

**NATIONAL INSTITUTE OF TECHNOLOGY,
ROURKELA.**



DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING.

THESIS REPORT

**Dissertation submitted in partial fulfillment of the requirements for the
award of the degree**

BACHELOR OF TECHNOLOGY.

**TOPIC: OFFLINE SIGNATURE VERIFICATION
SCHEME**

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DECLARATION

This is to certify that the work in this Thesis Report entitled “Offline Signature Verification Scheme” by Prabhit Kumar Mishra and Mukti Ranjan Sahoo has been carried out under my supervision in partial fulfillment of the requirements for the degree of *Bachelor of Technology*, in Computer Science during session 2008-2009 in the Department of Computer Science and Engineering, National Institute of Technology Rourkela, and this work has not been submitted elsewhere for a degree.

Place: Rourkela

Date: May 11, 2009

Prof. Banshidhar Majhi

Professor and Head

Department of CSE

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It is with great satisfaction and pride that we present our thesis on the project undertaken under the “Research Project” paper during 7th and 8th semesters, for partial fulfillment of our Bachelor of Technology degree at NIT Rourkela.

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Prabit Kumar Mishra

Mukti Ranjan Sahoo

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Abstract

Offline signature verification schemes are necessary to determine the authenticity and genuineness of a variety of things which require certification using signatures. Most offline verification schemes till date have required perfect alignment of the signature to the specified axes. However there are situations when the sample to be verified may not be aligned to the required axis. In that situation the current verification schemes could reject the signature even though it may be genuine.

The suggested scheme aims to make the verification of signatures size and angle invariant. The invariance can be achieved by scaling and rotational manipulations on the target image.

The shape of a person's signature remains similar in all translational, scaled and rotational alignments of the sign. That is the number of crests, troughs and curves remains the same irrespective of the size and orientation of the image. The ratio between consecutive crests and troughs there by remain the same and hence can be used to determine the genuineness of a signature.

The proposed scheme also proposes a novel way to store the information extracted from the image after processing. The ratios obtained for verification can be stored in a linear array, which required much less space as compared to the previously followed schemes. The success of the proposed scheme can be determined from the appreciable FARs and FAAs.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

1.2 Motivation

1.3 Thesis Layout

Chapter 1

Introduction

1.1 Introduction

Signature has been a distinguishing feature for person identification. Even today an increasing number of transactions, especially related to financial and business are being authorized via signatures. Hence the need to have methods of automatic signature verification must be developed if authenticity is to be verified and guaranteed successfully on a regular basis. Approaches to signature verification fall into two categories according to the acquisition of the data: On-line and Off-line.

On-line data records the motion of the stylus (which is also part of the sensor) while the signature is produced, and includes location, and possibly velocity, acceleration and pen pressure, as functions of time. Online systems use this information captured during acquisition. These dynamic characteristics are specific to each individual and sufficiently stable as well as repetitive [1].

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 nature and the variety of the writing pen may also affect the nature of the signature obtained. 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. A robust system has to be designed which should not only be able to consider these factors but also detect various types of forgeries. The system should neither be too sensitive nor too coarse. It should have an acceptable trade-off between a low False Acceptance Rate (FAR) and a low False Rejection Rate (FRR). The designed system should also find an optimal storage and comparison solution for the extracted feature points [1][2][3].

We approach the problem in two steps. Initially the scanned signature image is preprocessed to be suitable for extracting features[2]. Then the preprocessed image is used to extract relevant geometric parameters that can distinguish signatures of different persons. The next step involves the use of these extracted features to verify a given image.

1.2 Motivation

The motivation behind the project is the growing need for a full proof signature verification scheme which can guarantee maximum possible security from fake signatures. The idea behind the project is also to ensure that the proposed scheme can provide comparable and if possible better performance than already established offline signature verification schemes.

The prospect of minimizing the memory required for storing the extracted feature points has also been a driving force in the commencement of this project[1][2][3].

1.3 Thesis Layout

In Chapter 2 the various concepts involved in extraction of images, their preprocessing, and extraction of feature points, verification and finally the classification of images as fake or genuine are discussed. We also discuss the types of forgery that hinder image authentication and the various parameters that decide the success of proposed signature schemes. We also offer an insight into offline and online signature characteristics.

In Chapter 3 the proposed signature verification scheme along with its implementations are looked into.

In Chapter 4, the analysis of the parameters that determine the success and failure of the proposed signature scheme that is the quality analysis parameters are done and the feasibility of the scheme is discussed.

CHAPTER 2

OVERVIEW

2.1 Classification of Analysis Schemes

2.2 Types of Forgery

2.3 Existing Methods

2.3.1 Fixed Point Arithmetic Method

2.3.2 Feature Point Extraction Method

CHAPTER 2 An Overview

2.1 Classification of Analysis Schemes

The analysis schemes can typically be classified into 2 types, depending on the way in which the data is received. They are online and offline signature schemes[1] :

2.1.1 Online Analysis Schemes

Online signature schemes the data is received through sensors. The data obtained is usually active data which includes the speed, acceleration, pressure, tip pressure, gradient etc. These data are usually intra-person invariant that is they usually remain constant for a particular person. So this type of signature verification is highly reliable and offers a high degree of accuracy.

However the basic shortcoming in this practice is the availability and costs involved in the procurement of highly sensitive instruments used for obtaining and analyzing the data. These constraints limit the usage of online identification.

Online identification can easily be extended to various other domains like iris identification, finger print analysis , palm print analysis and retina analysis.

2.1.2 Offline Analysis Schemes

Offline analysis schemes involve extraction of passive data, the data which is obtained after the imprint is obtained by various 3rd party hardware like cameras and scanners in a digital format.

These methods are usually cost effective; however they lack the basic active information which could have been obtained from other active devices. The static information derived in an off-line signature verification system may be global, structural, geometric or statistical.

2.2 Types of Forgery

The various types of forgery include [1] :

- a. **Random Forgery:** Random forgery is done by a person who doesn't know the shape and structure of the original signature.fig 1(b)
- b. **Simple Forgery:** In this type of forgery the person concerned has a vague idea of the actual signature, but is signing without much practice. fig 1(c)
- c. **Skilled Forgery:** This type of forgery considers appropriate knowledge about the original signature along with ample time for proper practice. Our proposed scheme eliminates random and simple forgeries and also reduces skilled forgery to a great extent. fig 1(d)

The original signature of R Mahapatra is written in a fluid, cursive script. The 'R' is large and prominent, followed by 'Mahapatra' in a continuous, flowing line.

(a)

A random forgery of the signature, where the letters are written in a more blocky, less connected manner, attempting to mimic the general shape but lacking the fluidity of the original.

(b)

A simple forgery, where the signature is written in a more straightforward, less stylized manner, capturing the basic outline but missing the intricate details of the original.

(c)

A skilled forgery, where the signature is written in a manner that closely resembles the original, with fluid, connected letters and a similar overall shape.

(d)

Fig: 1 Types of Forgery (a). Original Signature (b). Random Forgery (c). Simple Forgery
(d). Skilled Forgery

2.3 Existing techniques:

2.3.1 Fixed Point Arithmetic method

This technique is based on geometrical features which are based on two vectors which represent the envelope description and the interior stroke distribution in polar and Cartesian coordinates[2].

2.3.1.1 Outline Detection and Representation:

The outline is calculated by means of morphological operations as is shown in Fig.2: First, we apply a dilatation in order to reduce the signature variability and, afterward, a filling operation is applied to simplify the outline extraction process. When several objects are detected after filling, a horizontal dilatation is performed until all the objects are connected. The outline is represented as a sequence of its Cartesian coordinates $(X_t, Y_t)_{t=1}^T$ being its length. This sequence follows the counterclockwise and starts in the point $(X_1, Y_1) = C_x, \max(Y_t | X_t = C_x)$, (C_x, C_y) being the geometric center of the outline[2].

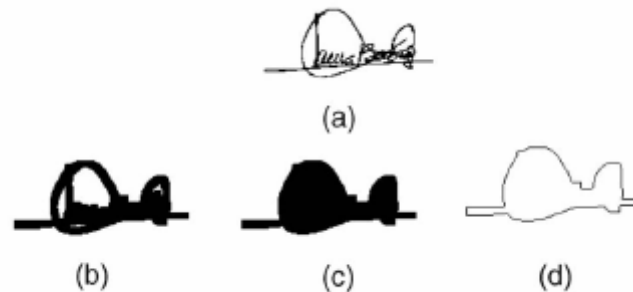


Fig 2 (a) Original (b) Dilated, (c) Filled, (d) Outline of the signature

2.3.2 Feature Poin Extraction Method:

2.3.2.1 Feature Vector Based on Polar Coordinates:

To represent the signature outline in the polar coordinates, it is decimate selecting T_r equidistant samples of the envelope $(X_{tp}, Y_{tp})_{t=1}^{T_r}$ (being $p = fix(T/T_r)$ and fix rounds to the nearest integers toward zero) and represent each sample as a three components feature vector, which are: the derivation of the radius, is angle and the number of black pixel that the radiuses cross when sweeping from one selected point to the next. The latter components have been obtained with an algorithm designed for fixed-point microprocessor.

