SIGNATURE RECOGNITION USING IMAGE PROCESSING & ARTIFICIAL INTELLIGENCE

PROJECT REPORT

By

Amol Ambardekar.
Vinayak Bharadi.
Reshma Darekar.
Pradnya Punaskar.
Abhijeet Varhadi.

Under the Guidance of
Mr. V. B. Kulkarni.
Department of Electronics Engineering

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&
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RATNAGIRI

CERTIFICATE

THIS IS TO CERTIFY THAT THE FOLLOWING STUDENTS

	NAME OF THE STUDENT	REG. NO.
1.	AMBARDEKAR AMOL.	N - 98- 03
2.	BHARADI VINAYAK.	N - 98- 09
3.	DAREKAR RESHMA.	N - 97- 03
4.	PUNASKAR PRADNYA.	N - 97- 44
5.	VARHADI ABHIJEET.	ND - 99- 07

OF THE FINAL YEAR DEGREE COURSE IN ELECTRONICS ENGINEERING HAVE COMPLETED THEIR PROJECT WORK ON "SIGNATURE RECOGNITION USING IMAGE PROCESSING & ARTIFICIAL INTELLEGENCE" AS A PARTIAL FULFILMENT OF THE REQUIREMENT PRESCRIBED BY MUMBAI UNIVERSITY FOR THE COURSE OF EIGHTH SEMESTER IN THE YEAR 2001-2002.

INTERNAL EXAMINER

EXTERNAL EXAMINER

PROJECT GUIDE **HEAD OF DEPARTMENT** **DIRECTOR**

FINOLEX ACADEMY OF MANAGEMENT & TECHNOLOGY
RATNAGIRI

Department of Electronics Engineering

ACCEPTANCE CERTIFICATE

The B.E. project entitled

SIGNATURE RECOGNITION USING IMAGE PROCESSING
&
ARTIFICIAL INTELLIGENCE

Submitted by

Amol Ambardekar.
Vinayak Bharadi.
Reshma Darekar.
Pradnya Punaskar.
Abhijeet Varhadi.

is authentic & work is done under my guidance. Above project is completed successfully & the results are satisfactory. Hence, this project is accepted.

Date: ………………….

Place: …………………

Mr. V. B. Kulkarni.
(Project Guide)

ACKNOWLEDGEMENTS

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We are also thankful to **Dr. K. L. Asanare** sir, Director & HOD Electronics Engineering Branch, for making facilities available and giving his support and guidance.

We are also thankful to all the faculty members who helped us directly and indirectly. We are also thankful to all the staff in library & office.

It would have been very difficult for us to reach at this stage without their guidance and support.

AMBARDEKAR AMOL.
BHARADI VINAYAK.
DAREKAR RESHMA.
PUNASKAR PRADNYA.
VARHADI ABHIJEET.

ABSTRACT

In the 21st century, it has become a trend that machines are replacing the man in many fields.

But, there are a lot many fields still untouched to machines. But the evolution of modern computers and the development of the branch of Artificial Intelligence, gives man a chance to make a machine that can really replace man from the field which, up till are considered to be the fields reliable on human intellectual power.

Signature is the characteristic of the particular person & hence used globally for identifying a person, validity of the documents signed, banking etc. Up till now, in banks where signature of a person is the basic code for transaction, the validity of the signature is generally checked by a man.

This is a project, which simulates the ability of a man to recognize a signature from the standard signature he has. We have tried to implement a system which recognizes the signature. We deal with the signature as an image which is scanned through scanner.

The image undergoes different normalisation techniques. For recognition we use morphological & template matching techniques, & the remark for signature recognition is given on the basis of Image Realisation techniques. For recognition, standard signatures i.e. images are to be stored in the database. The universally available image formats do not fulfil all criteria & hence we have implemented an application specific Image Encryption Format which saves disk space & also retains the quality of the picture to be stored. The software is developed using Visual Basic 6.0 & 12000 lines of code is written for the software.

Contents

1. OVERVIEW OF ARTIFICIAL INTELLIGENCE

Artificial intelligence, as we know it today, is a relatively new field. Even though some groundwork had been laid earlier, AI began in earnest with the emergence of the modern computer during the 1940s and 1950s. It was the ability of these new electronic machines to store large amounts of information and process it at very high speed that gave researchers the vision of building systems which could emulate some human abilities.

During the past forty years, we have witnessed the realization of many of these early researcher’s visions. We have seen computer systems shrink in size and cost by several orders of magnitude. We have seen memories increase in storage capacity to the point where they equal a significant fraction of the human brain’s storage capacity. We have seen the speed and reliability of systems improves dramatically. And, we have seen the introduction of many impressive software tools.

Given these new hardware and software systems and our improved understanding of Homosapiens, we are on the threshold of witnessing a whole new horizon of exciting innovations. During the next few decades we will witness the introduction of many intelligent computer systems never dreamed of by the early visionaries. We will see the introduction of systems which equal or exceed human abilities, and see them become an important part of most business and government operations as well as our own daily activities.

1.1 NECESSITY OF AI

Artificial intelligence develops working computer systems that are truly capable of performing tasks that require high level of intelligence.

It includes the ability to recognize and remember numerous diverse objects in a scene, associate them with the objects and concepts to adapt readily too many diverse new situations.

The study of intelligence is also one of the oldest disciplines. For over 2000 years, philosophers have tried to understand how seeing, learning, remembering, and reasoning could, or should, be done. The advent of usable computers in early 1950s turned the learned but armchair speculation concerning these medical faculties into a real experimental and theoretical discipline. Many felt that the new **‘ELECTRONIC SUPER-BRAINS’** had unlimited potential for intelligence. ‘’Faster than Einstein”: was a typical headline. But as will as providing a tool for testing theories of intelligence, and many theories failed to withstand the test - a case of ‘Out of the armchair, into the fire’. AI has turned out to be more difficult than many at first imagined and modern ideas are much richer, more subtle, and more interesting as a result.

1.2 HISTORY OF AI

When digital computers were first being developed in 1940s and 1950s, several researchers wrote programs that could perform elementary reasoning tasks. Prominent among these were papers describing the first computer program that could play chess [Shannon 1950, newell, Shaw and simon1958] and checkers [Samuel 1959, Samuel 1967] and prove theorems in plane geometry [Gelernter 1959]. In 1956, **John McCarthy** and **Claude Shannon** co-edited a volume entitled Automata studies [Shannon & McCarthy 1956]. Disappointed that the papers dealt mainly with the **Mathematical theory of automata**, McCarthy decided to use the phrase Artificial intelligence as the title of 1956 Dartmouth conference. Several important early papers were delivered at that conference ,including one by Allen Newell, Cliff Shaw , Herbert Simon on a program called the **logic Theorist** [Newell, Shaw & Simon 1957] , which could prove theorems in propositional logic.

The first of many steps towards AI was taken long ago by Aristotle [384-322 B.C] when he set about to explain and codify certain styles of deductive reasoning that he called syllogisms. Some efforts to automate intelligence would seem quixotic to us today. Ramon Lull [Ca 1235-1316], Catalen mystic & poet, built asset of wheels, called the Art magna [Great art], that was supposed to be a machine capable of answering all questions. But the quest to bottle reason was pursued by scientist and mathematicians also. In 1958, John McCarthy proposed using the predicate calculus as a language for representing and using knowledge in a system he called the **‘advice taker’** [McCarthy 1958]. This system was to be told what it needs to know rather than program.

Much of the early AI work (during the 1960s & 1970s) explored a variety of problem representations, search techniques, and general Heuristics employing them in computer programs that could solve simple puzzles, play games and retrieve information. Projecting present trends into the future, there will be new emphasis on integrated, autonomous systems ‘**robots’ and ‘softbots** ‘.

Softbots [Etzioni & Weld 1994] are software agents that roam the internet, finding information they think will be of interest to their users. The constant pressure to improve the capabilities of robot & software agents will motivate and guide Artificial Intelligence research for many years to come.

1.3 WHAT IS AI?

Artificial Intelligence (AI), broadly (and some what circularly) defined, is concerned with intelligent behaviour in artefacts. Intelligent behaviour, in turn, involves perception, reasoning, and learning, communicating, and acting in complex environments. AI has as one of its long-termed goals the development of machines that can do these things as well as humans can, or possibly even better. Another goal of AI is to understand this kind of behaviour whether it occurs in machines or in humans or other animals. Thus AI has both **Engineering and scientific goals**. AI has always been surrounded by controversy, the question 'Can machine think?' has interested philosophers as well as scientists and engineers. In a famous article Allen Turing, one of the founders of computer science, rephrased that question in terms more amenable to an empirical test, which has come to be called the Turing test. Turing also noted that he answer to the question 'can machines think?' depends on how we define the word machine and think.

1.4 CHARACTERISTICS OF AI:

1. **AI** requires an understanding of related terms such as intelligence, knowledge, reasoning, thought, learning and a number of computer related terms.
2. **Intelligence** is the ability to acquire, understand and apply knowledge or the ability to exercise thought and reason.
3. It embodies all of the knowledge and feats, both conscious and unconscious which we have acquired through study and experience.

Finally, a better understanding of AI is gained by looking at the components areas of study that make up the whole. These include such topics as robotics, memory organization, knowledge representation, storage and recall, learning models, commonsense reasoning, decision making, understanding natural language, pattern recognition, speech recognition and synthesis and a variety of AI tools.

AI addresses one of the ultimate puzzles. AI strives to build intelligent entities as well as understand them. AI is one of the newest disciplines. Artificial intelligence is a part of computer science concerns with the characteristics we associate with intelligence of the human behaviour. However, conceptualizing various types of the behaviour generally associated with the intelligence is not difficult. Several characteristics come immediately to mind:

1. Understanding language
2. The ability to extract pertinent information from a background of the irrelevant details, and to have decision based on this information.
3. The capability to learn from examples and to generalise this knowledge so that it will apply in view different circumstances.
4. The ability to make inferences from incomplete information.

2. IMAGE PROCESSING

2.1 What are images?

In the broadest possible sense, images are pictures: a way of recording and presenting information visually. Pictures are important to us because they can be an extraordinarily effective medium for the storage and communication of information. We use photography in everyday life to create a permanent record of our visual experiences, and help us to share those experiences with others. In showing someone a photograph we avoid the need for a lengthy, tedious and in all likelihood ambiguous verbal description of what were seen. This emphasises the point that humans are primarily visual creatures. We rely on our eyes for most of the information we receive concerning our surroundings, and our brains are particularly adept at visual data processing. There is thus, scientific basis for the well-known saying that **"A picture is worth thousand words"**.

2.2 What is image processing?

IMAGE PROCESSING a general term for the wide range of techniques that exist for manipulating and modifying images in various ways. Photographers and physicists can perform certain image processing operations using chemicals or optical equipments.

Manipulation of brightness, contrast and colour in images is very common. Often; there is a need to increase the contrast in an image, to make certain features clearly visible for purpose of human interpretation. For an example, we see an image of a car in which very little detail is visible. It is a simple matter to increase both brightness and contrast in this image, making it easier to identify the vehicle and read its plate number.

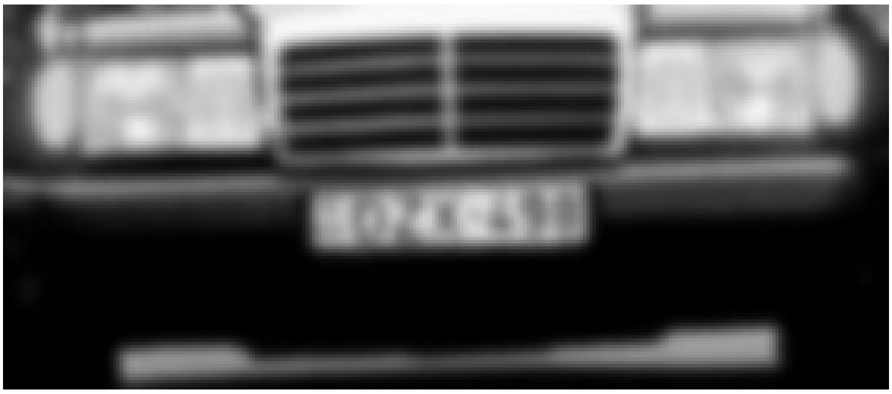


Image prior to contrast enhancement

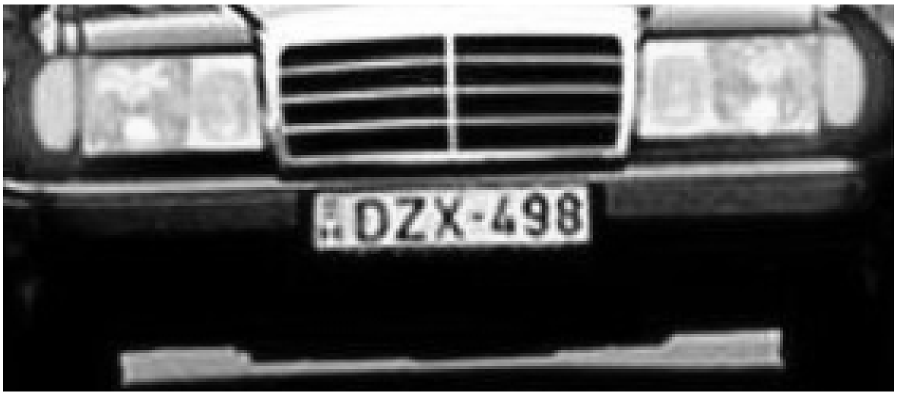


Image after contrast enhancement

Many of image processing operations are meant to remove or suppress the defects present in images. Some defects manifest themselves as a blurring of the image. For example imagine a military scenario in which an enemy aircraft must be identified from an image, but the speed of the aircraft is such that image suffers from motion blur. Provided that we have accurate knowledge of how the aircraft was moving at the time of image acquisition, a technique known as deconvolution can be applied to remove the motion blur and hence assist identification.

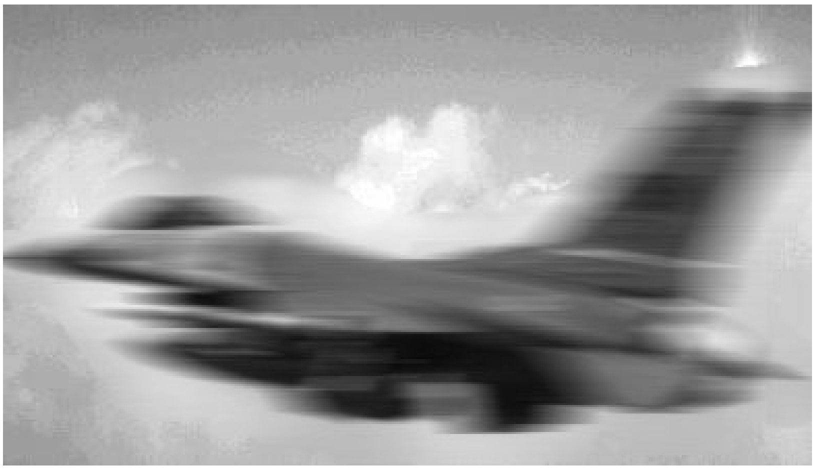


Image Prior to removal of motion blur

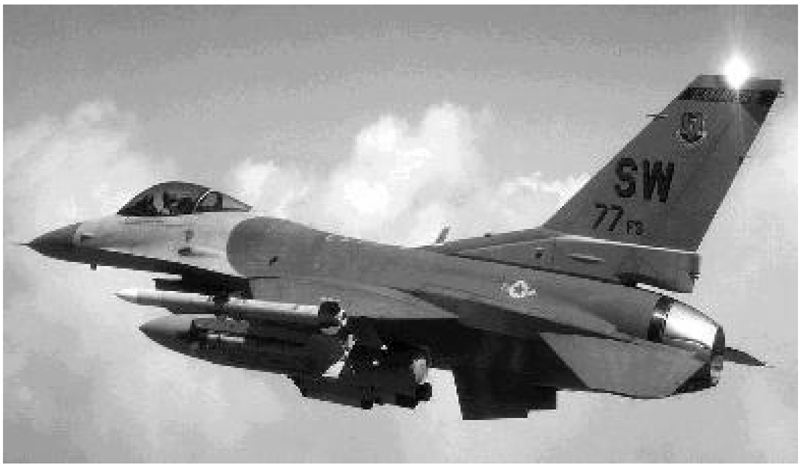


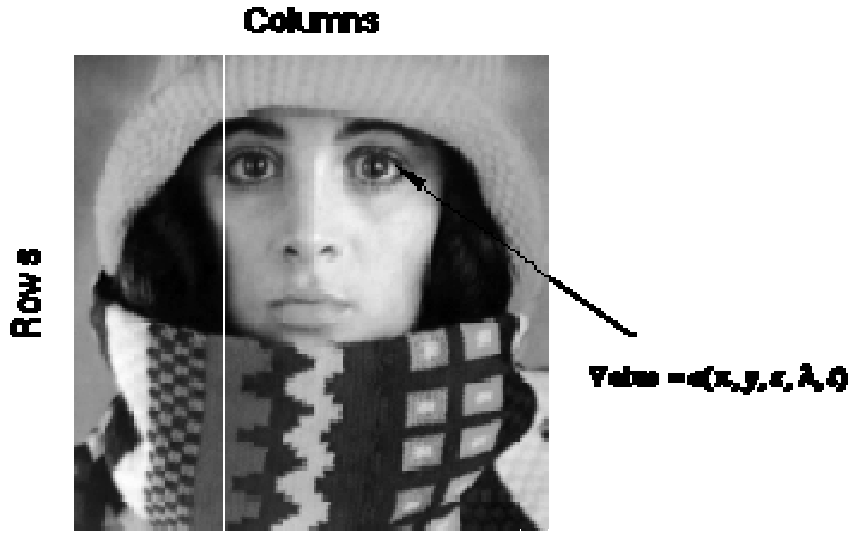
Image after removal of motion blur

3. DIGITAL IMAGE

3.1 Definition of Digital Image:

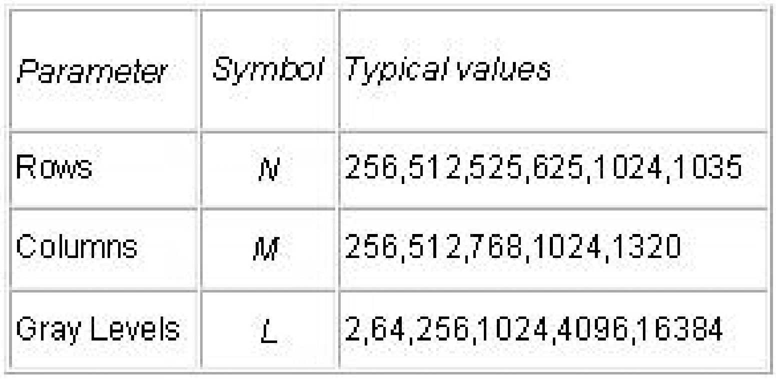
A digital image is an image f(x, y) that has been discretized both in spatial co-ordinate and brightness. A digital image can be considered a matrix whose row and column indices identify a point in the image and the corresponding matrix element value identifies the grey level at that point. The elements of such a digital array are called image elements, picture elements, pixels or pels.

There are two common conventions in use for representing the position of a pixel in an image. Usually the ordinary Cartesian coordinate system is used. In this system, g(x, y) is the grey level at the pixel (x, y) and the pixel (1,1) (sometimes (0,0) is at the lower left corner of the image. As x (horizontal component) increases, (x, y) moves to the right, and as y (vertical component) increases (x, y) moves upward. Typical image sizes for low cost commercial image processing systems range from 256 * 256 pixels to 512 * 512 pixels.



3.2 Common Values

There are standard values for the various parameters encountered in digital image processing. These values can be caused by video standards, by algorithmic requirements, or by the desire to keep digital circuitry simple. Table 1 gives some commonly encountered values.



Parameter	*Symbol*	*Typical values*
Rows	N	256,512,525,625,1024,1035
Columns	M	256,512,768,1024,1320
Gray Levels	L	2,64,256,1024,4096,16384

Table 1: Common values of digital image parameters

Quite frequently we see cases of M=N=2^K where {K = 8, 9, 10}. This can be motivated by digital circuitry or by the use of certain algorithms such as the (fast) Fourier transform.

