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A Novel Image Thinning Method for Signature Recognition System

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Abstract- Signature is considered to be an important behavioral biometric of a person and signature recognition is a relevant research area in the field of personal authentication. Hence signature recognition is a tedious process in the day to day life. Most of the signature recognition system is not efficient due to poor preprocessing, normally due to poor thinning methodology. In this work various thinning algorithms have been studied and comparisons among them were performed. But none of the thinning methods gives a convenient result. Hence a new method for thinning has been proposed, which gives an acceptable result compared to the existing algorithms.

Index Terms- Signature recognition (SR), Thinning, Skeleton, Morphological operation, Erosion

I. INTRODUCTION

Handwritten signature is one of the most widely authorized biometric features for authentication and identity of an individual. A signature is a handwritten depiction of someone's name and usually consists of combination of special characters or symbols. The writer of the signature is noted as the signatory or the signer. Signature recognition (SR) [1] is the process of identifying signature owner (the signer). The system is also capable of checking the authenticity of signatures [2]. That is to check whether the signature is forged or not. Each person has a unique handwritten signature written in his own style, but it can be differ at each time. Hence the signature recognition is a challenging problem in daily life [3]. Signature recognition system is applicable on many fields such as Bank cheque processing, Credit card transactions, Visa application, Academic certificates, and Governmental documents etc.

Thinning of signature image [4] is one of the major difficulties faced by the SR system. Thus the poor thinning strategy leads to misclassification of signatures. To thin an image various thinning algorithms [5], [6], [7] are used. But none of the algorithms gives a satisfactory result on the signature image. So the proposed work will focus on a new novel method for signature thinning. Thinning [8], [9] is normally a significant pre-processing step in signature recognition system to facilitate the structural analysis of an image. It is a morphological [10] operation commonly applied to binary images [11], [12] and produces another binary image as an output. The primarily use of thinning is to remove selected foreground pixels from the binary image by preserving overall structure of the image. Hence the output of thinning is a skeletonized image [13] with one pixel width. The processed skeleton possesses some of the characteristics such as connectivity preservation, single pixel width preservation, Prevention of excessive erosion and conservation of important attributes of an image. In general thinning is a reduction process and its benefit in signature recognition system includes topological property preservation, morphological feature extraction, Data reduction, Complexity reduction etc. Hence in the day to day life thinning of signatures is a necessary criterion for proper classification of SR system.
Signature Recognition system is classified into several phases. Fig. 1 shows the flow chart for SR system.

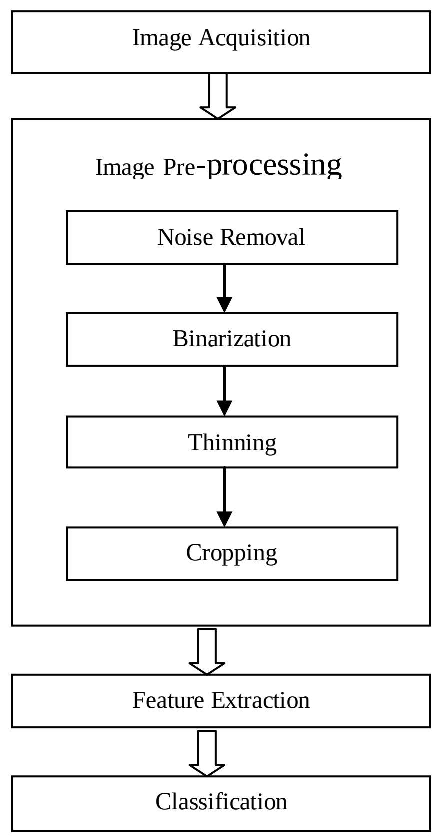


Figure1. Overview of SR system

II. RELATED WORKS

Thinning algorithms should perform thinning effectually by successive deletion of object pixels (changing them to background pixels) along the image until it becomes one pixel width. There is a collection of thinning methods including Hilditch, ZS, LW, Guo-Hall, WHF, Enhanced parallel and Arabic parallel.

