BIOMETRIC TECHNOLOGIES AND DEVELOPMENT OF TOUCH-LESS FINGERPRINT RECOGNITION SYSTEM

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DEPARTMENT OF COMPUTER SCIENCE ENGINEERING & INFORMATION TECHNOLOGY

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

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(i)

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CERTIFICATE

This is to certify that the work titled “**BIOMETRIC TECHNOLOGIES AND DEVELOPMENT OF TOUCHLESS FINGERPRINT RECOGNITION SYSTEM”** submitted by **SAKSHI BAWA** in partial fulfillment for the award of degree of B.Tech Computer Science Engineering of Jaypee University of Information Technology, Waknaghat has been carried out under my supervision. This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma.

(Signature of Supervisor)

Name of Supervisor: Prof. Dr. S. P. Ghrera

Designation: Professor, Brig (Retd.) and Head, Dept. of CSE and ICT

Date:

ACKNOWLEDGEMENT

I take this opportunity to express my profound gratitude and deep regards to Prof. S.P.Ghrera, my Project Guide, for guiding and correcting me at every step of my work with attention and care. He has taken pain to go through the project and make necessary correction as and when needed. Thanks and appreciation to the helpful people at college for their support. I would also thank my university and my faculty members without whom this project would have been a distant reality. I also extend my heartfelt thanks to my family and friends for their undaunted support and faith in me.

Signature of the Student……………………………….

Name of the Student – Sakshi Bawa

Date -

SUMMARY

Objective

To develop a reliable touch-less fingerprint recognition application based on biometric technologies in order to overcome the limitations of touch based fingerprint technology for better security purposes.

Description

Capturing a 3D image of the finger, recognizing the ridge-valley pattern of the finger and then performing different algorithms in order to extract the basic features like minutiae. In the end then matching the image with the images in the array. This complete process after capturing an image using a digital camera will take place in three phases, namely, Pre-Processing phase, Feature-Extraction Phase and Matching phase.

Why I chose this topic?

Rapid growth in computer vision and image processing applications has been evident in recent years. One area of interest in vision and image processing is biometrics. Fingerprint recognition identifies people by using the impressions made by the minute ridge formations or patterns found on the fingertips. Finger printing takes an image of a person's fingertips and records its characteristics - whorls, arches, and loops are recorded along with patterns of ridges, furrows, and minutiae. Information is processed as an image and further encoded as a computer algorithm.

It is one of the most developed biometrics, with more history, research, and design. Since the information in the database is encoded with a mathematical algorithm, recreation of a fingerprint is extremely difficult on even a limited scale with most modern systems.

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Chapter1 : INTRODUCTION

Chapter 1: INTRODUCTION

1.1 General

Touch-less Fingerprint Recognition

Fingerprint recognition or fingerprint authentication refers to the automated method of verifying a match between two human fingerprints. Fingerprints are one of many forms of biometrics used to identify individuals and verify their identity. A touch-less fingerprint technology is a remote sensing technology to capture the ridge-valley pattern which provides essential information for recognition. Since there is no contact between finger and any rigid surface, the skin does not deform during capture. Digital camera is used to present the recognition system.

Current Applications for Fingerprint Recognition

Fingerprint based biometrics has primarily been used to secure entry devices for building door locks and computer network access. A small number of banks use fingerprint readers for authorization at ATMs. Grocery stores are experimenting with a fingerprint scan checkout that automatically recognizes and bills a registered user's credit card or debit account. More recent applications of finger recognition include use of fingerprints for voter registration.

Advantages of using Touch-less Finger Recognition

- Fairly small storage space is required for the biometric template, reducing the size of the database required.
- It is one of the most developed biometrics, with more history, research, and design.
- Each and every fingerprint including all the fingers are unique, even identical twins have different fingerprints.

- Sound potential for forensic use as most of the countries have existing fingerprint databases.
- Relatively inexpensive and offers high levels of accuracy.
- Capturing of 3D object on a 2D flat surface creates distortion in the captured image.
- Image quality changes according to the skin conditions (dry or wet).
- Minuatiae information changes according to the pressure applied by the individual.
- It cannot discriminate between silicone fake fingerprints.

Use of touch-less fingerprint recognition system in Airline Industry:

There are a number of steps that can be taken immediately to improve our capacity to properly identify people who are arriving at the airport. Most of the airports use optical card and finger image readers. In this, the finger image of the card bearer can be extracted from the card by an optical card reader, and compared to the "live" image of the person applying for boarding the airplane by using a low-cost finger image reader. With touch-based fingerprint technology, input images from the same finger can be quite different and there are latent fingerprint issues that can lead to forgery and hygienic problems. Touch-less fingerprint technology provides a near perfect solution to the problems in terms of hygienic, maintenance and latent fingerprints.

ADVANTAGES OF TOUCH-LESS FINGERPRINT TECHNOLOGY

No discrimination: No sex, race, age related enrolment issues.

No Latent Fingerprints: The touch-less recognition process leaves a fingerprint behind. It is therefore impossible for the sensor to make errors due to latent fingerprints.

No restriction on number of users: there are no restrictions on the number of users as the technology is touch-less.

Identification accuracy: The ridges on the fingers are always reproduced in consistently high quality, independent of the finger's appearance, pressure applied or ambient conditions. There are no problems of false minutiae or bad contact.

Large Clear Image: The image capturing area is not limited to a small contact surface but, to a certain extent, wraps around the finger. The touch-less technology allows for clear, precise pictures that are not influenced by movements on a contact surface.

Robust and Reliable: Dirt or dust on the protective glass has virtually no influence on the quality of the image and the function of the sensor.

Maintenance free and durable: The complete sensor optic is protected behind a glass screen and never is touched when in use. Therefore it cannot be worn, damaged or affected by environmental factors, nor can the sensor be influenced by any substances or chemicals attached to the finger.

User comfort: The assembly is extremely easy to use. Touch-free fingerprint identification allows the highest standard of hygiene, which further increases the system's user acceptance.

1.2 Problem Statement

What will be done in the project?

I have investigated all the biometric technologies and have studied them one by one and I found that the most appropriate of all to work with is fingerprint recognition system which is reliable, cheaper and accurate than other biometric technologies. Among fingerprint recognition I am going to work on touch-less fingerprint recognition system because it helps in capturing of an accurate image of the 3D object i.e. finger and accounts for other advantages over touch based fingerprint recognition system..

