles and risks to system applications.

## **Summary**

The objective of embodiments of the present invention is to provide a biometric recognition method and apparatus, and a device and a storage medium, to improve the reliability of biometric identification by means of comparison ranking of multiple matching algorithms and a sorting weight of each algorithm.

A first aspect of the embodiments of the present invention provides a biometric recognition method, including: acquiring a biometric sample to be recognized; comparing the biometric sample with feature templates in a feature template library one by one by using multiple feature matching algorithms, to obtain a candidate feature template set corresponding to each feature matching algorithm; performing weighted calculation on sorting of each candidate feature template set respectively based on a sorting weight of each feature matching algorithm in a weight matrix; and determining a final target object corresponding to the biometric sample based on each candidate feature template set that has been subjected to weighted sorting.

In an embodiment, comparing the biometric sample with the feature templates in the feature template library one by one by using the multiple feature matching algorithms, to obtain the corresponding candidate feature template set under each feature matching algorithm includes: comparing the biometric sample with the feature templates in the feature template library one by one by using a first feature matching algorithm among the multiple feature matching algorithms, so as to select a first candidate feature template set; and comparing the biometric sample with feature templates in the first candidate feature template set one by one by using each remaining feature matching algorithm among the multiple feature matching algorithms, to obtain a second candidate feature template set corresponding to the each remaining feature matching algorithm among the multiple feature matching algorithms.

In an embodiment, before the weighted calculation is performed on the sorting of each candidate feature template set respectively based on the sorting weight of each feature matching algorithm in the weight matrix, the biometric recognition method further includes: constructing the weight matrix of the multiple feature matching algorithms based on an identification error rate of each candidate feature template set, wherein the weight matrix includes the sorting weight of each feature matching algorithm.

In an embodiment, the identification error rate includes: a false identification selection rate of each candidate feature template set, and the weight matrix of the multiple feature matching algorithms is constructed by using the following formula:

$$W = (w_i)_{1 \times m}, i = 1 \sim m$$

$$w_i = (\frac{1}{FISR_i}) \div \sum_{x=1}^m (1/FISR_x), \sum_{i=1}^m w_i = 1;$$

wherein m denotes the total number of the multiple feature matching algorithms, and m is a positive integer; W denotes the weight matrix of the multiple feature matching algorithms;  $w_i$  denotes the sorting weight corresponding to the ith algorithm among the multiple feature matching algorithms; and  $FISR_i$  denotes the false identification selection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms.

In an embodiment, the identification error rate includes: a false identification selection rate and a false identification rejection rate of each candidate feature template set; and the weight matrix of the multiple feature matching algorithms is constructed by using the following formula:

$$W = (w_i)_{1 \times m}, i = 1 \sim m$$

$$w_i = (\frac{FIRR_i}{FISR_i}) \div \sum_{x=1}^m (\frac{1}{FIRR_x * FISR_x}), \sum_{i=1}^m w_i = 1;$$

wherein m denotes the total number of the multiple feature matching algorithms, and m is a positive integer; W denotes the weight matrix of the multiple feature matching algorithms;  $w_i$  denotes the sorting weight corresponding to the ith algorithm among the multiple feature matching algorithms;  $FISR_i$  denotes the false identification selection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms; and  $FIRR_i$  denotes the false identification rejection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms.

In an embodiment, performing the weighted calculation on the sorting of each candidate feature template set respectively based on the sorting weight of each feature matching algorithm in the weight matrix includes: generating an initial sorting matrix corresponding to the multiple feature matching algorithms based on the candidate feature template set corresponding to each feature matching algorithm; calculating a reciprocal of each element of the initial sorting matrix, to generate a reciprocal sorting matrix; performing standardization processing on the reciprocal sorting matrix, so as to obtain a standardized sorting matrix; and multiplying the weight matrix by the standardized sorting matrix, so as to obtain a final sorting matrix of the biometric sample corresponding to all candidate feature templates under the multiple feature matching algorithms.

In an embodiment, determining the final target object corresponding to the biometric sample based on each candidate feature template set that has been subjected to weighted sorting includes:

arranging elements in the final sorting matrix in a descending order, and determining a candidate feature template corresponding to an element of a preset top ranking in the final sorting matrix to be the final target object corresponding to the biometric sample.

A second aspect of the embodiments of the present invention provides a biometric recognition apparatus, including: an acquisition module, configured to acquire a biometric sample to be recognized; a comparison module, configured to compare the biometric sample with feature templates in a feature template library one by one by using a multiple feature matching algorithms, to obtain a candidate feature template set corresponding to each feature matching algorithm; a weighting module, configured to perform weighted calculation on the sorting of each candidate feature template set respectively based on a sorting weight of each feature matching algorithm in a weight matrix; and a determination module, configured to determine a final target object corresponding to the biometric sample based on each candidate feature template set that has been subjected to weighted sorting.