The number of distinct gray levels is usually a power of 2, that is, L=2^B where B is the number of bits in the binary representation of the brightness levels. When B>1 we speak of a *gray-level image*; when B=1 we speak of a *binary image*. In a binary image there are just two gray levels which can be referred to, for example, as "black" and "white" or "0" and "1".

4. ELEMENTS OF IMAGE PROCESSING

The major elements of image processing are:

4.1 IMAGE ENHANCEMENT:

The principle objective of enhancement technique is to process an image so that the result is more suitable than the original image for a specific application. The word specific is important, because different techniques are used for different problems. Thus, a method which is useful for enhancing x-ray images may not be necessarily be the best the approach for enhancing pictures of mars transmitted by space probe. The approaches fall into two broad categories spatial domain method and frequency domain methods. The spatial domain refers to the image plane itself, and approaches in this category are based on direct manipulation of pixels in an image. Frequency domain processing techniques are based on modifying the Fourier transform of an image. Thus, image enhancement involves improving the quality of various types of image information.

4.2 IMAGE RESTORATION

Restoration is a process that attempts to reconstruct or recover an image that has been degraded by using some priori knowledge of the degradation phenomenon. The ultimate goal of restoration technique is to improve an image in some sense. Thus restoration techniques are oriented towards modelling the degradation and applying the inverse process in order to recover the original image. This approach usually involves formulating a criterion of goodness that we yield some optimal estimate of desired result. By contrast enhancement techniques basically are heuristic procedures designing to manipulate an image in order to take advantage of psychophysical aspects of human visual system.

For example, contrast stretching is considered as an enhancement technique because it is based primarily on the pleasing aspects it might present to viewer, whereas removal of image blur by applying a deblurring function is considered a restoration technique.

4.3 IMAGE COMPRESSION

An enormous amount of data is produced when 2-D light intensity function is sampled and quantized to create a digital image. In fact, the amount of data generated may be so great that it results in impractical storage, processing and communication requirements. Image compression addresses the problem of reducing the amount of data required to represent a digital image. It tries to remove some of the redundant data. From mathematical view point, this amounts to transforming a 2-D pixel array into a statistically uncorrelated data set. The transformation is applied prior to storage of transmission of image. At some later time, the compressed image is decompressed to reconstruct the original image or an approximation to it.

Image compression techniques makes efficient storage and transmission possible by reducing the amount of data needed to represent an image. The techniques are either lossless or lossy, meaning that image is modified in subtle ways to create redundancy which is then removed to achieve compression. Many, ‘real’ images contain only a small amount of redundant data. Lossless techniques give only moderate compression of such images. Higher compression is possible using lossy compression techniques, which discard some of the information present in the image.

4.4 IMAGE ANALYSIS

Image analysis is a process of discovering, identifying and understanding patterns that are relevant to the performance of an image based task.

One of the principle goals of image analysis by computer is to endow a machine with the capability to approximate in some sense, a similar capability in human beings. For example, in a system for automatically reading images of typed documents, patterns of interest are alphanumeric characters and the goal is to achieve character recognition, accuracy that is as close as possible to the superb capability exhibited by human beings for performing such tasks. Thus an automated image analysis system should be capable of exhibiting various degrees of intelligence.

However, conceptualizing various types of behaviours generally associated with intelligence is not difficult. Several characteristics that come to mind are:

1. The ability to extract **pertinent information** from a background of irrelevant details.

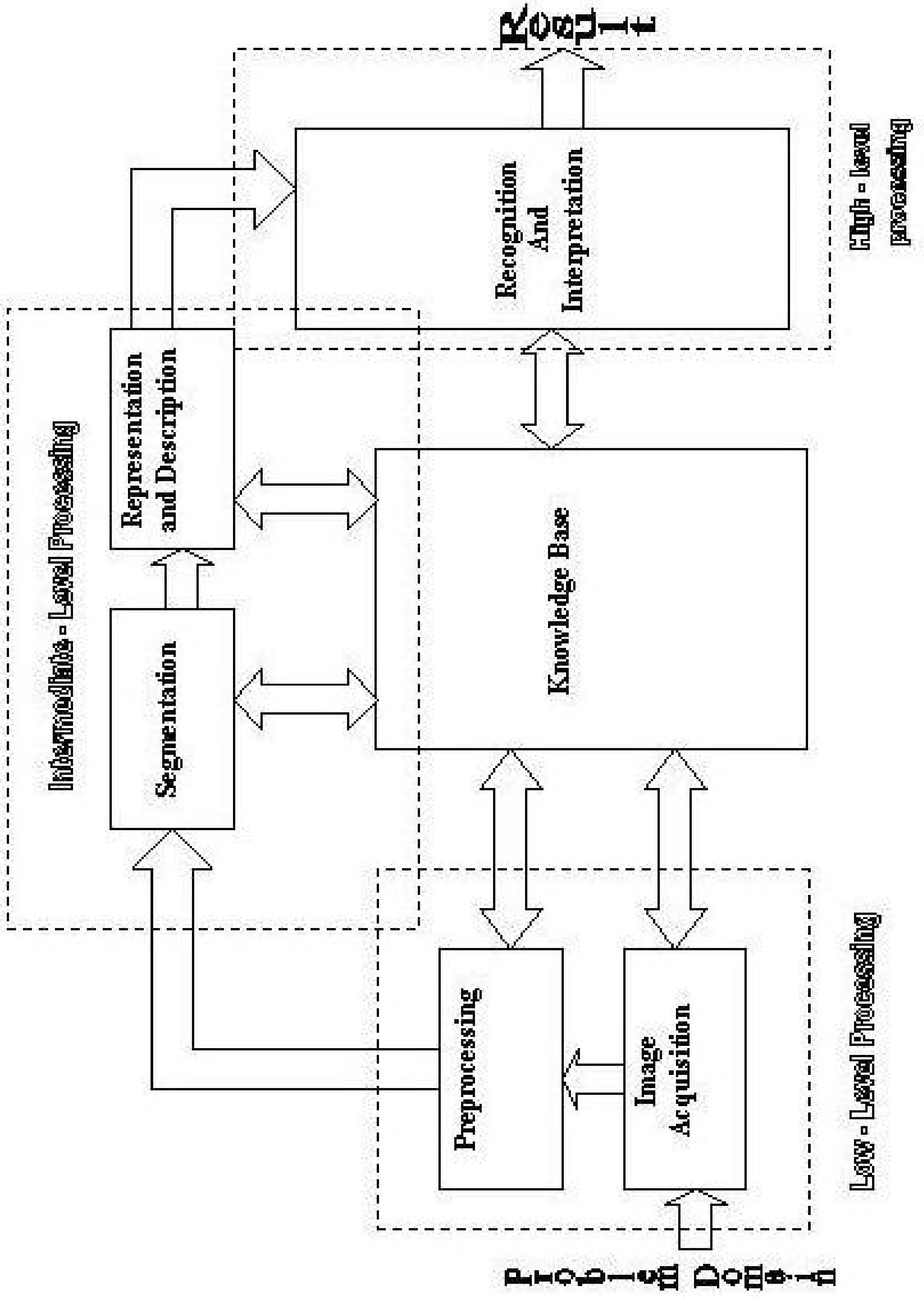
The capability to learn from examples and to **generalise**
this knowledge so that it will apply in new and different
circumstances.

2. The ability to make **inferences** from incomplete information.

Image analysis is divided into three basic areas. These areas are

1. **Low-level processing**
2. **Intermediate-level processing**
3. **High-level processing**

The general block diagram is as follows: (on the following page)


Result
Recognition And Interpretation
High - level processing
Representation and Description
Segmentation
Intermediate - Level Processing
Knowledge Base
Preprocessing
Image Acquisition
Low - Level Processing
Problem Domain

4.4.1 Low level processing

It deals with the functions that may be viewed as automatic reactions, requiring no intelligence on the part of image analysis system. We treat image acquisition (i.e. to acquire a digital image) and pre-processing as low level functions.

Image Acquisition:

Two elements are required to acquire digital images. The first is a physical device that is sensitive to a band in electromagnetic energy spectrum (such as x-ray, UV, visible or infrared bands) and that produces an electrical signal output proportional to the level of energy sensed. The second, called a digitizer, is a device for converting the electrical output of the physical sensing device into digital form.

Pre-processing:-

Pre-processing is the improving the image in ways that increases the chances for a success of other processes. Pre-processing typically deals with techniques for enhancing contrast, removing noise, and isolating regions whose texture indicate a likelihood of alphanumeric information.

4.4.2 Intermediate level processing

It deals with the tasks of extracting and characterizing components in an image resulting from low level process .It includes segmentation representation and description.

Segmentation:

Segmentation partitions an input image into its constituent parts or objects .The output of segmentation stage usually is raw pixel data, constituting either the boundary of a region or all the points in the region itself. The output of the segmentation stage usually is raw pixel data, constituting either the boundary of a region or all the points in the region itself.

Representation:

Representation aims for transforming raw data into a form suitable for subsequent computer processing. A method must also be specified for describing the data so that features of interest are highlighted. Basically, representing a region involves two choices, 1. We can represent the region in terms of its external characteristics (its boundary), or 2. we can represent it in terms of its internal characteristics (the pixels comprising the region). Choosing a representation scheme is only part of the task of making the data useful to the computer.

Description:

It is called feature selection which deals with extracting features those results in some quantitative information of interest or features that are basic for differentiating one class of objects from another.

4.4.3 High level processing

It involves recognition and interpretation. These two processes have a stronger resemblance to what generally is meant by the term intelligent cognition.

Recognition:-

It is a process that assigns a label to an object based on the information provided by its descriptors.

Interpretation:-

It involves assigning, winning to and ensemble of recognized objects. In terms of our example, identifying a character as say, a **c** requires associating the descriptors for that character with the label **c**. Interpretation attempts to assign meaning to a set of labelled entities.

Material in this section deals with

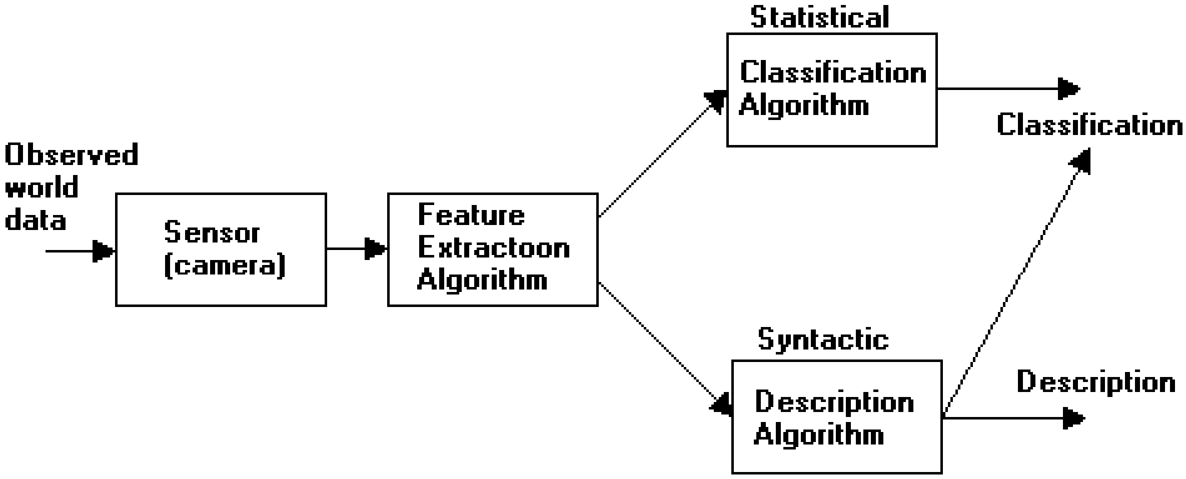
1. Decision -theoretic method for recognition.
2. Structural method for recognition.
3. Method for image interpretation.

5. PATTERN RECOGNITION

Pattern recognition is the science that concerns the description or classification of measurements, usually based on underlying model. The measurement or the properties used to classify the objects are called as **features,** and the types or categories into which they are classified are called as classes. Since most pattern recognition tasks are first done by humans and automated later, the most fruitful source of features has been to asked the people who classify the objects how they tell them a part. The two main approaches to pattern recognition are the statistical (decision theoretic) and the syntactic approaches. Of particular interest are the following concerns:

1. Reducing the general statistically based pattern or feature classification approach to a practical formulation that is use of image processing.
2. The selection of lowest - level feature to be used .The selection of features of primitives in general pattern recognition problem is typically more art than science, although the principles presented here provide some theoretical guidelines.
3. The development and application of syntactic approaches to image processing problems from the point view of grammars and productions. These may be integrative with the rule based system.

The structure of a typical pattern recognition system is shown below:



Typical Pattern Recognition System

6. METHODOLOGIES:

1. **TEMPLATE MATCHING**
2. **NEURAL NETWORK**
3. **MOMENT BASED**
4. **CONTOUR BASED APPROACH**
5. **MORPHOLOGICAL APPROACH**

6.1 TEMPLATE MATCHING

TEMPLATE MATCHING refers to the process of detecting an object having a certain size shape and orientation in an image by applying an operator containing positive weights in a region resembling the objects to be detected and containing negative weights in a region surrounding the positive weight. An operator without negative weights such as

2 2 2 2 2

Would not be a good horizontal line detector. Although it would respond to the horizontal line of 1's. In the figure below with an output of 10,

0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	1	1	1	1	1	1

It would also produce the same output when applied anywhere inside the large region of 1s on the right in the same figure. This would not usually be desirable. To create an operator that will respond to a bright horizontal line only if it is surrounded by a darker background, some negative weights must be included in the template such as

$$\begin{matrix} \mathbf{-1} & \mathbf{-1} & \mathbf{-1} & \mathbf{-1} & \mathbf{-1} \\ \mathbf{2} & \mathbf{2} & \mathbf{2} & \mathbf{2} & \mathbf{2} \\ \mathbf{-1} & \mathbf{-1} & \mathbf{-1} & \mathbf{-1} & \mathbf{-1} \end{matrix}$$

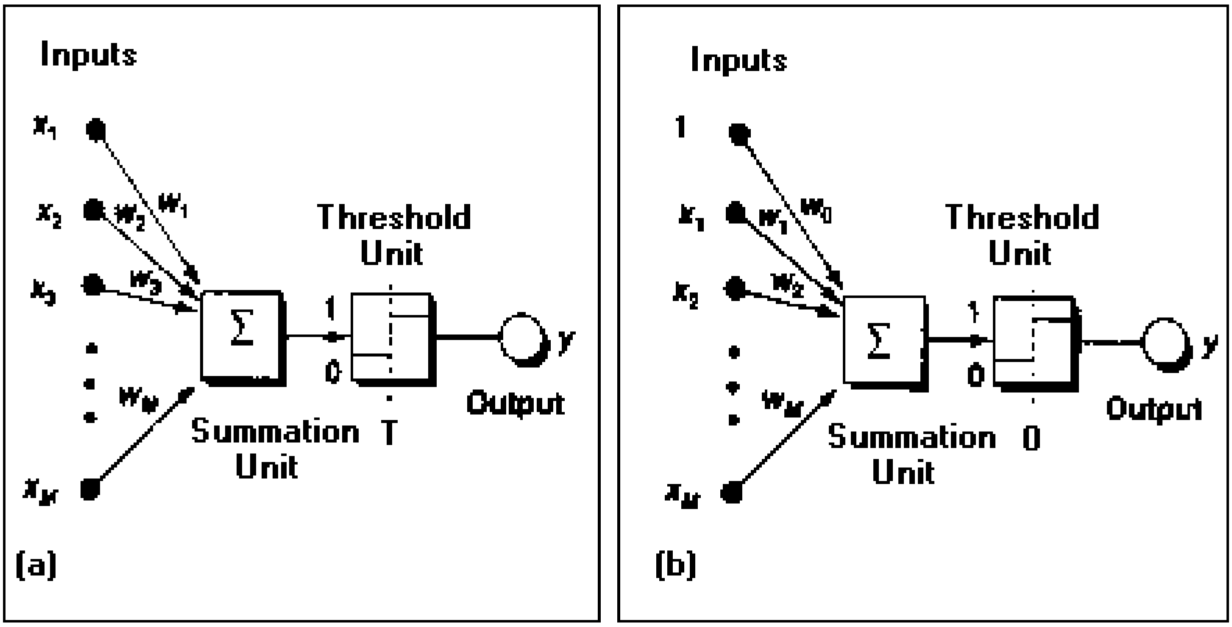
(The signs would be reversed if positive outputs for dark lines were desired). This operator will produce an output of 10 when applied near the centre of line of 1s on the left of figure 2. The best operator is the one that most closely resembles the feature to be emphasised or detected, including a reasonable portion of its typical background .These operators are often called TEMPLATES.

6.2 Neural networks:

This section presents an introduction to the exciting, emerging application of neural network to low and high level image processing tasks. Neural networks are also referred to under the heading of parallel distributed computation and connectionist computing.

Researchers from such diverse areas as neuroscience mathematics, psychology, and computer science are beginning to see connections between underline models for visual perception, the computation desired parallelism that naturally may be achieved, and operation of related biological systems. And emerging non-algorithmic computational paradigm involves large interconnected networks of relatively simple neuron like unit that form neural networks. There appears to be numerous potential applications of neural network although few concrete examples of practical network are currently available. Pattern recognition, including character recognition and image processing application and direct and parallel implementation of relaxation algorithm, is an example of one potential application.

The brain is composed of approximately 20 billion nerve cells termed neurons. Although each of these elements is relatively simple in design, it is believed the brains computational power is derived from interconnection, hierarchical organization, firing characteristics and shear no of elements.



(a)The McCulloch-Pitts Model of neuron

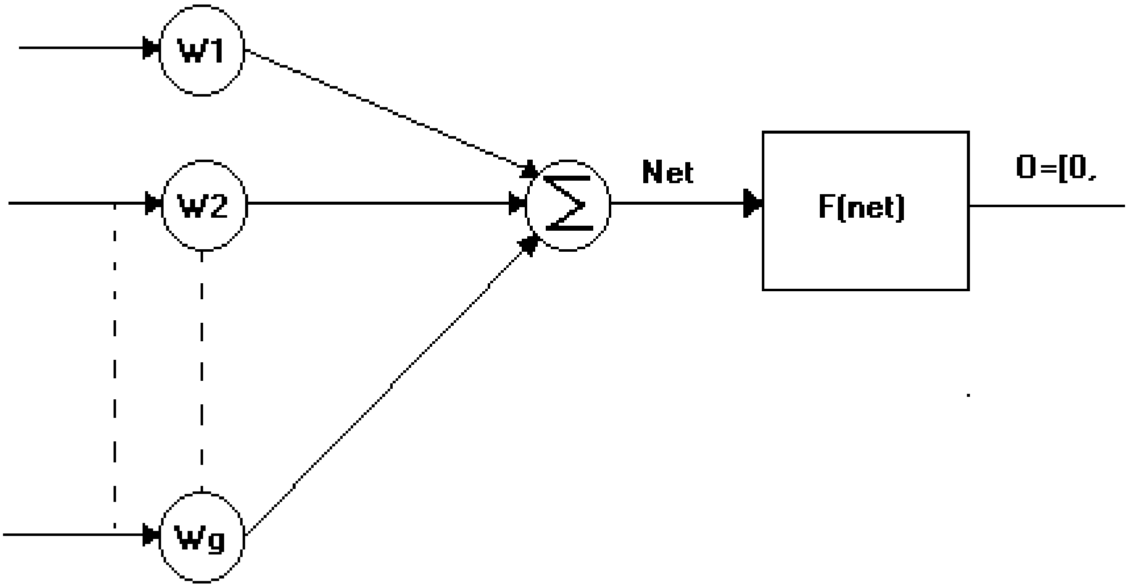
(b)Model of neuron with a bias weight

NEURAL NETWORK MODEL:-

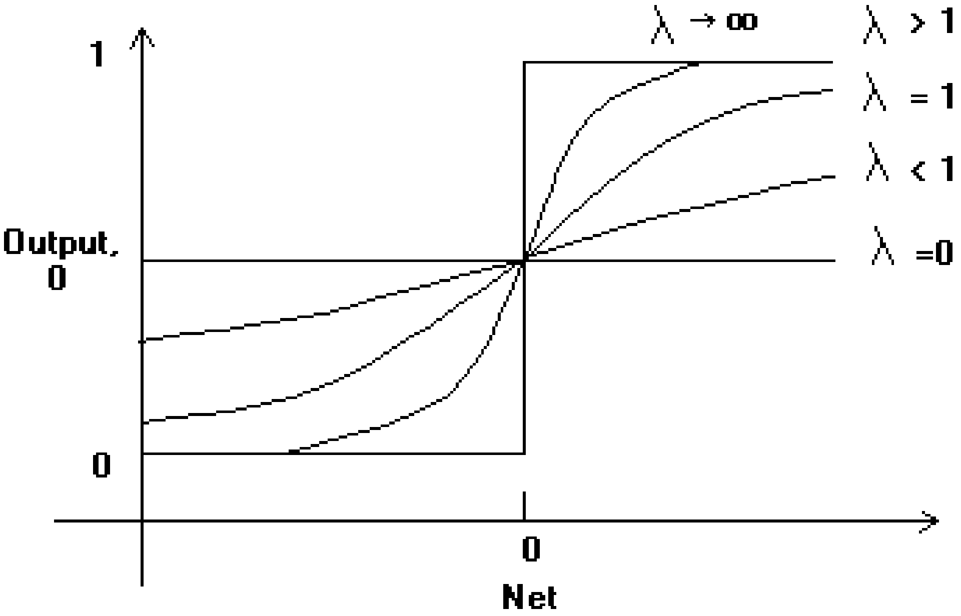
The essence of neural network is the interconnection of massively parallel array of non-linear logic elements that have variable interconnections. Specifically, there are 5 general entities that characterise the design and application of neural network.