Chapter2 : LITERATURE REVIEW

Background

Biometric technologies are becoming the foundation of an extensive array of highly secure identification and personal verification solution. As the level of security breaches and transaction fraud increases, the need for highly secure identification and personal verification technologies is becoming apparent.

Advances in automatic fingerprint recognition are driven by improved fingerprint sensing and advancements in areas such as computer architecture, pattern recognition, image processing and computer vision. In addition to the new developments in science and technology, several recent social and political events have increased the level of interest in fingerprint recognition for the purpose of positive person identification. This highlightened interest in fingerprint technology and its promise to deliver cost-effective solutions have prompted us to undertake the endeavour to take up this project and work on it and deliver high accuracy rate than found earlier.

Security is the most important aspect of Technology. To reach the goals of security, every business or industry have their own security systems. So, the airline industry is no behind the others. Till date the airline reservations and airplane boarding were done examining the identity cards such as License, PAN Card or Passport. But these can be manipulated and security can be breached. To avoid this, some airports have used the concept of biometrics. In this, the authentication of the boarders can be done by using some biometric techniques like Finger Print Recognition, Face Recognition, etc. For fingerprint recognition, fingerprint sensors are used. Most of the sensors available today use "touch" method since it is simple and little training is required. But there are some drawbacks of touch base fingerprints. To overcome the above limitations, touch-less fingerprint technology came into existence.

Introduction

Biometrics embraces a range of techniques for identity verification using physical data and/or behavioral such as handwriting recognition, Iris recognition, speech recognition and fingerprint recognition. This project deals with touch-less fingerprint recognition. In the past, the acquisition of fingerprint images was performed by "ink-technique" which is also referred as off- line fingerprint acquisition in the law enforcement .Now-a-days, fingerprint sensors are used. Most of the sensor available today use "touch" method since it is simple and little training is required. These touch sensors acquire fingerprint images as the user's fingerprint is contacted on a solid flat sensor. Both the sensor method and ink-technique requires the person to press his/her finger against a flat rigid surface. For this reason they are known as touch-based methods. In touch-based fingerprint recognition, the elastic skin of the finger alters. The magnitude and direction of the pressure applied by the user, the skin conditions, and the projection of an irregular 3D object i.e. the finger onto a 2D flat plane introduce distortions and discrepancy on the captured fingerprint image. Due to these limitations, the representation of the same fingerprint changes every time the finger is placed on the sensor platen and increases the complexity of the fingerprint matching.

TOUCH-LESS FINGERPRINT TECHNOLOGY: AN OVERVIEW

The touch-less fingerprint technology requires no contact between the skin of the finger and the sensing area. Touch-less fingerprint acquisition is a remote sensing technology to capture the ridge-valley pattern which provides essential information for recognition. Because of the lack of contact between the finger and any rigid surface, the skin does not deform during the capture and the repeatability of the measure is quite ensured. Digital camera is used to present a touch-less fingerprint recognition system. Fingerprint images that are acquired using digital camera consist of certain constraints such as low contrast between the ridges and the valleys, defocus and motion blurriness.

Touch-less fingerprint recognition system comprises of three stages:

1. Pre-processing

Pre-processing is an essential step in detecting minutiae from the fingerprints. It is used to reduce the noises and increase the contrast between ridges and valleys. In pre-processing, firstly, the RGB fingerprint image is converted to grey scale [0-255]. To reduce the degradation that is caused by the illumination, the image is then normalized by changing the dynamic range of the pixel intensity values. After the normalization, segmentation is done by the skin colour detection, adaptive thresholding and followed by the morphological processing. The fingerprint image is multiplied with the binary mask obtained from the segmentation later on.

Consequently, the resulting image is cropped and enhanced. Finally, the core point is detected on the enhanced image.

2. **Feature Extraction**

The feature vectors are extracted from the images after pre-processing. The Gabor filter based feature extractor is used to form the feature vectors. A properly tuned Gabor filters are famous in smoothing out noise, preserving the true ridge furrow structures in addition to capture both frequency and orientation information from a fingerprint image. Due to the number of extracted Gabor features is large, Principle Component Analysis (PCA) is used for reducing the dimensionality of the feature vectors while the characteristics of the feature vectors are retained that contribute most to its variance by eliminating the later principal components.

3. **Matching**

For the comparison purpose in verifying the individuality of a person through the feature matching, many distance measures can be adopted like Manhattan distance, Euclidean distance and Cosine .The result of the experiments justify that Cosine Angle is the best measure.

Let x and y be two normalized feature vectors in n dimensional. Then the Cosine Angle (Cosine similarity) is defined as the cosine of the angle between them and is formulated as:

$$dcos(y,x) = (y \cdot x) / |y||x|$$

Let d be the computed distance score from above equation given a threshold T, the claim is accepted when $d < T$ and rejected when $d \geq T$.

APPROACHES OF TOUCH-LESS FINGERPRINT TECHNOLOGY

The different approaches to capture a fingerprint based on touch-less technology can be grouped in two families:

•Reflection-based Touch-less Finger Imaging (RTFI)
•Transmission-based Touch-less Finger Imaging (TTFI)

Reflection-based Touch-less Finger Imaging

In RTFI, the light sources are placed in front of the fingerprint to illuminate it. Part of this light is absorbed by the skin, while the majority is reflected and thus, collected by a detector. The quantity of light energy incident on the detector surface is quantized to 256 grey values, providing the final image representing a fingerprint.

To obtain an image with sufficient contrast and distinguish between ridges and valleys, it is necessary that the finger skin absorbs only a small portion of the incident light, while the majority of it is reflected back to the detector. It is also compulsory that the quantity of the light absorbed by the valleys is much lower than the quantity absorbed by the ridges. This is achieved using the correct light wavelength, the correct light incident angle and the emission power of the light sources.

Experiments have demonstrated that the wavelength value to obtain the best contrast is around 469 nm (blue light). Blue light is also the complementary color of yellow that is the main color component of the skin.

Transmission-based Touch-less Finger Imaging

This touch-less capture approach, is based on the transmission of the light through the finger. This time, the light sources are placed in such a way that they illuminate the nail side. Red light with a wavelength of 660 nm is used, because it has high transmittance ratio to the skin tissue. Hence, the light penetrating the finger is collected by the detector placed in front of the fingerprint .

