

# Fundamental research on the fingerprint recognition algorithm

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**Abstract:** With the further need for security, the fingerprint pattern recognition technology began to be used in various fields, from the theoretical field to practice. Digital fingerprint processing concerns the algorithms and processes of automated fingerprint image processing, feature measurement, detail description, pattern analysis, recognition and classification by the computer instead of manual. In this article, four modules for fingerprint identification are introduced: the modules for fingerprint image sampling, for image pre-processing algorithm, for feature extraction and for feature matching algorithm. Finally this article gives the completed procedure of the fingerprint image processing and feature extraction.

**Keywords:** fingerprint recognition, image processing, feature extraction, pattern recognition

## 1 INTRODUCTION

Fingerprint refers to the finger's end positive skin with uneven ridge, which is arranged in a regular formation of different texture. As the fingerprint has lots of characteristic (lifelong invariance, uniqueness, etc.) and convenience, it almost becomes synonymous with biometric identification [1].

At present, the solutions of security problems and the problem of identification method have been more and more important, it also has increasingly and widely application. Fingerprint characteristic is the inherently physiological feature and compared with traditional identification method, it has many advantages. Consequently the method of fingerprint identification has become one of the most important methods in the identification field.

Fingerprint identification is executed after fingerprint analysis. The purpose of fingerprint analysis is to extract the fingerprint features, in order to match the template of the special fingerprint. These features include the types of the texture (the arch, loop and whorl types), the shapes of the line (the straight line, arc or wavy lines), and the details in fingerprint (the end, the branch, the central point, the short line, etc.) [2].

There are three processes for the traditional manual fingerprint identification: establishing the fingerprint template card, sampling the fingerprint, and matching the sampled fingerprint to the templates. This method requires excessive personnel and needs many staffs. Thus it is gradually replaced by the digital fingerprint identification method.

Digital fingerprint identification method depends on the computer vision, and it can establish the electronic

fingerprint templates automatically, sample the electronic fingerprint and match it with the templates.

The usage of the RFID technology, the embedded system, the communication and other technologies expands the application of fingerprint recognition. Further more, with the rapid development of the network information technology and E-Commerce, the research on the fingerprint pattern recognition becomes more important.

## 2 PREPROCESSING

### 2.1 Fingerprint mode conversion

There are six steps for the conversion of the fingerprint modes, from the real fingerprint to the final extracted features, which is shown in Fig. 1.

(1) Transfer the real fingerprint to the color image: scan the real fingerprint digitally by the fingerprint-sampling device using the proper resolution rate.

(2) Transfer the color image of fingerprint to the grayscale image: calculate all the pixels one by one by the color/gray conversion formula. The converted gray levels range from 0 to 255. The higher the value, the brighter the point is.

(3) Transfer the grayscale fingerprint image to the object mode: the fractal dimension of pixels between the background and fingerprint in the image is different. Thus we can extract the fingerprint object from the background.

(4) Transfer the fingerprint object to the fingerprint textural characteristic mode: by using the knowledge of the fingerprint analysis, we can mark each fingerprint feature point, so that we can obtain the information of the fingerprint texture and form the fingerprint feature pattern.

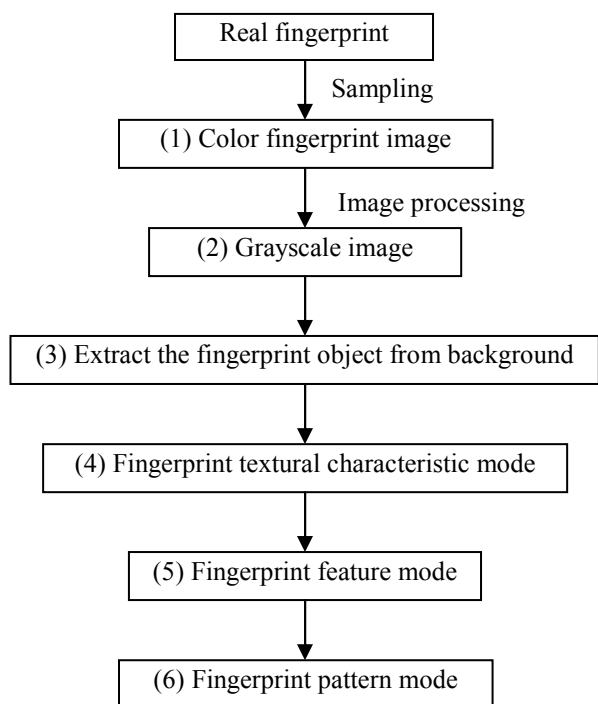


Fig.1. Fingerprint mode conversion

(5) Transfer the fingerprint textural characteristic mode to the fingerprint feature mode: using knowledge of topology, the fingerprint texture characteristic is classified according to the different characteristic branches. After transferring, the pattern can be recognized with high efficiency, and the recognition time can be decreased.