1. The individual neural unit activation characteristics:

Examples are shown in figure below. This activation characteristic may, e.g. be simply a threshold characteristics, thus emulating a relay characteristics. In a more general sense neural unit may be think of as programming objects. Feldman and Ballard (1982) described a no. of characterisations of this concept.



(a) Sample neural model Diagram



(b) Hopfield Sigmoid function model

2. The neural unit interconnection strategy or network Structure:

This may be as simple as allowing each neural output to be connected to all other neurons (perhaps with varying interconnection strength) or constraining the neural unit interconnection to be localised. Conversely the neural network interconnection strategy may be quiet complex and reflect an n-dimensional and / or hierarchical structure.

3. The goal or desired behaviour of the network:

This is reflected in the choice of a numerical performance index, enumeration of a set of stable network states or specifications of a desired network.

4. The choice of features used as input to the network as well as interpretation of the outside state of the network. Implementations from situations where e.g. The states of individual neurons correspond to the values of individual pixel intensities in the input image to cases where group of neurons are used to represent the value of certain features of an object.

5. The training or pre-programming of the network:

Stable states (example in character recognition problem.) Furthermore, it is often desire to store more information in the network as new input occurs. This may be done in several ways, including adjustment of interconnection network.

The design of neural net for a specific application involves considering the characteristics of above in an interrelated manner. For example one may not choose the performance index, neural activation characteristics, and network interconnection for a given application independently of each other. These design parameters are interrelated and choice of third parameter is often constrained by the choice of other two.

6.3 Moments Based Approach:

The shape of a boundary segments (and of signatures) can be described quantitatively by using moments. In order to see how this can be accomplished consider the fig. A given below, which shows the segments of a boundary, and fig. B, which shows the segment represented as a 1-D function g(r) of an arbitrary variable r. Let us treat the amplitude of b as a random variable v and form an amplitude histogram p (v_i), I=1, 2, …, K is the number of discrete amplitude increments. Then, the n^{th} moment of v about its mean is

$$\mu_n(v) = \sum_{i=1}^{k} (v_i - m)^n \, p(v_i)$$

Where,

$$m = \sum_{i=1}^{k} (v_i) \, p(v_i)$$

The quantity m is recognized as the mean or average value of v and μ_2 as its variance. Generally, only the first few moments are required to differentiate between the signatures of the clearly distinct shape.

An alternative approach is to normalize g(r) to unit area and treat it as histogram. In this case, r becomes the random variable and the moments are

$$\mu_n(r) = \sum_{i=1}^{l} (r_i - m)^n \, g(r_i)$$

Where,

$$m = \sum_{i=1}^{l} (r_i) \, g\,(r_i)$$

In this notation, l is the no. of points on the boundary and $\boldsymbol{\mu_n(r)}$ is directly related to the shapes of g(r). For example, the second moment $\boldsymbol{\mu_2(r)}$ measures the spread of the curve about the mean value of r and the third moment **$\mu_3(r)$** measures its symmetry with reference to the mean. Both moment representations may be used simultaneously to describe the boundary segment or signature.

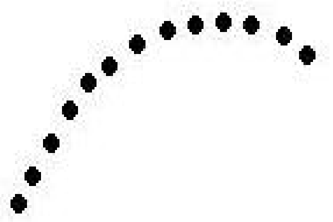


Figure A

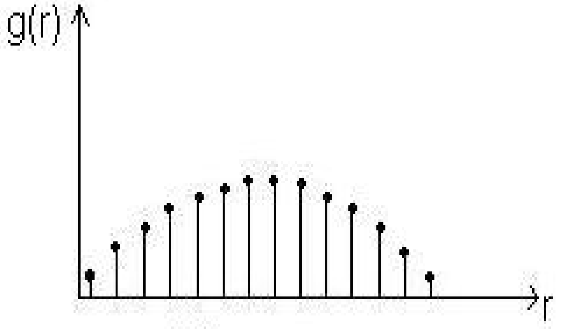


Figure B

Basically, what we have accomplished is to reduce the description task to that of 1-D functions. Although, moments are by far the most popular method, they are not the only descriptors that could be used for this purpose. For instance, another method involves computing 1-D discrete Fourier transform, obtaining its spectrum and using the first k components of the spectrum to describe the g(r). The advantage of moments over other techniques is that the implementation of the former descriptors is straightforward and they also carry a “physical” interpretation of the boundary shape. The insensitivity of this approach to rotation is clear from figure. Size normalization, if desired, can be achieved by scaling the contents of r.

6.4 Contour Représentations:

- **Chain code**
- **Chain code properties**
- **Crack code**
- **Run codes**

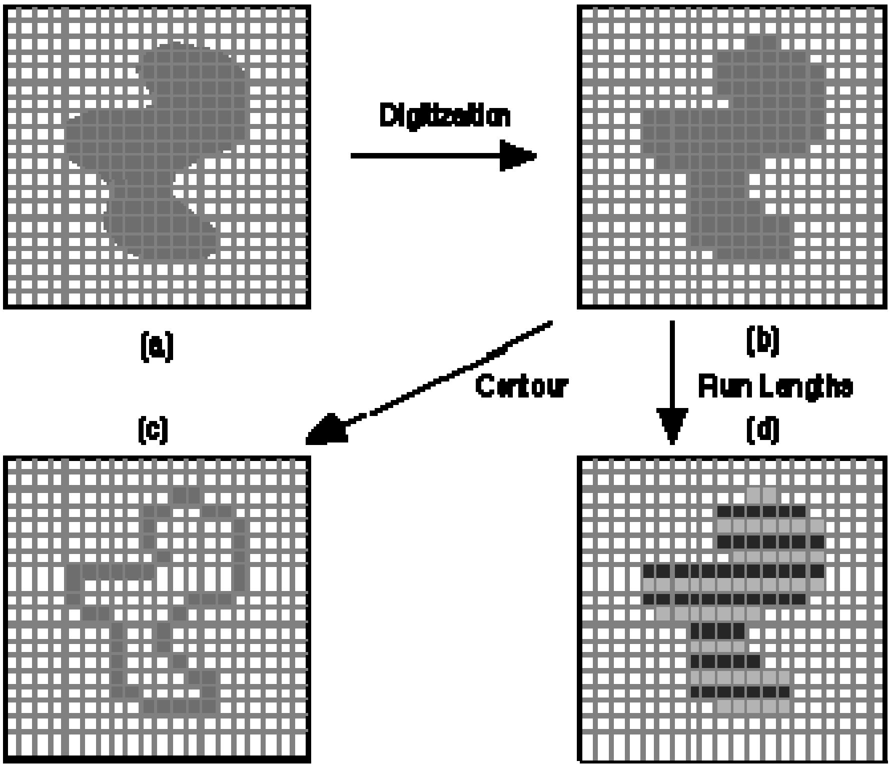
When dealing with a region or object, several compact representations are available that can facilitate manipulation of and measurements on the object. In each case we assume that we begin with an image representation of the object as shown in following Figure a, b. Several techniques exist to represent the region or object by describing its contour.

Chain code:

This representation is based upon the work of Freeman. We follow the contour in a clockwise manner and keep track of the directions as we go from one contour pixel to the next. For the standard implementation of the chain code we consider a contour pixel to be an object pixel that has a background (non-object) pixel as one or more of its 4-connected neighbours.

The codes associated with eight possible directions are the chain codes and, with *x* as the current contour pixel position, the codes are generally defined as:

$$Chain\ codes = \begin{matrix} 3 & 2 & 1 \\ 4 & x & 0 \\ 5 & 6 & 7 \end{matrix}$$



Region (shaded) as it is transformed from (a) continuous to (b) discrete form and then considered as a (c) contour or (d) run lengths illustrated in alternating colours.

Chain code properties

* Even codes {0, 2, 4, 6} correspond to horizontal and vertical directions; odd codes {1, 3, 5, 7} correspond to the diagonal directions.

* Each code can be considered as the angular direction, in multiples of 45 deg., which we must move to go from one contour pixel to the next.

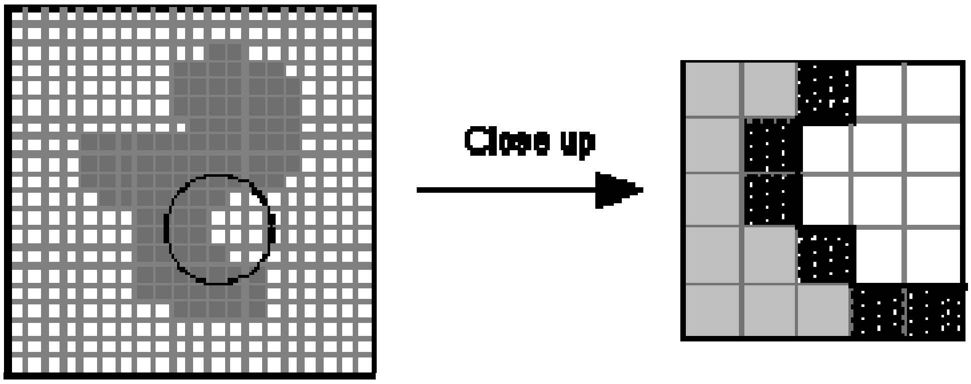
* The absolute coordinates [*m*, *n*] of the first contour pixel (e.g. top, leftmost) together with the chain code of the contour represent a complete description of the discrete region contour. When there is a

change between two consecutive chain codes, then the contour has changed direction. This point is defined as a *corner*.

Crack code:

An alternative to the chain code for contour encoding is to use neither the contour pixels associated with the object nor the contour pixels associated with background but rather the line, the "crack", in between. This is illustrated with an enlargement of a portion of above Figure as shown in Figure below. The "crack" code can be viewed as a chain code with four possible directions instead of eight.

$$\textit{Crack codes} = \begin{array}{ccc} & 1 & \\ 2 & x & 0 \\ & 3 & \end{array}$$



(a) **(b)**

(a) Object including part to be studied. (b) Contour pixels as used in the chain code are diagonally shaded. The "crack" is shown with the thick black line.

The chain code for the enlarged section of Figure 9b, from top to bottom, is {5, 6, 7, 7, 0}. The crack code is {3, 2, 3, 3, 0, 3, 0, 0}.

Run codes

A third representation is based on coding the consecutive pixels along a row--a run--that belong to an object by giving the starting position of the run and the ending position of the run. Such runs are illustrated in first Figure d. There are a number of alternatives for the precise definition of the positions. Which alternative should be used depends upon the application and thus will not be discussed here.

6.5 MORPHOLOGY

The word ***morphology*** commonly denotes a branch of biology that deals with the form and structure of animals and plants. We use the same word here in the context of ***mathematical morphology*** as a tool for extracting image components that are useful in the representation and description of the region shape, such as boundaries, skeletons and the convex hull. The morphological techniques for pre or post processing include filtering, thinning, pruning, erosion & dilation, opening & closing.

Morphology is a study of **forms** and **shapes**. This broad area includes the topics of integral geometry, topology, set theory and cellular automata. Historically, morphological approaches have been applied to binary images. In mathematical terms it is a tool for extracting image components that are useful in representation and description of region shape, such as boundaries, skeletons and convex hull. In these morphological techniques, for pre or post processing operations such as morphological filtering, thinning, and pruning must be carried out.

● **Erosion and Dilation:**

The Erosion and Dilation operations make objects smaller and larger. These operations are valuable in them and are the foundations for the opening and closing operation. EROSION makes object smaller by removing or eroding away the pixels on its edges.

DILATION makes objects larger by adding pixels around its edges.

● Opening and Closing:

OPENING generally smoothes the contour of an image breaks narrow Isthmuses, and eliminates thin protrusions. Opening spaces objects that are touching and should not be, and enlarges the holes inside the objects. Opening involves one or more erosions followed by one dilation.

CLOSING also tends to smooth sections of contour but, as opposed to opening, it generally fuses narrow breaks and long thin gulfs, eliminates small holes, and fills the gaps in the contour. Closing joins broken objects and fills in unwanted holes in the object. Closing involves one or more dilation followed by one erosion.

● Outlining:

OUTLINING is a type of edge detection. Outlining helps you to understand an object. To outline the interior of the object, you erode the object and subtract the eroded image from the original. To outline the exterior of an object, you dilate an object and subtract the original image from the dilated image.

●Thinning:

Thinning is a data reduction process that an object until it is one pixel wide, producing a skeleton of the object. There are two basic techniques for producing the skeleton of an object:

I. Basic thinning.
II. Medial axis transforms.

I.Basic thinning:

Thinning erodes an object over and over again (without breaking it) until it is one pixel wide. This basic thinning technique works well, but one cannot re-create the original object from the result of thinning.

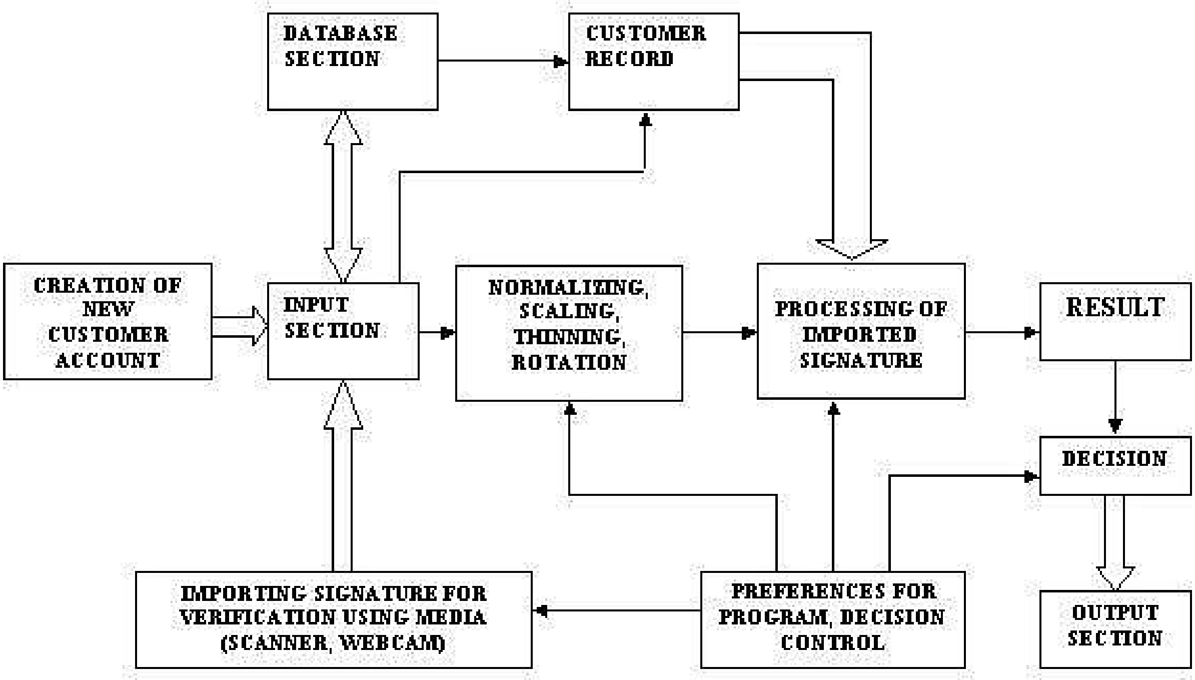
If one wants to do that, one must use medial axis transform.

II.Medial axis transforms:

The medial axis transforms finds the points in an object that form lines down its center, that is, its medial axis. The Euclidian Distance measure is the shortest distance from a pixel in an object to the edge of the object.

The medial axis transforms consists of all points in an object that are minimally distant to more than one edge of the object. The advantage of the medial axis transform is that you can re-create the original image from the transform. The medial axis, Also called as the Skeleton of an region, can be thought as a line or curve that runs middle of an elongated region and runs along the center of each branch if there are any branches. It can serve as a simplified description of a region in the same way that a stick figure can be used as a representation of a human being.

7. Block diagram of the project


DATABASE SECTION
CUSTOMER RECORD
CREATION OF NEW CUSTOMER ACCOUNT
INPUT SECTION
NORMALIZING, SCALING, THINNING, ROTATION
PROCESSING OF IMPORTED SIGNATURE
RESULT
DECISION
IMPORTING SIGNATURE FOR VERIFICATION USING MEDIA (SCANNER, WEBCAM)
PREFERENCES FOR PROGRAM, DECISION CONTROL
OUTPUT SECTION

7.1 Explanation of the block diagram

The above block diagram briefly explains how we are going to recognize the signature in step-wise manner.

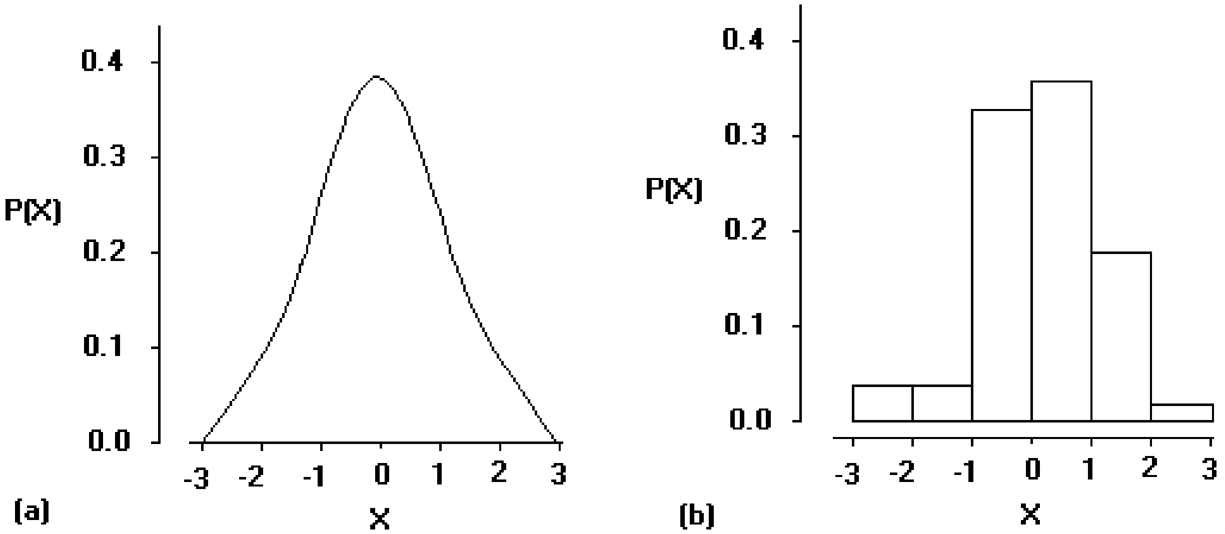
INPUT SECTION:

There are two inputs to this section. One input is used for creating new customer account in bank, while other being used for importing the signature for verification using media such as scanner, web-cam. For importing the signature there must be a copy of standardized signature for the corresponding user account number. If the customer opens new account then the related information is stored in database with some modifications according to the requirement. NO one can interfere with the database of the software as this facility is available only to the supervisor of program. The signature to be recognised i.e. the relevant part of signature is selected from the picture and this data is passed to the pre-processing block.