Chapter3 : ANALYSIS, DESIGN AND MODELING

3.1 Overall Description of the project

a) Product perspective

The project is an attempt to use techniques available for fingerprint recognition for real time and classification of the minute differences between the patterns through which can accurately identify the individual. For this purpose I have studied various algorithms and experimented with various libraries available.

b) Product Functions

The product helps in capturing of an image of the tip of the fingers and performs each algorithm step by step to figure out the ridge-valley pattern of an individual. This feature distinguishes one individual from another. Then matching of the patterns is done with the stored image and if found, the result displayed is either match found or fingerprint does not match the image.

c) User characteristics

The project does not have any constraints on who can use it; it can be used by anyone and everyone, from researcher, teacher and student to developer, anyone can use the product in accordance to his needs or build application on it. The user can be any human finger facing the digital camera with his finger facing towards the camera and must be straight and uncovered. The background can be of any colour other than skin colour.

d) Design and Implementation constraints

- All the programming code is written in Matlab using its inbuilt functions.
- A decent digital camera is required and can be used in darkness.
- The project is supposed to run both on windows and Mac.

e) Assumption and Dependencies

- The background should be of any colour other than skin colour.
- The fingers should be uncovered for detection.

3.2 Specific Requirements

3.2.1 External Interfaces

User Interface:

If anybody wants to have a look at step by step conversion of images he can also do that, and then there is an image matching process, which will go through matching process and will display the result.

Hardware Interface:

There is a digital camera .The only hardware used is digital camera.

Software Interface:

I have used MatLab for programming.

Communication Interface:

Digital camera is the only communication interface.

3.2.2 Functions

- Digital camera captures the image.
- Then the image is implemented through the Matlab.
- Image will go through three phases one by one.
- And then testing is done.

3.2.3 Performance Requirements

The basic requirement for running of the application is

- Digital camera
- Matlab

Dynamic Requirements

- Memory Available

3.2.4 Design Constraints

- The results are better on more efficient computers as the search process is faster.
- A still hand can give better results in recognition of the accurate ridge-valley patterns

3.2.5 Software System Attributes

a) Reliability:

Result should be as the application, further working depends on it. Feature vector points have to be accurate for best working of the application.

b) Robust:

As it takes a lot of computation and memory resources its necessary point that software must be a robust one and free memory resources used and gradually degrade there by annoying the user.

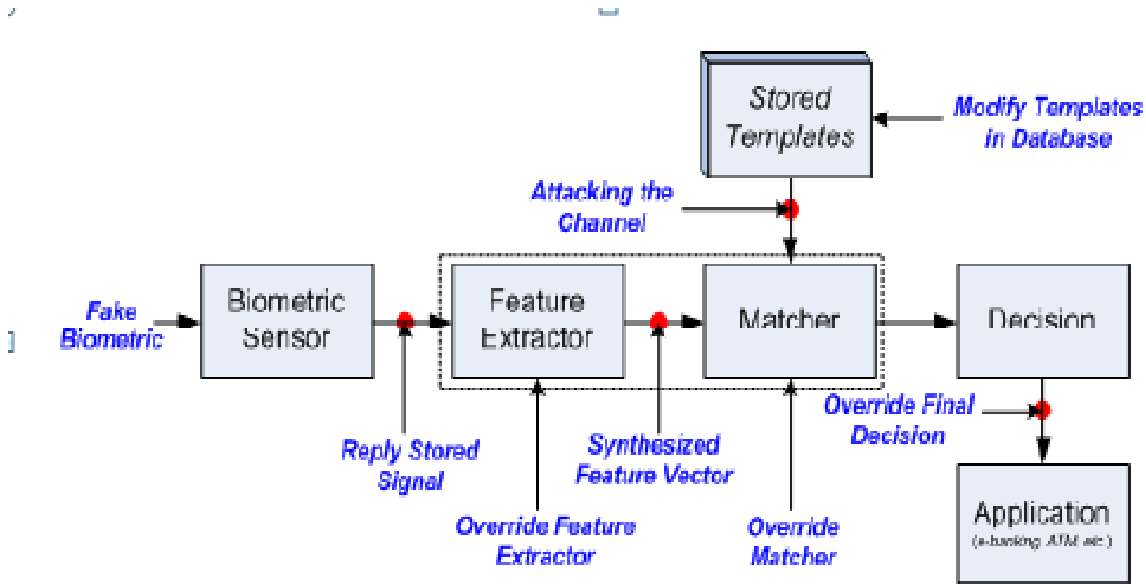
c) Maintenance:

Matching is an important phase for classification of better and efficient results. One needs to have a rich database so that it covers nearly all the possible users of the system, so that at any point of time it does not fail to recognition anyone.

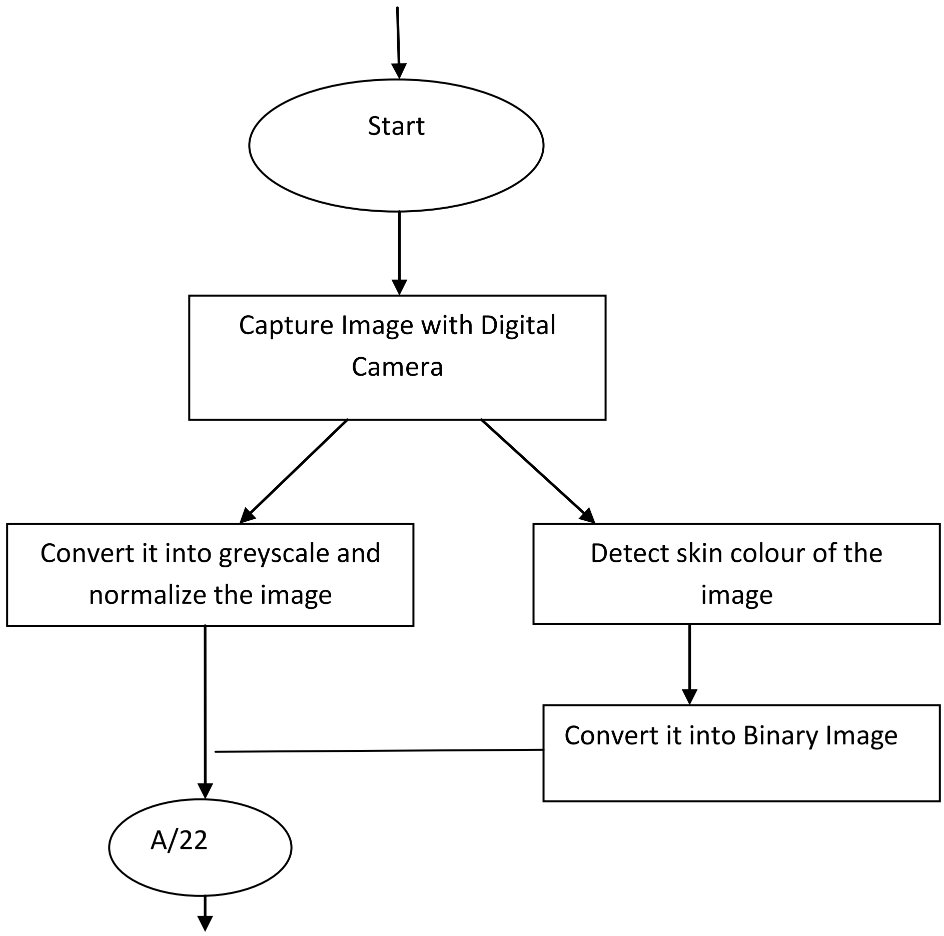
d) Portability:

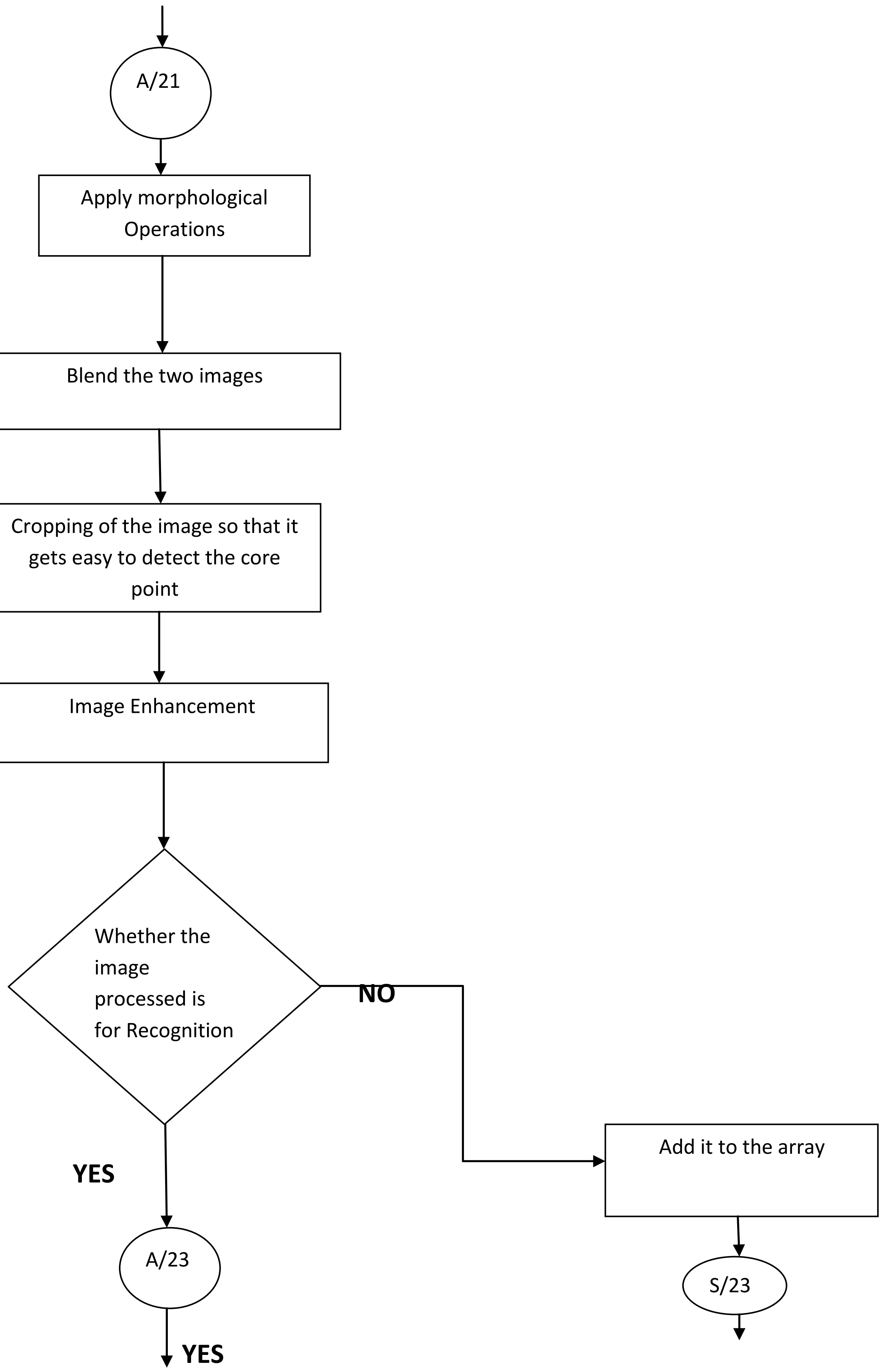
The software is portable, i.e. can be installed anywhere.

