A Multi-Matching Method of On-line Handwritten Signature Verification Based on Mixture Features

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Abstract: *Against large error rate in the signature verification process, this paper presents a multi-matching method for dynamic signature verification. The first matching uses global features and the second matching is based on local features. Experiment show that recognition is correct to 97.87% and equal error rate is2.13%.The performance is satisfactory.*

Keywords： *handwritten signature verification; feature extraction; multi-matching*

1. INTRODUCTION

With the fast growing technology of communication and networking and its widespread implementation, a search for reliable approaches to automatic personal identification becomes unavoidable[1]. Signature verification is one of the biometric approaches to authenticating personal identity, where individuals are required to provide their signatures as evidence for their claimed identity. Because of huge data acquisition and hard to imitate in signature verification, it has high safety and reliability [2].And signature verification is based on personal biologic character, it can be accepted by lots of people and the low cost. So it has been used in many fields, such as bank finance and so on.

But in the field of pattern recognition, the signature verification technique is developed much lag. Not only as the problem of recognition algorithm, but also the lag of device development. Recently, as the device development, signature verification technique has breakthrough in America and Japan.

In china the study of signature verification began later, there are many papers which only describe the algorithm quest, and appeared some commercial product. It is reported that Jilin university developed a series of signature verification used in finance, bank. The achievement is identified by the experts from science and technology department Jilin province.

As the International Biologic Recognition Industry Association predict, in the future, the industry of signature verification will reached a lager scale[3].

A classical signature verification system is consist of data acquisition, pre-process, feature extraction, model training , model matching and performance. The system frame is shown in fig 1.

In this paper we extract the local feature and some dynamic feature to match, we get the perfect recognition result.

2 DATA PRE-PROCESS

Data pre-process is a precondition of getting perfect performance in pattern recognition. The raw data should process in two aspects:

(1) because of the low precision of computer, there are many dots in the same time, we should re-sample;

(2) when put pen to paper ,there may be some smallish strokes, the direction of stroke is discretional. It is negative influence to match, so we should smooth it[4].

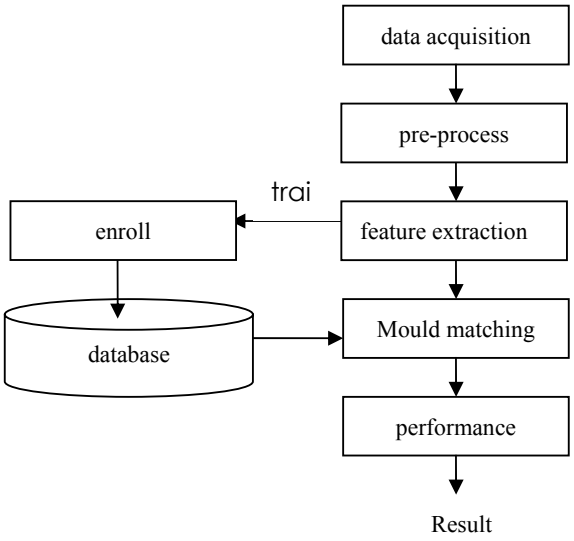

Fig 1 The system frame

Pre-process includes four parts: remove redundancy, re-sampling, smoothing and standardization. Remove redundancy is in order to delete some dots that in the same time; and re-sampling is to reduce the data and improve the system

speed; smoothing is to remove the noise; and standardization is to remove the influence of device and personal habit through geometric transformation.

After pre-process we get the standard data. The result of before pre-process and after pre-process is shown in fig 2:

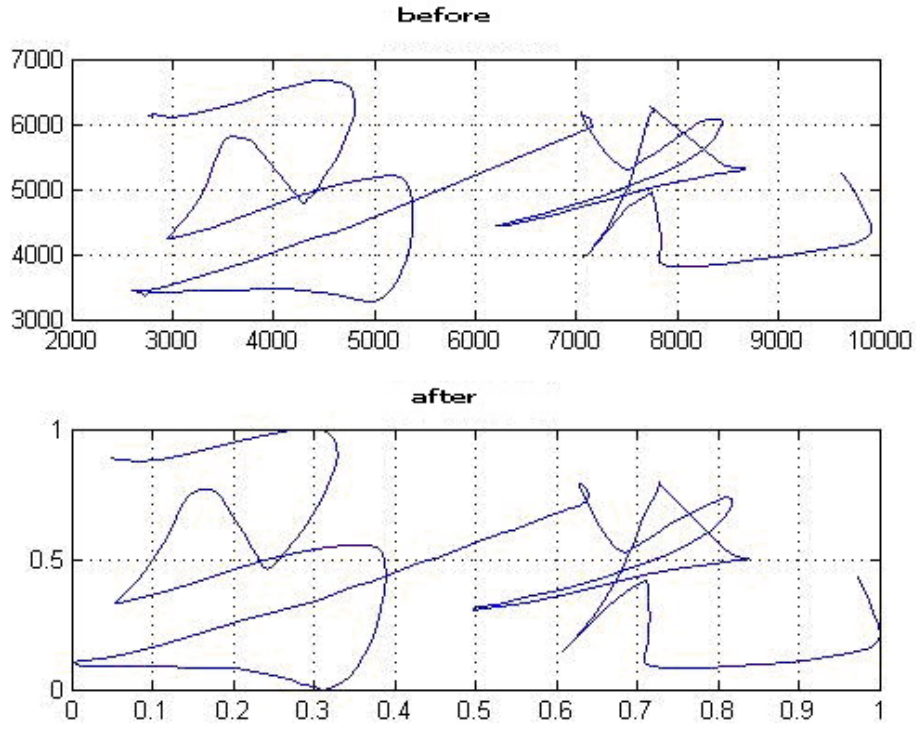

Fig 2 The comparison of before pre-process and after pre-process

Table 1 using first matching the FAR and FRR

ID	FRR	FAR	ID	FRR	FAR	ID	FRR	FAR	ID	FRR	FAR
1	0	25%	11	7.5%	0	21	2.5%	15%	31	0	5%
2	0	0	12	0	2.5%	22	2.5%	0	32	10%	32.5%
3	0	27.5%	13	5%	10%	23	0	0	33	5%	7.5%
4	0	22.5%	14	10%	10%	24	0	0	34	22.5%	0
5	7.5%	2.5%	15	0	2.5%	25	12.5%	0	35	10%	5%
6	17.5%	0	16	0	22.5%	26	2.5%	7.5%	36	12.5%	12.5%
7	0	22.5%	17	5%	32.5%	27	0	0	37	0	0
8	0	5%	18	0	15%	28	2.5%	0	38	2.5%	5
9	7.5%	0	19	0	5%	29	10%	2.5%	39	2.5%	2.5%

10	2.5%	2.5%	20	2.5%	0	30	2.5%	0	40	10%	0

Through first matching ,the FAR is 7.44% and the FRR is 4.38%.

Using second matching the result is shown in table 2:

Table 2: using second matching the FAR and FRR

ID	FRR	FAR	ID	FRR	FAR	ID	FRR	FAR	ID	FRR	FAR
1	0	0	11	0	0	21	0	10%	31	0	2.5%
2	0	0	12	0	0	22	0	0	32	0	5%
3	0	0	13	0	7.5%	23	0	0	33	0	5%
4	0	5%	14	0	0	24	0	0	34	0	0
5	0	0	15	0	0	25	2.5%	0	35	2.5%	2.5%
6	0	0	16	0	12.5%	26	0	5%	36	0	7.5%
7	0	0	17	0	10%	27	0	0	37	0	0
8	0	1	18	0	2.5%	28	0	0	38	0	2.5%
9	0	0	19	0	2.5%	29	0	0	39	0	0
10	0	0	20	0	0	30	0	0	40	0	0

Through two matching ,the FAR is 2% and the FRR is 0.125%.The accuracy is 97.87%.

3 FEATURE EXTRACTION

After data pre-process, we need to do feature extraction. There are more than 40 features are used in signature verification. The features can classify into two domains:

(1) there is big distinguish between truth and false;

(2) There is not sensitive in the true signature of the same person.

Consider the next matching , we select some local features, such as total time and some personal features. We select the features includes: the ratio of signature height and width, total time, coordinate variance(include X,Y,P), coordinate mean (include X,Y,P), the pen writing time[5].These features show the signature basic feature, and also is easy to get. Personal features are hard to get, but there are many signature information in it, and is different to imitate. Vander and Thuring confirm[6] that signature is a ballistic trajectory motion, it is a quick and skilled motion. In this paper , we extract the power feature through wavelet package.

4 MULTI-MATCHING and EXPERIMENT

4.1 MODEL ESTABLISH

We extract the feature describes in frontal paper from three true signatures. Calculate the corresponding feature's mean value and variance. These values form a two-dimension vector, this vector named template vector. Then we use the feature vector and template vector through formula 3-1 calculate the $d(\vec{s},\vec{t})$ match along with local feature and anther $d(\vec{s},\vec{t})$ match along with personal feature From the three local feature $d(\vec{s},\vec{t})$,we select the biggest one to set as the first matching threshold value d_1^{thres} ,as the same reason, the second matching threshold value d_2^{thres} .

$$d(\vec{s},\vec{t}) = \sqrt{\frac{1}{f}\sum_{i=1}^{f}(\frac{s_i - t_i}{\sigma_i})^2} \qquad \text{formula 3-1}$$

Where f is the dimension of vector; s_i is i_{th} feature value in vector $\vec{s}$; t_i is i_{th} feature value in template vector, σ_i is i_{th} variance in template vector.

4.2 FEATURE MATCHING

In this paper, he signature verification used local matching and part matching. First matching :we calculate the distance between test signature and template signature. We get a value *R1:*

$$R_1 = \begin{cases} 1, d(\vec{s},\vec{t}) \le d_1^{thres} \\ 0, d(\vec{s},\vec{t}) > d_1^{thres} \end{cases}$$ formula 3-2

Second matching is part matching: if R1=0 in the first matching ,we use the second matching, also use the formula 3-1 to calculate the distance, we get another value R2:

$$R_2 = \begin{cases} 1, d(\vec{s},\vec{t}) \le d_2^{thres} \\ 0, d(\vec{s},\vec{t}) > d_2^{thres} \end{cases}$$ formula 3-3

As above, when R1=1,we judge the test signature is true, when R1=0,and R2=1,we also judge the test signature is true, Only when R1=0 and R2=0, we judge the test signature is false.

4.3 EXPERIMENT

In the experiment, we use the svc2004 data[7],we select 40 person signature data, use first matching, the result is shown in table 1:

5 CONCLUSION

In the paper we describe a multi-matching method based on mixture features. Through local features, it can quickly distinguish the random false signature. Towards the training false signature, we use personal feature matching after local feature matching, improve the recognition speed .Besides ,the result of recognition is perfect, and have good functional value.

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