PRE-PROCESSING BLOCK:

The hardware being used for implementing the Software offers certain limitations as we are going to use the scanner, monitor and VGA of the computer which have finite resolution (not very high) and capabilities, which ultimately results in the loss of data at the input side of the program. Hence, pre-processing becomes necessary.

1. **Colour normalisation:** As the user can sign with any pen and with different coloured inks, it is necessary to convert the signature in black and background in white. To implement this we use histogram type of technique. One of the easiest ways of obtaining an approximate density function p(x) from sampled data if no parametric form is assumed for the underlying density is to form a histogram of the data as shown in figure below.



(a)The true normal density from which 50 random numbers were chosen

(b)A histogram of 50 normally distributed random numbers with 6 intervals

A histogram is a convenient way to describe the data. To form a histogram; the data from a single class are grouped into intervals. Over each interval, a vertical rectangle is drawn, with its area proportional to the number of data points falling into that interval. It basically gives us the information about the number of pixels in an image of particular intensity / luminosity. For coloured images, luminance can be calculated as

$$\mathbf{L = 0.3 * R + 0.59 * G + 0.11 * B}$$

Depending upon the result of histogram colour normalisation will be applied such that signature becomes black and background becomes white.

2. **Scaling:** As we are going to implement morphological concept for signature detection, signature must be considerably of large size as dilation operation is used for further processing. Also the signature should not be too large as it will increase the processing time. Hence, proper scaling of the signature should be done.

3. **Filtering:** After scaling, the signature becomes quite blocky. To reduce this effect i.e. blockiness of the signature we use averaging type of filter. Smoothening filters are used for blurring and for noise reduction. Blurring is used in pre-processing steps, such as removal of small details from an image prior to (large) object extraction, and bridging of small gaps in lines or curves. Noise reduction can be accomplished by blurring with a linear filter and also by nonlinear filtering. Blockiness effect must be reduced because after thinning operation it produces shaky lines.

4. **Thinning:** The tip of the pen being used for the signature may not be standardised hence thinning must be carried out. Basically thinning is a data reduction process of an object until it becomes one pixel wide, producing a skeleton of the object.

5. **Rotation:** It may be quite possible that the signature to be recognised is rotated at a certain angle. In order to avoid any misalignment with respect to the standardised signature it becomes necessary to rotate the signature to be recognised through particular angle.

PROCESSING BLOCK:

For processing of the signature, we use pixel by pixel comparison method. We also use some of the morphological operations such as erosion, dilation. After pre-processing of the standardised signature the check pattern is developed using the dilation operation. Flow-chart for the generation of check pattern is described previously. Now the signature to be recognised is thickened by some amount. The standardised signature and the signature to be checked are **EX-ORED** to produce the output result which gives us the whole information about the number of matching pixels, missing pixels, out of range pixels etc.

The preference block gives tolerance preferences to the various blocks according to the supervisor or by default programmer calculates tolerances by correlating standardised signature.

RESULT:

According to the output of the processing block decision is taken and the software outputs appropriate result about whether to accept the signature or reject it.

8. RECOGNITION OF THE SIGNATURES:

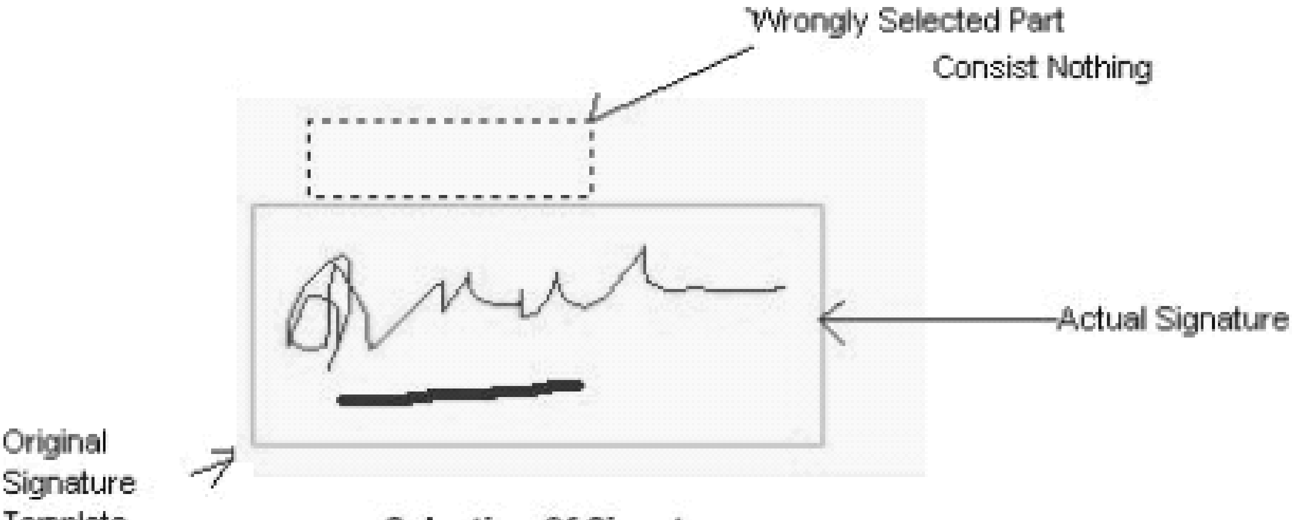
We discuss this process in steps. **Various operations are being performed on the signature prior to the recognition process is Initiated**. We follow the flow of the software, the different operation are discussed as follows:

8.1 PREVENTIVE MEASURES:

RESTRICTION TO SELECT THE BLANK PART:

Before proceeding towards the operations such as Normalization, Scaling, Thinning, and Rotation. Appropriate Data must be supplied to the subroutines; the user should select the relevant part of the signature. In case of a blank part is selected error may occur. So we have to use the preventive measures to prevent the user from selecting a blank part of the document.

When a part is selected checks are made to ensure that the selected part contains pixels. In case of blank part the user is prompted to select the relevant part.



Selection Of Signature

Criteria to select a signature

After the relevant part of the document is selected it is treated as the signature under test.

8.2 COLOUR NORMALISATION:

In recognition process colour normalization is very essential. The signatures can be done on any paper with different colour inks, hence colour normalization is used in which we make the signature BLACK and the background is made WHITE. Due to the image scaling process the picture becomes blocky; hence we perform a smoothening operation, which may introduce grey shades to the signature. Hence the colour normalization is re initiated.

Illustration of this operation:

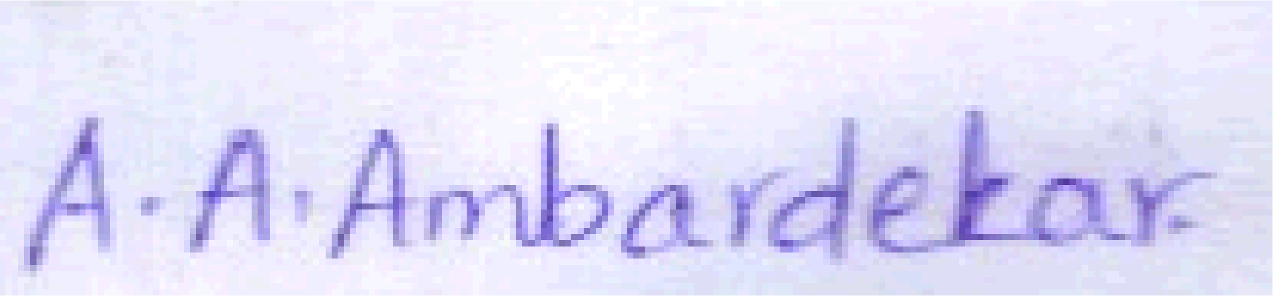


Image before Colour Normalization

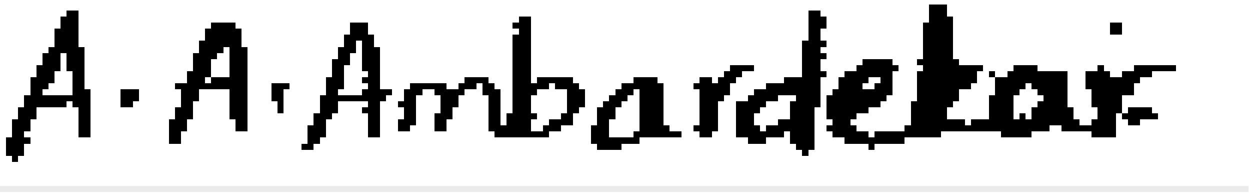
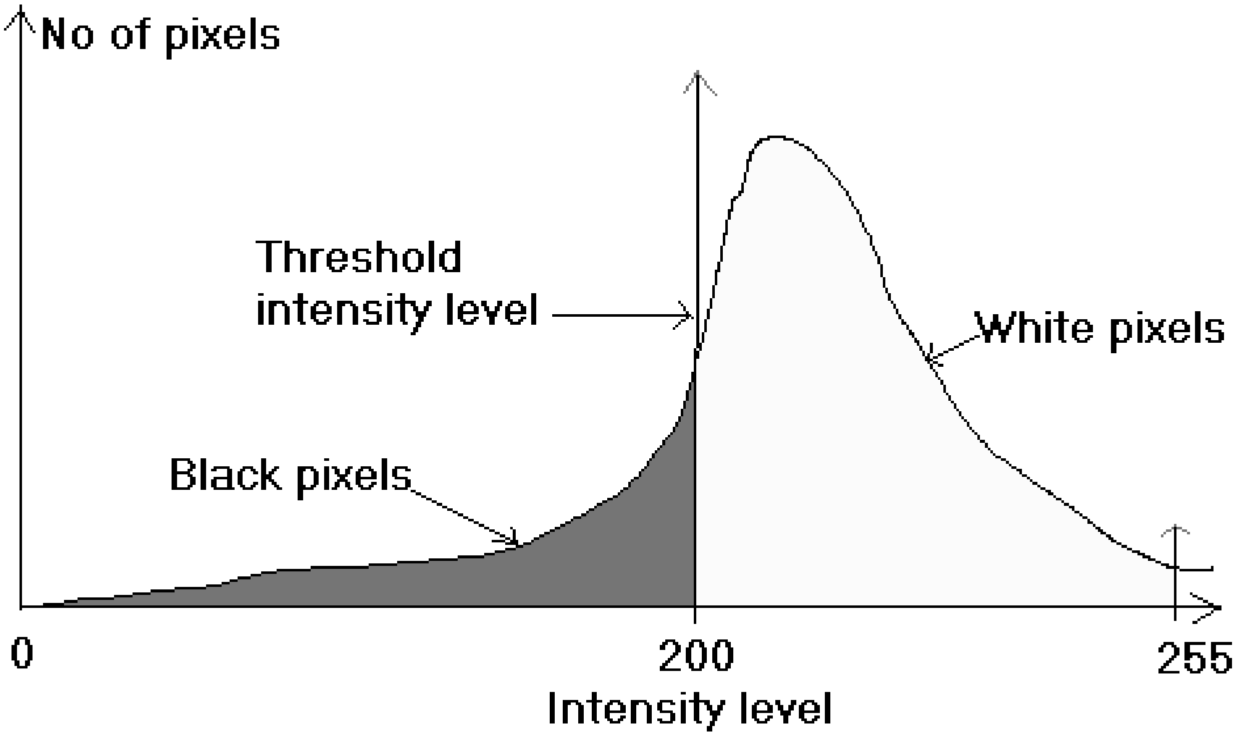


Image after Colour Normalization

Algorithm for colour normalization:

1. Select the relevant part of the signature.
2. Get the value of the threshold for the colour normalization process.
3. Scan the image from the top corner in a line by line manner. Take in account information of each pixel.
4. Store the R, G, B value of each pixel.
5. Calculate **$I = 0.3 * R + 0.59 * G + 0.11 * B$**
6. If I < Threshold Then make the corresponding Pixel Black, Else make the pixel white.

7. Carry out the same operation until the Whole image is scanned.



Intensity normalization process

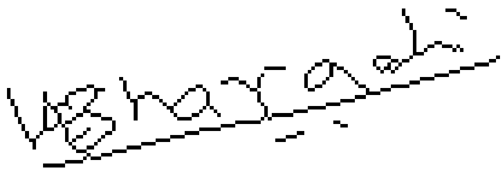
8.3 IMAGE SCALING:

The signature is required to be properly scaled. This is done as large signatures would take longer time to process .In case of small signature template the check pattern is not generated properly, which may cause wrong results. So if the signature is too big then it is scaled to reduce its size or if the signature is small then it is enlarged for proper check pattern generation.

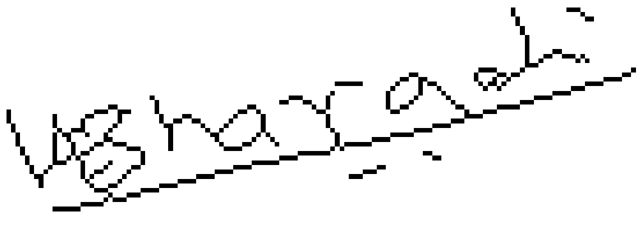
The standard size of the image used in our application is 400 pixels width or height, maximum of these. If the signature width or the height is more than the specified standard then, the image is scaled to the mentioned standard. Also if the signature is smaller than the mentioned standard then, it is enlarged.

After scaling the signature becomes blocky, hence smoothening filter is applied to remove the spike edges. Then colour normalization is performed to remove the grey shades.

The scaling operation works as follows.



Normal Signature



Signature after Scaling

8.4 FILTERS:

8.4.1 SMOOTHENING FILTERS:

Smoothening filters are used for blurring and for noise reduction. Blurring is used in preprocessing steps, such as removal of small details from an image prior to object extracting, and bridging of small gaps in lines or curves.

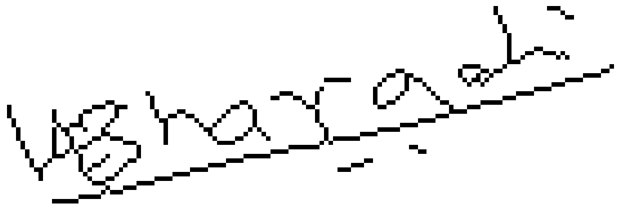
8.4.2 LOW PASS FILTER USED:

The filter used in our application is a simple low pass filter. After the scaling operation, either enlarge the smaller signature, or making smaller signature large makes the picture blocky. Hence to smoothen the image we use the low pass filter. It is a 3 x 3 low pass filter.

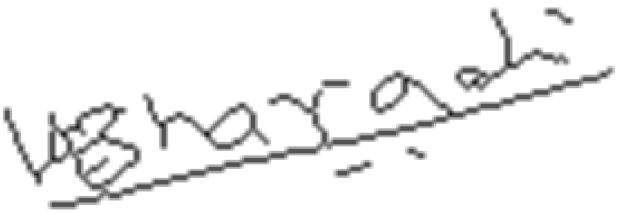
The low pass filter is shown in the following figure.

$$\begin{matrix} \mathbf{1} & \mathbf{1} & \mathbf{1} \\ \mathbf{1} & \mathbf{1} & \mathbf{1} \\ \mathbf{1} & \mathbf{1} & \mathbf{1} \end{matrix}$$

The smoothing filter applied to the signature shown above gives output as follows.



Before Smoothening

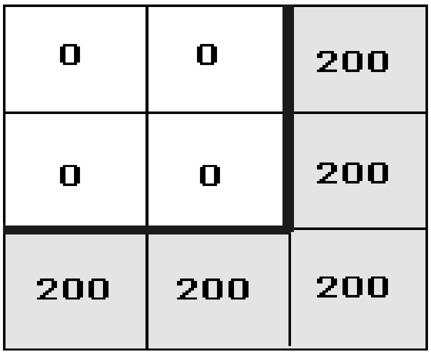


After Smoothening

Explanation of the low pass filters operation:

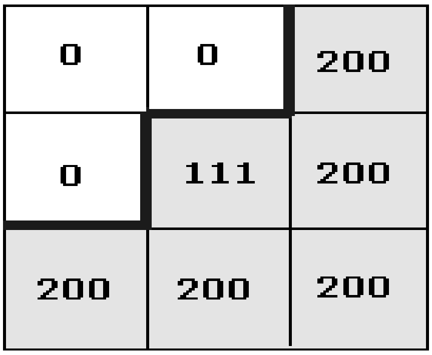
The low pass filter shown in the figure above is the averaging type filter. The image is scanned, the filter is considered as a 3 X 3 matrix which multiplies the intensity values of the pixels corresponding to each matrix element. The central pixels intensity is set to a specific value. This value is found by multiplying the neighbouring pixels intensity values by matrix elements, and averaging them. If a bias is to applied then it is added to that value.

Consider an example; here we consider only intensity values as follows,



0	0	200
0	0	200
200	200	200

Before smoothening



0	0	200
0	111	200
200	200	200

After smoothening

8.5 THINNING:

A modification of erosion known as thinning converts any elongated parts or strips in the image regardless of their bits, into narrow strips that are only about one pixel wide, but are still about as long as the original strips. The narrow strips lie near the centres of the original wide strips. Thinning could be useful, for example, in analyzing images that contain finger prints or handwriting. Also, if the output of an edge detector has been threshold to find the edges in an image, the edges may be more than one pixel wide in some places. The position of these edges could be refined by thinning the edge-detected image. The main problem with using simple erosion is that eroding a strip enough to cause the widest part of it to be only one pixel wide produces gaps in the narrow parts of it. The following algorithm assumes that regions are 4-connected, but they can easily modify to assume 8-connectedness.

The thinning algorithm, with updating of the image after each pixel is eliminated, consists of the following steps. The image is scanned left to right, top to bottom. Each object pixels that has a background pixel as aright 4-neighbor is eliminated, provided that eliminating the pixel would not cause any local chain-breaking and pixel is not at the end point.

Eliminating an object pixel p causes local chain-breaking if, when a 3 x 3 mask is centred at p and p is removed, two of the object pixels in the mask that where previously 4-connected by a chain in the mask becomes disconnected. For example, eliminating the centre pixel in each of the following 3 x 3 regions breaks a chain but no chain is broken in the following regions. However, the canter pixel in the region on the right below would not be removed because it is an end point.

An object pixel is an end point if it has exactly one 4- neighbour in the object. In the figure the uppermost pixel is removed, but the pixel under it is not removed because it becomes an end point when the pixel above it is removed.

Next the image is scanned again from left to right, top to bottom , and each object pixel that has a background pixel as a left 4-neighbour is eliminated ,provided the eliminating the pixel would not cause any local chain-breaking , the pixel is not an end point , and its left neighbour was not eliminated during the scan. This latter condition ensures that thinning will not be biased by eliminating more than one column of pixels from the left side of the image before eliminating pixels from the right side.

Next the image is again scanned left to right, top to bottom, and object pixel that has a background above it is eliminated, provided that eliminating the pixel could cause any local chain-breaking, the pixel is not an end point, and its upper neighbour was not eliminated during the scan. This latter condition ensures that thinning will not be biased by eliminating more than one row of pixels from the top before eliminating pixels from the bottom.

Finally, the image is again is scanned to right, top to bottom, and object pixel that has a background below it is eliminated, provided that eliminating the pixel would not cause any local chain-breaking and the pixel is not an end point.

These four scans are repeated until no more pixels are eliminated. The algorithm can be modified to eliminate updating the image after each pixel is eliminated during if it would not locally break a chain and is not an endpoint in the current image. These decisions are made for the entire pixels that have background pixels on their right before any of them are removed to picture an updated image. As in the algorithms with updating at each pixel, the procedure is repeated for object pixels that have background pixels on their left, top, and bottom. This algorithm allows some elongated region to become a bit shorter but generates a result with fewer branches than the algorithm with updating.