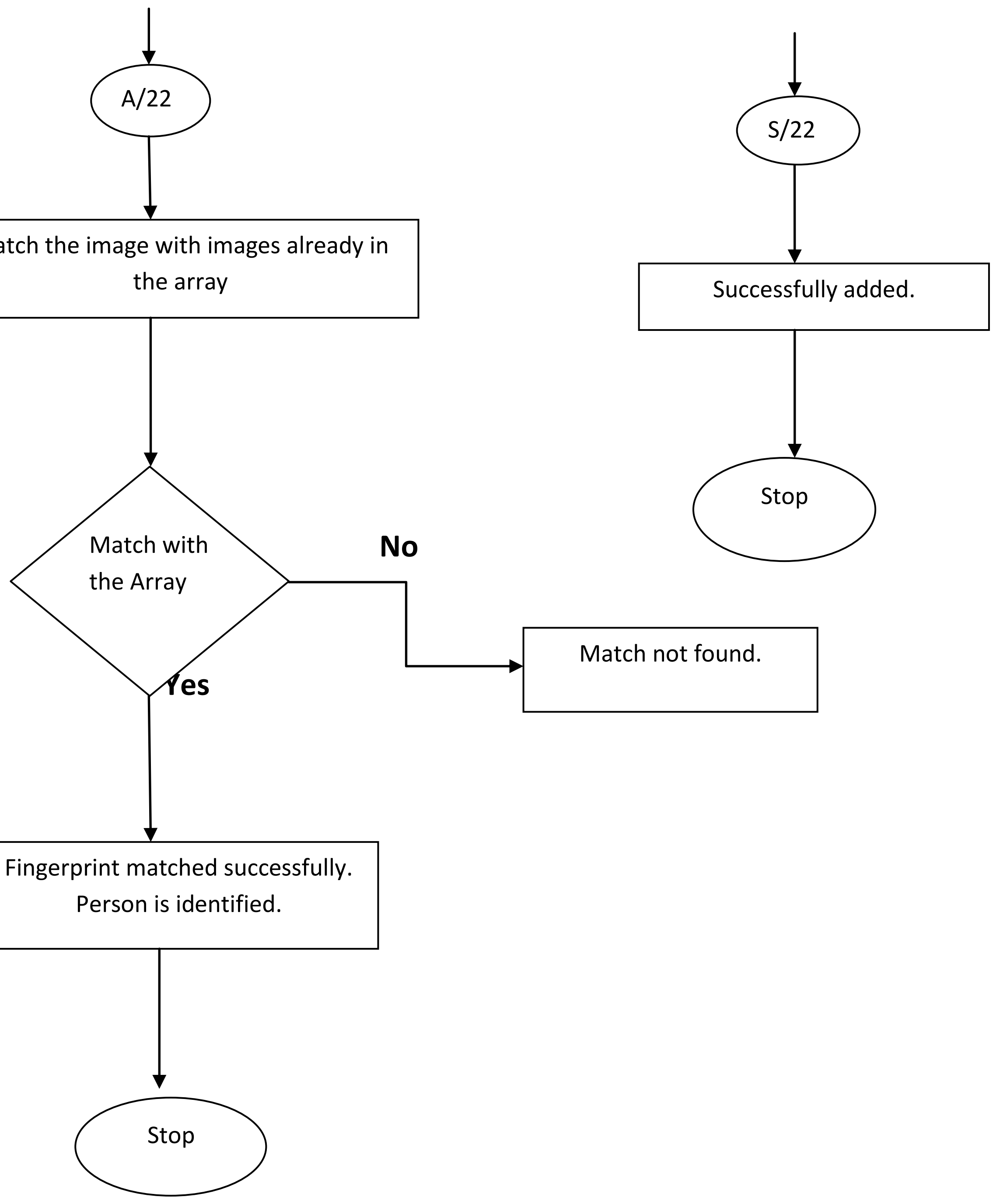
3.3 Design



3.4 Modeling




A/21
Apply morphological Operations
Blend the two images
Cropping of the image so that it gets easy to detect the core point
Image Enhancement
Whether the image processed is for Recognition
NO
Add it to the array
YES
A/23
S/23
YES


A/22
Match the image with images already in the array
Match with the Array
No
Yes
Match not found.
Fingerprint matched successfully. Person is identified.
Stop
S/22
Successfully added.
Stop

Chapter4 : IMPLEMENTATION

PRE-PROCESSING PHASE

a) RGB to Grayscale conversion

When converting an RGB image to greyscale, we have to take the RGB values for each pixel and make as output a single value reflecting the brightness of that pixel. One such approach is to take the average of the contribution from each channel: (R+B+C)/3. However, since the perceived brightness is often dominated by the green component, a different, more "human-oriented", method is to take a weighted average, e.g.: 0.3R + 0.59G + 0.11B.

Fig 1: It shows RGB image is converted to Grayscale

b) Normalisation of Grey Image

Normalization is a process that changes the range of pixel intensity values. Applications include photographs with poor contrast due to glare, for example. Normalization is sometimes called contrast stretching or histogram stretching. In more general fields of data processing, such as digital signal processing, it is referred to as dynamic range expansion.

Fig 2: It shows normalization of grey image

c) Skin Colour Detection

Skin detection is the process of finding skin-colored pixels and regions in an image or a video. This process is typically used as a preprocessing step to find regions that potentially have human faces and limbs in images. Several computer vision approaches have been developed for skin detection. A skin detector typically transforms a given pixel into an appropriate color space and then uses a skin classifier to label the pixel whether it is a skin or a non-skin pixel. A skin classifier defines a decision boundary of the skin color class in the color space based on a training database of skin-colored pixels.

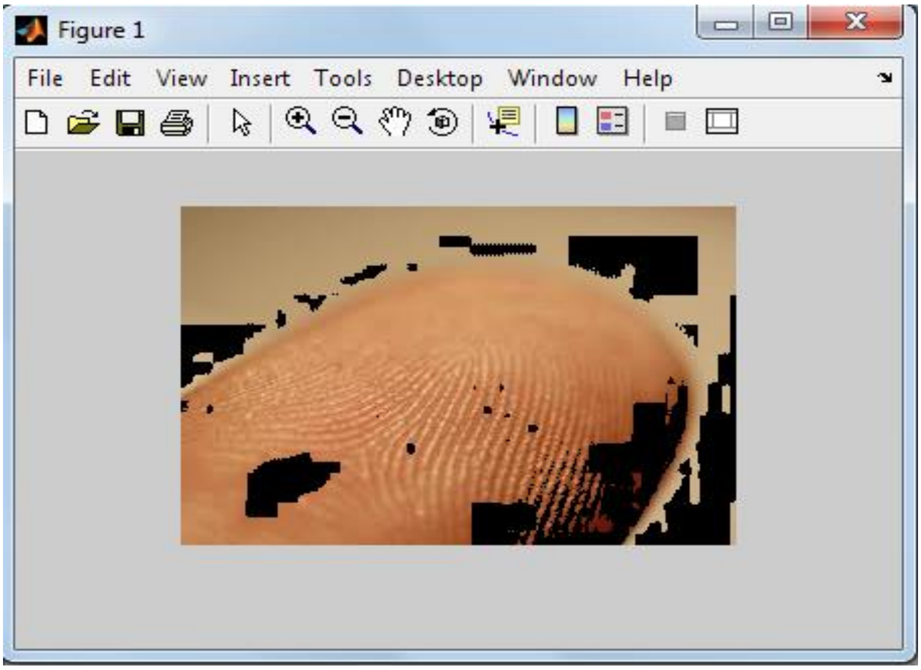


Fig 3 : It shows skin color detection

d) Conversion of an Image to Binary

A binary image is a digital image that has only two possible values for each pixel. Typically the two colors used for a binary image are black and white though any two colors can be used. The color used for the object(s) in the image is the foreground color while the rest of the image is the background color. In the document scanning industry this is often referred to as bi-tonal.