The Hilditch algorithm [14] is mainly used to thin the image edges. The algorithm checks all the pixels and decides to change a foreground pixel to background if these conditions are satisfied: the number of nonzero pixels in the 8-neighbourhood of processing pixel P are in the range 2 to 6; the number of 0, 1 patterns in the 8-neighbourhood of processing pixel P is exactly one; the two pixel wide horizontal and vertical lines do not get completely eroded. The main problem of the method is that it is more concentrated on thinning the image edges; it is less effective to thin the whole image and also produce unwanted branches in the thinned image.

The zhang suen (ZS) [15], [16] algorithm is a parallel thinning algorithm, which is simple and fast to be implemented. The algorithm performs sub iteration twice on the corresponding pixels. Here new rules for unwanted erosion of two pixel width lines are introduced. The algorithm removes boundary points identified from the image pattern parallel. The drawback of this method is that slanting lines with two pixel width are appeared and also possess discontinuity in image due to loss of pixels in the slanting lines.

The LW algorithm is proposed in order to solve the problem of ZS. The LW [6], [17] is a modified form of ZS. Here only a single condition in ZS is replaced. Using the modified condition it can preserve the 8-connectivity. So that the slant lines are retained but they are of two pixel width. Sometimes it also suffers with the complete elimination of two-pixel wide horizontal and vertical lines.

Guo-Hall's [15], [18] thinning is a two sub-iteration thinning algorithm suggested to preserve the end points and also removes the redundant pixels. Compared to ZS and LW, the Guo-Hall algorithm produce thinner skeletons by deleting the redundant pixels but the resultant skeleton is very poor in nature . The algorithm gives results in less number of iterations but it does not preserve the structure.

WHF [17]algorithm is a modified form of LW algorithm. It will resolve the problem of LW algorithm. In most cases it can produce one pixel width but sometimes it makes needless trees in the image and does not preserve 8-connectivity.

Enhanced parallel thinning [17] algorithm is a modified form of ZS algorithm. Here some additional conditions are added into each pass of the algorithm. This may helps to erase the remaining lines with two pixel width. This algorithm can extract one pixel slim lines by removing the undesirable branches in the image. It can also preserve the connectivity in the image.

In the Arabic parallel thinning [17] algorithm the input pattern is scanned from upper left corner to lower left corner in each passes. The algorithm contains 4 sub-iterations instead of 2 in the previous algorithms. Here the pixel connectivity and end point pixel preservation are checked. Since the algorithm passes through multiple iterations the presence of unwanted branches became reduced. This algorithm can gives one pixel width image but the image is not completely free with spurs.

Hence none of the above methods give an effective thinning on hand written signature images. So we proposed a new thinning algorithm.

III. PROPOSED METHOD

The proposed method is a new parallel thinning algorithm, which improves all of above existing algorithms. The new algorithm preserves all the characteristics of a skeletonized image. They include basic requirement like connectivity, one pixel width and end point preservation.

The proposed thinning algorithm uses a 3*3 neighborhood mask around the current pixel P. Fig. 2 shows such a mask for pixel removal. Thus a set of rules for deletion of foreground pixels are applied based on pixels in the neighborhood.

P_8	P_1	P_2
P_7	P	P_3
P_6	P_5	P_4

Figure2. 3*3 mask for pixel removal

The algorithm for the proposed method is as follows: Here in each pass of the algorithm contains four iterations and for each iteration the first two conditions are same.

Algorithm

1. $2 \leq N(Pi) \leq 6$ (The number of nonzero pixels in the 8-neighbourhood of processing pixel P are in the range 2 to 6)
2. $S(Pi)=1$(The number of 0, 1 patterns in the 8-neighbourhood of processing pixel P is exactly one)

First iteration
3. P2* P4* P6=0
4. P4* P6* P8=0

Second iteration
3. P2* P6* P8=0
4. P4* P6* P8=0

Third iteration

3. P2* P4* P8=0
4. P2* P6* P8=0

Fourth iteration

3. P2* P4* P6=0
4. P2* P4* P8=0

Fifth iteration

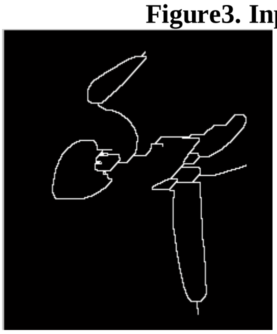
3. P1*P8* P6=1 & P3=0
4. P3*P4* P6=1 & P1=0
5. P5*P6* P8=1 & P3=0
6. P4*P6* P7=1 & P1=0