There are two basic techniques for producing the skeleton of an object:

1. Basic thinning.

2. Medial axis transforms.

8.5.1 Basic thinning:

Thinning erodes an object over and over again (without breaking it) until it is one pixel wide. This basic thinning technique works well, but one cannot re-create the original object from the result of thinning.

If one wants to do that, one must use medial axis transform.

8.5.2 Medial axis transforms:

The medial axis transforms finds the points in an object that form lines down its center, that is, its medial axis. The Euclidian Distance measure is the shortest distance from a pixel in an object to the edge of the object.

The medial axis transforms consists of all points in an object that are minimally distant to more than one edge of the object. The advantage of the medial axis transform is that you can re-create the original image from the transform. The medial axis, Also called as the

Skeleton of a region, can be thought as a line or curve that runs middle of an elongated region and runs along the center of each branch if there are any branches. It can serve as a simplified description of a region in the same way that a stick figure can be used as a representation of a human being.

8.5.3 Algorithm for thinning:-

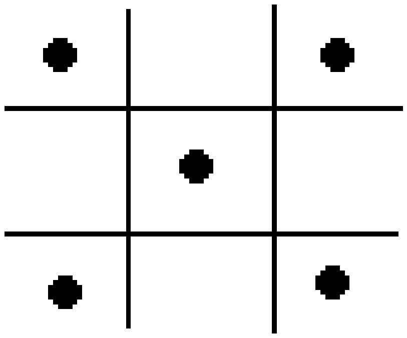


Figure1

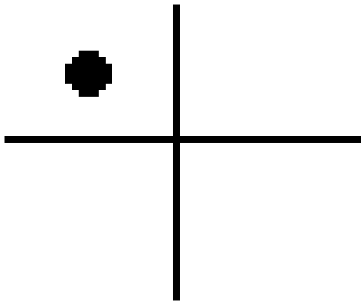


Figure 2

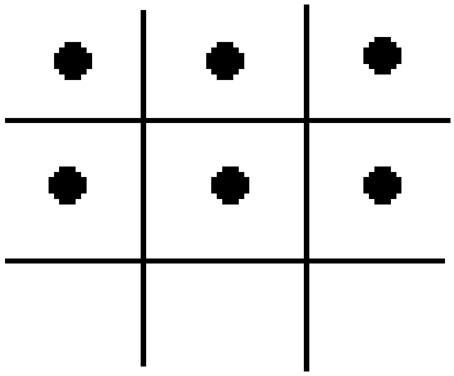


Figure 3

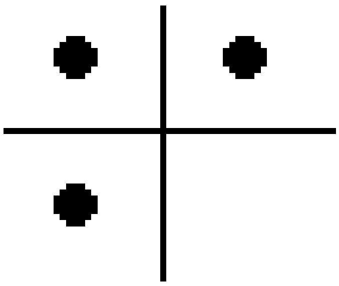


Figure 4

ALGORITHM:

- Acquire and realize the image.
- Normalize the image.
- Start scanning the image line wise.
- Go to a 3 X 3 pixel matrix, with central black pixel.
- Make centre pixel white temporarily.

- Figure 1 represents a matrix with black spots having black pixel in the original image. The figure 2 represents the left up corner part of the matrix selected; the central pixel in the original matrix is made temporarily white.
- Now start reading the matrix pixel by pixel. In case of a situation shown in figure 4, exit reading and make the centre pixel white or leave as it is. In case of situation like figure 2 starts scanning next iteration.
- The centre pixel can't be thinned in case of situation like figure3.
- Repeat the whole process for the whole image.

The thinning process has the output in the following format.

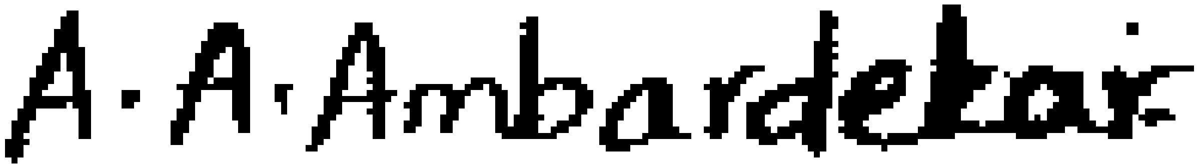


Image before Thinning

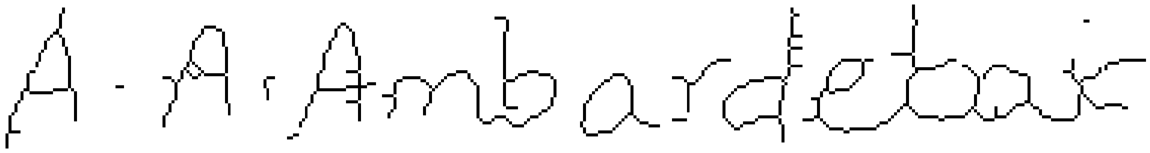
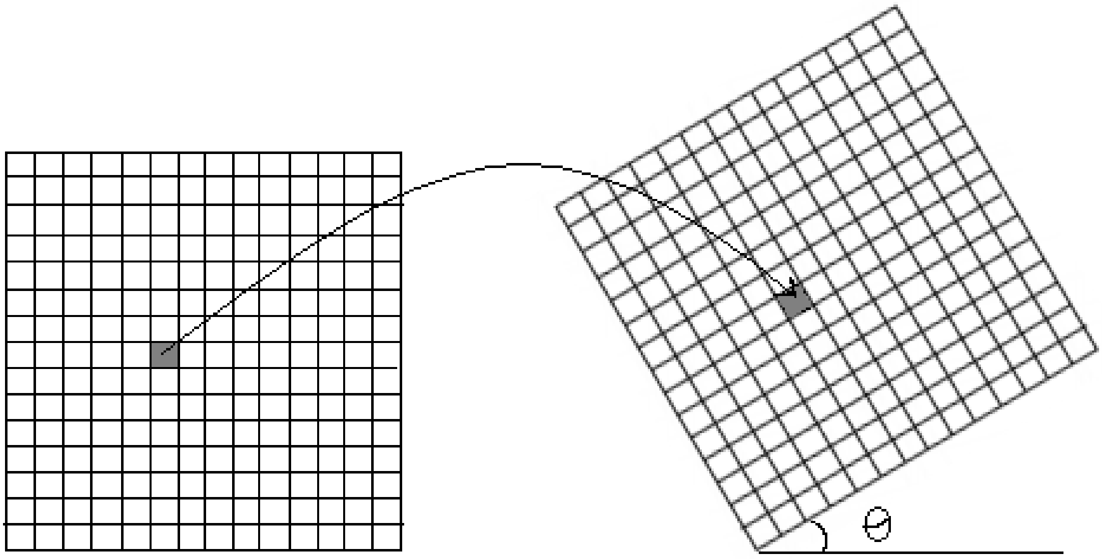


Image after the thinning operation performed

8.6 IMAGE ROTATION:

Rotation is also the part of the normalization. As it is not necessary that signature though correct, is also aligned in angular fashion with respect to the original signature that is standard signature in the database. Therefore, the program determines the angle in which the signature under consideration should be rotated. If the angle is within certain specified limit, then it is rotated; else the signature is rejected for further processing. The following diagram explains how an image is rotated. Each block in the image represents the pixel of the image.

Left hand side image is original image & right hand side image is rotated image. The diagram also illustrates how the pixel positions are changed after rotation.

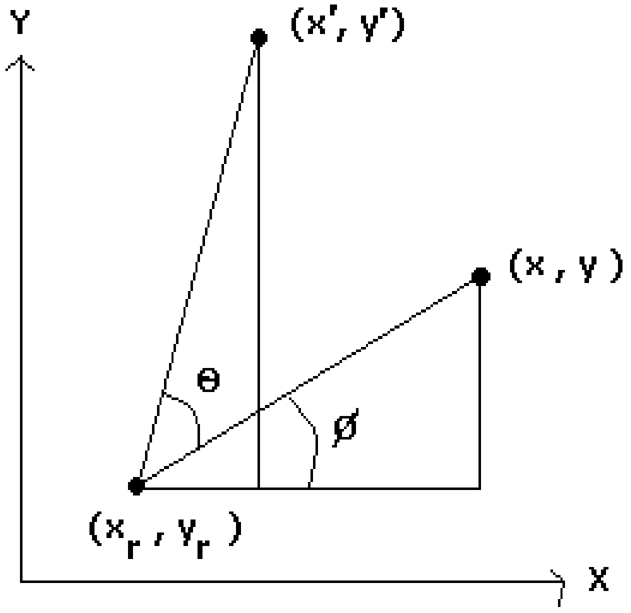


ORIGINAL IMAGE ROTATED IMAGE

In the operation of the recognition we may have to change the angular orientation of the signature for the overlapping purpose. Because in case of slanted signatures the slope angle may have variation from one sample to another. To compensate this variation the signature under test must be rotated through the difference angle. The process of rotation is shown below.

We use Trigonometric relations for rotating the image. For each point in the original image we map a point in the rotated image. The co-ordinates of the rotated point can be found from the formula given in following part.

The Figure explains the procedure for a single point.



The Formulae used for the rotation are as follows:

$$x' = x_r + (x - x_r)\cos\theta - (y - y_r)\sin\theta$$

$$y' = y_r + (x - x_r)\sin\theta + (y - y_r)\cos\theta$$

Algorithm:

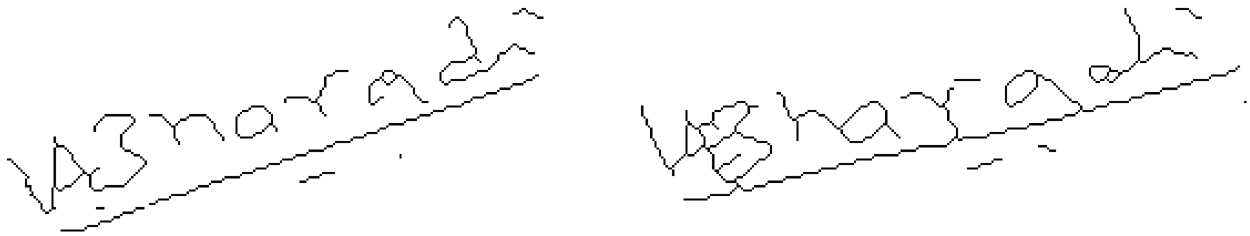
- Scan and realize the image.
- Select the relevant part.
- Determine the angle of rotation.
- By using the formulae find the map for each point in the main image in the target image.
- Save the image

Limitations:

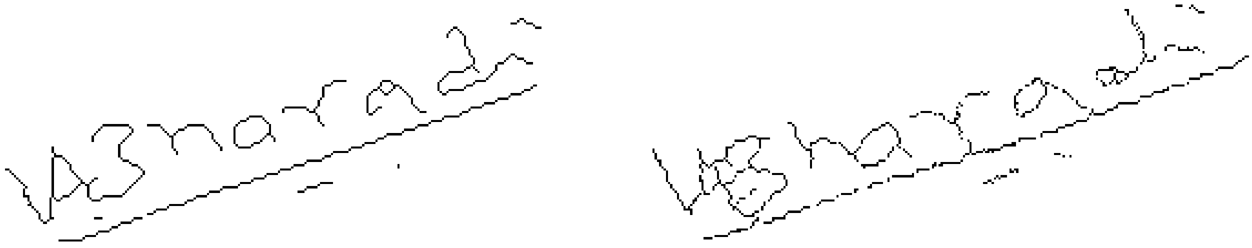
The procedure used to set a point in an image in the platform Microsoft VB 6.0 uses the co-ordinates in the form of integer data. The output of the used trigonometric formulae is not integers but they are Real numbers. Hence we may loss a point in the original image to map it in the rotated image i.e. the map for each and every point is no possible. Hence the image after rotation may have some pixel loss.

The rotation operation performed on an image gives output as follows:

The following two signatures have different angle of inclinations.



After performing rotation operation on the second signature we get following output.



One should note that the second signature has undergone loss of information.

8.7 EROSION & DILATION:

While measuring the shapes of objects in images, it is sometimes desirable to simplify the objects by filling in small holes or by eliminating small holes or by eliminating small protrusions from their boundaries. The elimination of boundary pixel from objects in the boundary image is called erosion, the boundary pixel of an object in binary images is called background neighbours. Various definitions of neighbours can be used. Erosion consists of re-labelling object boundary pixels as background pixels, which has an effect of making object smaller. The opposite operation, dilation, enlarges the object. Each background pixel that has a neighbour in the object is relabelled as an object pixel. Erosion and dilation are sometimes called shrinking and growing.

If there were small background holes in an object, some initial dilation would fill the holes with object pixels. The dilations would increase the size of the object but following this with an equal number of erosion operations would restore the approximate size of the object without causing the holes to reappear. Thus dilating an object is equivalent to eroding the background in its vicinity, and conversely, eroding an object is equivalent to dilating an background .if there were background pixels to be checked than object pixels, it is more efficient to erode the background region than to dilate the object.

If we erode or dilate using a 4 or 8 connected definition of neighbour, the region that is added to or deleted from an object is only one pixel wide, but erosion and dilation can be defined more generally so that wider strips are deleted or added to each step. This can be done by using an operator such as a 5x5 pixel square, with one of its pixels, usually the centre, designated as an origin. Although individual objects can be eroded, erosion is frequently applied to the entire object boundary pixel in an entire image. The original image is scanned with the operator by placing the origin of the operator at each object pixel in image in succession. When any part of the operator extends into background, the object point in the original image corresponding to the origin of the operator is changed to a background pixel in a separate new image which is created during the erosion process. If the operator does not cover any background pixel, corresponding to the origin of the operator remains an object pixel in the new image. The portion of the object that remains in the new image after single erosion consists of only those pixels where the origin of the operator can be placed such that the operator will lie completely within the object in the original image. The width of the boundary strip removed from the object by an operator is about half the height or width of the operator.

The erosion of the object pixels that form a region R in the original image by an operator A to produce a smaller region R′ in the new image is often represented as $R' = R \Theta A$, where the symbol Θ is read as “eroded by”. Although symmetric operators are often used, an operator can have any shape, and any pixel can be defined to be its origin. An operator that extends farther to the right of it’s origin than to the left could be used to erode the right side of an object more than it’s left, for example.

Deleting the pixels of R that are 8-neighbours of the background is equivalent to erosion using the square operator shown in figure because if this 3X3 square operator can be centred at a pixel and still lie completely within the region R, that pixel cannot have any 8-neighbours in the background. If the operator does not lie completely within R, then the pixel at which it is centred must have at least one 8-neighbour in the background. Similarly, deleting the object pixels that are 4-neighbours of the background is equivalent to erosion by the plus-shaped operator shown in figure. To erode more pixels per step, larger operators such as those shown in figure may be used.

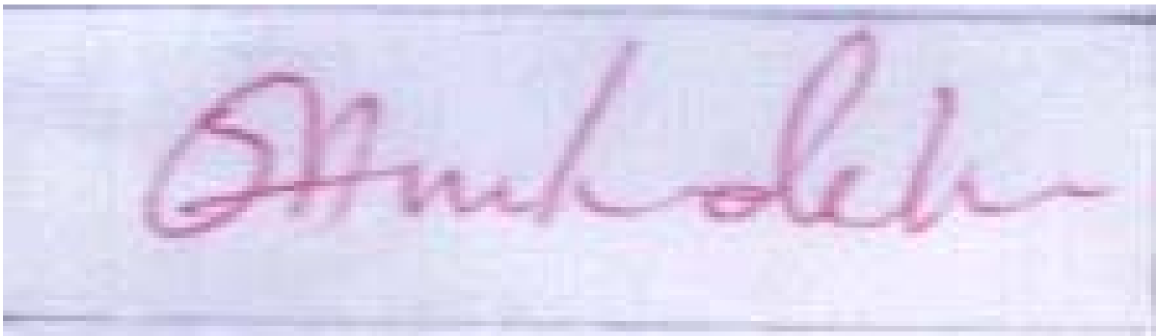
Similarly, the result R' of the dilation of region R by operator A, denoted by $R' = R \oplus A$, consists of all the pixels where A can be centred and still have any part in R. This converts a strip of background pixels near the object into object pixels. Single erosion followed by a single dilation by the same operator is called an opening, and a dilation followed by erosion by the same operator is called a closing.

8.7.1 Application in the software:

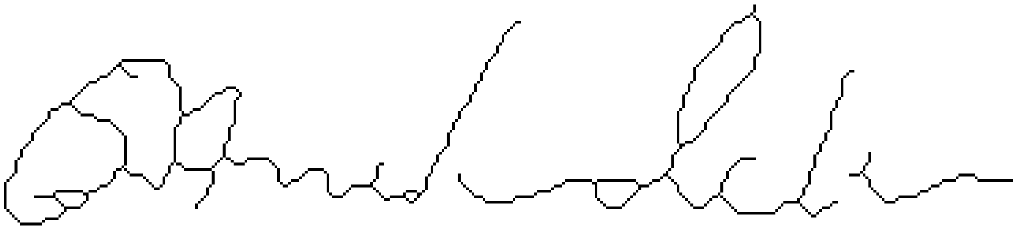
We frequently use erosion while performing the thinning operation. Actually thinning is continuous erosion until the width of the signature is single pixel wide.

The dilation process is applied when the check pattern is generated. The different Bands represent the dilations of the image with different extents.

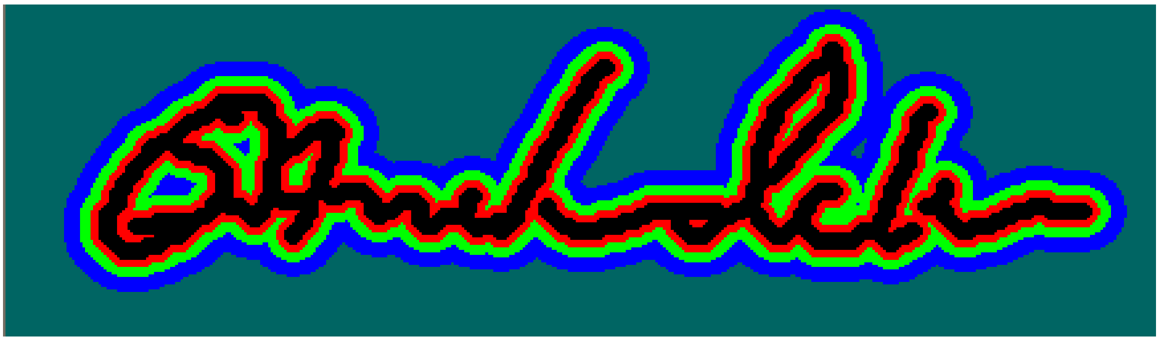
The check pattern generated is shown below



Original scanned signature



Processed Signature



The check pattern generated for the given signature

8.8 ENCRYPTION & IMAGE COMPRESSION:

Encryption is the process in which the image can be encoded in a special format so that authorized access is only permitted. The encryption is generally carried out in the field, where security is much more important. e.g. In Military communication, messages are encrypted, so that no one other than who knows the encryption code format can receive the correct message.

APPROACH:-

In this project, we have implemented encryption due to following reasons:

- Signature i.e. image can be stored in .bmp, .jpg or .gif format which are supported universally.
- As these formats are universal, one can open the signature image in other application & can make suitable modifications, which can corrupt our information and hence should be restricted.

- The image stored in above mentioned universal formats also lacks data compression. For example in bit map the signature takes 111KB, .jpg takes 14KB with data loss and for .gif 4KB with data loss.

All this disadvantages compelled us to make the use of the **.fmt** format which follows the encryption algorithm.

As we are dealing with signature recognition to recognize the signature, program requires standard signatures already stored in database; so that duplicate signatures can be verified with standard signatures to check its validity. To store the standard signatures, we tried to use universally recognized standard picture format such as .bmp, .jpg, .gif

.bmp	->	Bitmap Pictures
.jpg	->	Joint Photographic Experts Group
.gif	->	Graphics Interchange Format

Bitmap picture is well known for its quality, but this option is not much attractive as it requires ample amount of space i.e. generally picture files stored in this format have more size. On the other side, .jpg format stores images with lesser size but degrades the image which makes it less useful as some loose pixels may get lost. .gif is basically, used for internet as smaller size but one can store image of standard 256 colours only.

In our case, standard signatures that are to be stored are in the form of black and white, and hence out of other formats, one can choose .bmp (as quality) or .gif (as size).