The radius function r_t , $t=1,2,3,\dots,T_r$ is calculated as the number of pixels from the geometric center (C_x, C_y) to each outline selected point (X_{tp}, Y_{tp}) as [2][3]:

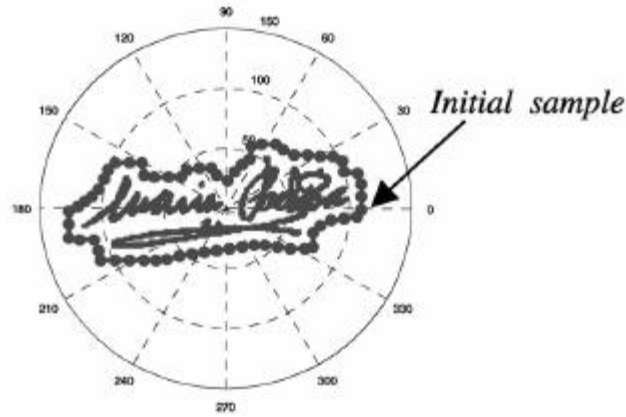


Fig 3: Original signature, its outline, and its selected samples

$$\begin{aligned} d1 &= X_{tp} - C_x, d2 = Y_{tp} - C_y \\ r_t &= \max(d1, d2) + \min(d1, d2)/4 \dots\dots\dots(1) \end{aligned}$$

The radius sequence is normalized to $r1 = 127$ and the first component of the feature vector, the derivative of the radius, is obtained as $_r_t = r_{t+1} - r_t$, $t = 1, 2, \dots, T_r$. The radius is not used because the probability density functions of the radius of different signatures are very similar. The density of the radius derivate is more discriminative. Here it is verified that a $T_r = 64$ value is a good trade-off between the recognition ratio and computational requirements. The second component of the feature vector is the angle of each selected contour sample, which is calculated by means of the arctan function implemented through lookup table[2]

$$_t = \arctan(X_{nT/T_r} / Y_{nT/T_r}), t = 1, 2, \dots, T_r \dots\dots\dots(2)$$

The third component contains the number of black pixels of the signature strokes that the radius crosses when sweeping from $_t$ to $_t+1$ normalized to maximum value equal to 1 in order to increase the stroke thickness independence. This new component, denoted as A_t , $t = 1; 2; \dots; T_r$, completes the information about the outline covered by the first and second components with a rough idea about the distribution of the signatures' strokes inside the outline. Therefore, the sequence of feature vectors based on polar coordinates that characterize the signature is

$$p_t = [dr_t, dt, A_t], t = 1; 2; \dots; Tr.[2][3]$$

Experimentally, $Tr = 64$. An example can be seen in Fig.4

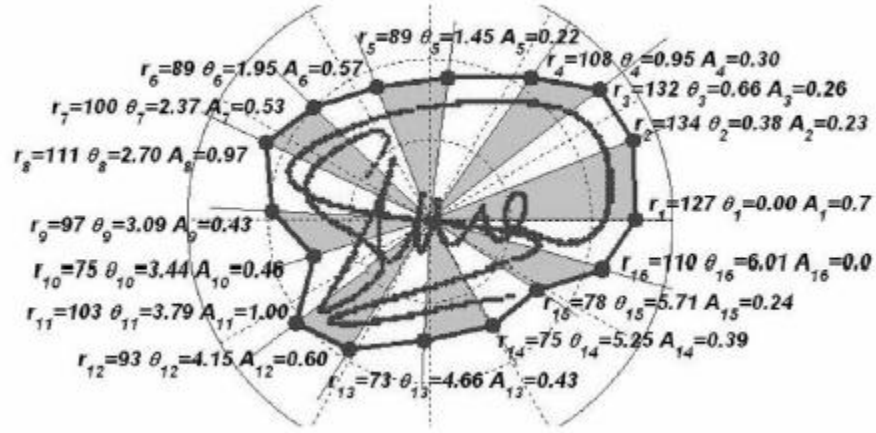


Fig 4: The signature and its envelop with the values r_t, θ_t, A_t of associated to selected sample on the envelop with $Tr = 16$.

2.3.2.2 Feature Vector Based on Cartesian Coordinates:

The second feature vector is also based on the envelope and the signature strokes density parameterization, but, in this case, in Cartesian coordinates. The envelope is divided through the geometric center into top and bottom halves. The measurements are the height of the top half at T_h equidistant points, obtaining the sequence uh_t , $t = 1; 2; \dots; T_h$. The bottom half height is also measured at the same T_h points, getting the sequence lh_t , $t = 1; 2; \dots; T_h$.

Next, the envelope is divided in two halves once again, this time the left and right-hand sides through the geometric center. T_w equidistant measures of the width of the right and left-hand sides are taken, obtaining the sequences rw_t , $t = 1; 2; \dots; T_w$, and lw_t , $t = 1; 2; \dots; T_w$.

The above sequences are combined, obtaining $T_h + T_w$ long sequences as follows from[2] :

$$ur_t = \begin{cases} uh_t & t = 1, \dots, T_h \\ rw_{t-T_h} & t = T_h + 1, \dots, T_h + T_w \end{cases} \dots\dots\dots(3)$$

And

$$ll_t = \begin{cases} lh_t & t = 1, \dots, T_h \\ lw_{t-T_h} & t = T_h + 1, \dots, T_h + T_w \end{cases} \dots\dots\dots(4)$$

Both sequences characterize the signature envelope shape. Here $T_h = 42$ and $T_w = 22$ are used in the experiments, looking for a trade-off between recognition ratio and computational load.

Once both sequences have been obtained, the feature vector sequence is composed of four dimensional vectors. The first component of the feature vector is the sequence ur_t , $t = 1; 2; \dots; T_h + T_l$, the second component is the values of ll_t , $t = 1; 2; \dots; T_w + T_l$.

The third feature vector component is the value of the index t in order to help the HMM synchronism. The fourth component is the sequence tr_t , $t = 1; 2; \dots; T_h + T_l$, defined as

$$tr_t = \begin{cases} tht & t = 1, 2, \dots, Th \\ twt - T_h & t = Th + 1, Th + 2, \dots, Th + Tw \end{cases} \dots\dots\dots(5)$$

where th_t , $t = 1; 2; \dots; T_h$, from [2], contains the number of transitions (black to white or white to black) originated by the signature strokes when we go from the bottom side to the top side of the signature envelope following the vertical lines used to work out uh_t or lh_t . Similarly, tw_t , $t = 1; 2; \dots; T_w$, contains the number of transitions when we go from the right-hand side to the left-hand side of the signature envelope following the horizontal lines used to work out rw_t or lw_t . These sequences are gathered in the sequence of vectors $c_t = [u_{rt}; l_t; t; t_t]$, $t = 1; 2; \dots; T_h + T_l$. Here $T_h = 42$ and $T_w = 22$ sequence is used.

These sequences are illustrated in Fig.5.

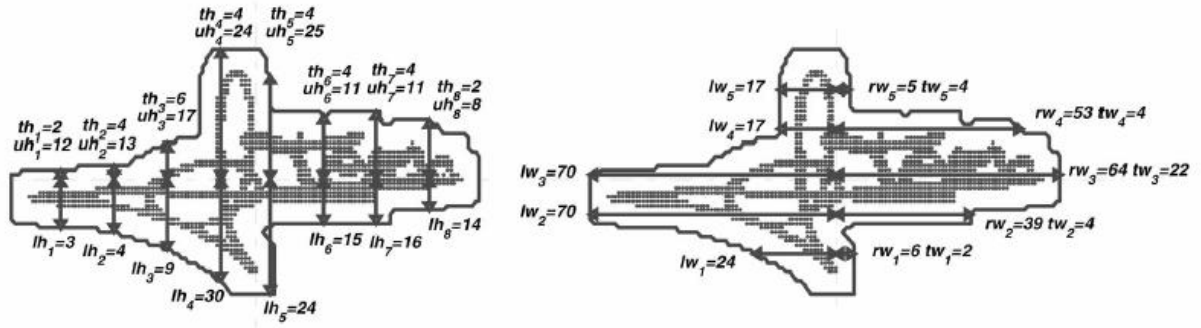


Fig 5: The signature, its envelope and sequences $th_t, uh_t, lh_t, tw_t, rw_t, lw_t$ with $T_h=8$ and $T_w=5$.