In an embodiment, the comparison module is configured to: compare the biometric sample with the feature templates in the feature template library one by one by using a first feature matching algorithm among the multiple feature matching algorithms, to select a first candidate feature template set; and compare the biometric sample with feature templates in the first candidate feature template set one by one by using each remaining feature matching algorithm among the multiple feature matching algorithms, to obtain a second candidate feature template set corresponding to the each remaining feature matching algorithm among the multiple feature matching algorithms.

In an embodiment, the biometric recognition apparatus further includes: a construction module, configured to: before the weighted calculation is performed on the sorting of each candidate feature template set respectively based on the sorting weight of each feature matching algorithm in the weight matrix, construct the weight matrix of the multiple feature matching algorithms based on an identification error rate of each candidate feature template set, wherein the weight matrix includes the sorting weight of each feature matching algorithm.

In an embodiment, the identification error rate includes: a false identification selection rate of each candidate feature template set, and the construction module is configured to construct the weight matrix of the multiple feature matching algorithms by using the following formula:

$$W = (w_i)_{1 \times m}, i = 1 \sim m$$

$$w_i = \left( \frac{1}{FISR_i} \right) \div \sum_{x=1}^m (1/FISR_x), \sum_{i=1}^m w_i = 1;$$

wherein  $m$  denotes the total number of the multiple feature matching algorithms, and  $m$  is a positive integer;  $W$  denotes the weight matrix of the multiple feature matching algorithms;  $w_i$  denotes the sorting weight corresponding to the  $i$ th algorithm among the multiple feature matching algorithms; and  $FISR_i$  denotes the false identification selection rate of the candidate feature template set corresponding to the  $i$ th algorithm among the multiple feature matching algorithms.

In an embodiment, the identification error rate includes: a false identification selection rate and a false identification rejection rate of each candidate feature template set; and the construction module is configured to construct the weight matrix of the multiple feature matching algorithms by using the following formula:

$$W = (w_i)_{1 \times m}, i = 1 \sim m$$

$$w_i = \left( \frac{FIRR_i}{FISR_i} \right) \div \sum_{x=1}^m \left( \frac{1}{FIRR_x * FISR_x} \right), \sum_{i=1}^m w_i = 1;$$

wherein  $m$  denotes the total number of the multiple feature matching algorithms, and  $m$  is a positive integer;  $W$  denotes the weight matrix of the multiple feature matching algorithms;  $w_i$  denotes the sorting weight corresponding to the  $i$ th algorithm among the multiple feature matching algorithms;  $FISR_i$  denotes the false identification selection rate of the candidate feature template set corresponding to the  $i$ th algorithm among the multiple feature matching algorithms; and  $FIRR_i$  denotes the false identification rejection rate of the candidate feature template set corresponding to the  $i$ th algorithm among the multiple feature matching algorithms.

In an embodiment, the weighting module is configured to: based on the candidate feature template set corresponding to each feature matching algorithm, generate an initial sorting matrix corresponding to the multiple feature matching algorithms; calculate a reciprocal of each element of the initial sorting matrix, to generate a reciprocal sorting matrix; perform standardization processing on the reciprocal sorting matrix, so as to obtain a standardized sorting matrix; and multiply the weight matrix by the standardized sorting matrix, to obtain a final sorting matrix of the biometric sample corresponding to all candidate feature templates under the multiple feature matching algorithms.

In an embodiment, the determination module is configured to: arrange elements in the final sorting matrix in a descending order, and determine a candidate feature template corresponding to an element of a preset top ranking in the final sorting matrix to be the final target object corresponding to the biometric sample.

A third aspect of the embodiments of the present invention provides an electronic device,

including: a memory, configured to store a computer program; and a processor, configured to execute the computer program to implement the method according to any embodiment of the first aspect of the embodiments of the present invention.

A fourth aspect of the embodiments of the present invention provides a non-transitory electronic device-readable storage medium, including: a program that, when being executed by an electronic device, causes the electronic device to execute the method according to any embodiment of the first aspect of the embodiments of the present invention.

According to the biometric recognition method and apparatus, and the device and the storage medium provided in the present invention, by comparing the biometric sample with the feature templates in the feature template library one by one by using the multiple feature matching algorithms, to obtain the candidate feature template set corresponding to each feature matching algorithm, constructing the weight matrix of the multiple feature matching algorithms based on the identification error rate under each feature matching algorithm, and finally, respectively performing weighted calculation on the sorting of each candidate feature template set based on the sorting weight of each feature matching algorithm in the weight matrix, not only the comparison ranking of the multiple matching algorithms is utilized, but the sorting weight of each algorithm is taken into account, thereby improving the reliability of biometric identification.

### **Brief Description of the Drawings**

To illustrate methods in the embodiments of the present invention or in the prior art more clearly, a brief introduction on the drawings which are needed in the description of the embodiments or the prior art is given below. Apparently, the drawings in the description below are merely embodiments of the present invention, based on which other drawings may be obtained by those ordinary skilled in the art without any creative effort.

