Statistical Features Based Off Line Signature Verification System using Image Processing Techniques

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Abstract: ***Handwritten signature recognition can be divided into online (or dynamic) and off-line (or static) recognition. Online recognition refers to a process that the signer uses a special pen called a stylus to create his or her signature, producing the pen locations, speeds and pressures, while off-line recognition just deals with signature images acquired by a scanner or a digital camera. In general, offline signature recognition is a challenging problem. Unlike the on-line signature, where dynamic aspects of the signing action are captured directly as the handwriting trajectory, the dynamic information contained in off-line signature is highly degraded. Handwriting features, such as the handwriting order, writing-speed variation, and skillfulness, need to be recovered from the grey-level pixels. The presented work is focused on development of robust algorithm for verification of hand written signature verification. The goal of an automatic signature verification system is to confirm or invalidate the presumed identity of the signer from information obtained during the Recognition of the signature.***

Keywords: signature recognition, handwriting trajectory

1. Introduction

Signature verification is one of the most important tasks in banking applications either on-line or off-line. Banks when dealing with their customer maximally rely on their signature. Therefore, authentic and fast signature verification becomes a very sensitive issue in daily banking. Signature verification requires the use of electronic tablets or digitizers for on-line capturing and optical scanners for off-line conversion. Handwriting recognition is still an open problem, even though it has been extensively studied for many years. Signature verification is a reduced problem that still poses a real challenge for researchers. Off-line data is a 2-D image of the signature. Processing Off-line is complex due to the absence of stable dynamic characteristics. Difficulty also lies in the fact that it is hard to segment signature strokes due to highly stylish and unconventional writing styles. The non-repetitive nature of variation of the signatures, because of age, illness, geographic location and perhaps to some extent the emotional state of the person, accentuates the problem. All these coupled together cause large intra-personal variation.

2. Brief Literature survey

The literature on signature verification is quite extensive and shows two main areas of research, off-line and on-line systems. Off-line systems deal with a static image of the signature, i.e. the result of the action of signing while on-line systems work on the dynamic process of generating the signature, i.e. the action of signing itself. The system proposed in this paper falls within the category of on-line systems since the visual tracker of handwriting captures the timing information in the generation of the signature.

In the last few decades, many approaches have been developed in the pattern recognition area, which approached the offline signature verification problem. M. Hanmandlu [1] proposes an off-line signature verification system using Hidden Markov Model. R. Sabourin [4] proposed handwritten signature verification system based on Neural 'Gas' based Vector Quantization. Vélez, Sánchez and Moreno (2003) propose a robust off-line signature verification system using compression networks and positional cuttings. Arif and Vincent (2003) concerned data fusion and its methods for an off-line signature verification problem which are Dempster-Shafer evidence theory, Possibility theory and Borda count method. C. Quek [6] used line segment distribution of sketches for Persian signature recognition. Sansone and Vento (2000) increased performance of signature verification system by a serial three stage multi-expert system.

3. Algorithm

In the presented work, A pattern comparison of pixels captured within a specified boundary of scanned signature is made with original one. For, very firstly, the signature under test is scanned through a scanner. After acquiring the signature from the user, it has to undergo the pre-processing stages in order to get a good quality image. Pre-processing is to develop a clear and good clarity images. Pre-processing stages consists of normalization gray-scale manipulation, edge detection and noise removal. Normalization is used to have images of fixed size. If the sizes of the images are different, comparison becomes tedious process. Gray-scale manipulation is an intensity mapping method in which each pixel is assigned a gray value to improve the contrast of the images.

4. Thresholding

Acquired signature image is converted to gray scale color scheme using MATLAB command rgb2gray. Local and global thresholding approaches may be utilized to produce a binary image from the gray scale image. In the present work, a thresholding algorithm based on Otsu method is applied (global thresholding) [6]. Fig. 1.0, 2.0, 3.0 and 4.0 shows the original image taken from the scanned signature. Fig. 1.1, 2.1, 3.1 and 4.1 are the images after converting the same into gray shade format. The results after applying the Otsu algorithm over the gray image are shown in Fig. 1.2, 2.2, 3.2, and 4.2.

Fig. 1.0 JPEG Image

Fig. 2.0 JPEG Image

Fig. 1.1 Gray Image

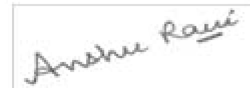

Fig. 2.1 Gray Image

Fig. 1.2 Binary Image

Fig. 2.2 Binary Image

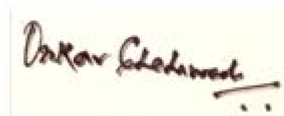

Fig. 3.0 JPEG Image

Fig. 4.0 JPEG Image

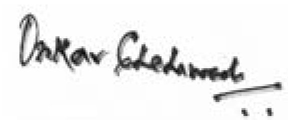

Fig. 3.1 JPEG Image

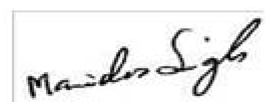

Fig. 4.1 JPEG Image

Fig. 3.2 JPEG Image

Fig. 4.2 JPEG Image

5. Noise Removal

Salt and Pepper noise are removed by applying the following algorithm:
If (P0 = BLACK) & P1= P2 = P3 = P4 = P5 P6 = P7 = P8 = WHITE)
Then P0 is the Background Pixel.
If (P0 = WHITE) & P1= P2 = P3 = P4 = P5 P6 = P7 = P8 = BLACK)
Then P0 is the Object Pixel.