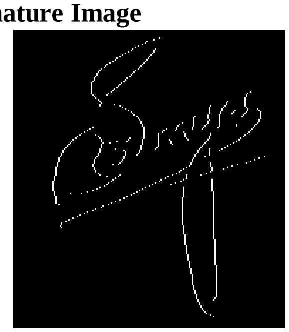
Here the first condition ensures that no end point pixel and no isolated pixel be deleted. The second condition provides a connectivity test, in which is no image pattern be disconnected. The remaining conditions perform removal of two pixel wide horizontal and vertical lines in all directions.

IV. EXPERIMENTAL RESULTS

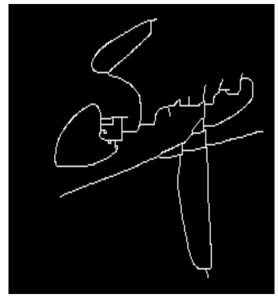
Various image thinning methods such as Hilditch, ZS, LW, Guo-Hall, WHF, Enhanced parallel and Arabic parallel has been performed in MATLAB 2014a platform on a sample of 325 input images collected from various persons in different situations. The results show that none of the above algorithm provides an effective thinning on signature images. In most cases the thinning is improper because which results discontinuities and unwanted branches in the thinned pattern. But the results showing that the proposed method gives an efficient thinning. Fig. 3 shows the input signature image and Fig. 4, Fig. 5 shows the results of existing and proposed thinning methods respectively.

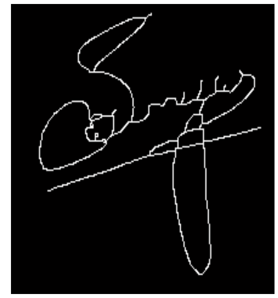
Figure3. Input Signature Image



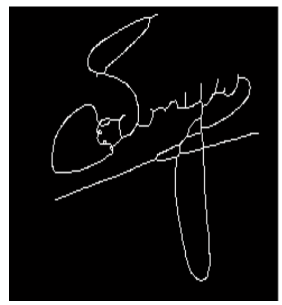


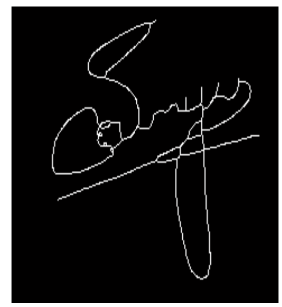
(a) (b)



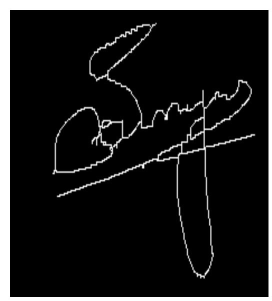


(c) **(d)**





(e) **(f)**



(g)

Figure4. Result of different thinning methods (a) Hilditch, (b) ZS, (c) LW, (d) Guo-Hall, (e) WHF, (f) Enhanced parallel, (g) Arabic parallel

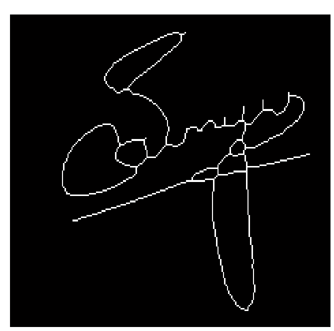


Figure5. Result of proposed thinning method

V. CONCLUSION

In this work different methods for thinning of signature images was studied and based on the information obtained from literature survey some of the thinning methods (such as Hilditch, ZS, LW, Guo-Hall, WHF, Enhanced parallel and Arabic parallel) have been implemented. But none of the implemented methods provide a proper thinning of signature images. Hence new thinning algorithm has been proposed, which gives an effective result. The proposed work preserves all the characteristics of signature image such as one pixel width, connectivity and spurs removal. It also helps to extract critical features for proper classification of signatures.

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