Signature Recognition by Segmentation and Regular Line Detection

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***Abstract*-This paper presents a method of identifying handwritten signature by a good algorithm capable of identifying a signature with high accuracy. Here first a signature image is segmented and then data is extracted from individual blocks. After data is collected then accuracy is measured from both numbers of segments along with regular line matching coefficient. A mathematical formula is used to perform the accuracy measurement. A test signature is compared with a standard signature that is in the database. As the level of accuracy is determined from both number of segments and similarity of lines in these segments, reliability of this method is very high. It has the capability to identify even a skilled forgery.**

I. Introduction

Handwritten signature is a form of identification for a person. Nowadays signatures are used in banks, public places and other areas. It is very important that a person's signature be identified uniquely. For this reason digital computers are introduced for signature recognition purposes. Many researches have been done on this topic. Many methods are also introduced for proper signature recognition in offline mode. Some methods use complex stroke algorithm that is sometimes time consuming. Some algorithm needs six or seven samples for database that consumes huge memory storage. Movement of pen, pressure of writing is needed in some cases even for off-line verification where data input is very complex. A method is introduced by Ahmed [1] where a feature from a signature is compared with a known collection of features. In a coonectionist approach by Isabelle [2] uses both image processing and connectionist approach to recognize a signature. Dang [3] and Ye [4] also showed methods to find a match for signatures. All these methods need to extract huge data from a signature image and complex method to find a match. A segmentation approach was performed by Brault [5] that uses many vector calculations for finding a single critical point. Method presented here also uses segmenting feature but with less difficulty. Some method needs to have many signatures even for a single person for a perfect match [6]. In an on-off line method by Alessandro [7] needs to change contour of a handwritten signature image to three different levels that reduces reliability. The method presented here does not require any complex mathematics. It is based on segmentation of a particular signature image and extracting data from it in very easy fashion.

II. Proposed Scheme

Method for the identification of signature in this paper is described here. This method is unique. No research work has used this procedure before. So full method along with its sub sections are presented thoroughly. Full procedure can be divided in six sub-sections. Associated plots and necessary mathematical models are presented whenever needed. After observing all the sub sections, full procedure can be thoroughly understood.

A. Getting the Signature Image and Thinning Process

First an input signature is taken. The input is via pen held by a user. But real input for the method has to be in a form such that computer processors can use them. This can be done by taking the signature in a touch screen board or scanning a signature image from paper. And then converting it to bitmap or gif or any other picture format. Thus we have an image that can be handled by digital computers that means our proposed method. The first process that is done by the proposed algorithm is thinning of signature image. There are a lot of algorithms for thinning process. But here a unique method is used. It is because this method shows higher accuracy than other methods in detecting a correct sign image. Standard width of signature is taken to be unit. Here a unit width image means lines in that image are of unit width. An example is shown in the Figure 1. The first figure is a part of a signature given input by a person. Thinning is done by taking the mid point of two extremely positioned points having only dark points between them (or any solid continuous colored points) and maintaining minimum distance between them. After this process another point is chosen a little away from previous point. The distance of this point is such that data lost due to this is negligible. Figure 2 shows the full procedure. Although other algorithms such as Morphological operations [9] or Zang and Suens thinning process [10] can be applied. It was seen that little error occurs in accuracy (about .1% to .7%) if we use other thinning procedures.

B. Normalization of Signature Image

After the thinning procedure normalization of the signature image is done. It is necessary for the presented method that both the signatures in database and in the input side are of same size. So stretching is performed to the input signature in case it is smaller than standard size or squeezing is done for being bigger. Normally all the signatures in the database are

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made to fit inside a rectangle of same width and length. Whole step is shown in figure 3.

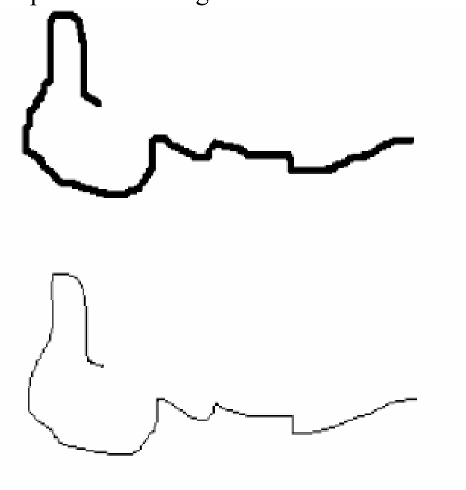

Fig. 1. First signature is input signature. Second one is obtained after thinning process.

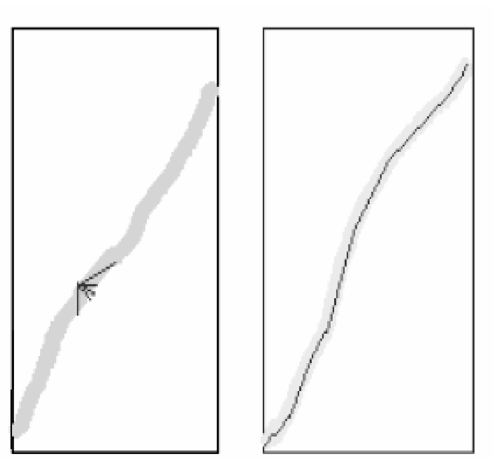

Fig. 2. Making a thick line to a thin line of unit width.