(6) Transfer the fingerprint feature mode to the fingerprint pattern mode: we form a template by combining the fingerprints and the holder's ID number, so that the database is established. Thus the pattern of the sampled fingerprint can be recognized.

## 2.2 Fingerprint recognition algorithm

There are four modules consist of the fingerprint pattern recognition algorithm [2], which is shown in Fig. 2:

(1) Fingerprint image acquisition module: the fingerprint image is sampled and the digital fingerprint data matrix is obtained.

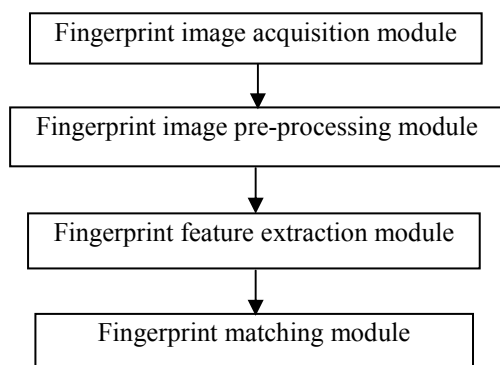


Fig.2. Four modules for fingerprint pattern recognition

(2) Fingerprint image pre-processing modules: restoration from the original fingerprint image. The process includes three steps, which are restoration, intelligent enhancement processing and thinning processing.

(3) Fingerprint feature extraction module: extract the features of the fingerprint.

(4) Fingerprint matching module: matching and comparison are included in this module.

## 3 DESIGN AND ANALYSIS

For the four modules discussed above, we need to make overall process planning and selection to each module respectively [1, 2].

First is the fingerprint image acquisition module: fingerprint image collector is used to sample the fingerprint image, but we need to judge its integrity and clarity. Here the difference-filtering algorithm is chosen for process, and then through the threshold to judge whether the image is qualified. If the result is zero, it means that none of the fingerprint data is collected, if it is more than the threshold, it means that the complete clear fingerprint image has been collected.

Secondly, the fingerprint image pre-processing module is executed: by using the aberration correction, segmentation, equilibrium, convergence, smooth, intelligent enhancement, binarization and thinning algorithms to get a clearer skeleton of the fingerprint image. The detailed algorithm is divided into the following seven steps, which is shown in Fig. 3 and Fig. 4.

(1) Distortional image correction processing includes geometrical optics and grayscale mapping.

(2) By calculating the distribution of intensity and gradient field to extract the fingerprint object: the fingerprint object has a higher value of both intensity and gradient fields than those of the background.

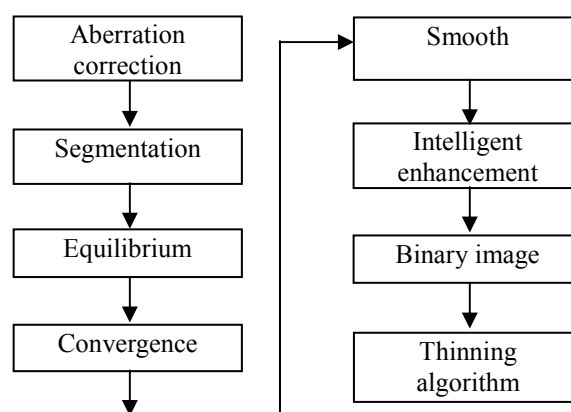


Fig.3. Fingerprint image pre-processing module

(3) The purpose of the gray level balance is to calculate the gray value of each pixel, and make images evenly distributed for each gray level.

The contrast processing for images is to solve the problem of balance. Because histogram is always used to describe the distribution of gray values, we need to establish a histogram distribution of the image and then make use of the grayscale algorithm to establish the mathematical model to balance the image.

(4) It exists objectively that the fingerprint image is divergent, and the convergence of overall picture is a micro process. Thus according to the chaotic divergent fingerprint physical model, the Gaussian function is used to do the image convergence.

(5) When the fingerprint image is sampled by the photoelectric sensor, it is easy to bring the surrounding dust and stain in the image, and this forms the noise points. In order to eliminate the noisy points in the fingerprint image, the average template for relevant pixels should be considered to smooth the image.

(6) Intelligence enhancement is the inherent ability of human eyes. To apply that ability to the computer, the Gabor physical model, which can do intelligence convergence and intelligence enhancement, is set up according to the fingerprint field of line direction.

(7) Threshold makes the gray value to be 255 at the valley line pixels in the fingerprint image, and 0 at the ridgeline pixels. There are two methods to realize binarization, which are the gray threshold segmentation method and the intelligent binary domain analysis method. If we want to extract the fingerprint skeleton, it's necessary to do the refined fingerprint image processing, and the common thinning algorithm and querying method are always used.

The third is the fingerprint feature extraction module: extracting all the fingerprint feature points from the preprocessing module, eliminating the false and retaining the true feature points, and saving to the database.