CHAPTER 3

IMPLEMENTATION

3.1 Obtaining gray scale image

3.2 Maintaining Uniformity Across All Pixels

3.3 Rotation of the image

3.4 Dilation

3.5 Thinning

3.6 Thinning Algorithm

3.7 Determination of the crests and troughs

3.8 Obtaining the required lengths

CHAPTER 3: IMPLEMENTATION:

However, various problems are associated with scanning. We might have less critical information. Also, the image often picks up noise which hampers the analysis. As the algorithm is rotation invariant, there is absolutely no necessity to maintain orientation during scanning.

3.1 Obtaining gray scale image

Comparing and verifying an image having multiple color strains is pretty complex. Moreover it is unnecessary to compare the color as it has no known effect on the signature pattern[5].

So, we have extracted the gray scale(fig 6) format of the scanned image. We use gray scale for further analysis.

The gray scale image is obtained by using predefined functions of image processing available in the MATLAB implementation.

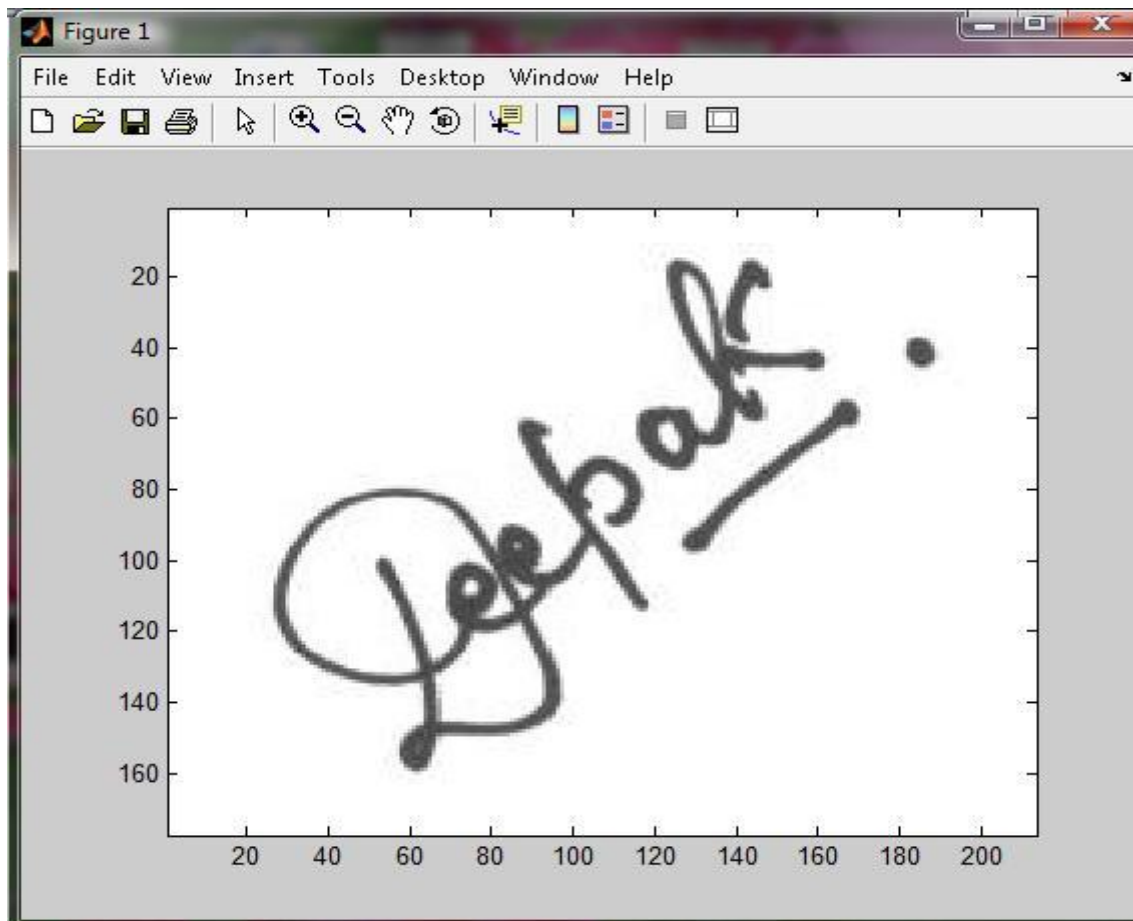


Fig 6: Grayscale Image

3.2 Maintaining Uniformity Across All Pixels:

Often the thickness of the pen tip, type of the tip etc. Affect the image we get post scanning. The image often contains lighter shades surrounding the actual core signature.

These often create anomalies in verification schemes. To settle matters we have created an uniform image pattern in which all shades from black to gray are colored black and the rest area colored white.

There are 256 gray levels of a gray scale image. We need a binarized image having only black and white values. To do so we can take any threshold value depending on our capturing device. We can have lower values of threshold for a good image recorder. The threshold value will be high if lighter images are obtained by the scanner.

This uniform image (fig 7) is the basis of all future analysis. The image is devoid of vague pixels and hence is easier and more suitable to manipulate.

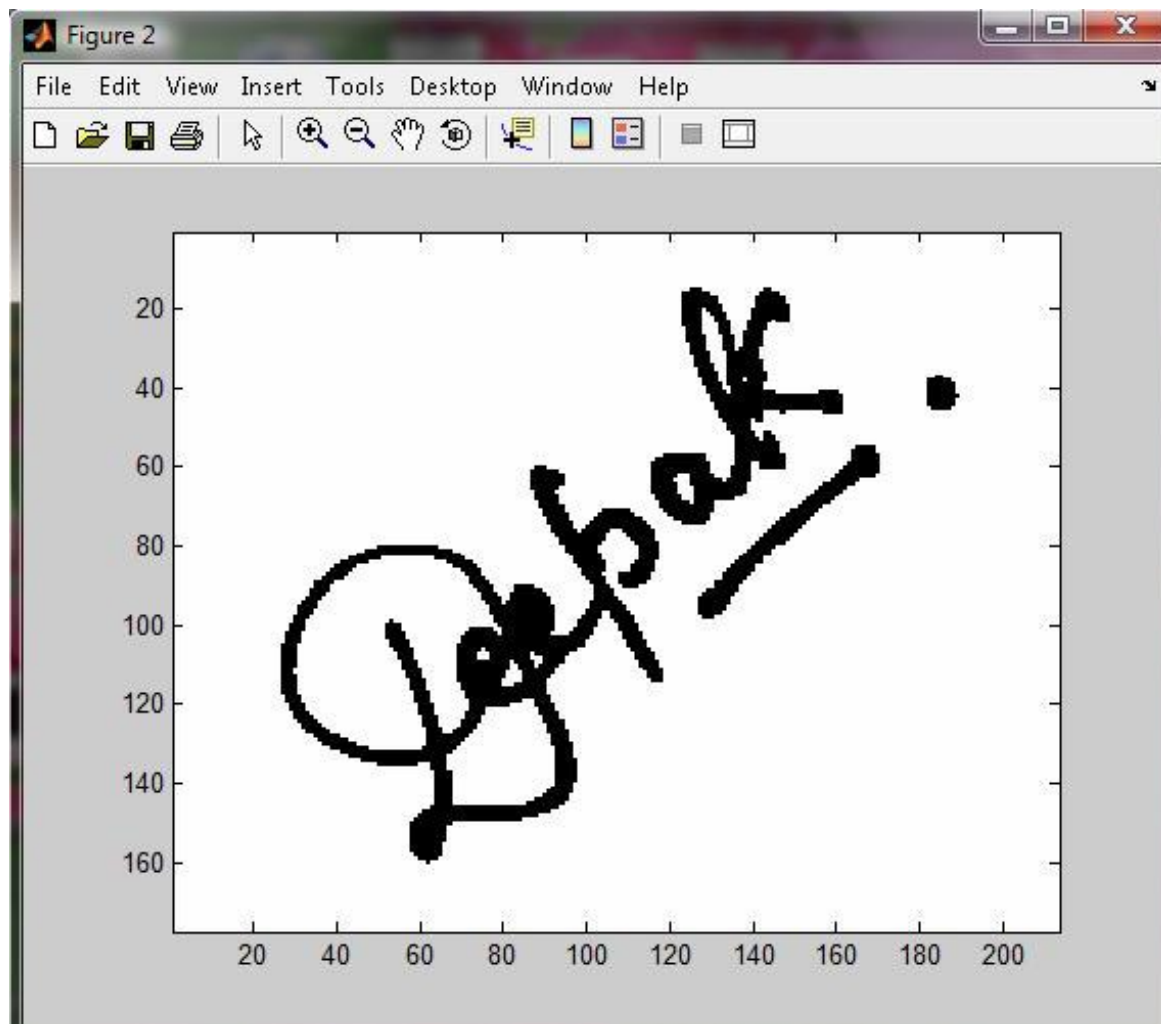


Fig 7 : Uniform Image

3.3 Rotation of the image

The image is rotated such that maximum feature points are made horizontal. The image is rotated as follows :-

1. The geometric centre of the image is calculated by determining the centre considering the image as rectangular.
2. A line is passed through the geometric centre and rotated from -90^0 to $+90^0$.
3. The perpendicular distance of each pixel is calculated from the line and the sum of all distances from it is calculated.
4. The line which has least sum of distances from it is found and the image is rotated about geometric centre through an angle of $\tan^{-1} m$ where 'm' is the slope of the line so obtained.