C. *Segmentation*

This is the most important part. Via this step signature image is divided into small parts. From these smaller parts we are going to take data for matching purposes. Two steps do the segmentation.

1) Vertical Segmentation: This step is done by starting scanning the signature image. First the image is put inside a rectangle so that it is properly fitted inside this rectangle. Scanning is started from left most upper point. Here vertical scanning is performed and if any peak or crest in the image is found then a line is drawn through it. Similar process is performed by scanning from left most lower point and going upwards while scanning. In this way total image is divided in vertical segments.

2) Horizontal Segmentation: Horizontal segmentation is done on each vertical segment. Here scanning is done from upper left point and down to lower left point. In each case scanning is moved from left to right to find any peak or crest. If found a horizontal line is drawn through it. Similar operation is performed for right most upper point to lower point in each vertical segment. But in later case scanning is moved from right to left. Two segmentation processes are shown in figure 4.

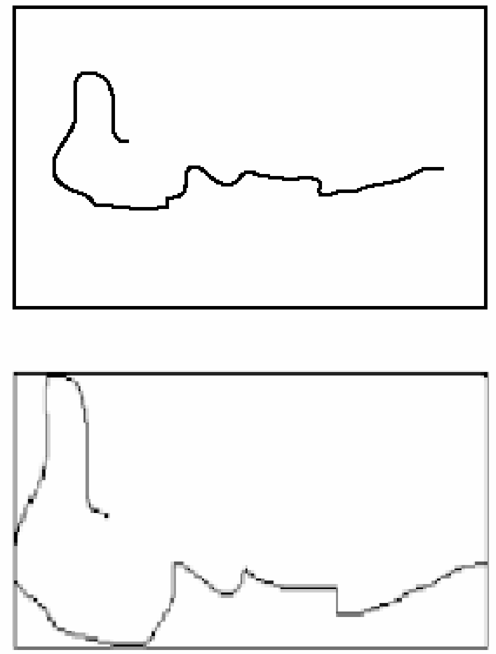

Fig. 3. Normalization of signature image.

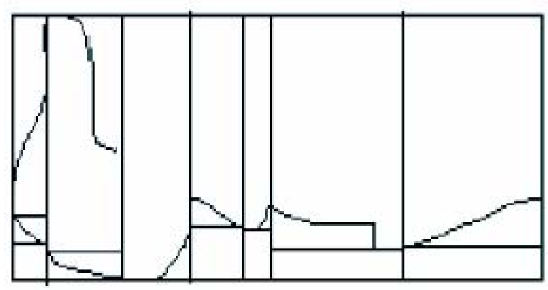

Fig. 4. Image after both vertical and horizontal segmentation.

D. *Data Collection*

After vertical and horizontal segmentation, signature is divided to small parts. Only a few basic shapes can be present in these small parts. These shapes are shown in figure 5. We can say these shapes are regular. Data can be collected from these shapes via fit curve method. But it is not easy to fit any line to a known mathematical shape (such as parabola, circle, straight line, hyperbola etc). Fit curve method will introduce huge error. For this reason a new method is introduced. For a particular line in a block two extreme points and mid point is located. After these two lengths (for two extreme points to the mid point) are calculated. Angle between these two lines is also determined. Length and width of the particular box is also determined. These five data are essential for a unit box. They are stored for a specific block. For all other segmented blocks similar data are obtained and stored. Thus regular line detection is performed.

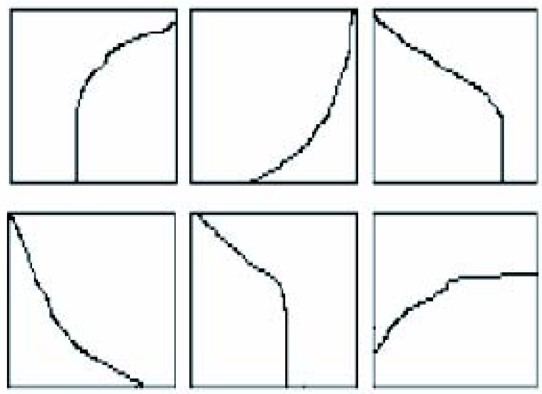

Fig. 5. Shapes that occur.

E. Comparison

After data is collected for a particular signature comparison is made. An input signature is compared with all the signatures in the database. For a particular image number of segmented blocks and five unique data (as mentioned above) for each block are gained. Matching is performed via certain steps,

(1) Block Matching: The algorithm starts from first horizontal block in first vertical block in the input signature. It is checked whether area of that block is near 20% margin (means 80% to 120%) of any blocks in the data base signature.

2) Size of Image in Each Block: If it finds a block then it is seen whether content of image in that block is near 20% of margin.