Binary images are also called bi-level or two-level. This means that each pixel is stored as a single bit (0 or 1). The names black-and-white, B&W, monochrome or monochromatic are often used for this concept, but may also designate any images that have only one sample per pixel, such as grayscale images.

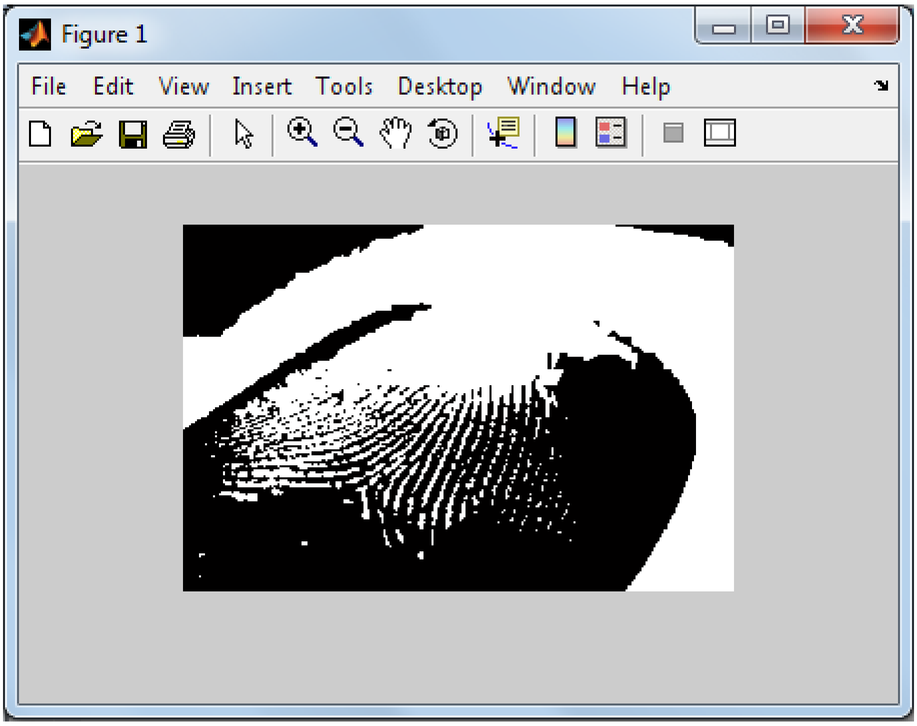
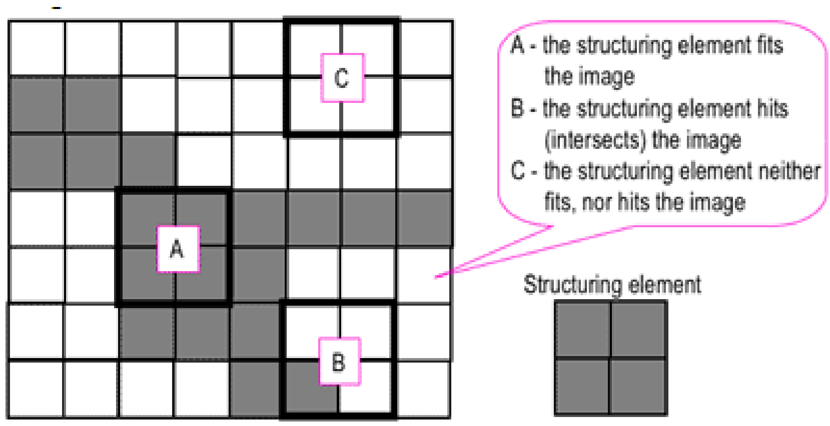


Fig 4: Conversion of grey image to binary

e) Morphological Processing

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. According to Wikipedia, morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological operations can also be applied to greyscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest.

Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighbourhood of pixels. Some operations test whether the element "fits" within the neighbourhood, while others test whether it "hits" or intersects the neighbourhood:



Probing of an image with a structuring element
(white and grey pixels have zero and non-zero values, respectively).

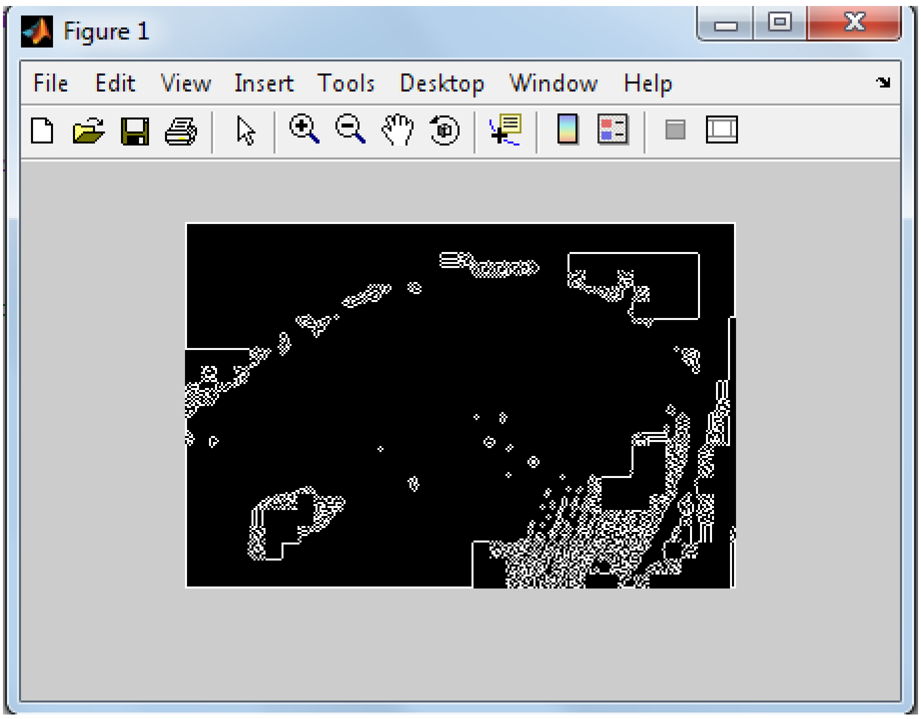


Fig 5 : Morphological processes

f) Blending of two images

There are several types of blending functions. Here in this project we are multiplying the values of the normalized greyscale image and binary image.

g) Cropping of an image

Cropping refers to the removal of the outer parts of an image to improve framing, accentuate subject matter or change aspect ratio. Depending on the application, this may be performed on a physical photograph, artwork or film footage, or achieved digitally using image editing software. The term is common to the film, broadcasting, photographic, graphic design and printing industries.