Fig. 1 is a schematic structural diagram of an electronic device according to an embodiment of the present invention.

Fig. 2 is a schematic flowchart of a biometric recognition method according to an embodiment of the present invention.

Fig. 3 is a schematic flowchart of a biometric recognition method according to an embodiment of the present invention.

Fig. 4 is a schematic structural diagram of a biometric recognition apparatus according to an embodiment of the present invention.

Fig. 5 is a schematic diagram of an internal structure of a biometric recognition device according to an embodiment of the present invention.

### **Detailed Description of the Embodiments**

To make the above objectives, features and advantages of the present invention clearer and more comprehensible, implementations of the present invention are described in detail below in combination with the drawings. In the following descriptions, numerous details are set forth to fully understand the present invention. However, the present invention can be implemented in many different ways than those described herein, and those skilled in the art can make similar improvements without departing from the connotation of the present invention, therefore the present invention is not limited by the embodiments disclosed below.

In the descriptions of the present invention, the terms "first", "second" and the like are only used for distinguishing descriptions, and cannot be understood as indicating or implying relative importance.

As shown in Fig. 1, the present embodiment provides an electronic device 1, including: at least one processor 11 and a memory 12. One processor is taken as an example in Fig. 1. The processor 11 and the memory 12 are connected via a bus 10. The memory 12 stores a computer instruction executable by the processor 11, and the computer instruction is executed by the processor 11, so that the electronic device 1 can execute all or some processes of the method in the following embodiments, to improve the reliability of biometric identification by means of the comparison ranking of a multiple matching algorithms and a sorting weight of each algorithm.

In some embodiments of the present invention, the electronic device 1 may be a mobile phone, a tablet computer, a notebook computer, a desktop computer, or a server composed of multiple computers, and the like.

Referring to Fig. 2, it illustrates a biometric recognition method according to an embodiment of the present invention, and the method may be executed by the electronic device 1 shown in Fig. 1, so as to improve the reliability of biometric identification by means of the comparison ranking of a multiple matching algorithms and a sorting weight of each algorithm. The method includes the following steps:

Step 210: acquiring a biometric sample to be recognized.

In the step 210, the biometric sample to be recognized refers to an inherent physiological feature of a human body, such as a fingerprint, a human face, an iris, a finger vein, etc.

In some embodiments of the present invention, if the biometric sample is the fingerprint, the acquisition manner of a fingerprint image may be an optical fingerprint collection technology, a capacitive sensor fingerprint collection technology, a temperature sensing fingerprint acquisition technology, an ultrasonic fingerprint collection technology, an electromagnetic fingerprint collection technology, etc.

In some embodiments of the present invention, a fingerprint feature sample to be recognized may be obtained by using image collection software, such as Anguli and ABIS multi-modal biometric recognition unified platforms, etc.

Step 220: comparing the biometric sample with feature templates in a feature template library one by one by using multiple feature matching algorithms, to obtain a candidate feature template set corresponding to each feature matching algorithm.

In the step 220, the feature matching algorithm refers to an algorithm for matching the features of the biometric sample with the feature templates in the feature template library.

In some embodiments of the present invention, if the biometric sample is a human face, a human face recognition algorithm includes a geometric feature-based human face recognition method, a subspace-based human face recognition method, a statistics-based human face recognition method, an elastic map matching method, a hybrid model-based human face recognition method, a three-dimensional model-based human face recognition method, a deep neural network-based human face recognition method, and the like, wherein the statistics-based human face recognition method further includes a KL transformation-based human face recognition method, and a hidden Markov model-based human face recognition method, etc.

In some embodiments of the present invention, the multiple feature matching algorithms of different types may be employed, for example, the first feature matching algorithm is a deep neural network-based human face recognition method, the second feature matching algorithm is a subspace-based human face recognition method, and the third feature matching algorithm is a different type of algorithm. In an embodiment:

Firstly, the deep neural network-based human face recognition method is used as the first feature matching algorithm, the deep neural network-based human face recognition method is used to compare a human face to be recognized with human face feature templates one by one, to obtain matching scores, and the obtained matching scores are sorted in a descending order; and meanwhile, feature templates corresponding to the top k rankings are used as a first candidate feature template set, wherein k is a self-defined length.

Then, the subspace-based human face recognition method is used to compare the human face to be recognized with feature templates in the first candidate feature template set one by one, to obtain matching scores, and the obtained matching scores are sorted in the descending order, to obtain a second candidate feature template set corresponding to the human face to be recognized under the subspace-based human face recognition method.

By means of reason by analogy in sequence, the remaining human face recognition algorithms are respectively used to compare the human face sample to be recognized with the feature templates in the first candidate feature template set one by one, to obtain a second candidate feature template set corresponding to each feature matching algorithm.

In some embodiments of the present invention, the multiple feature matching algorithms may also be algorithms of the same type, for example, all the feature matching algorithms are neural network-based algorithms, but the neural networks are different, and the feature matching algorithms may also be different.