P_8	P_1	P_2
P_7	P_0	P_3
P_6	P_5	P_4

P8	P1	P2
P7	P0	P3
P6	P5	P4

6. Thinning

Thinning the black and white image results are always in a huge information loss. Therefore it is essential to select a thinning algorithm which gives a good abstraction of the original signature, with a low noise level. We selected an algorithm, which removes pixels so that an object without holes shrinks to a minimally connected stroke, and an object with holes shrinks to a connected ring halfway between each hole and the outer boundary.

When used with the 'thin' option, bwmorph uses the following algorithm: Divide the image into two distinct subfields in a checkerboard pattern. In the first sub iteration, delete pixel p from the first subfield if and only if the conditions G1, G2, and G3 are all satisfied. In the second sub iteration, delete pixel p from the second subfield if and only if the conditions G1, G2, and G3’ are all satisfied.

Condition G1:

XH(p) = 1

Where XH(p) = ∑ bi i = 1 - 4

bi = 1 if X2i-1 = 0 and X2i=1 or X2i+1 = b

= 0 otherwise

Where x1, x2, ..., x8 are the values of the eight neighbors of p, starting with the east neighbor and numbered in counter-clockwise order.

Condition G2:

2<= min [n1(p) . n2(p)] <= 3

Where n1(p) = ∑ X2k-1 ∨ X2k

n2(p) = ∑ X2k ∨ X2k+1

k = 1 to 4

Condition G3:

X2 ∨ X3∨ X8) ∧ X1 = 0

Or

(X6 ∨ X7∨ X4) ∧ X5 = 0

X8	X1	X2
X7	X0	X3
X6	X5	X4

The two sub iterations together makes up one iteration of the thinning algorithm. When the user specifies an infinite number of iterations (n= Inf), the iterations are repeated until the image stops changing. Below images fig. 1.3, 2.3, 3.3 and 4.3 shows the thinned image of the above discussed binary images.

Fig. 1.3

Fig. 2.3

Fig. 3.3

Fig. 4.3

7. Feature Extraction Process

The feature extraction algorithm is applied on thinned image as shown in fig. 1.3, 2.3, 3.3 and 4.3.

Following features are extracted from the thinned image:

Centre of Gravity of the signature pattern
Min. radii in each quadrant
Max. radii in each quadrant
Mean of min. radii.
Mean of Max. radii
Mean Radius
Standard Deviation of Radii
Signature Length
Signature Width
Signature Figure Aspect
Normalized Perimeter
Radii profile form COG
Radii profile form Origin

The above mentioned parameters are computed using the coordinate geometrical formulas of radius calculation. The minimum and maximum radii are computed by applying the sorting algorithm. The computation algorithm has been implemented in matlab version 7.5 and a result text file (log file) is generated for each signature scan. The perimeter is computed by counting the no. of pixels of the signature as the image is thinned to single pixel level.

8. Results

The result as obtained by applying the algorithm on thinned image fig. 1.3, 2.3, 3.3 and 4.3 are summarized in the table given below:

Table 1: Algorithm Results

Features	*Fig. 1.3*	*Fig. 2.3*	*Fig. 3.3*	*Fig. 4.3*
Min. Radii R1 R2 R3 R4 Mean	0.03 0.01 0.06 0.03 0.03	0.15 0.04 0.04 0.13 0.09	0.13 0.01 0.04 0.01 0.05	0.42 0.52 0.12 0.07 0.28
Max. Radii R1 R2 R3 R4 Mean	1.91 1.54 1.65 2.38 1.87	1.91 0.47 1.78 0.30 1.12	1.51 1.65 1.55 2.21 1.73	1.84 0.71 2.09 0.98 1.40
Mean Radius	36.63	75.73	12.92	50.99
SD of Radii	59.72	93.06	157.45	50.43
Sig. Length	70.38	26.62	173.01	78.00
Sig. Height	4.00	9.32	12.04	1.00
Fig. Aspect	17.59	2.79	14.37	78.00
Normalized Perimeter	10.73	8.81	12.92	9.17

9. Conclusion

The results so obtained for different signature are singleton to the respective signatures. This means that when a signature is analysed using all the feature parameters, then the signature can be identified for its verification. The depository in bank should have the signature feature map at the time of registration of signature of customer. After that, when the bank find signature of a customer on a paper or cheque leaf, the same may be verified by computing the entire feature through the s/w. The error margin or acceptance level can be set by the authorised bank authority according to their policy. Thus, the feature based analysis of signature gives a fast and reliable tool in authenticating the signatures.

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