The last is the fingerprint pattern matching module: its main content is to match the fingerprint feature point topologically to the database precisely.

## 4 RESULT

Fig. 4 gives the completed procedure of fingerprint image processing and feature extracting. The gray level image Fig. 4(a) is used as the original image, at last the

fingerprint feature points are extracted, which is shown in Fig. 4(k). And then, pattern matching and recognition [3] is used to find the fingerprint belongs to which person that is stored in the database.

## 5 CONCLUSION

In this article, the background and the basic content of the traditional and the digital fingerprint are described. And then the four modules for fingerprint identification are introduced: the modules for fingerprint image sampling, for image pre-processing algorithm, for feature extraction and for feature matching algorithm. After that, the detailed description for each module is expressed.

From the article, we see that the fingerprint recognition is not difficult unless the feature points can be defined and extracted by image processing, pattern matching and recognition.

In the future, the face recognition, voice recognition and signature recognition [4-6] are also considered for the security recognition system.

## ACKNOWLEDGMENT

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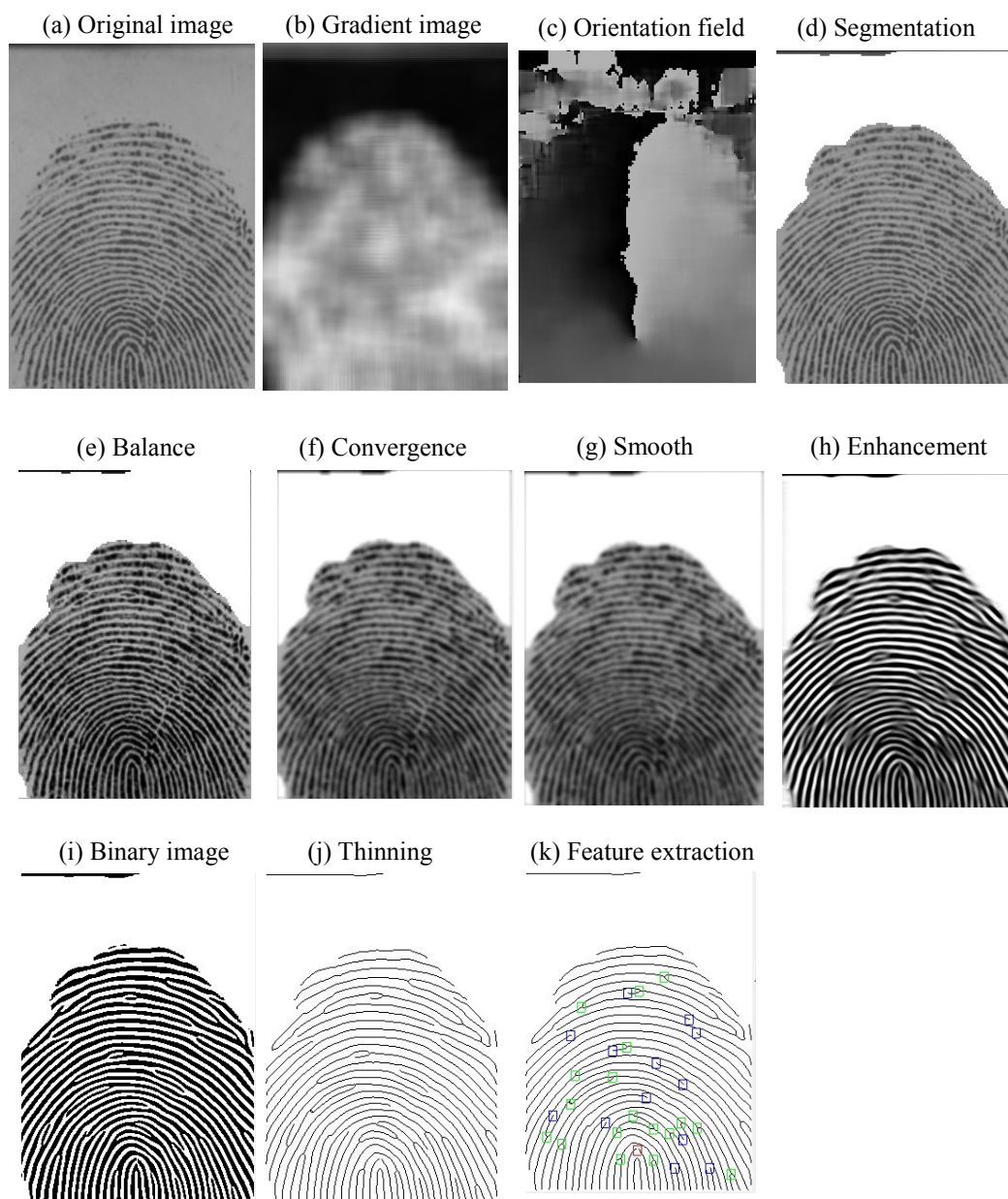


Fig.4. Image processing and feature point extraction