Step 230: constructing a weight matrix of the multiple feature matching algorithms based on an identification error rate of each candidate feature template set.

In the step 230, the weight matrix includes a sorting weight of each feature matching algorithm, so that the sorting weight of each feature matching algorithm may be counted in advance, to form the weight matrix. The feature template set refers to a registration set, that is, a registration template set for biometric identification (1: N comparison). The performance of a biometric identification algorithm is embodied in, for example, a false identification selection rate (FISR), a false identification rejection rate (FIRR), a top recognition rate (TOP 1), a top k recognition rate (Top k) and other indicators. The evaluation of algorithm performance indicators is performed on a certain test sample set. The test sample set may be divided into a registration set and a probe set, wherein the probe set is used for a set of samples to be recognized (also referred to as probes) for algorithm performance evaluation.

There may be a matched template of the sample to be recognized in the registration set or not. The number of samples in the registration set and the number of samples in the probe set may be consistent or not. In the performance evaluation of the biometric identification algorithm, the number of samples of the test set is generally constructed according to the data scale of an actual application, for example, a ten thousand level, a one hundred thousand level, a million level, a ten million level, and the like. The quality of the algorithm performance indicators is related to the quality of the test samples. The quality of the test samples in the sample set should follow a sample quality standard corresponding to biometric modality.

The identification error rate includes a false identification selection rate (FISR) and a false identification rejection rate (FIRR). The FISR indicator is related to the number  $N$  of samples in the registration set, the length  $K$  of a candidate list, a comparison threshold  $T$ , and the like, and may be expressed by  $FISR(N, K, T)$ . The statistical method of the FISR indicator is that in the search of unmatchable target persons, there are candidates (who are all false matchers) having scores exceeding the threshold  $T$  and ranking within top  $K$  in a comparison result list, and  $FISR(N, K, T)$  denotes the ratio of the number of candidates to the number of unmatchable samples in the probe set.

The calculation manner is as follows:

$$FISR(N, K, T) = \frac{C_2}{C_1} \times 100\%;$$

in the formula,  $N$  denotes the number of samples in the registration set,  $K$  denotes the length of the candidate list,  $T$  denotes the comparison threshold,  $C_2$  denotes the total number of candidates having scores exceeding the threshold  $T$  and ranking within top  $K$  in  $C_1$  rounds of comparison search, and  $C_1$  denotes the number of unmatchable samples in the set of samples to be recognized.

When  $N$  and  $K$  are constant, with the increase of  $T$ , the FIRR ( $N, K, T$ ) is decreased, which indicates that the probability of false matching is smaller, and thus the identification reliability is improved.

The FIRR indicator is associated with the number  $N$  of samples in the registration set, the length  $K$  of the candidate list, the comparison threshold  $T$ , and the like, and may be expressed as by  $FIRR(N, K, T)$ . The statistical method is that in the search of matchable target persons, there are probes having comparison scores with corresponding templates not exceeding the threshold  $T$  or false rejectees ranking beyond top  $K$  (losers who should be matched but not matched) in the comparison result list, and the  $FIRR(N, K, T)$  denotes the ratio of the number of false rejectees to the number of matchable samples in the probe set.

The calculation manner is as follows:

$$FIRR(N, K, T) = \frac{C_4}{C_3} \times 100\%;$$

in the formula,  $C_4$  denotes the number of false rejectees having scores exceeding the threshold  $T$  and ranking beyond the top  $K$  in  $C_3$  rounds of comparison search, and  $C_3$  denotes the number of matchable samples in the set of samples to be recognized.

When FISR (N,K,T) is constant, the smaller the FIRR (N,K,T) is, the smaller the probability of being rejected is, which is equivalent to that the recognition pass rate is increased, and thus the identification reliability is improved.

Generally, on the premise that N and K are constant, the threshold T is adjusted, so that the FISR (N,K,T) reaches an available reliability level (e.g., one ten-thousandth, one hundred-thousandth), and the value of the FIRR (N,K,T) may be determined according to the threshold T at this time.

In some embodiments of the present invention, the weight matrix of the multiple feature matching algorithms is constructed by using the following formula:

$$W = (w_i)_{1 \times m}, i = 1 \sim m$$

$$w_i = \left( \frac{1}{FISR_i} \right) \div \sum_{x=1}^m (1/FISR_x), \sum_{i=1}^m w_i = 1;$$

in the formula, m denotes the total number of the multiple feature matching algorithms, and m is a positive integer; W denotes the weight matrix of the multiple feature matching algorithms;  $w_i$  denotes the sorting weight corresponding to the ith algorithm among the multiple feature matching algorithms; and  $FISR_i$  denotes the false identification selection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms.

