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A Study of Hand Vein Recognition Method

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Abstract: In this paper, the theoretical foundation and difficulties of hand vein recognition are introduced at first. Then, the threshold segmentation method and thinning method of hand vein image are deeply studied and a new threshold segmentation method and an improved conditional thinning method are proposed. The method of hand vein image feature extraction based on end points and crossing points is studied initially, and the matching method based on distances is used to match vein images. The matching experiments indicated that this method is efficiently.

Keywords : Hand vein recognition, Threshold segmentation, Feature matching

Ⅰ. INTRODUCTION

There are great changes happened in the human society following the advent of the information age. People's dependence and requirement on information are enhanced day by day. Information safety is looked more important. And the identity authentication has new connotation in the information age. The identity authentication technology based on biological characteristic has showed a great of advantages because of the use of inherent physiology and behavior characteristics of human.

At present, fingerprint recognition is comparatively a perfect identify authentication technology. The capability of fingerprint recognition algorithm has arrived at an applied degree. The price of it is comparatively lower than other feature extraction technologies. And it has been accepted by large customers. But, the fingerprint recognition is confronted with a bottle problem that the applicable people have been restricted largely. First，people may lose the usable fingerprint suddenly. Sometimes the finger is too wet, dry or desquamated and such other characters dandification. As a result of that the fingerprint image may be dilapidated or blur, the possibility of successful matching must fall down, there must be a big descends in the recognition rate. And these cases are familiar sights, so they must affect the applications of fingerprint recognition technology in a large range. Secondly the biggest fault of fingerprint recognition is the easily duplication and imitation, because that the fingerprint is the surface character of body. Besides, the fingerprint has the hygiene problem brought by direct contact, and so on.

For these disadvantages of fingerprint recognition, a new biology feature recognition technology - hand vein recognition technology has been studied in this paper.

Fig.1 The exactly place of hand vein extracting

Compared with fingerprint recognition, the vein recognition has many advantages as follow.

1) The vein is the inner features of body, can't be fabricated.

2) The vein recognition is contactless, don't contact with body of human and don't impinge on human body.

3) The vein characteristics are lasting.

At present, the identity authentication technology based on hand vein recognition has been reported in some countries such as Occident，Japan[1], Korea[2]. The product of hand vein recognition has been born in some companies of Japan [3] and Korea [4]. But, Up to now, there isn't any hand vein recognition products coming out in China. Only Tsinghua University studied this question. What's more, there is only one paper about feature extracting and matching of hand vein image in Journal of Tsinghua University.

For this case, we studied the vein recognition on trial in this paper. We think about that there are several difficulties in vein recognition.

1). On normal conditions gray scale discrimination of vein image is very small. If there is no good threshold segmentation method, there is no possible that we get the effective binary image which has enough information.

2). The general conditional thinning can't achieve single pixel completely, this can bring us quite big trouble on the feature extracting based on endpoints and crossing points, so we must improve it further.

3). Because of that there is less study of vein recognition in china or international, we have little reference for vein feature extracting and matching.

Ⅱ.THRESHOLD DISPOSAL OF VEIN IMAGE ---THRESHOLD IMAGE METHOD

The same as other image recognitions, they all go

through the same process, the process is mainly shown as the Fig.2. Following with image extracting and image standardization, we will go on with the vein image threshold disposal. This is the one of the main contents in this paper.

Fig.2 General flowchart of vein recognition

For vein image, our experiment indicated that good segmentation effects can't be got by Single threshold (fixed threshold, total mean, total OSTU and so on) and multi-thresholds segmentation methods (local mean, local OSTU)[5]. But the segmentation effect has been improved from the single threshold to multi-thresholds.

So we proposed a completely new method to segment the vein image, we call it the threshold image method[6] . That is to increase the number of the thresholds to the number of the image pixels. It is also to say that if we get a threshold image in the same size as the original image, we can segment the original image by the threshold image.

The principle of the algorithm is as follow. For every pixel $f(x,y)$ there is one gray scale value T which can decide the pixel's value (0 or 255) in binarization process. T is decided by $f(x,y)$ and the N points around it (N=(2k-1)*(2k-1)-1). For the vein image, the value of k is 5 in this paper.

Let's describe the process of the algorithm briefly. First of all, the image must be smooth enough. Then we segment it. The first step of segmentation is the same as the smoothing image algorithm. Here we still use the smoothing template whose size is 31×31. The mean value of the gray scale in this range is calculated and is regarded as the pixel gray scale in the center of the template (the size of the template is decided by the Actual conditions). Here a new bitmap $T(x,y)$ is created and every pixel scale of it is set to 0. The original image is $f(x,y)$. We know that the first pixel is at the left bottom. Starting with the left bottom of $f(x,y)$, we calculate the first gray scale value T_0 with the template. The pixel of it should be (16, 16). So the gray scale of the new bitmap at (16, 16) is set to T_0, that is to say $T(16,16)=T_0$. Then move the whole template one pixel right, figure out the new threshold T_1 as the gray scale of the new point (16, 17), $T(16,17)=T_1$. We figure out the whole threshold image $T(x,y)$ like that.