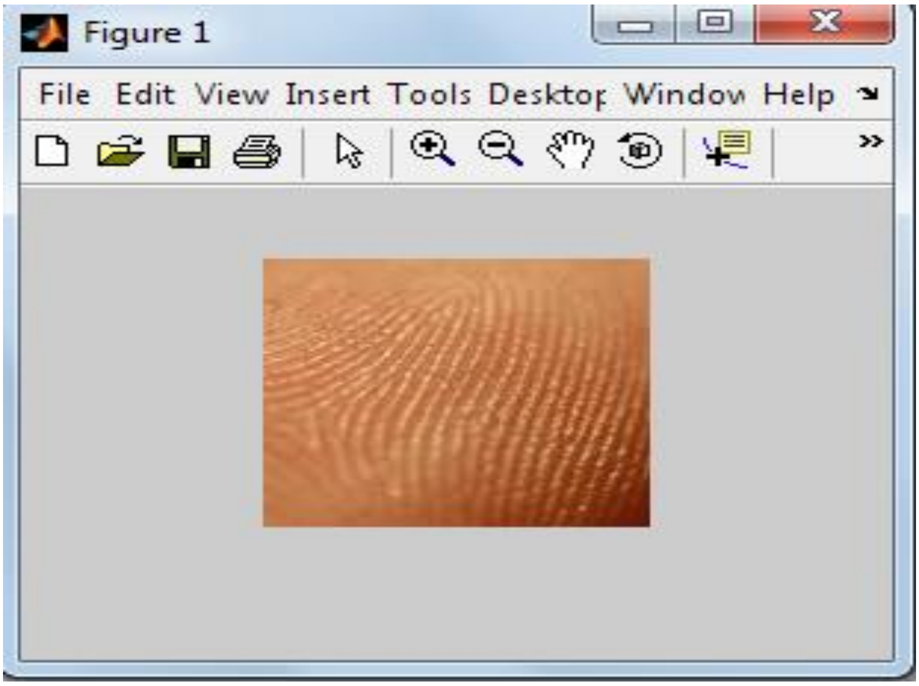


Fig 7: Cropping of an image

h) Enhancement of an image

Image enhancement is the improvement of digital image quality (wanted e.g. for visual inspection or for machine analysis), without knowledge about the source of degradation. If the source of degradation is known, one calls the process image restoration. Both are conical processes, viz. input and outputs are images.

Many different, often elementary and heuristic methods are used to improve images in some sense. The problem is, of course, not well defined, as there is no objective measure for image quality. Here, we discuss a few recipes that have shown to be useful both for the human observer and/or for machine recognition. These methods are very problem-oriented: a method that works fine in one case may be completely inadequate for another problem.

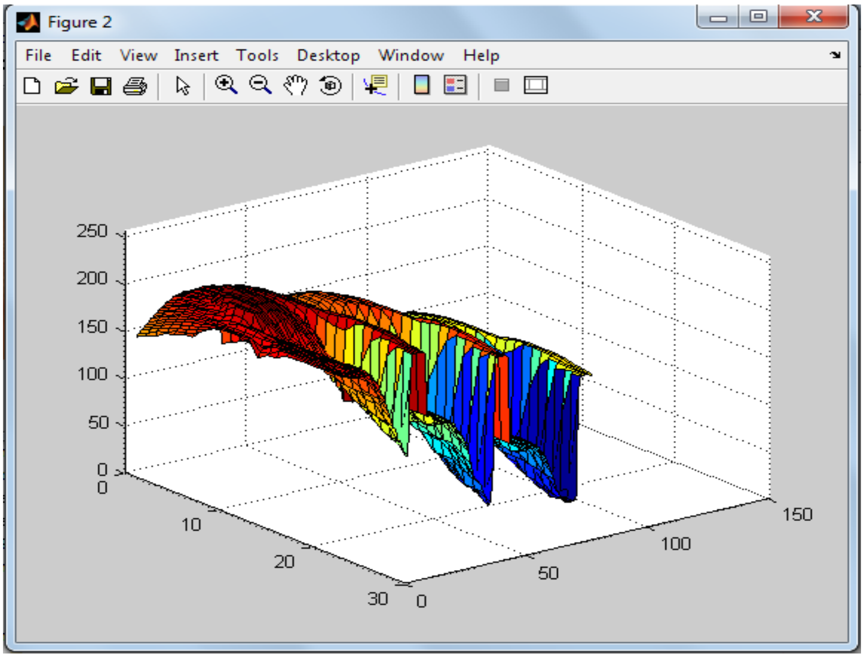


Fig 8: Histogram for enhancement

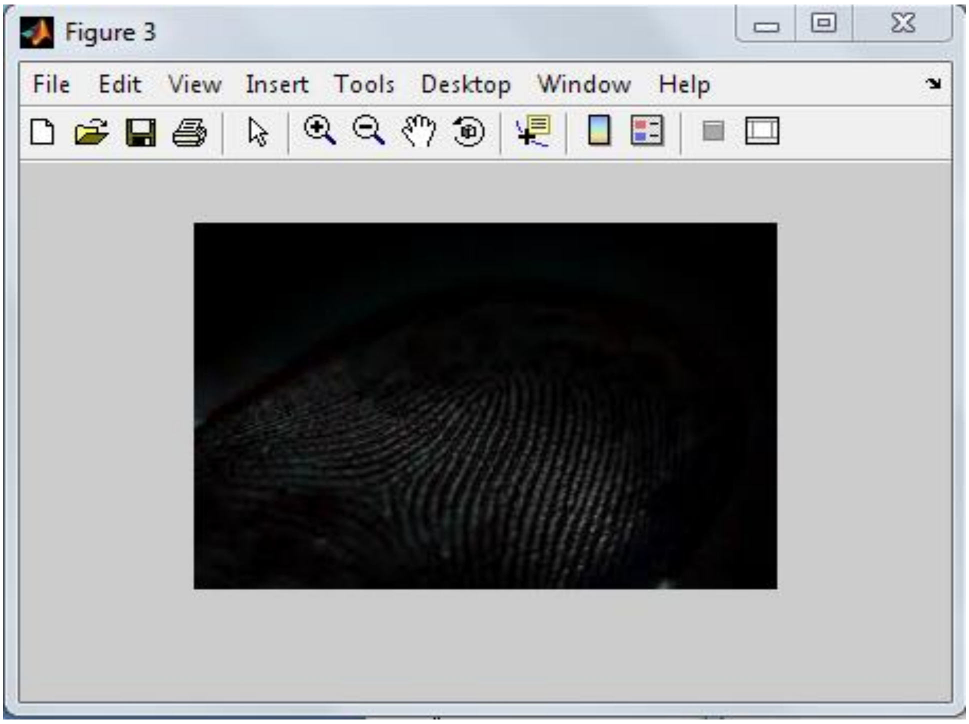


Fig 9: Image enhancement

FEATURE EXTRACTION PHASE

a) Using Gabor filter

After the pre-processing phase the feature vectors are extracted from the images. A Gabor filter based feature extracted is used to form the feature vectors. It is used for smoothing out noise and to preserve the true ridge and furrow structures. It uses PCA (Principle component Analysis) due to large dimensionality of the feature vectors.