In some embodiments of the present invention, the weight matrix of the multiple feature matching algorithms is constructed by using the following formula:

$$W = (w_i)_{1 \times m}, i = 1 \sim m$$

$$w_i = \left( \frac{FIRR_i}{FISR_i} \right) \div \sum_{x=1}^m \left( \frac{1}{FIRR_x * FISR_x} \right), \sum_{i=1}^m w_i = 1;$$

wherein m denotes the total number of the multiple feature matching algorithms, and m is a positive integer; W denotes the weight matrix of the multiple feature matching algorithms;  $w_i$  denotes the sorting weight corresponding to the ith algorithm among the multiple feature matching algorithms;  $FISR_i$  denotes the false identification selection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms; and  $FIRR_i$  denotes the false identification rejection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms.

It should be noted that, the construction of the weight matrix in the step 230 needs to be performed before the step 240, after the multiple feature matching algorithms used are determined,

the weight matrix may also be determined. When biometric recognition is actually performed, as long as the feature matching algorithms are unchanged, it is not necessary to construct the weight matrix every time, therefore the step 230 can also be performed before the step 210 to the step 220, or is performed at the same time. The occurrence sequence of the step 230, the step 210 and the step 220 is not limited in the present embodiment.

Step 240: performing weighted calculation on the sorting of each candidate feature template set respectively based on a sorting weight of each feature matching algorithm in the weight matrix.

In the step 240, the sorting of each candidate feature template set refers to a matrix composed of a sorting score of each candidate feature template.

Step 250: determining a final target object corresponding to the biometric sample based on each candidate feature template set that has been subjected to weighted sorting.

In the step 250, the final target object may be a target object ranking first after the weighted sorting, and may also a result set of candidates returned in a descending order according to a set length.

Referring to Fig. 3, it illustrates a biometric recognition method according to an embodiment of the present invention, and the method includes the following steps:

Step 310: acquiring a biometric sample to be recognized. For details, reference may be made to the descriptions of the step 210 in the above embodiment.

Step 320: comparing the biometric sample with feature templates in a feature template library one by one by using a multiple feature matching algorithms, to obtain a candidate feature template set corresponding to each feature matching algorithm. For details, reference may be made to the descriptions of the step 220 in the above embodiment.

Step 330: constructing a weight matrix of the multiple feature matching algorithms based on an identification error rate of each candidate feature template set. For details, reference may be made to the descriptions of the step of 230 in the above embodiment.

Step 340: based on the candidate feature template set corresponding to each feature matching algorithm, generating an initial sorting matrix corresponding to the multiple feature matching algorithms.

Step 350: calculating a reciprocal of each element of the initial sorting matrix, to generate a reciprocal sorting matrix.

In the Step 350, the initial sorting matrix refers to a sorting matrix  $(r_{ij})_{m \times k}$ , which is generated according to each round of comparison candidate list, and the specific form is as follows:

$$R = \begin{pmatrix} r_{11} & \cdots & r_{1k} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mk} \end{pmatrix}$$

wherein m denotes m rounds of comparison of the biometric sample to be recognized, k denotes the length of the candidate set, and  $r_{ij}$  denotes the matching score of the biometric sample to be recognized at the ranking of j after i rounds of matching.

The reciprocal of each element of the sorting matrix is taken, that is, matrix transformation is performed on  $(r_{ij})_{m \times k}$ , and the reciprocal of  $r_{ij}$  may be obtained:

$$b_{ij} = 1/r_{ij};$$

thus, the reciprocal sorting matrix is obtained, and the specific form is as follows:

$$B = \begin{pmatrix} b_{11} & \cdots & b_{1k} \\ \vdots & \ddots & \vdots \\ b_{m1} & \cdots & b_{mk} \end{pmatrix}.$$

Step 360: performing standardization processing on the reciprocal sorting matrix, to obtain a standardized sorting matrix.

In the step 360, the standardization processing refers to performing z-score transformation on the elements in the reciprocal sorting matrix, to obtain a standardized sorting matrix

$(z_{ij})_{m \times k}$ , and the specific form is as follows:

$$Z = \begin{pmatrix} z_{11} & \cdots & z_{1k} \\ \vdots & \ddots & \vdots \\ z_{m1} & \cdots & z_{mk} \end{pmatrix}$$

wherein, the z-score transformation manner is as follows:

$$z_{ij} = (b_{ij} - \mu) / \delta;$$

in the formula,  $b_{ij}$  denotes the numerical value of the  $i$ th row and the  $j$ th column in the reciprocal sorting matrix,  $\mu$  denotes an average value of  $b_{ij}$ , and  $\delta$  denotes a standard deviation of  $b_{ij}$ .

Step 370: multiplying the weight matrix by the standardized sorting matrix, to obtain a final sorting matrix of the biometric sample corresponding to all candidate feature templates under the multiple feature matching algorithms.

In the step 370, the specific formula of multiplying the weight matrix by the standardized sorting matrix is as follows:

$$(c_j)_{1 \times k} = (w_i)_{1 \times m} * (z_{ij})_{m \times k}$$

then, the weighted sorting matrix is  $C=(c_1, c_2, \dots, c_k)$ , and the elements in the matrix are arranged in a descending order, so as to obtain the final sorting matrix.