Take it attention, that in the whole process of calculating the threshold image the gray scale value of the pixels on the original image didn't be changed, instead, they were only read out. The new image $T(x,y)$ is called threshold image, because the whole image is regarded as the threshold of the original one. Then we compare them pixel by pixel.

$$\begin{cases} f(x,y)=0 & f(x,y)\geq T(x,y) \\ f(x,y)=255 & f(x,y)<T(x,y) \end{cases}$$

For the Fig.3 we compare the fore-and-aft effect of segmentation. It is obvious that the grain of the original image has been got as Fig.4. The effect is comparatively ideal.

Median filtering method can eliminate burrs and make the borderline smooth. In addition, because the result of the new threshold dispose algorithm inducts massive noises, these noises are wiped off according to the size of them in this paper. The effect of filtering is as Fig.5.

Fig.3 The standard image

Fig.4 Threshold segmentation

Fig.5 Filtering

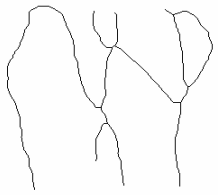

Fig.6 The thinning image

III. IMAGE THINNING

In this paper we thin the vein image using the combination method of general conditional thinning and templates. Get rid of the special un-single pixel point after the general conditional thinning.

A. The conditional thinning algorithm[7]

Mark the target point 1, the background 0. The target point in whose 8-neighborhood there is at least one background point is defined as boundary point. The algorithm manipulates the boundary point as follow.

Consider the 8-neighborhood centered by the boundary point**.** That is to say that the center point is p1, its 8-neighborhood points are signed as p2, p3 … … p9 deasil. P2 is on the top of p1. If p1 is 1 and satisfy the following four conditions at the same time, then delete p1.

1). $2\leq N(p1)\leq 6$;

2). $S(p1)=1$;

3). $p2*p4*p6=0$;

4). $p4*p6*p8=0$;

Where N(p1) is the count of the nonzero neighbor points.， S(p1) is the changing times of the points' value from 0 to 1 in the order of p2, p3,……p9. All points marked are eliminated after all of boundary points have been checked out. Repeat it for every point of the image till all of the pixel point can't be deleted.

The advantage of the conditional thinning algorithm is that the connected points of lines, the turning points of the polyline and the T type breakouts can be coherent with the original image. But it thinks too much of image connectivity, so there are superabundant points in the thinning result under some conditions, and we can't get the thinning line with one pixel wide all the time. In this paper，some parts of the thinning image are enlarged as the following pictures. From these pictures we can see that the thinning line with one pixel wide didn't be gotten. This can bring us many troubles when we do feature extraction on the basis of the end points and crossing points, so it is necessary to be improved more.

B. The improved thinning algorithm

The algorithm improvement is on the base of the conditional thinning. On the conditional thinning image, the template algorithm is added to get rid of the un-single pixel point in this paper.

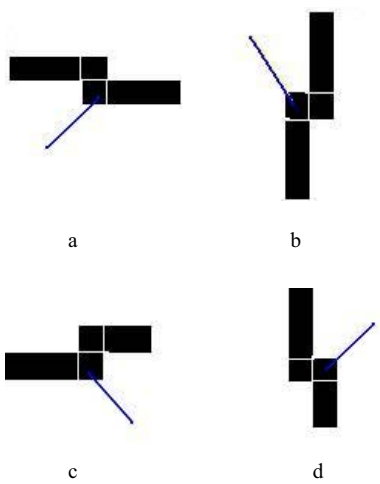

Fig.7 The un-single pixel points of the first kind

First let's see the un-single pixel points of the first kind. For the case of Fig.7, we must think of one method to get rid of the pixels pointed by the blue line because they are the superabundance points in the image (the target can still be assured the connectivity after getting out of these points). These points can be deleted according to the connection of 4-neighborhood and 8-neighborhood, and the method of templates also can be used. The templates are as follow Fig.8. The center of template is the reference point. "1" is the point of target image, "0" is the point of background image, "x" can be the both two points.

x	1	X
0	1	1
0	0	X

Ta

0	0	x
0	1	1
x	1	x

Tb

x	1	X
1	1	0
x	0	0

Tc

x	0	0
1	1	0
x	1	x

Td

Fig.8 The un-single pixel point templates of the first kind

The Fig.7a satisfies the Ta condition. Getting rid of the pixel which satisfy the place of 1 in Ta can reduce the width of the image grain and dispel the pixel points signed by the blue line a. According to this, the points of Fig.7b,c,d which satisfy conditions will be dispelled by the templates Tb, Tc, Td. Do iteration based on the conditional thinning image until the un-single pixel points of the first class are dispelled completely. Next, let's see the un-single points of the second kind.