For finding the geometric centre of the image, we scan the image in horizontal lines to obtain the maximum and minimum row values. We scan the image in vertical lines to obtain the maximum and minimum column values. The mean of these maximum and minimum values gives the required point.

For finding the angle in which the given image has been rotated, we consider the line for which the sum of the distances of all the pixels from the line is minimum to be the horizontal line. So, we can rotate the image to make this line horizontal and have our upright image. To do this we rotate a line about the geometric centre from -90^0 to $+90^0$ in steps of 1^0 . For each line we find the sum of the perpendicular distances of all the pixels from this line. We obtain the slope of the line for which this sum is minimum.

By doing so we obtain a generalized line keeping a particular signature in view. The same signature will always have the same line as the minimum sum line for any angle of rotation. So, this makes our scheme fully rotation invariant. We are obtaining a feature which can give the angle rotated.

The angle so chosen is taken in to account considering all the pixel points of the image. So, the error of obtaining the angle will be very less. All the pixels contribute to this angle and we have a lot of points for a single image.

The image is rotated about geometric centre through an angle obtain from this iteration using sine and cosine transformation used to rotate an image.

$$x = j * \cos(a) + i * \sin(a)$$

$$y = -i * \cos(a) + j * \sin(a)$$

where,

i is the row value of the pixel being rotated

j is the column value of the pixel being rotated

a is the angle of rotation.

This differs from the image rotation in rectangular co-ordinates because here the centre of axes is at the top left corner of the image and the values in y axis increase towards the bottom.

Noise is added to the image (fig 8) so obtained because we take rounded values for pixels as they have only integral values. By doing so, many white pixels are obtained in the rotated image which should actually be black. So, the obtained image should be treated before it is processed further.

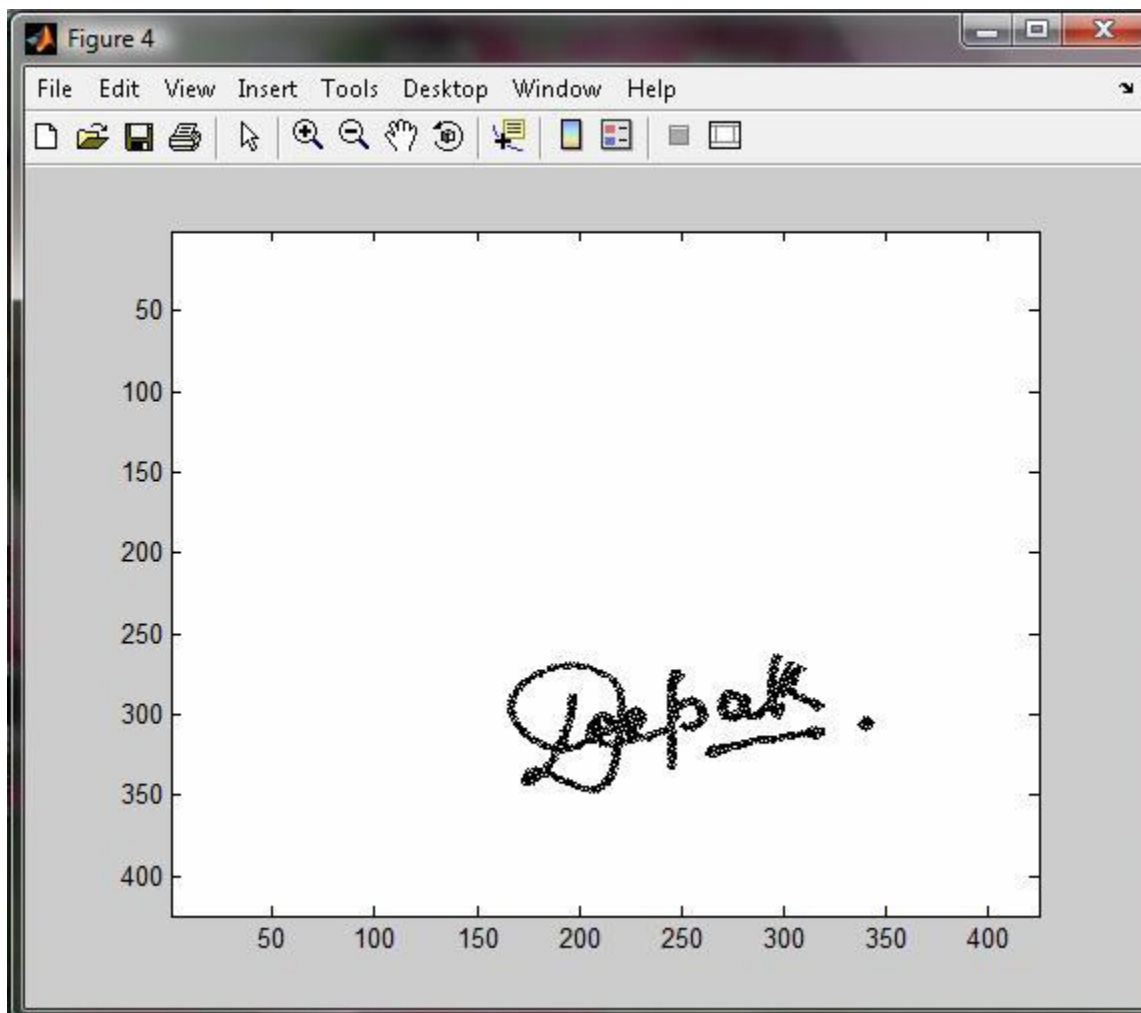


Fig 8 : Rotated Image

3.4 Dilation

The rotated image has certain pixels overlapped and lost due to rounding problems. Also the rotation brings about abnormality in the image texture.

So, we dilate the rotated image to restore normality. The dilated image is the perfect format after which we can employ the matching techniques [2].

It is devoid of all noise, is rotation invariant, and uniform.

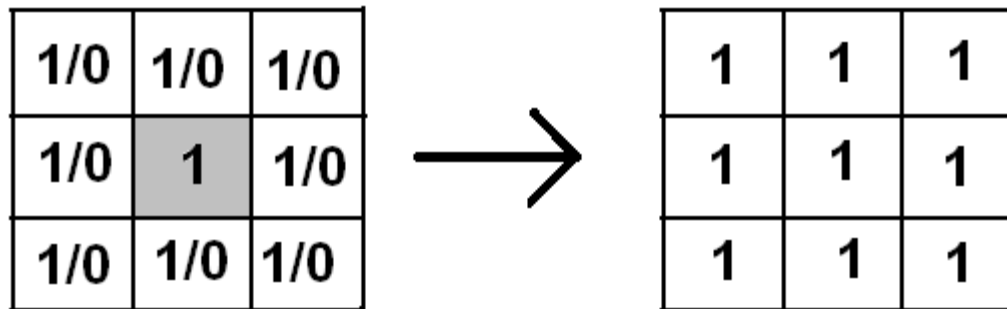


Fig 9: The change in the pixel values made during dilation

For dilation, we scan the whole image. We highlight the neighboring 8 pixels of a highlighted pixel. Care is taken such that we do not consider the points obtained in the present process of highlighting for highlighting other pixels. This algorithm works well because the noise lies within the black region and these are generally too small in size. So, by just illuminating the sides of illuminated pixels we remove the distortion and we do not have to apply any complicated algorithm. And also we need not worry for obtaining a thicker image as we do thinning at a later stage which just inverts the process of blurring.

Dilation thickens the image and increases the no. of illuminated pixels there by giving a 'bold' look to the image.

This process also helps to obtain a connected image which may have become disconnected after rotation. Rotation may make the image to have many white pixels within it. These points give a different image after thinning. Dilation makes the image (fig 10) continuous due to which we get a clear and correct image after thinning.