Step 380: determining a final target object corresponding to the biometric sample based on each candidate feature template set that has been subjected to weighted sorting. For details, reference may be made to the descriptions of the step 250 in the above embodiment.

Referring to Fig. 4, it illustrates a biometric recognition apparatus 400 provided in an embodiment of the present invention, the apparatus may be applied to the electronic device 1 shown in Fig. 1, and improves the reliability of biometric identification by means of comparison ranking of a multiple matching algorithms and a sorting weight of each algorithm. The apparatus includes an acquisition module 401, a comparison module 402, a weighting module 403 and a determination module 404, wherein the principle relationships of the modules are as follows:

the acquisition module 401 is configured to acquire a biometric sample to be recognized;

the comparison module 402 is configured to compare the biometric sample with feature templates in a feature template library one by one by using multiple feature matching algorithms, to obtain a candidate feature template set corresponding to each feature matching algorithm;

the weighting module 403 is configured to perform weighted calculation on the sorting of each candidate feature template set respectively based on a sorting weight of each feature matching algorithm in a weight matrix; and

the determination module 404 is configured to determine a final target object corresponding to the biometric sample based on each candidate feature template set that has been subjected to weighted sorting.

In some embodiments of the present invention, the comparison module 402 is further configured to: compare the biometric sample with the feature templates in the feature template library one by one by using a first feature matching algorithm among the multiple feature matching algorithms, to select a first candidate feature template set; and compare the biometric sample with feature templates in the first candidate feature template set one by one by using each remaining feature matching algorithm among the multiple feature matching algorithms, to obtain a second candidate feature template set corresponding to the each remaining feature matching algorithm among the multiple feature matching algorithms.

In some embodiments of the present invention, the biometric recognition apparatus 400 further includes: a construction module 405, configured to: before the weighted calculation is performed on the sorting of each candidate feature template set respectively based on the sorting weight of each feature matching algorithm in the weight matrix, construct the weight matrix of the multiple feature matching algorithms according to an identification error rate of each candidate feature template set, wherein the weight matrix includes the sorting weight of each feature matching algorithm.

In some embodiments of the present invention, the identification error rate includes: a false identification selection rate of each candidate feature template set; and the construction module 405 is further configured to construct the weight matrix of the multiple feature matching algorithms by using the following formula:

$$W = (w_i)_{1 \times m}, i = 1 \sim m$$

$$w_i = \left( \frac{1}{FISR_i} \right) \div \sum_{x=1}^m (1/FISR_x), \sum_{i=1}^m w_i = 1;$$

wherein m denotes the total number of the multiple feature matching algorithms, and m is a positive integer; W denotes the weight matrix of the multiple feature matching algorithms;  $w_i$  denotes the sorting weight corresponding to the ith algorithm among the multiple feature matching algorithms; and  $FISR_i$  denotes the false identification selection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms.

In some embodiments of the present invention, the identification error rate includes: a false identification selection rate and a false identification rejection rate of each candidate feature template set; and the construction module 405 is further configured to construct the weight matrix of the multiple feature matching algorithms by using the following formula:

$$W = (w_i)_{1 \times m}, i = 1 \sim m$$

$$w_i = \left( \frac{FIRR_i}{FISR_i} \right) \div \sum_{x=1}^m \left( \frac{1}{FIRR_x * FISR_x} \right), \sum_{i=1}^m w_i = 1;$$

wherein m denotes the total number of the multiple feature matching algorithms, and m is a positive integer; W denotes the weight matrix of the multiple feature matching algorithms;  $w_i$  denotes the sorting weight corresponding to the ith algorithm among the multiple feature matching algorithms;  $FISR_i$  denotes the false identification selection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms; and  $FIRR_i$  denotes the false identification rejection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms.

In some embodiments of the present invention, the weighting module 403 is further configured to: based on the candidate feature template set corresponding to each feature matching algorithm, generate an initial sorting matrix corresponding to the multiple feature matching algorithms; calculate a reciprocal of each element of the initial sorting matrix, to generate a reciprocal sorting matrix; perform standardization processing on the reciprocal sorting matrix, to obtain a standardized sorting matrix; and multiply the weight matrix by the standardized sorting matrix, to obtain a final sorting matrix of the biometric sample corresponding to all candidate feature templates under the multiple feature matching algorithms.

In some embodiments of the present invention, the determination module 404 is further configured to: arrange elements in the final sorting matrix in a descending order, and determine a candidate feature template corresponding to an element of a preset top ranking in the final sorting matrix to be the final target object corresponding to the biometric sample.

For other detailed descriptions of the biometric recognition apparatus 400, reference may be made to the descriptions of related method steps in the above embodiments.