3) Block Matching with Image Matching: If second criterion is met, position of the block in input signature and base signature are compared. If a block in first vertical block is matched with a block in first vertical block of data base signature then it is given higher accuracy ratio. More deviation it sees in position less is the accuracy ratio. If more than one block is matched then the one with highest accuracy is taken.

4) Succeeding Blocks Accuracy Checking: After this another accuracy ratio is made. This is illustrated as follows. When a block is matched with one in data base signature, it is seen whether next succeeding block of input signature is matched with the succeeding one of data base signature. If answer is yes then next blocks are checked in similar manner. If any block is found as mismatch then whole procedure is stopped for that block. Now the block is given an accuracy ratio depending on how many succeeding blocks are in match. This step can identify any match of part of signature pattern with another part of another signature despite of their position.

5) Result: After all the accuracies are gained total accuracy of the signature is obtained via following formula

$$A = \frac{\sum (a_{ij} \times \frac{q_{1a}}{q_{1b}} \times \frac{r_{1a}}{r_{1b}} \times \frac{s_{1a}}{s_{1b}} \times t_1 \times mn_1)}{\sum a_{ij}} \qquad (1)$$

Here,
A= Total accuracy
a_{ij}=Area of individual blocks
q_{1a}=Length of first line in first image
q_{1b}=Length of first line in second image
r_{1a}=Length of second line in first image
r_{1b}=Length of second line in second image
s_{1a}=Angle for first image
s_{1b}=Angle for second image
t_1=1, if s_{1a} and s_{1b} are of same sign (both positive or both negative)
t_1=0, if s_{1a} and s_{1b} are of different sign (one positive and other negative)
mn_1=Accuracy from succeeding blocks
The whole comparison process may seem a little difficult. But it is clearly discussed in experimental result portion.

6) Error Handling Capability: The process has some error handling capability within itself. They are discussed below. Twisted Line in a Block: It can be possible that after vertical and horizontal segmentation, more than one line stays in a block. In this case vertical and horizontal segmentation is done in the block itself. And the block is considered as an independent image. Mismatch of Number of Vertical Segments: If numbers of vertical segments are not equal problems can occur for the comparison. Method needs to find out the position of dissimilarity of two signatures. For this reason all the vertical segments widths are checked successively from both directions. First vertical segments are checked which are generated from scanning from upper side. After this lower ones are checked. This is shown in figure 6. Any extra block in input sign may be given accuracy 0.

Mismatch of Number of Horizontal Segments: Another error can occur due to different number of horizontal segments. In this case number of horizontal segments for a specific vertical segment is compared with the number of horizontal segments for that particular vertical segment of experimental sign. If horizontal segments are mismatched then width of vertical segment is increased and decreased and horizontal segmentation is done on that portion. This increase and decrease is done up to 20% of original vertical segment in all directions successively. If no success is obtained after this than value of accuracy for those horizontal segments for which mismatch occurred is taken as 0. In figure 7 it is shown.

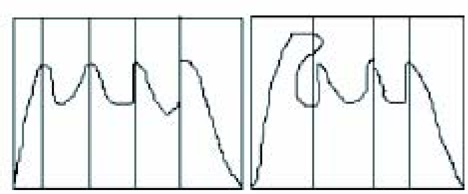

Fig. 6. Normal vertical segmentation and error in vertical segmentation due to irregular shape.

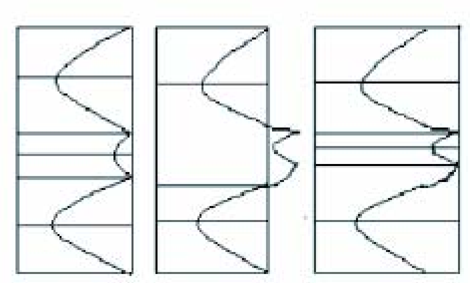

Fig. 7. Correction in number of horizontal segments.

III. EXPERIMENTAL RESULT

A complete MATLAB program is written for the whole process. Now an operation of the proposed algorithm is shown on two signatures step by step. For understanding two different signature images are taken. These two images are shown in figure 8.

After all the calculations matching percentage is 84.54%. This result is expected due to slight mismatch between two signature images. This method was capable to find the mismatched portion also which is lower left one. Another comparison was made with two signatures where there is a slight mismatch that can barely seen in eyes. First image is same as the first one in figure 8. So second image is shown in figure 10.

Complete operation was performed on these two images too. Here matching percentage was 96.02%. Another experimental procedure was performed. In this case a persons signature is compared with six different signatures. Person Mr. X is let to put a signature and it was compared with signatures of Mr. X, Y, Z, U, V and W. From results it is seen a match is found.

Fig. 8. Actual image in database.

Fig. 9. Input image to be compared.

Fig. 10. Image to be compared in second case.

Person's name	Accuracy
Mr. X	99%
Mr. Y	72%
Mr. Z	60%
Mr. U	9%
Mr. V	12%
Mr. W	27%

IV. CONCLUSION

A new method to identify handwritten signature is presented here. This method has the capability of finding dissimilarities between two signatures with high accuracy. It can even find the place where the dissimilarity occurs. Experimental results clearly show that this method can indeed differentiate forgery with actual ones.

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