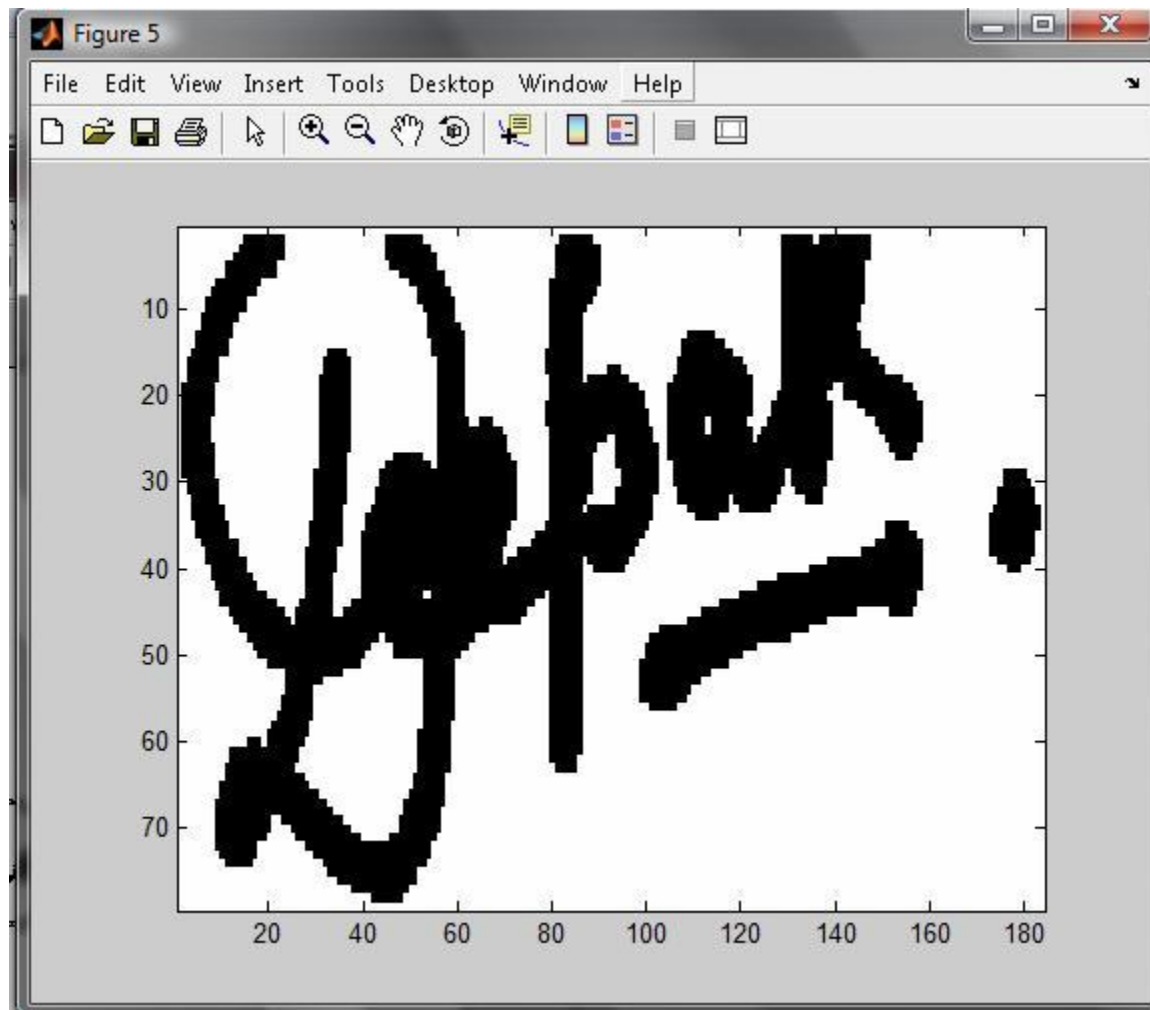


Fig 10: Blurred Image

3.5 Thinning

It is well known that the general problem of pattern recognition lies in the effectiveness and efficiency of extracting the distinctive features from the patterns. Our suggested stroke analysis method is a powerful approach to recognizing the signature pattern. It should be noted that the strokes thinned by hardware or software are accompanied by different kinds of distortion. At the same time, the pixels are labeled so that the original image can be reconstructed from its skeleton. Our goal is to find a faster and efficient parallel thinning algorithm. The distortion should be as little as possible. Experimental results indicate that this method can be used to thin a variety of digital patterns [4].

Image details

A binary digitized picture is defined by a matrix IT where each pixel $IT(i, j)$ is either 1 or 0. The pattern consists of those pixels that have value 1. Each stroke in the pattern is more than one element thick. Iterative transformations are applied to matrix IT point by point according to the values of a small set of neighboring points. It is assumed that the neighbors of the point (i, j) are $(i - 1, j)$, $(i - 1, j + 1)$, $(i, j + 1)$, $(i + 1, j + 1)$, $(i + 1, j)$, $(i + 1, j - 1)$, $(i, j - 1)$, and $(i - 1, j - 1)$, as is shown in Figure 1. In parallel picture processing, the new value given to a point at the n th iteration depends on its own value as well as those of its eight neighbors at the $(n - 1)$ th iteration, so that all picture points can be processed simultaneously. It is assumed that a 3×3 window is used, and that each element is connected with its eight neighboring elements. The algorithm presented in this paper requires only simple computations[4].

$P_9 (i-1, j-1)$	$P_2 (i-1, j)$	$P_3 (i-1, j+1)$
$P_8 (i, j-1)$	$P_1 (i, j)$	$P_4 (i, j+1)$
$P_7 (i+1, j-1)$	$P_6 (i+1, j)$	$P_5 (i+1, j+1)$

Figure 11 : Designation of the 9 pixels in a 3 X 3 window

3.6 Thinning Algorithm

Our method for extracting the skeleton of a picture consists of removing all the contour points of the picture except those points that belong to the skeleton.[4] In order to preserve the connectivity of the skeleton, we divide each iteration into two sub iterations. In the first sub iteration, the contour point P_1 is deleted from the digital pattern if it satisfies the following conditions :

(a) $2 \leq B(P_1) \leq 6$

(b) $A(P_1) = 1$

(c) $P_2 * P_4 * P_6 = 0$

(d) $P_4 * P_6 * P_8 = 0$

where $A(P_1)$ is the number of 01 patterns in the ordered set $P_2, P_3, P_4, \dots, P_8, P_9$ that are the eight neighbors of P_1 (In Figure),

and $B(P_i)$ is the number of nonzero neighbors of P_1 , that is,

$$B(P_1) = P_2 + P_3 + P_4 + \dots + P_8 + P_9. [4]$$

If any condition is not satisfied, e.g., the values of $P_2, P_3, P_4, \dots, P_9$ as shown in Figure, then

$$A(P_i) = 2$$

0	0	1
1	P_1	0
1	0	0

Figure 12 : Counting the 01 patterns in the ordered set $P_2, P_3, P_4, \dots, P_9$

Therefore, P_1 is not deleted from the picture.

In the second subiteration, only conditions (c) and (d) are changed (Figure 3) as follows:

$$(c') P_2 \times P_4 \times P_8 = 0$$

$$(d') P_2 \times P_6 \times P_8 = 0$$

and the rest remain the same [4].

$$(a) 2 \leq B(P_1) \leq 6$$

By condition (a), the endpoints of a skeleton line are preserved.

$$(b) A(P_1) = 1$$

condition (b) prevents the deletion of those points that lie between the endpoints of a skeleton line, as shown in Figure 5. The iterations continue until no more points can be removed.

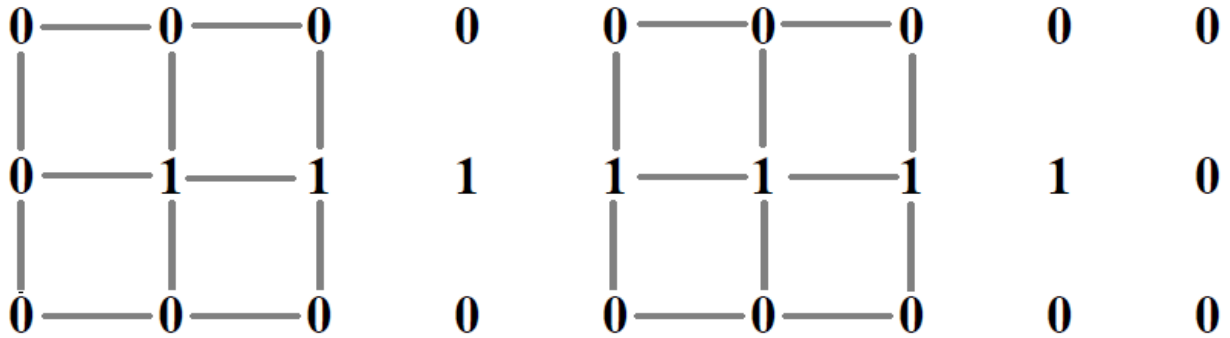


Figure 13: Preventing the deletion of end points

By conditions (c) and (d) of the first sub iteration, it will be shown that the first sub iteration removes only the south-east boundary points and the north-west corner points which do not

belong to an ideal skeleton. The proof for the first sub iteration is given, that is, the points to be deleted satisfy conditions:

$$(c) P_2 \times P_4 \times P_6 = 0 \quad (1)$$

$$(d) P_4 \times P_6 \times P_8 = 0 \quad (2)$$

The solutions to the set of equations (1) and (2) are $P_4 = 0$ or $P_6 = 0$ or $(P_2 = 0 \text{ and } P_8 = 0)$. So the point P_1 , which has been removed, might be an east or south boundary point or a north-west corner point. Similarly, it can be proved that the point P_1 deleted in the second sub iteration might be a north-west boundary point or a south-east corner point.