An embodiment of the present invention further provides a biometric recognition device, the device may be a separate computer device, the computer device may be a server, and an internal structure diagram of the device may be shown in Fig. 5. The computer device includes a processor, a memory, a network interface and a database, which are connected via a system bus. The processor of the computer device is configured to provide computing and control capabilities. The memory of the computer device includes a non-volatile storage medium and an internal memory. The non-volatile storage medium stores an operating system, a computer program and a database. The internal memory provides an environment for the operation of the operating system and the computer program in the non-volatile storage medium. The network interface of the computer device is configured to communicate with an external terminal via a network connection.

The computer program, when being executed by the processor, implements a biometric recognition method. The device may also include an actual operating apparatus or the like, which uses at least one of the methods or at least one apparatus embodiments of the present specification. The biometric recognition device may include at least one processor and a memory in which a computer-executable instruction is stored, and the processor, when executing the instruction, implements the steps of the biometric recognition method in any at least one of the above embodiments.

An embodiment of the present invention further provides a non-transitory electronic device-readable storage medium, including: a program that, when running on an electronic device, causes the electronic device to execute all or some processes of the method in the above embodiments. The storage medium may be a magnetic disk, an optical disk, a read-only memory (ROM), a random access memory (RAM), a flash memory, a hard disk drive (HDD), or a solid-state drive (SSD). The storage medium may further include a combination of the above types of memories.

Various technical features of the above embodiments may be combined in any manner, for the brevity of the descriptions, not all possible combinations of the technical features in the above embodiments are described, however, as long as there is no contradiction in the combinations of these technical features, the combinations should be considered as the scope recorded in the present specification.

The above embodiments only express several implementations of the present invention, the description thereof is more specific and detailed, but it cannot be understood as a limitation on the scope of the present invention. It should be noted that, for those ordinary skilled in the art, several variations and improvements may also be made without departing from the concepts of the present invention, and these variations and improvements all fall within the protection scope of the present invention. Therefore, the protection scope of the patent of the present invention shall be subject to the appended claims.

### **Claims:**

1. A biometric recognition method, comprising:

acquiring a biometric sample to be recognized;

comparing the biometric sample with feature templates in a feature template library one by one by using multiple feature matching algorithms, to obtain a candidate feature template set corresponding to each feature matching algorithm;

performing weighted calculation on sorting of each candidate feature template set respectively based on a sorting weight of each feature matching algorithm in a weight matrix; and

determining a final target object corresponding to the biometric sample based on each candidate feature template set that has been subjected to weighted sorting.

2. The method as claimed in claim 1, wherein the step: comparing the biometric sample with the feature templates in the feature template library one by one by using the multiple feature matching algorithms, to obtain the corresponding candidate feature template set under each feature matching algorithm, comprises:

comparing the biometric sample with the feature templates in the feature template library one by one by using a first feature matching algorithm among the multiple feature matching algorithms, to select a first candidate feature template set; and

comparing the biometric sample with feature templates in the first candidate feature template set one by one by using each remaining feature matching algorithm among the multiple feature matching algorithms, to obtain a second candidate feature template set corresponding to the each remaining feature matching algorithm among the multiple feature matching algorithms.

3. The method as claimed in claim 1, wherein before the weighted calculation is performed on the sorting of each candidate feature template set respectively based on the sorting weight of each feature matching algorithm in the weight matrix, the method further comprises:

constructing the weight matrix of the multiple feature matching algorithms based on an identification error rate of each candidate feature template set, wherein the weight matrix comprises the sorting

weight of each feature matching algorithm.

4. The method as claimed in claim 3, wherein the identification error rate comprises: a false identification selection rate of each candidate feature template set, and the weight matrix of the multiple feature matching algorithms is constructed by using the following formula:

$$W = (w_i)_{1 \times m}, i = 1 \sim m$$

$$w_i = \left( \frac{1}{FISR_i} \right) \div \sum_{x=1}^m (1/FISR_x), \sum_{i=1}^m w_i = 1;$$

wherein, m denotes the total number of the multiple feature matching algorithms, and m is a positive integer; W denotes the weight matrix of the multiple feature matching algorithms;  $w_i$  denotes the sorting weight corresponding to the ith algorithm among the multiple feature matching algorithms; and  $FISR_i$  denotes the false identification selection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms.

5. The method as claimed in claim 3, wherein the identification error rate comprises: a false identification selection rate and a false identification rejection rate of each candidate feature template set; and the weight matrix of the multiple feature matching algorithms is constructed by using the following formula:

$$W = (w_i)_{1 \times m}, i = 1 \sim m$$

$$w_i = \left( \frac{FIRR_i}{FISR_i} \right) \div \sum_{x=1}^m \left( \frac{1}{FIRR_x * FISR_x} \right), \sum_{i=1}^m w_i = 1;$$

wherein, m denotes the total number of the multiple feature matching algorithms, and m is a positive integer; W denotes the weight matrix of the multiple feature matching algorithms;  $w_i$  denotes the sorting weight corresponding to the ith algorithm among the multiple feature matching algorithms;  $FISR_i$  denotes the false identification selection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms; and  $FIRR_i$  denotes the false identification rejection rate of the candidate feature template set corresponding to the ith algorithm among the multiple feature matching algorithms.