So, if we choose any of the above formats it comes with one of these drawbacks. Also, as this software deals with one type of security system, one has to take care of the fact that if we store picture using any of the above format all the standard signatures are readily accessible to any other person & can modify them in any manner as he wants, as there are no. of image editing tools available. e.g. MS-Paint.

To avoid all the above drawbacks we have tried to implement new image format .fmt which is application specific. We know that image i.e. the standard signature to be stored is B&W and no. of black pixels in the image are very less as it is already thinned. Therefore, we encrypt the signature in the fashion so that, we only store black pixels.

STEPS:

1. We store only black pixel information.
2. We store only X co-ordinate of black pixels.
3. Image size is maximum 512 X 512 pixels.

LIMITATIONS:

1. Fixed encryption word length.
2. No special consideration for continuous black pixels.

Decryption:

The encrypted format is not readable to other software. Hence, it provides security, as well as compression in the on disk size required to store the data. The encrypted image should be first decrypted to retrieve the original signature. The algorithm for decryption is the reverse of that of encryption. The decryption algorithm is as follows

STEPS:

1. Locate the file and then open it temporarily in text format
2. Get the height and width
3. Recover the pixel information from the code
4. Put the pixels according to the positions indicated by the code

8.9 EXTREMES FINDING:

The extremes of the signature can be found by scanning the signature image. The signature is scanned from left to right and also from right to left. The point at the minimum of x – co-ordinate is the left extreme and the maximum of x- co-ordinate is the right extreme. This distance between the two extremes gives the signature width.

While scanning from top to bottom and from bottom to top the minimum y-co-ordinate is the top extreme and the maximum

Y -co-ordinate is the bottom extreme of the signature and now the distance between these two extremes is signature height.

Algorithm of finding width and height:

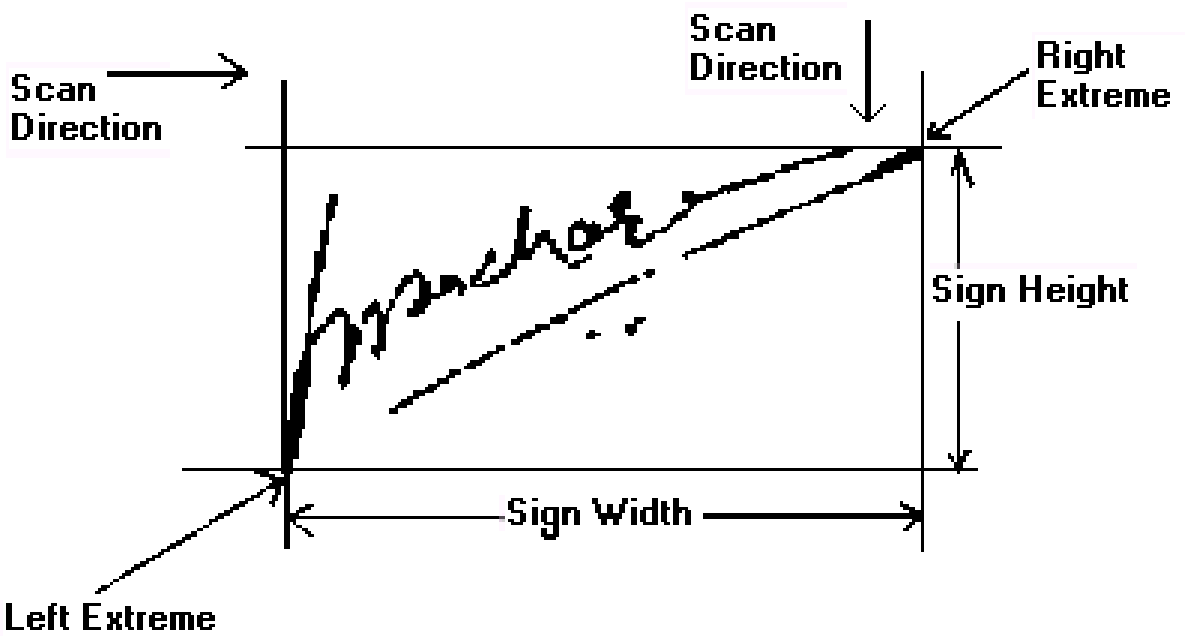
1. Select the relevant part of the signature. Scan the image from left to right as well as from right to left. The point of minimum of the x-co-ordinate and maximum of the X-co-ordinate is noted.

2 .These are the **left and the right extreme** of the signature. The difference between these two extremes gives us the **Sign width**.

3. Scan the image from top to bottom as well as from bottom to top.

4. The point of **minimum of y-co-ordinate and Maximum of y-co-ordinate** is noted.

5. The **difference** between the two gives the **sign height**. This process is used to select the signature from the selected area.



Finding the extremes, Sign height, sign width

8.10 Finding the centroid of an image:

During the process of EX-Oring i.e. checking the signature, it is required that the program must try to overlap the test signature in such a fashion that maximum no. of pixels are marked as correct. Though man can do this difficult thing very easily; to find out the resonating position for the test signature is quite difficult, as trial and error method though can give maximum resonance is very much time consuming. Another method that can be used is by finding the extreme of the signature & overlaps the test signature (duplicate signature) over the standard signature using the extremes.

But as many of the signatures have changing extreme parts this method may result drastically false results in some cases. Hence, we have implemented the centroid method in which the test signature is moved in such fashion that centroids of the both signatures are same.

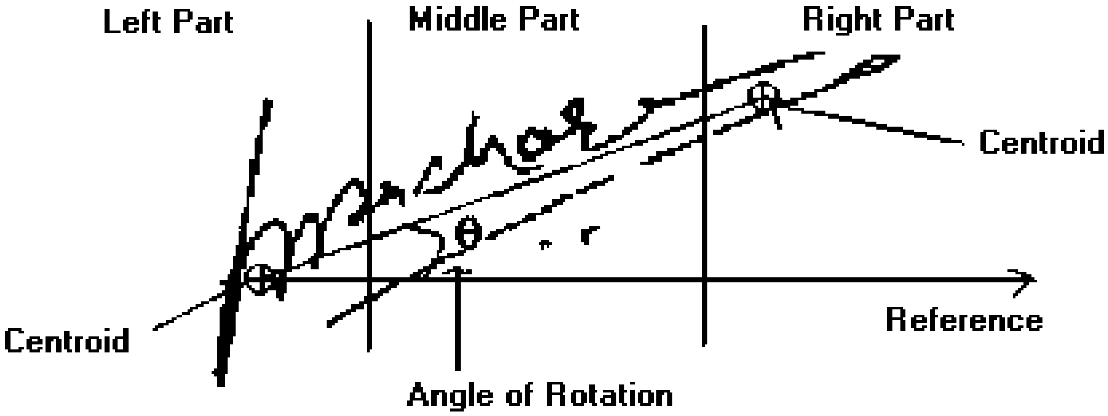
Although, this method is also not ideal, but is more reliable than the other two methods, discussed above. The steps for finding the centroid of an image are as follows:

- Open the image.
- Start scanning the image from right to left in a row wise manner. We are concerned about only black pixels.
- Add all the 'X' co-ordinates as well as count the total no. of pixels.
- The 'X' co-ordinate of the centroid is give by **X= (∑x)/ n** where **'n'** is the total no. of pixels.
- Similarly add all the 'y' co-ordinates, the 'y' co-ordinate for the centroid is given by **Y= (∑y)/ n** where **'n'** is the total no. of pixels.

8.11 Finding the angle of rotation of a signature:

Finding the angle of the signature is also important. Many of the times though the signature is correct, it is not aligned in the angular fashion & hence it become necessary to rotate the test signature so that it will be aligned to the standard signature in the database.

While finding the angle of rotation the signature is segmented in three parts, **left extreme, middle part, right extreme**. The centroids of the left & right extremes are calculated & depending on those centroids the angle of rotation of the test signature is calculated. The test signature is then rotated according to the difference angle between standard signature & test signature, calculated using the method discussed above. **The figure is as follows.**

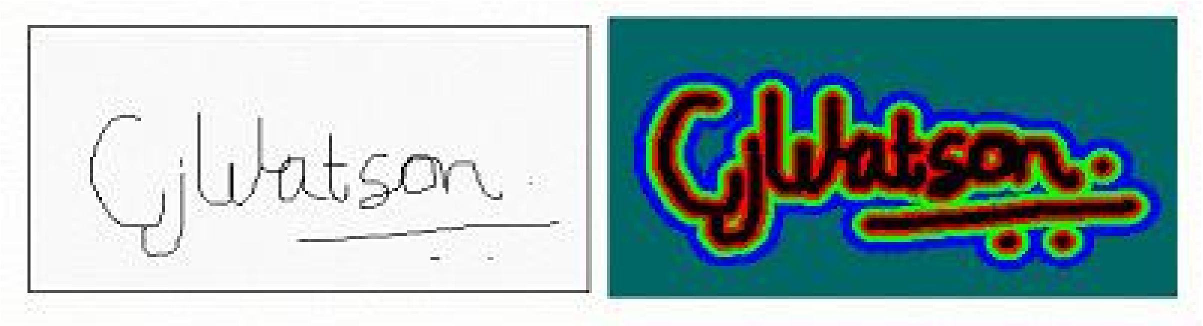


Finding the angle of rotation

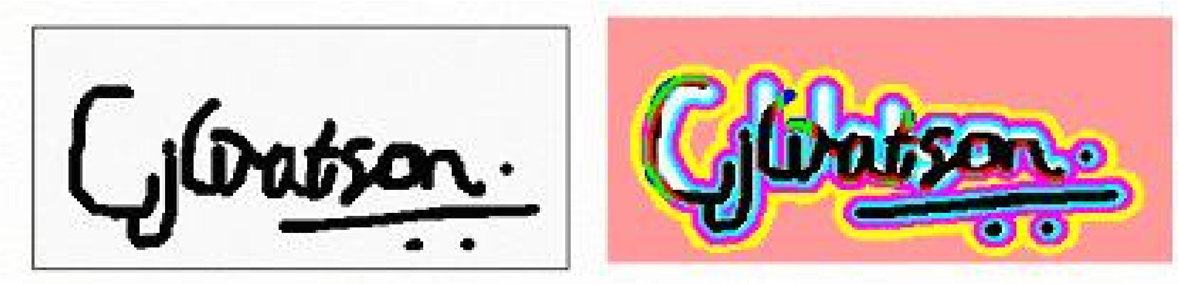
8.12 Overlapping and finding the Percentage Matching:

The important step in the recognition process is the overlapping of the two signatures. The standard signature is opened in a picture box and the check pattern is generated for that image. Then the test signature is processed and the angle of rotations are found. If there is remarkable change in the angle of rotation, the test signature is rotated through the difference angle.

Then the two images are overlapped to generate the final check pattern. The final check pattern is then analyzed as discussed above to find the percentage matching. The process is illustrated in the following figures.



Standard signature and its corresponding check pattern



Test signature and the result of overlapping on the check Pattern

8.13 PREFERENCES & PERFORMANCE OF THE SOFTWARE:

8.13.1 How preferences affect the performance:

The program generates the check pattern, takes the decisions about the validity of the signature depending the values set In the preferences. The values can be edited by observing the program performance and depending on the application.

In the preferences we have different values for the radii for generating the check pattern, the threshold value for the Intensity Normalization operation, the decision Thresholds, the threshold for maximum pixel change, the threshold for maximum rotation angle.

Change in any of the above values changes the decision criteria of the program.

8.13.2 Setting preferences:

Whenever a new account is being prepared, while storing the signatures in the database and creating the database parameters the program asks the user to select the tolerance option. Three tolerance options are provided by the program, they are

1. **Global preference level**
2. **Exclusively set preference level**
3. **Autocorrelation preference level.**

These aspects are discussed below.

8.13.2.1 Global preference level:

This preference level includes the standards that are decided by the programmer. These values are found out by experimenting and considering different cases. These values are as follows

Black band Radius: 16

Red band Radius: 10

Green band Radius: 6

Blue band Radius: 3

Intensity threshold value: 200

Maximum pixel change in percentage: 30

Maximum permissible angle for rotation: 8 Degrees.

Decision Thresholds:

Perfect Grade: 95 %

Better Grade: 90 %

Good Grade: 82%

Acceptable Grade: 74 %

Okay Grade: 64 %

8.13.2.2 Exclusively Set Preferences:

These preferences are set manually by the authorized person. This is because the supervisor may want to give a special importance to a certain customer account. This threshold has to be set exclusively. The decision thresholds can be set for hard decision or normal decision level. Setting of these preferences drastically affects the performance of the program as well as the decision power.

Unless and until one has proper Knowledge about these preferences, one should not try to mess with these values.

8.13.2.3 Autocorrelation preference Level:

Another option for setting the preferences is the autocorrelation preference level. The three standard signatures from the customer are taken as input by the autocorrelation routine. This routine correlates the three signatures with each other and finds out the maximum and minimum matching between the three signatures and decides how much variation is there in the three signature samples.

Depending on these the decision thresholds are set by the program automatically. In case of normal accounts one can set the account to the autocorrelation level. This aspect considers the mutual variation in the three standard signatures, and keeping this variation in mind it decides the signature under test is valid or not. This is a sort of artificial intelligence. The other values are same as the global preference values.

Black band Radius: 16

Red band Radius: 10

Green band Radius: 6

Blue band Radius: 3

Intensity threshold value: 200

Maximum pixel change in percentage: 30

Maximum permissible angle for rotation: 8 Degrees.

The program finds the percentage matching for a specific signature by calculating the number of pixels lying in the deviation bands in the check pattern. Each band in the check pattern represents a deviation percentage. For example the black band indicates the perfect pixels. The red, Green and blue band indicate 10, 20, 30 percent deviation respectively. The pixels lying in the background colour are having deviation greater than 30 percent.

For each pixel having a specific colour, in the check pattern after overlapping the signature, certain marks are assigned, and depending on these marks the percentage matching is found out.

The marking scheme is as follows:

• **Black pixels**	**10**	(0 -10% Deviation)
• **Red pixels**	**08**	(10 -20% Deviation)
• **Green pixels**	**06**	(20 -30% Deviation)
• **Blue pixels**	**02**	(30 -40% Deviation)
• **Background pixels**	**-15**	(40-100%Deviation)
• **Missing or Extra pixels**	**-18**	(Surplus or extra)

These values are calculated from the experimental results and they do not have any firm mathematical base, but they indicate the deviation percentage.

8.14 STEPS IN THE RECOGNITION PROCESS:

- **Firstly the signature to be recognized is opened (imported).**
- **The operations such as normalization, thinning, scaling are performed.**
- **The standard signature in the database is opened.**
- **The angle of rotation of the test signature is calculated.**
- **If required, the test signature is rotated by the difference angle, to compensate the angle change.**
- **The centroids for both the images are found.**
- **The check pattern is generated for the standard image.**
- **According to the centroids the test image is moved and then put on the check pattern.**
- **The Exclusive-Or operation is performed.**
- **The resultant pattern is analyzed and the matching percentage is calculated.**
- **According to the decision thresholds the decision is given about the validity of the signature.**

8.15 SUPPORTED DATABASE OPERATIONS:

8.15.1 Creating New Account:

This software can be used in E-Commerce application, Banking Applications. The new customer account can be created, for this we take three standard signatures of the customer, Name, Address, Date of Birth, Telephone number & A/c Number as input to store in the database.

These three signatures are treated as standard signatures & the signature to be recognized is compared with these signatures.

8.15.2 Finding a Specific Account:

To find a specific account two options are provided

- Find by Name of the customer.
- Find by the Account Number of the customer.

The Search result displays the Account Information.

8.15.3 Modifying an Account:

The customer account's Database Record may be needed to be updated in some circumstances. There are two Aspects related to this

- **General Aspect**: The operator can change the Name, Address, Date of Birth & Telephone number.
- **Security Aspect:** In Some cases the standard signatures stored in the database required to be changed, this modification can be only done by the supervisor. The new signatures should be scanned and then given as input to the modifying routine.

8.15.4 Viewing Database status:

The software gives database status and the status of a specific Account whenever referred.

The status of an Account contains Information about the Customer Record, The Signature Parameters Such as Pixel count, Rotation angle, Decision Limits.

The database Status contains information about total number of customers, their preference levels etc.

8.15.5 Deleting an Account:

In case of expiration of an Account, the account can be deleted. The record corresponding to this Account is cleared from the database.

8.15.6 Security Aspect:

As security is of much concern in case of Banking and E-commerce we have tried to make the software operation more and more secured. At the same time the flexibility is also maintained.

The Standard Signatures can only be modified by the Person having Proper Authority & Password as mentioned. The Preferences are accessible only to the supervisor.

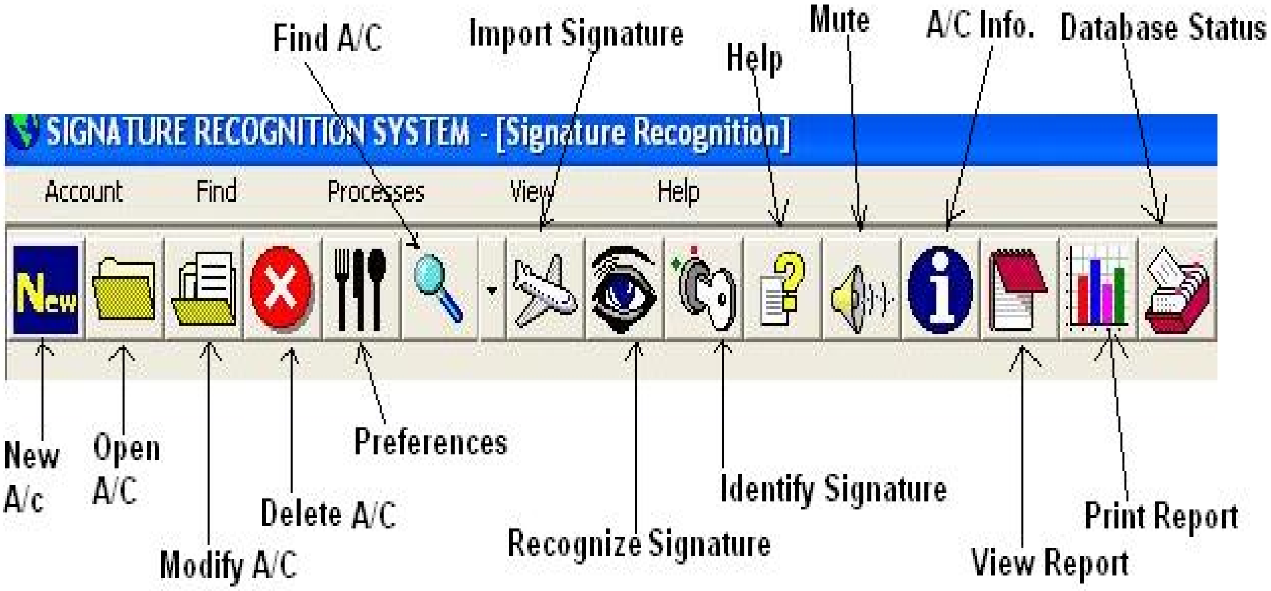
The signatures are stored in the encrypted format; No one can make desirable changes in the signatures.