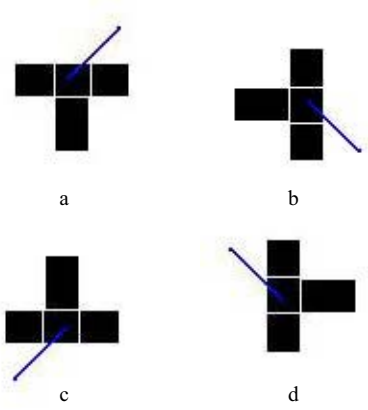

Fig. 9 The un-single pixel points of the second kind

It is similar to the first kind. Distinguish is that the templates are different. The templates are as follow.

x	0	x
1	1	1
x	1	x

Ta

x	1	x
1	1	0
x	1	x

Tb

x	1	x
1	1	1
x	0	x

Tc

x	1	x
0	1	1
x	1	x

Td

Fig.10 Templates of the second kind

We can get the real single pixel vein image after the two kinds of templates dispose, the thinning result is as Fig.6.

Ⅳ. The Feature Extraction and Matching

There are many classification and matching algorithms for pattern recognition, for example, K-L transformation method, immovability moment method and so on. But there are not many algorithms fit for vein recognition, so this is one of the difficulties in our study. Now, we introduce the methods of Tsinghua University and ours separately.

A. The method of Tsinghua University[8]

Supposing that the letters from A，…，Z are the end points and the crossing points of the image waiting for matching, the letters a,…,z are the end points and crossing points in the data-base. The displacement discrepancy with A is calculated from a, then this change is taken to the grain image waiting for matching. They match the original image and the changed image by coordinate. Here if the threshold r (coincidence ratio) arrives at 80%, the matching is recognized to be successful. Else, if the matching is unthread, they go on matching from b to z. This is the exhaustion method. And then make B the datum mark, analogy until Z or the matching is successful.

B. The scheme we adopt----feature point distance method

In this paper the feature extraction of the vein image is based on the end points and the crossing points. First, account the end points and crossing points based on the vein image collected (Generally, the count of the end points and crossing points won't be larger than 12). And then, calculate the distances between the end points and the distances between the crossing points, arrange the distances in the size sequence. In most cases, we can get more than 100 distances. Then do matching experiment using these distances.

Ⅴ. The Experiment Result and Analysis

A. The experiment result of Tsinghua University

First, build up the sample database of the hand vein images according to the fixed format. Take 5 images of one hand at different time. 65 pictures (13*5=65) have been taken to be the small scale sample database totally, and then carry on matching. First carry on self-matching, it is to say that the 5 images of every hand match with each other. This is used to judge the rate of refusing identifying, examine the rationality of the matching algorithm. The matching result is showed in TableI.

TABLE Ⅰ

Ratio of Refusing Identifying

number of samples	matching times	number of passes	refusing Times	pass ratio (%)	refusing ratio(%)	matching time (s)
65	130	124	6	95.4	4.6	5.2

Afterwards, do matching between the different samples. This is used to judge the rate of mistaken identifying. The matching result is showed in the Table II.

TABLE Ⅱ

Ratio of Mistaken Identifying

number of samples	matching times	mistaken times	mistaken identifying ratio (%)	matching times
65	1950	0	0	215

B. Ours experiment result

Take 5 images of one hand at different time, 240 pictures (48*5=240) have been taken to be the small scale sample database totally. And then carry on matching. First carry on self-matching, it is to say that the 5 images of every hand match with each other. This is used to judge the ratio of refusing identifying, examine the rationality of the matching algorithm. The matching result is showed as Table III. The recognition ratio is comparatively high.

TABLE Ⅲ

number of samples	matching times	number of passes	refusing Times	pass ratio (%)	refusing ratio(%)
240	120	119	4	99.1	0.9

Ratio of Refusing Identifying

TABLE Ⅳ

Ratio of Mistaken Identifying

number of samples	matching times	mistaken times	mistaken identifying ratio (%)
240	1000	0	0

Seen from the experiment result of algorithm within the small scope, the technical criteria of this experiment prototyping system meet a very high request. The experiment result is very exciting.

C. The performance comparison of the two matching schemes

Speaking in principle, these two matching schemes both take the method of extracting feature points. The difference is that Tsinghua University uses the method of coordinate matching, but we take the method of distance matching. Seen from the experiment result, the refusing identifying ratio and the error identifying ratio of our matching scheme are much lower than that of Tsinghua University, so the matching scheme in this paper has more practicability.

VI. CONCLUSION

Seen from the experiment result, the vein recognition algorithm we introduced has a comparatively good recognition effect. There may be speed problems in the part of threshold segmentation then the algorithm needs further improvement. In the part of feature extracting and matching, the feature points including the cyclic structures can be extracted. But in the process of matching algorithm study, the matching algorithm is comparatively simple. We will study other classifying algorithms and compare with present method then find out the best one. In addition, we will expand the experiment range further. In conclusion, as a new identity authentication technology the vein recognition has a better long term potential, need to be studied further, and can be applied to the lives of people better.

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