6. The method as claimed in claim 1, wherein performing the weighted calculation on the sorting of each candidate feature template set respectively based on the sorting weight of each feature matching algorithm in the weight matrix comprises:

generating an initial sorting matrix corresponding to the multiple feature matching algorithms based on the candidate feature template set corresponding to each feature matching algorithm;

calculating a reciprocal of each element of the initial sorting matrix, to generate a reciprocal sorting matrix;

performing standardization processing on the reciprocal sorting matrix, to obtain a standardized sorting matrix; and

multiplying the weight matrix by the standardized sorting matrix, so as to obtain a final sorting matrix of the biometric sample corresponding to all candidate feature templates under the multiple feature matching algorithms.

7. The method as claimed in claim 6, wherein determining the final target object corresponding to the biometric sample based on each candidate feature template set that has been subjected to weighted sorting, comprises:

arranging elements in the final sorting matrix in a descending order, and determining a candidate feature template corresponding to an element of a preset top ranking in the final sorting matrix to be the final target object corresponding to the biometric sample.

8. The method as claimed in claim 6, wherein the initial sorting matrix refers to a sorting matrix  $(r_{ij})_{m \times k}$ , which is generated based on each round of comparison candidate list, and the specific form is as follows:

$$R = \begin{pmatrix} r_{11} & \cdots & r_{1k} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mk} \end{pmatrix}$$

wherein m denotes m rounds of comparison of the biometric sample to be recognized, k denotes the length of the candidate set, and  $r_{ij}$  denotes the matching score of the biometric sample to be

recognized at the ranking of j after i rounds of matching.

9. The method as claimed in claim 6, wherein the standardization processing refers to performing z-score transformation on the elements in the reciprocal sorting matrix, to obtain a standardized

sorting matrix  $(Z_{ij})_{m \times k}$ , and the specific form is as follows:

$$Z = \begin{pmatrix} Z_{11} & \cdots & Z_{1k} \\ \vdots & \ddots & \vdots \\ Z_{m1} & \cdots & Z_{mk} \end{pmatrix}$$

wherein, the z-score transformation manner is as follows:

$$Z_{ij} = (b_{ij} - \mu) / \delta;$$

wherein  $b_{ij}$  denotes the numerical value of the ith row and the jth column in the reciprocal sorting matrix,  $\mu$  denotes an average value of  $b_{ij}$ , and  $\delta$  denotes a standard deviation of  $b_{ij}$ .

10. A biometric recognition apparatus, comprising:

an acquisition module, configured to acquire a biometric sample to be recognized;

a comparison module, configured to compare the biometric sample with feature templates in a feature template library one by one by using multiple feature matching algorithms, to obtain a candidate feature template set corresponding to each feature matching algorithm;

a weighting module, configured to perform weighted calculation on the sorting of each candidate feature template set respectively based on a sorting weight of each feature matching algorithm in a weight matrix; and

a determination module, configured to determine a final target object corresponding to the biometric sample based on each candidate feature template set that has been subjected to weighted sorting.

11. The apparatus as claimed in claim 8, further comprising:

a construction module, configured to: before the weighted calculation is performed on the sorting of each candidate feature template set respectively based on the sorting weight of each feature matching algorithm in the weight matrix, construct the weight matrix of the multiple feature matching algorithms based on an identification error rate of each candidate feature template set, wherein the weight matrix comprises the sorting weight of each feature matching algorithm.

12. The apparatus as claimed in claim 8, wherein the weighting module is configured to:

generate an initial sorting matrix corresponding to the multiple feature matching algorithms, based on the candidate feature template set corresponding to each feature matching algorithm;

calculate a reciprocal of each element of the initial sorting matrix, to generate a reciprocal sorting matrix;

perform standardization processing on the reciprocal sorting matrix, to obtain a standardized sorting matrix; and

multiply the weight matrix by the standardized sorting matrix, so as to obtain a final sorting matrix of the biometric sample corresponding to all candidate feature templates under the multiple feature matching algorithms.

13. The apparatus as claimed in claim 12, wherein the initial sorting matrix refers to a sorting matrix  $(r_{ij})_{m \times k}$ , which is generated based on each round of comparison candidate list, and the specific form is as follows:

$$R = \begin{pmatrix} r_{11} & \cdots & r_{1k} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mk} \end{pmatrix}$$

wherein m denotes m rounds of comparison of the biometric sample to be recognized, k denotes the length of the candidate set, and  $r_{ij}$  denotes the matching score of the biometric sample to be recognized at the ranking of j after i rounds of matching.

14. An electronic device, comprising:

a memory, configured to store a computer program; and

a processor, configured to execute the computer program to implement the method according to any one of claims 1-9.

15. A computer-readable storage medium, comprising: a memory for storing a processor-executable instruction, wherein when the instruction is executed by a processor, the method according to any one of claims 1-9 is implemented.