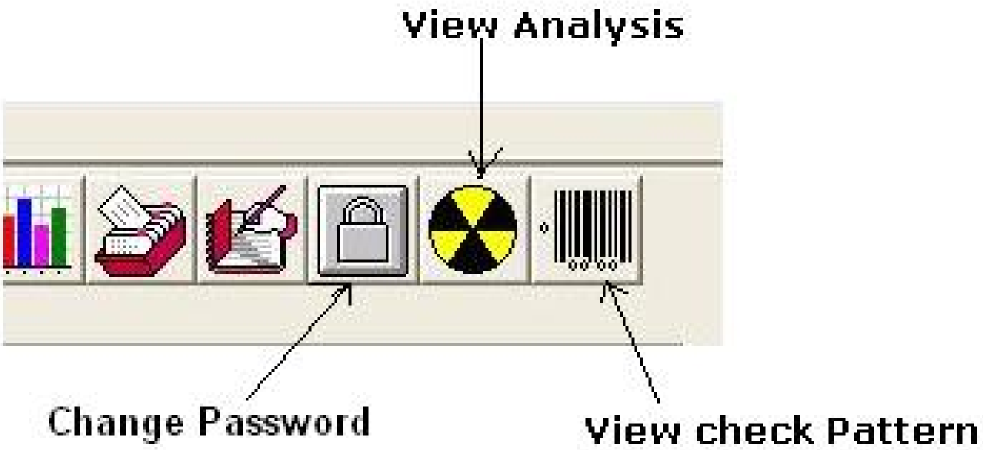
8.15.7Generating the HTML report:

The report of matching is given in the HTML format. This Format can be saved anywhere by the user. The printing of this report is directly supported. This report gives the summary of the recognition operation. One can know why a specific signature has been accepted or rejected. The summary is presented in a Graphical format. **The result can be directly exported to Microsoft Excel to keep the record in the database.**

8.16 GENERAL EXPLANATION OF THE TOOLBAR:

The toolbar has various buttons. The functions of various buttons are explained as below; the following figures are self explanatory**:**





New: To open new account in the database use this button.

Open: To open accounts for processing use this button.

Modify: To modify the information regarding an account.

Delete: Deletes an account from the database.

Preferences: To apply decision thresholds.

Find: To find a specific account in the database.

Import: To import a signature for processing.

Recognize: To recognize a given signature.

Identify signature: To find a match of a signature from the database.

Help: To get a Help, Regarding to the software.

Mute: To mute the help agent.

A/C info: To view the information about any account currently opened.

View Report: To view the report of the recognition process.

Print report: Prints the report.

Database Status: To acquire information about the database status.

Change Password: To change a supervisor Name or password.

View Analysis: To view the mathematical analysis of the recognition Process.

View Check Pattern: To view the check Pattern generated.

8.17 Help and Support:

The help is also provided in the html format. In case of any confusion the user can refer help. **The help supports the Find option to find information regarding to a specific topic.**

Also the software **Implements a Speaking Agent which informs the user about the errors and restrictions**, this speaking agent is implemented by using the Microsoft Speak engine.

8.18 About the Programming Language:

We have used MICROSOFT™ VISUAL BASIC® 6.0 for the programming. Visual Basic is not just a language. It's an Integrated Development Environment in which one can develop, run, test, and debug his applications.

Microsoft based Visual Basic on a *programming language* written for beginners called ***BASIC***. BASIC has been around for more than 35 years in one form or another. BASIC stands for *Beginners All-purpose Symbolic Instruction Code*.

As the ancestors of Visual Basic were interpreted languages, they give good learning platforms because of their quick feedback. A compiled language requires extra steps, called compilation and linking before the programmer can run the program. To make the programming interface easier and also make the code faster as that of code by compiled languages, Visual Basic creates P-CODE which is at most optimized. After the Visual Basic 5.0 Microsoft realized that P-CODE cannot be optimized too much and hence Visual Basic 6.0 comes with native code compilation option.

As the language comes from the creator of operating system itself it gives sufficient interface with the hidden API's in the operating system, so that the program can be optimized for better performance. As Visual Basic comes with ACTIVEX^{TM} and Visual Basic for Application (VBA) one can use the different internal functions of Third Party Applications and utilities, and also can automate some softwares supporting VBA. (e.g. Microsoft WORD® , COREL DRAW 10.0 etc.).

Though the programming Environment is good, the code is not as fast as that of windows programming languages e.g. Microsoft Visual C+ +.

We are using a certain Method inherent to Visual Basic that plots the pixel, takes considerably more time than general windows method and declared as BUG in Visual Basic 6.0 (REFERENCE: MSDN Library OCT 1999). As we are going to use this Method SEVERAL TIMES it is just possible that the program may run quite slower.

However, it gives readymade basic Windows components, which can be configured in a simpler way. And advanced Professional Programmer can achieve much optimized level of the code using WIN32 API's etc.

We have used WIN32 API for optimized performance.

The Hardware Requirements for Proper Working Are:

- Pentium II Processor 133MHZ, 32MB RAM

- 500MB Of Free disk space
- Multimedia support
- Scanner With DPI At least 100
- Operating System Windows 98

For Optimum Performance We Recommend:

SYSTEM

- Pentium 4 1.4 GHZ, 256 MB RD RAM, 40 GB HDD, Scanner 1200 DPI.
- Pentium III, 1GHZ,256MB SDRAM,40 GB HDD
- **Operating System : Windows 98, Windows ME, Windows XP, Windows NT**

The performance of the program Increases if you use a faster Processor and Scanner with Higher DPI.

Note: We have tested this Software on following operating systems:

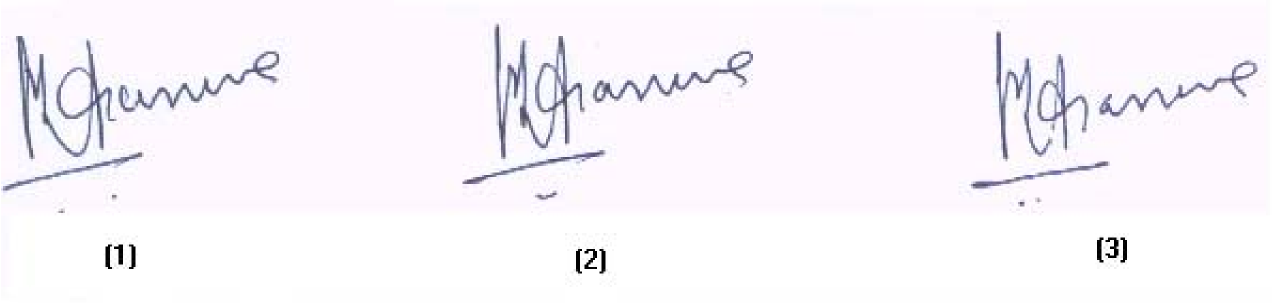
- **Windows 98**
- **Windows ME**
- **Windows XP**

We recommend you that you should use one of the above listed Operating Systems.

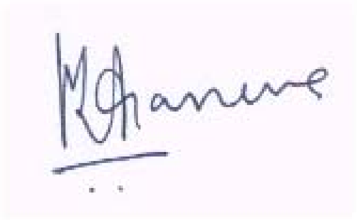
9. RESULTS:

Consider an account in the database which has three Standard signatures in the database & we check a signature imported from a document; these signatures are as shown below.

The following signatures has the representation same as they have in the real world, but in the database of the computer these signatures are stored after they are processed. These signatures are first colour normalized, scaled, smoothened & then thinned. One more operation which has security aspect is also performed that is Encryption. These processed & Encrypted signatures are stored in the database.

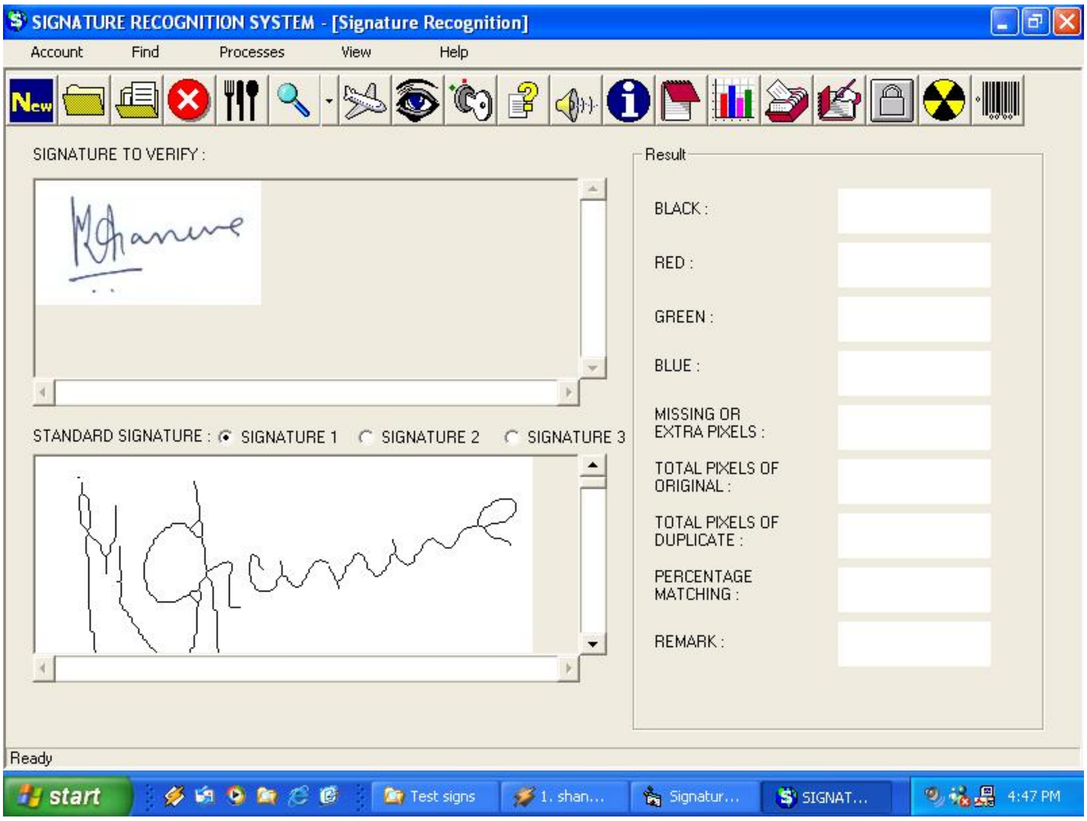


Standard Signatures in the Database



Signature to be checked

The front panel looks like as shown below when you open an account and its corresponding test signature. This figure represents just one part of the front panel.



SIGNATURE TO VERIFY :

STANDARD SIGNATURE : ● SIGNATURE 1 ○ SIGNATURE 2 ○ SIGNATURE 3

Result

BLACK :

RED :

GREEN :

BLUE :

MISSING OR EXTRA PIXELS :

TOTAL PIXELS OF ORIGINAL :

TOTAL PIXELS OF DUPLICATE :

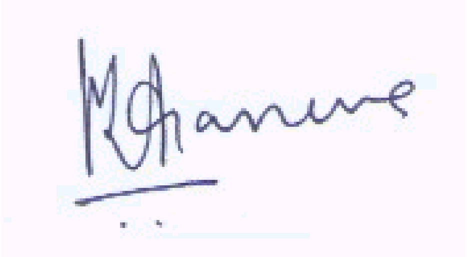
PERCENTAGE MATCHING :

REMARK :

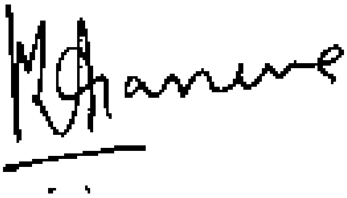
Ready

Now we step by step consider the different operations that are performed on the imported signature

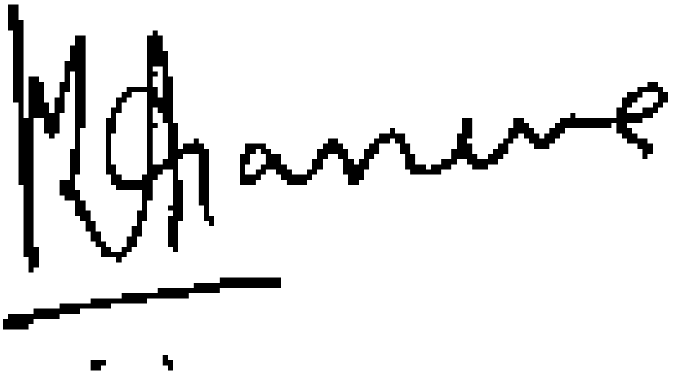
1. The signature which is under test is shown below



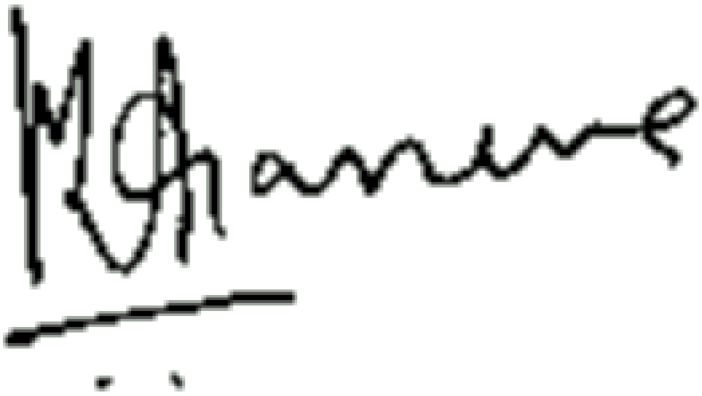
2. This signature is Colour normalized, scaled, smoothened & then thinned. These operations are illustrated in following figures.



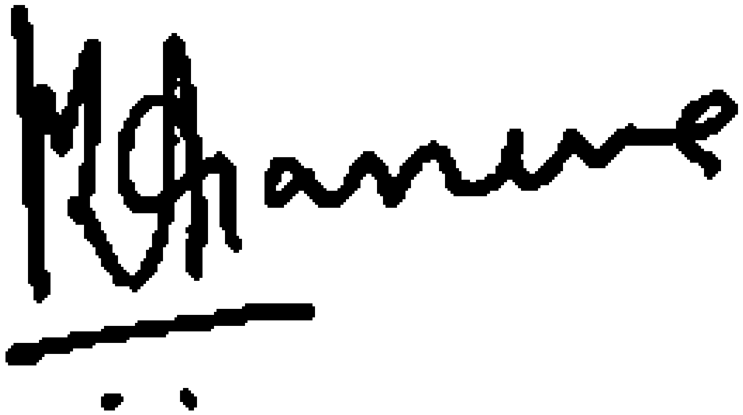
3. The colour normalized signature is then scaled by the required amount as follows.



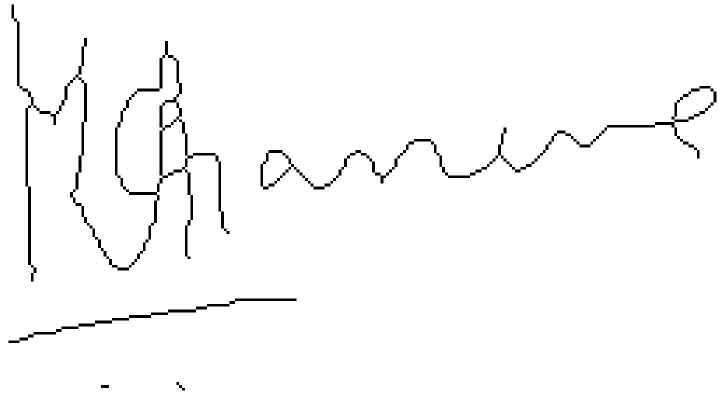
4. The scaled signature is then smoothened by applying the smoothening filter, this operation is illustrated below



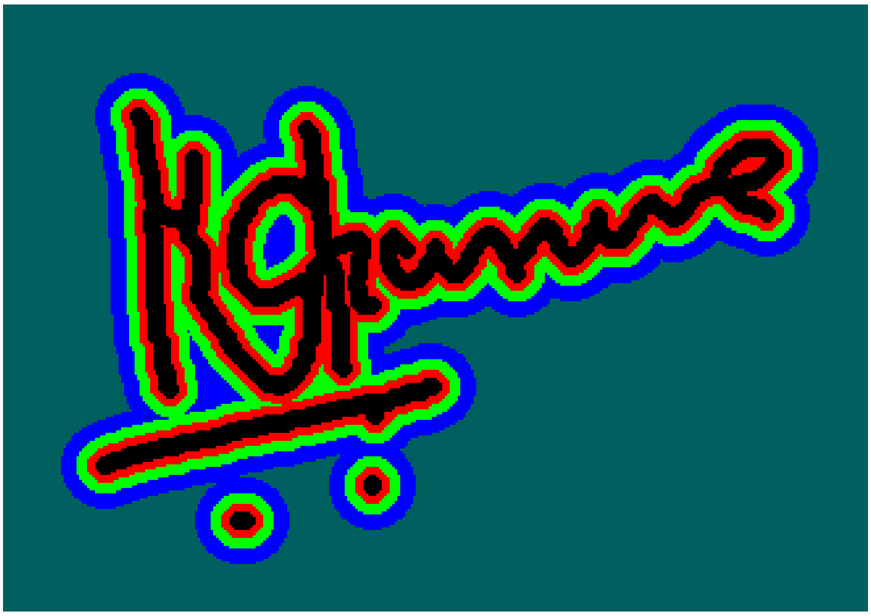
5. After this, colour normalization is again performed as follows so as to minimize the loss.



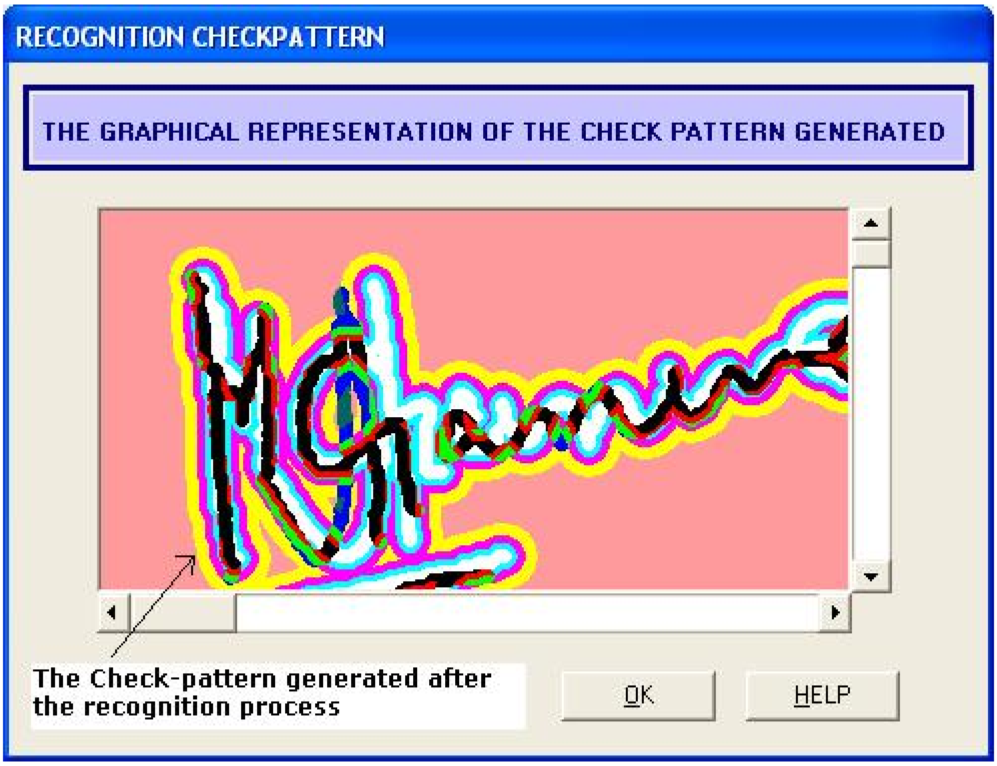
6. This colour normalized image is thinned as follows.



7. Then the check-pattern is generated from first standard signature



8. The check-pattern is generated internally by the program after putting test signature on the standard signature as described above looks like following image.