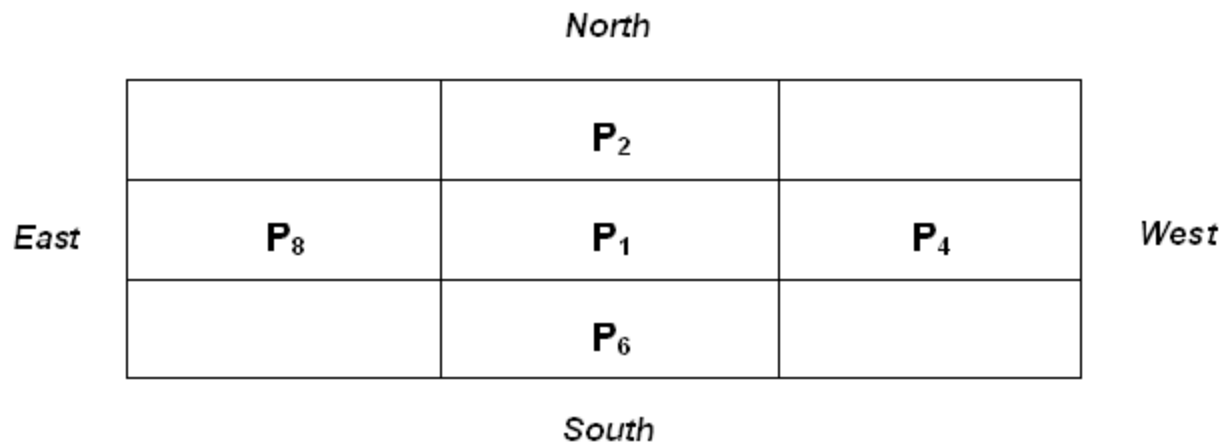


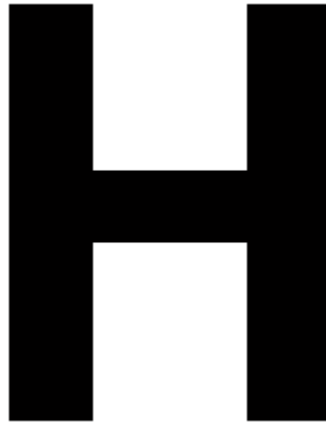
Figure 14 : Points under consideration and their locations

$$(c') P_2 \times P_4 \times P_8 = 0$$

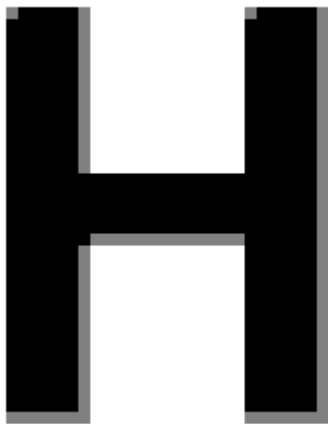
$$(d') P_2 \times P_6 \times P_8 = 0$$

$P_2 = 0$ or $P_8 = 0$ or $(P_4 = 0 \text{ and } P_6 = 0)$. So the point P_1 , which has been removed, might [4]

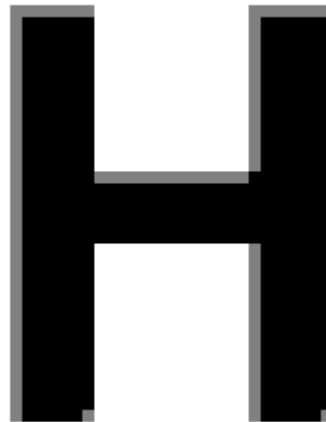
be a north or west boundary point or a south-east corner point.



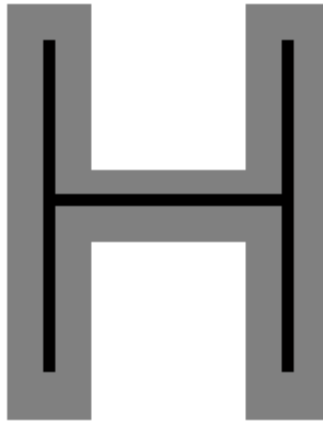
a. Original image



b. Image after 1st sub iteration



c. Image after 2nd sub iteration



d. final Image

Fig15: Image Thinning

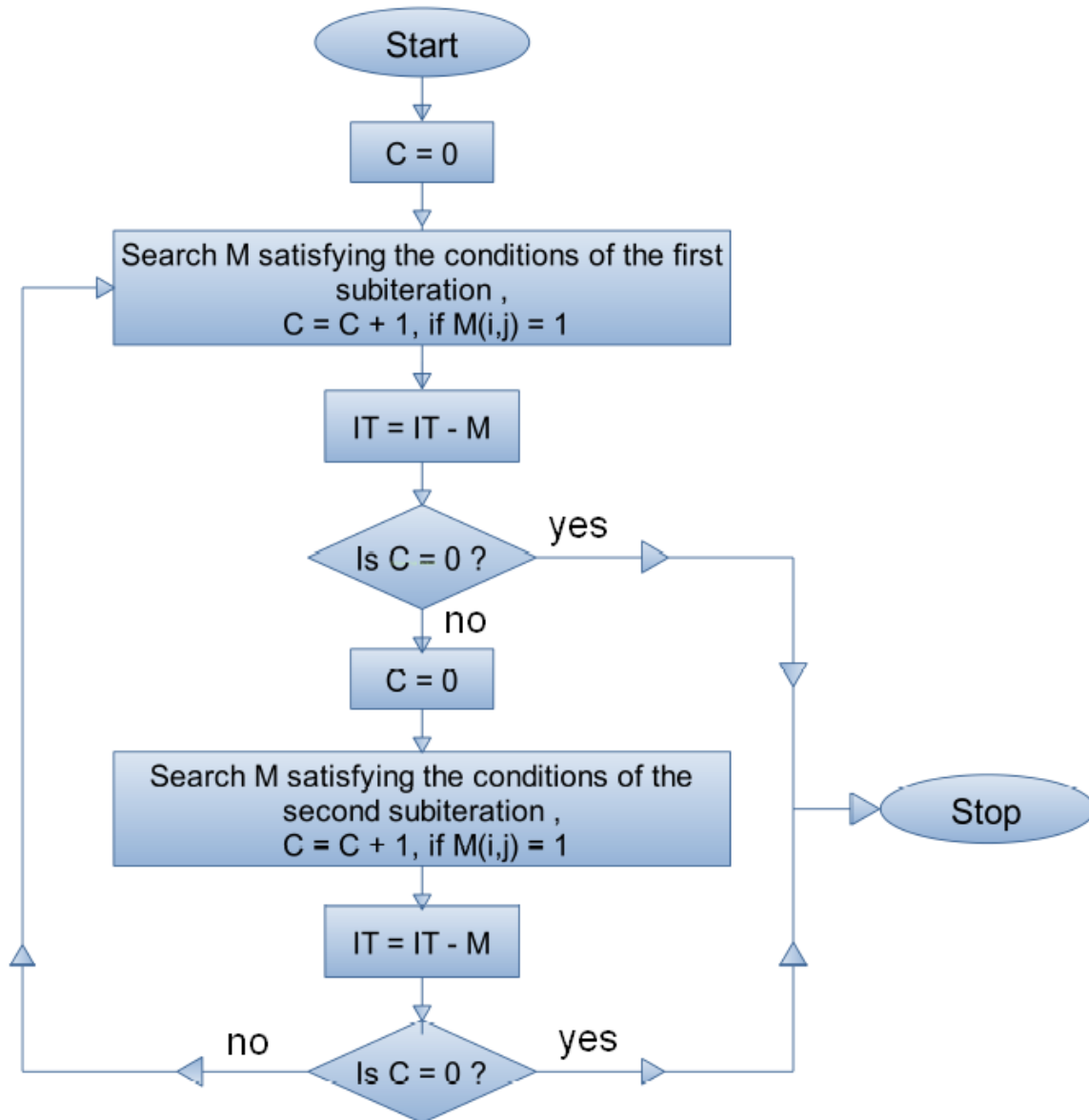


Fig 16 : Flowchart of thinning algorithm

A flow chart of the proposed thinning algorithm is shown in the figure. Initially the original image is stored in the matrix IT and a counter C is set to 0. The result of the processed picture is stored in IT and a counter C is set to 0. The result of the processed image is stored in the matrix IT. To save memory only two matrices IT and M are used in the program.