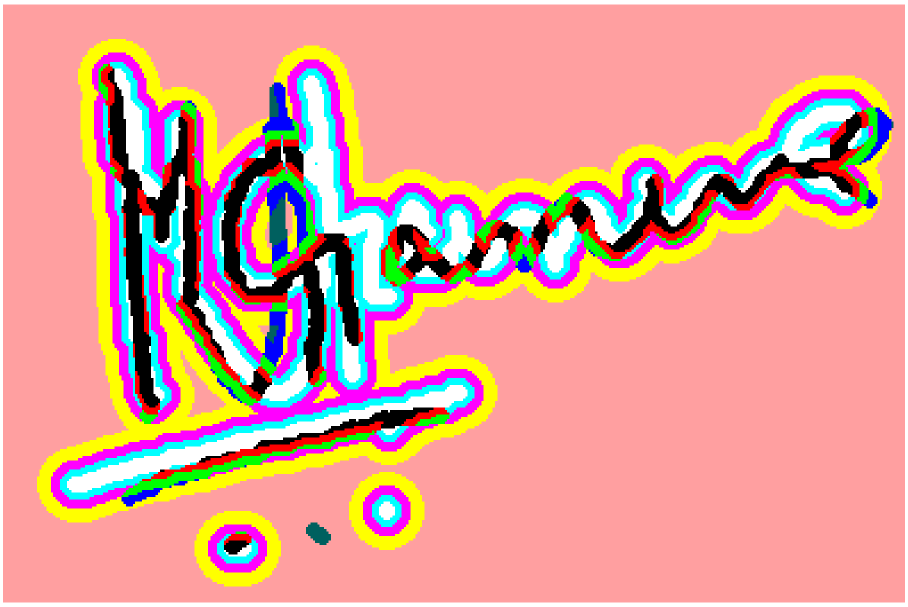


RECOGNITION CHECKPATTERN

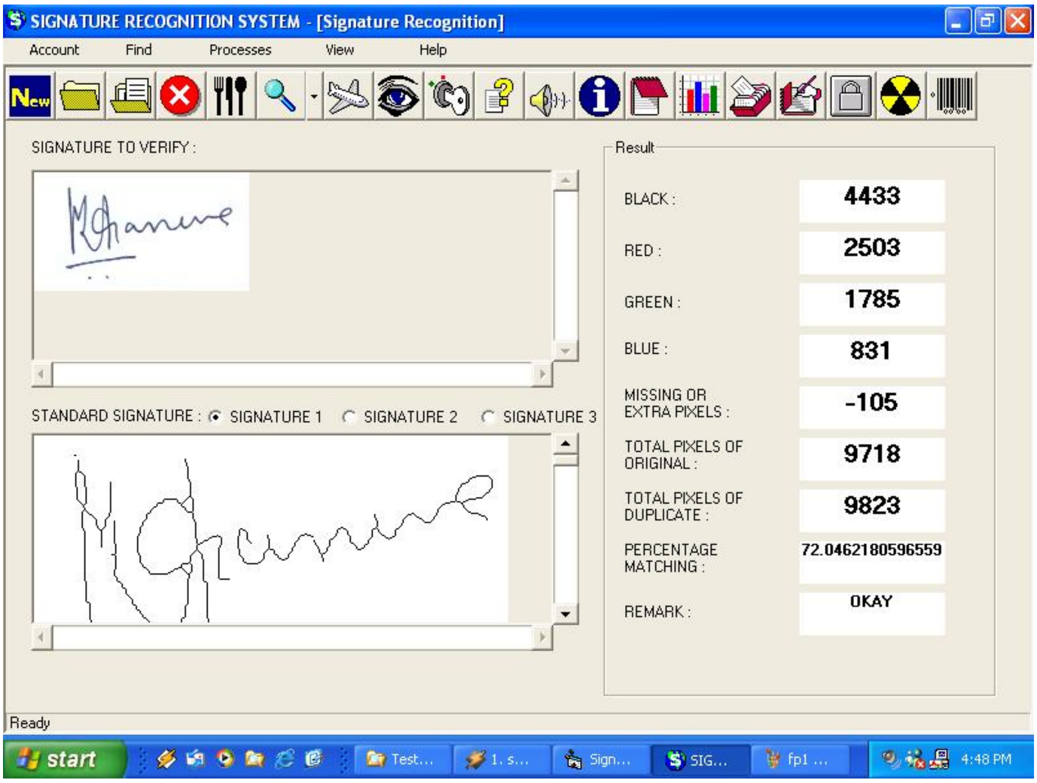
THE GRAPHICAL REPRESENTATION OF THE CHECK PATTERN GENERATED

The Check-pattern generated after the recognition process

As it is clipped in the previous image it is illustrated fully as shown below:



9. The result of the recognition process is displayed on the panel as follows.



SIGNATURE RECOGNITION SYSTEM - [Signature Recognition]

SIGNATURE TO VERIFY :

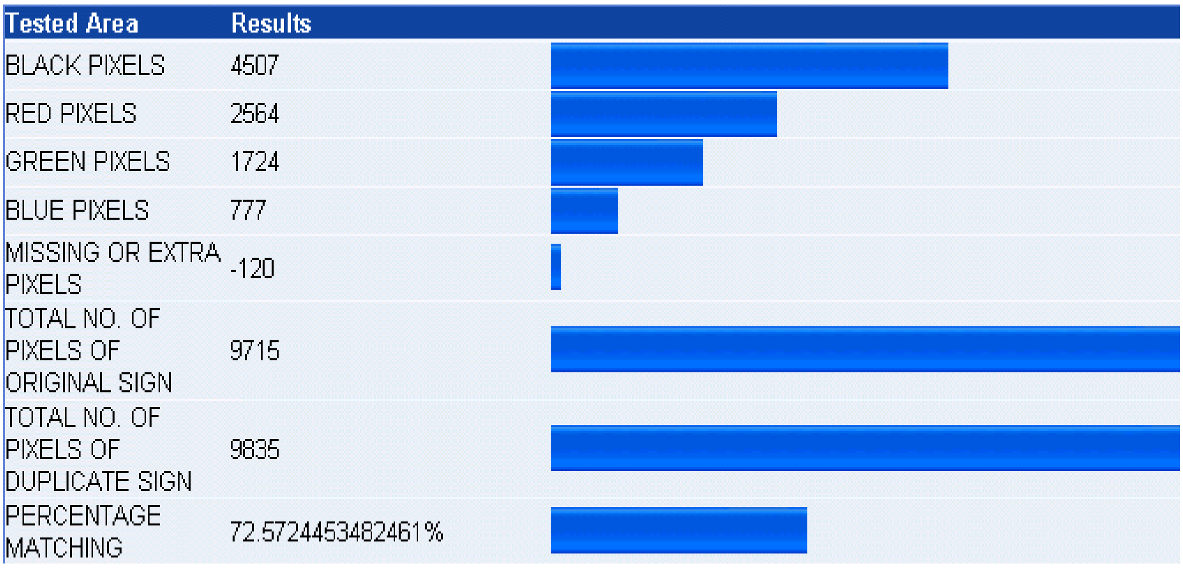
STANDARD SIGNATURE : ● SIGNATURE 1 ○ SIGNATURE 2 ○ SIGNATURE 3

Result

BLACK :	4433
RED :	2503
GREEN :	1785
BLUE :	831
MISSING OR EXTRA PIXELS :	-105
TOTAL PIXELS OF ORIGINAL :	9718
TOTAL PIXELS OF DUPLICATE :	9823
PERCENTAGE MATCHING :	72.0462180596559
REMARK :	OKAY

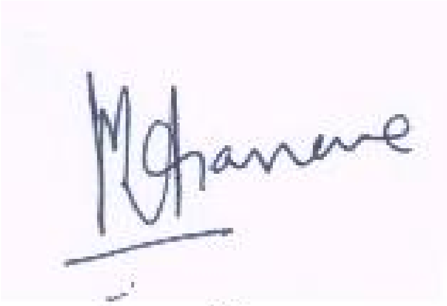
Ready

10. The report in the html format has following appearance.

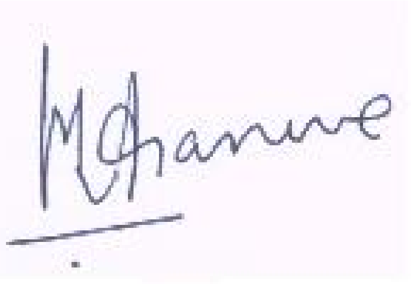


Tested Area	Results
BLACK PIXELS	4507
RED PIXELS	2564
GREEN PIXELS	1724
BLUE PIXELS	777
MISSING OR EXTRA PIXELS	-120
TOTAL NO. OF PIXELS OF ORIGINAL SIGN	9715
TOTAL NO. OF PIXELS OF DUPLICATE SIGN	9835
PERCENTAGE MATCHING	72.5724453482461%

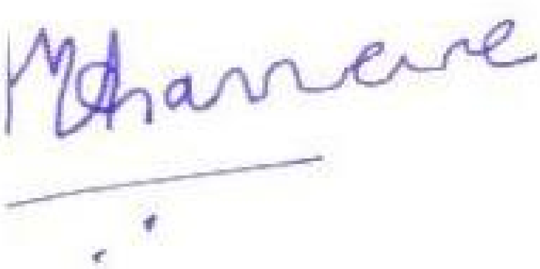
11. On the same lines we have following four test signatures, the result of recognition process is listed in the table below. The test reports follow on next page.



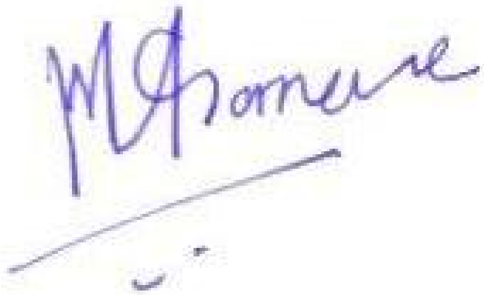
[1]



[2]

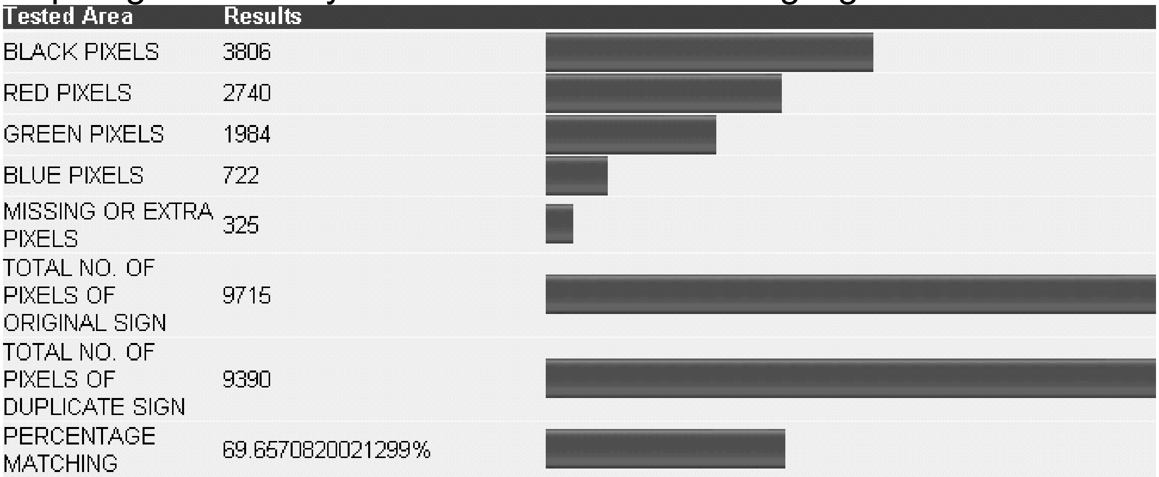


[3]



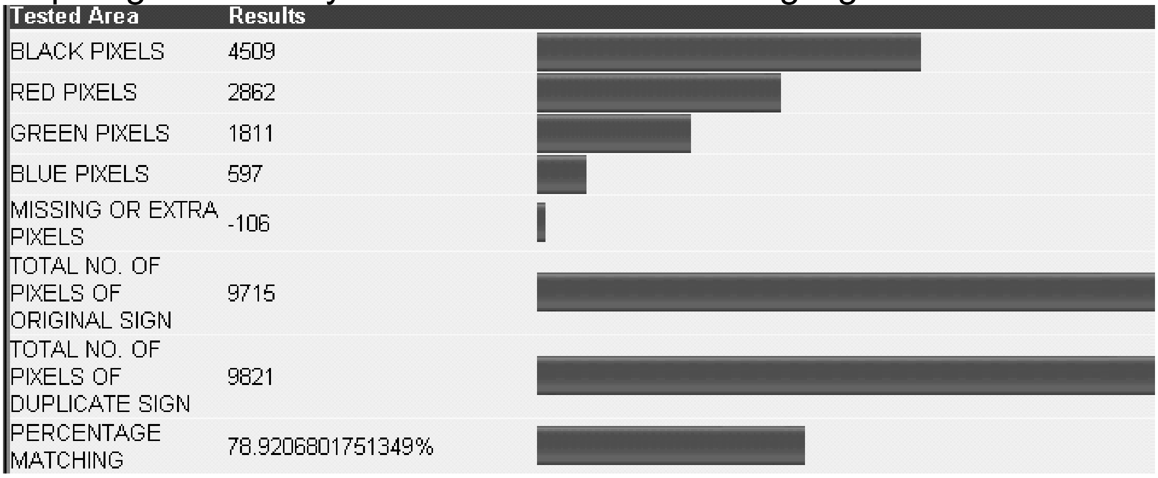
[4]

Report generated by the software after checking sign 1



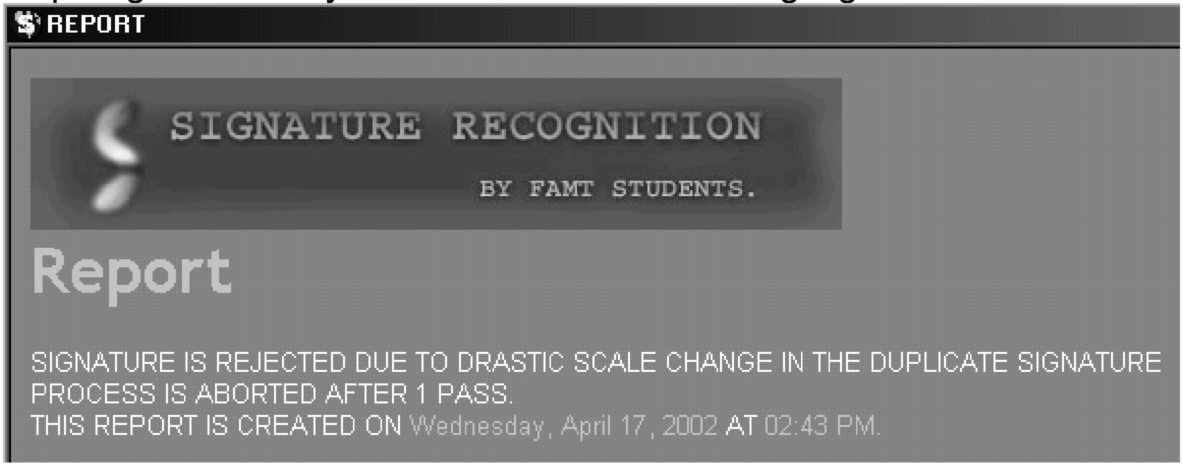
Tested Area	Results
BLACK PIXELS	3806
RED PIXELS	2740
GREEN PIXELS	1984
BLUE PIXELS	722
MISSING OR EXTRA PIXELS	325
TOTAL NO. OF PIXELS OF ORIGINAL SIGN	9715
TOTAL NO. OF PIXELS OF DUPLICATE SIGN	9390
PERCENTAGE MATCHING	69.6570820021299%

Report generated by the software after checking sign 2



Tested Area	Results
BLACK PIXELS	4509
RED PIXELS	2862
GREEN PIXELS	1811
BLUE PIXELS	597
MISSING OR EXTRA PIXELS	-106
TOTAL NO. OF PIXELS OF ORIGINAL SIGN	9715
TOTAL NO. OF PIXELS OF DUPLICATE SIGN	9821
PERCENTAGE MATCHING	78.9206801751349%

Report generated by the software after checking sign 3

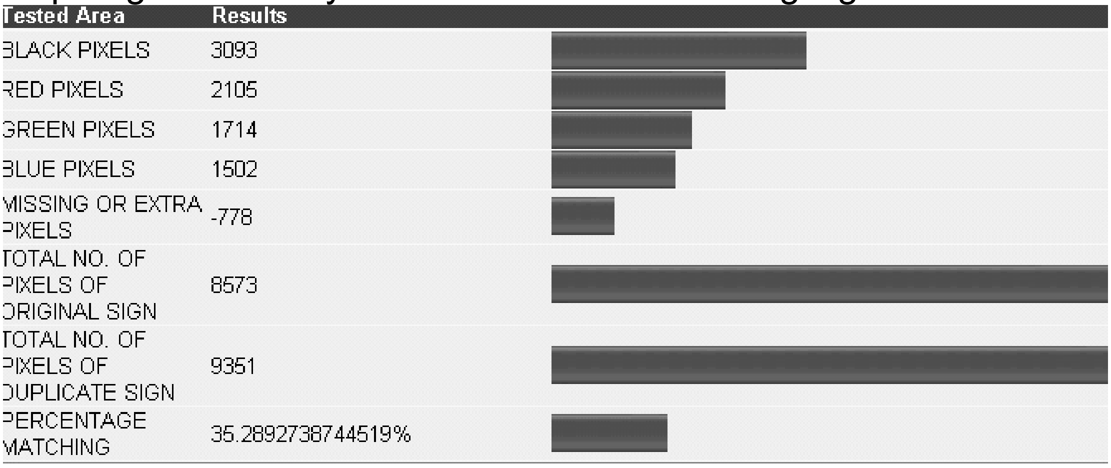


Report

SIGNATURE IS REJECTED DUE TO DRASTIC SCALE CHANGE IN THE DUPLICATE SIGNATURE
PROCESS IS ABORTED AFTER 1 PASS.
THIS REPORT IS CREATED ON Wednesday, April 17, 2002 AT 02:43 PM.

The last report follow on the next page.

Report generated by the software after checking sign 4



Tested Area	Results
BLACK PIXELS	3093
RED PIXELS	2105
GREEN PIXELS	1714
BLUE PIXELS	1502
MISSING OR EXTRA PIXELS	-778
TOTAL NO. OF PIXELS OF ORIGINAL SIGN	8573
TOTAL NO. OF PIXELS OF DUPLICATE SIGN	9351
PERCENTAGE MATCHING	35.2892738744519%

The following table summarizes the above operations & the results.

	SIGN 1	SIGN 2	SIGN 3	SIGN 4
BLACK	3806	4509	__	3093
RED	2740	2862	__	2105
GREEN	1984	1811	__	1714
BLUE	722	597	__	1502
MISSING OR EXTRA	325	-106	__	-778
PIXELS (ORIGINAL)	9715	9715	__	8573
PIXELS (DUPLICATE)	9390	9821	__	9351
MATCHING (%)	69.66	78.92	__	35.28
REMARKS	Acceptable	Okay	Rejected	Rejected

Remark For Signature No.3:

SIGNATURE IS REJECTED DUE TO DRASTIC SCALE CHANGE IN THE DUPLICATE SIGNATURE AFTER 1 PASS.

Remark for signature No. 4:

THIS RESULT IS COMPLETED AFTER 3 PASSES.
THIS REPORT IS THE RESULT OF DUPLICATE SIGNATURE COMPARING WITH SIGNATURE NO. 3.

10. CONCLUSION:

We have tested the software on various operating systems & we find that it works very well & satisfactory. While implementing the recognition process, we have used quite simpler way. At this stage we are getting accuracy up to about 70% to 80%. These conclusions are made on the basis of testing of 30 person’s database. This software is not fully commercial grade software but it is at a stage that it can be developed to commercial grade software. After checking several signatures, we found that the irrelevant signatures are surely rejected by the software but it is possible that the signature that one thinks to be passed will be rejected. We have implemented tight preferences for this.

11. ACHIEVEMENTS & FUTURE SCOPE:

We have been working over this project for at least last one year. The completion of this project is not a big achievement but we are proud of what we have done.

The main things that we will like to highlight are:

- Accuracy of this software is up to 80%
- The software is user friendly.
- Software comes with a speaking agent & online help.
- We have tested signatures of 30 persons, 6 signatures of each person was taken to build the database.
- For the sake of security we have implemented a special Encryption algorithm.
- Image Compression is also achieved up to a minimum level of 90% as compared to Bitmap format. Without loss of any kind of pictorial information.
- The setup of this software is compact, has a size of 20Mb only.
- The software has coding of 12000 (Twelve thousands) lines.
- Windows API's has been used in this software to optimize the software.
- We have provided setups compatible with operating systems like Windows 98, Windows ME, and Windows XP.
- A commercial grade system can be developed by using more sophisticated ways like Neuro-Fuzzy approach.

Future scope

1. It is possible to improve the recognition capability of the software by using neuro-fuzzy approach etc.
2. To improve the execution speed, some functions of the software which are graphics related can be implemented using DirectX API.

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Index

List of Figures