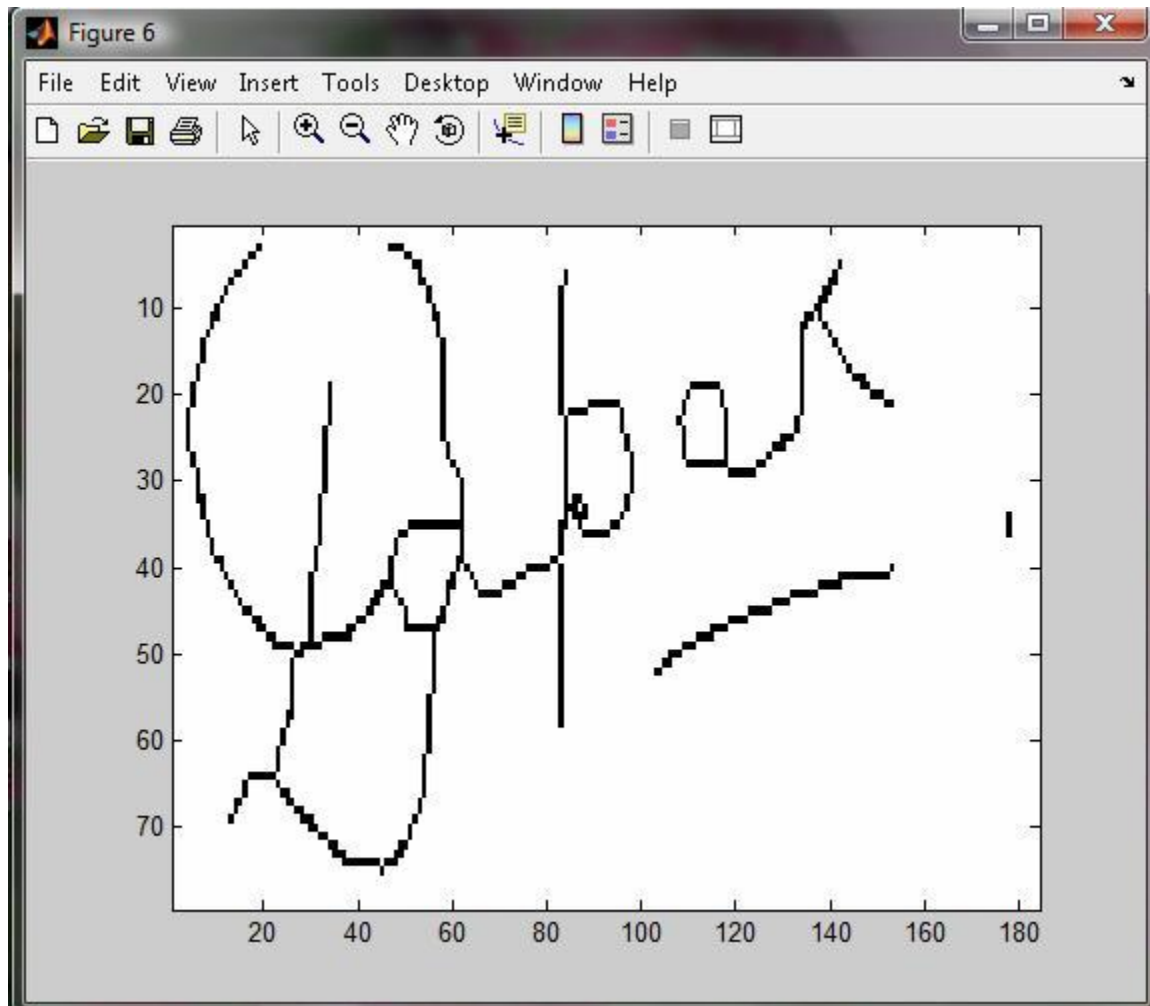


Fig 17: Thinning Implementation

3.7 Determination of the crests and troughs

The algorithm centers itself on the theory that smaller or larger, the ratio of distances between essential feature points remains the same.

In other words we determine the crests and troughs in a signature pattern, use them as the feature points and calculate the distance between them. For simplicity of storage we normalize the process and calculate the ratios with the highest value taken to be 1.

Finding crest :

For a point to be crest , the following conditions are made to be satisfied

- a) $P(i,j) = 1$
- b) $P(i-1,j) = P(i-1,j+1) = P(i-1,j-1) = P(i,j-1) = 0$
- c) Continuing in a horizontal straight line till the conditions

$P(i,j+1) = 1$ and $P(i-1,j+1) = 0$ are satisfied

- d) At the end of the line

$P(i-1,j) = 0$ and $P(i,j+1) = 0$ and $P(i-1,j+1) = 0$

When these all conditions are satisfied the mid-point of the straight line is the required crest point.

Condition (b) ensures the starting pixel is formed by an upward slope only

For a horizontal line formed as the crest we take the midpoint of the line. To ensure it that the full line forms the crest conditions (c) and (d) are used.

Condition (c) takes care of the points present at the middle of the line i.e. Except the end point. No pixel above them should be highlighted.

Condition (d) takes care of the end point. Here, the slope must be decreasing.

Finding trough :

For a point to be trough , the following conditions are made to be satisfied

- e) $P(i,j) = 1$
- f) $P(i+1,j) = P(i+1,j+1) = P(i+1,j-1) = P(i,j-1) = 0$

g) Continuing in a horizontal straight line till the conditions

$$P(i,j+1) = 1 \text{ and } P(i+1,j+1) = 0 \text{ are satisfied}$$

h) At the end of the line

$$P(i+1,j) = 0 \text{ and } P(i,j+1) = 0 \text{ and } P(i+1,j+1) = 0$$

When these all conditions are satisfied the mid-point of the straight line is the required trough point.

Condition (b) ensures the starting pixel is formed by an downward slope only

For a horizontal line formed as the trough we take the midpoint of the line. To ensure it that the full line forms the trough , conditions (c) and (d) are used.

Condition (c) takes care of the points present at the middle of the line i.e. Except the end point. No pixel below them should be highlighted.

Condition (d) takes care of the end point. Here, the slope must be increasing.

The crests and troughs are arranged in increasing order of their x-coordinates. Distances are calculated between i^{th} and $(i+1)^{\text{th}}$ points. The output is similar to fig 18.

The last step is dividing all the distances with the maximum distance, there by normalizing it.

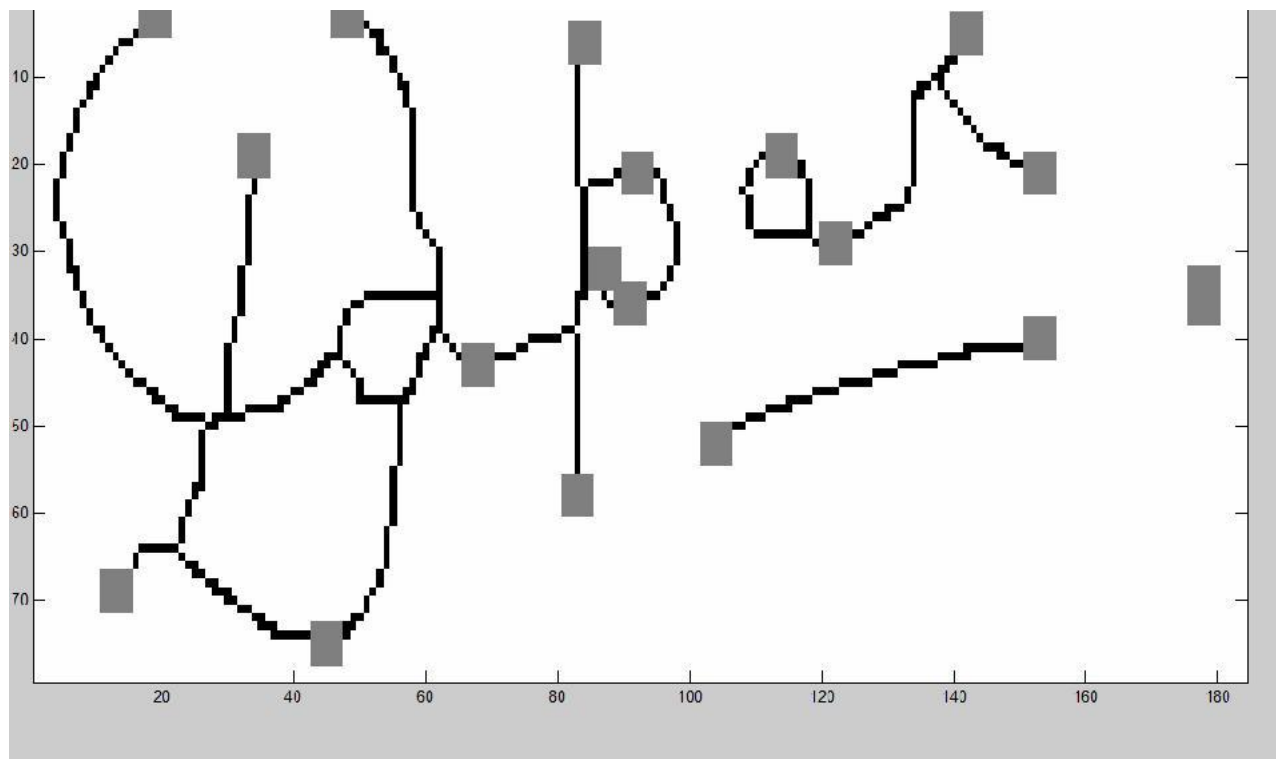


Fig18 : Finding crest and trough

3.8 Obtaining the required lengths

According to our scheme , we need find the distances between consecutive crests and troughs.

To find the order in which the occur, we arrange them in ascending order of their corresponding column values. For the values which have the same column value we take their row values to arrange them in ascending order.

After this, we find the distances between the consecutive points so obtained. We then find the maximum of the distance obtained. We use it to divide all the distance values to obtain the normalized values with maximum value as 1. By doing so we make our scheme size invariant. The size of signatures may vary. But, the relative positions of the crests and troughs should be same for valid signatures. So, by dividing the maximum value we normalize the signatures of all sizes to the signature with the maximum distance value as 1.

The lengths so obtained are used in verifying other signatures which are to be matched. The standard deviation between of these lengths is obtained and two signatures are said to be matched if the variance lies within some threshold value, called the threshold variance. Or else it is declared as an fake image.

CHAPTER 4

ANALYSIS OF THE PROPOSED SCHEME

4.1 Analysis

4.2 Quantitative Analysis of Space Required for storing feature points.

Chapter 4: Analysis of the Proposed Scheme

4.1 Analysis – The analysis of a signature scheme involves the evaluation of 2 parameters: FAR & FRR.

4.1.1 Important Terms[2]

FAR – False Acceptance Ratio. The false acceptance ratio is given by the number of fake signatures accepted by the system with respect to the total number of comparisons made.

FRR – False Rejection Ratio – The false rejection ratio is the total number of genuine signatures rejected by the system with respect to the total number of comparisons made.

Both FAR and FRR depend on the threshold variance parameter taken to decide the genuineness of an image. If we choose a high threshold variance then the FRR is reduced, but at the same time the FAR also increases.

If we choose a low threshold variance then the FAR is reduced, but at the same time the FRR also increases.

ERR – Error rejection Rate – If the FAR of a system is same as the FRR then the system is said to be in an optimal state. In this condition, the FAR and FRR are also known as ERR.

4.1.2 Variation of FAR and FRR with Threshold Variance

Srl. No	Threshold Variance	No of genuine signatures rejected (out of 70)	FRR	No of fake signatures accepted (out of 70)	FAR
1	0.15	10	14.2%	25	35.71%
2	0.10	13	18.6%	15	20%
3	0.08	23	33.3%	10	14.2%
4	0.06	34	48.5%	5	7.1%

Table 1: Variation of FAR and FRR with the threshold Variance.

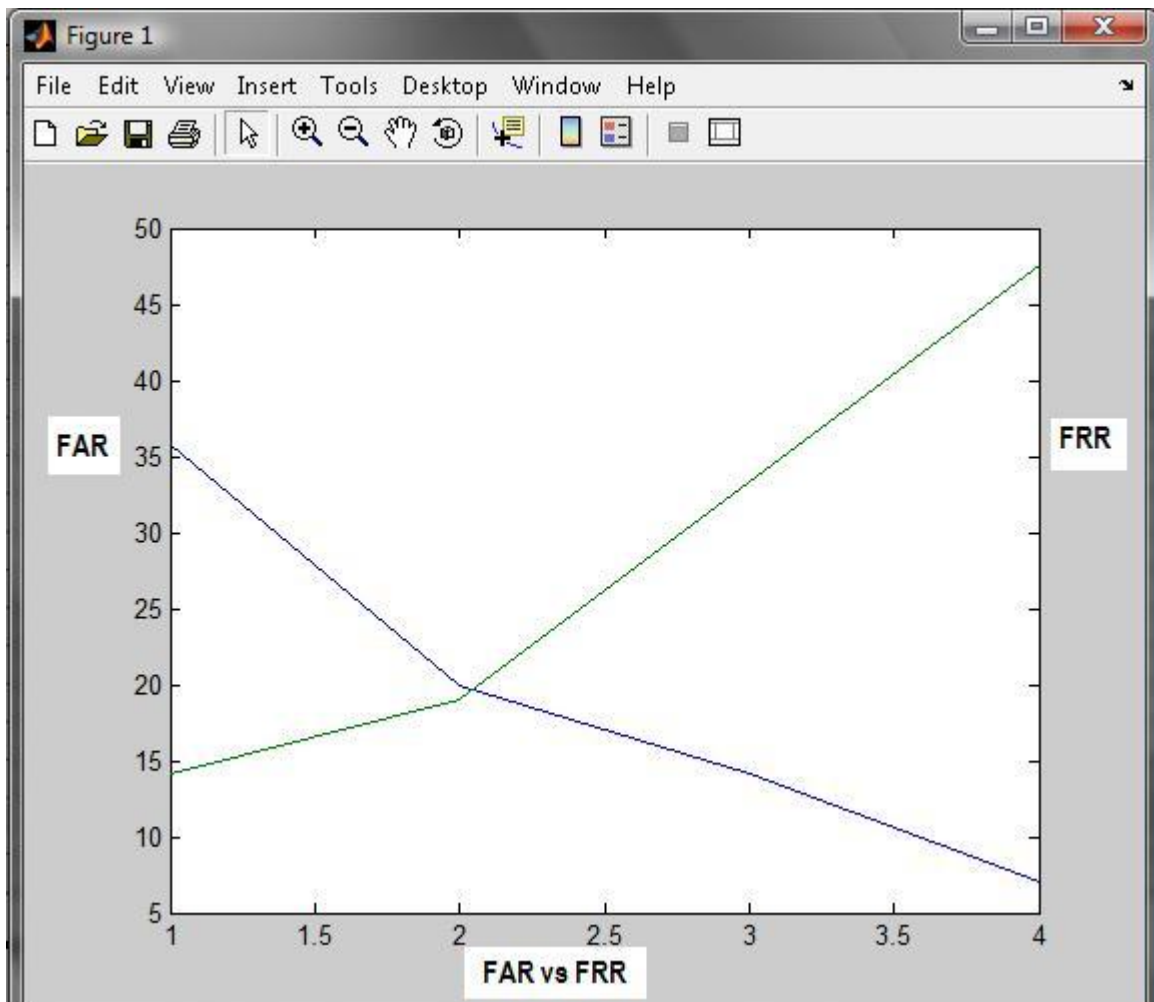


Fig 19: Variation of FAR with FRR

The point in the graph (fig 19)where FAR intersects FRR gives the ERR.

Because of the obtained results, the threshold variance for the project was chosen at **variance=0.1**.

The ERR of the system was found to be **about 20.2%**.

4.2 Quantitative Analysis of space required for storing Feature Points

The feature point extraction method used as basis of the 60 feature point extraction method, which requires storing of 3 parameters (A , r , Θ) as floating point values, each taking 8 bytes of memory.

Hence the total memory consumed for storing feature points of 1 signature = $8 * 3 * 60 \text{ bytes} = 1440 \text{ bytes}$.

In comparison, let's consider the crests and troughs obtained from **fig 18**.

In this case there are 18 feature points in all. They are stored as 16 normalized distances.

The memory consumed = $8 * 16 \text{ bytes} = 128 \text{ bytes}$.

Though this figure varies from figure to figure, it is rare that a signature could contain as many as 180 feature points (When there are 180 feature points, the memory consumed by both the schemes would be equal.) .

Hence it can be proved that the proposed scheme is more memory efficient as compared to the 60 feature points model.

CHAPTER 5

CONCLUSION

Chapter 5 Conclusion

The proposed algorithm can be used as a effective signature verification system. The algorithm proposed was successfully made rotation invariant by the rotation of the image. The Error Rejection rate was found to be 20.2%.

The error rejection rate can further be improved by using better techniques for rotation, blurring and thinning. Using these algorithm random and simple forgeries can be easily detected. A great number of skilled forgeries can also be removed.

It uses a compact and memory efficient storage of feature points which reduces memory overhead and results in faster comparisons of the data to be verified.

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