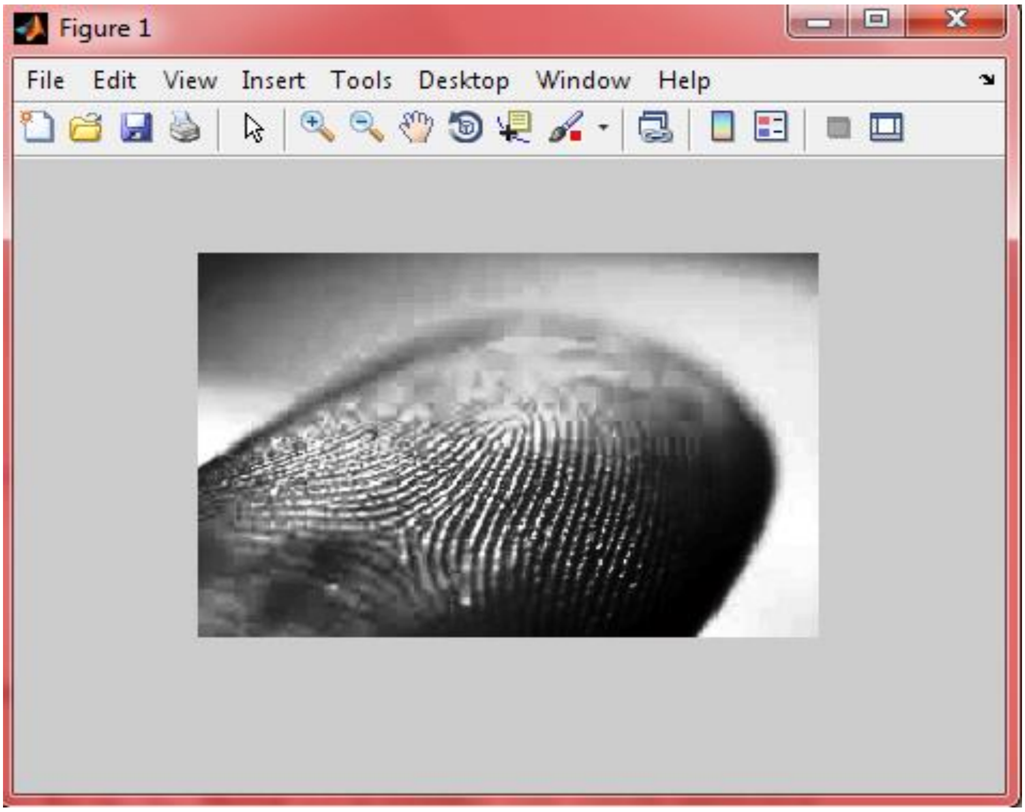


FIG 10: GABOR FILTER USED ON THE ENHANCED IMAGE.

b) MINUTAE EXTRACTION

The various minutiae features are extracted from the image so that they could be used for the matching phase later on. The minutiae are various points like the ridge ending point, ridge bifurcation, ridge and furrow distance etc. that are used for the matching purpose and to distinguish between the various fingerprints.

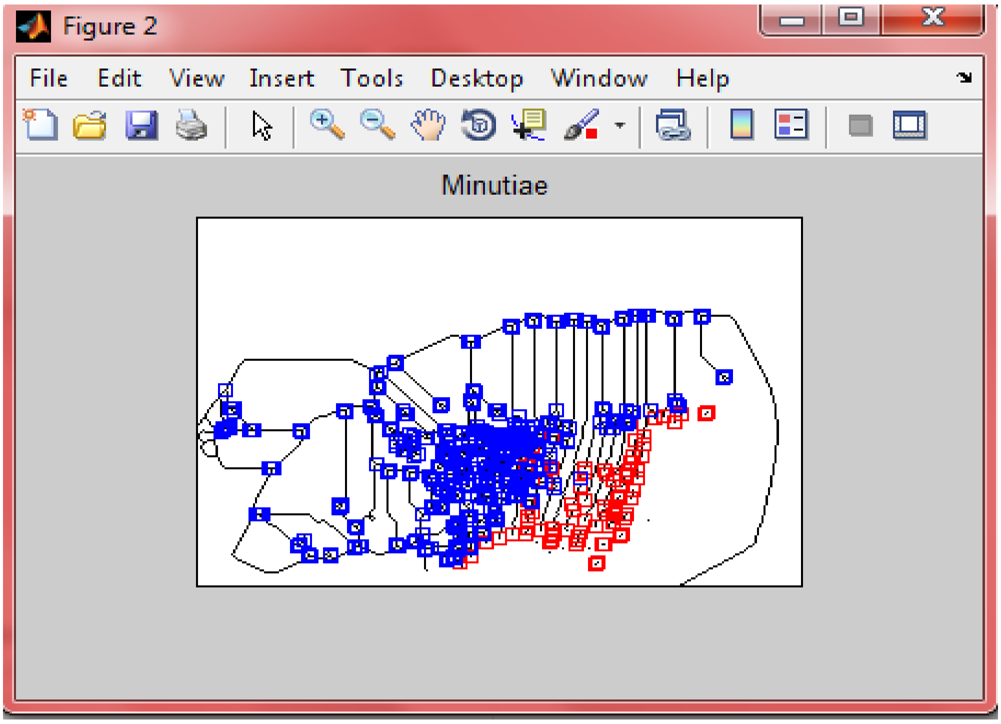


FIG 11: MINUATIAE FEATURE EXTRACTS

C) IMAGE THINNING:

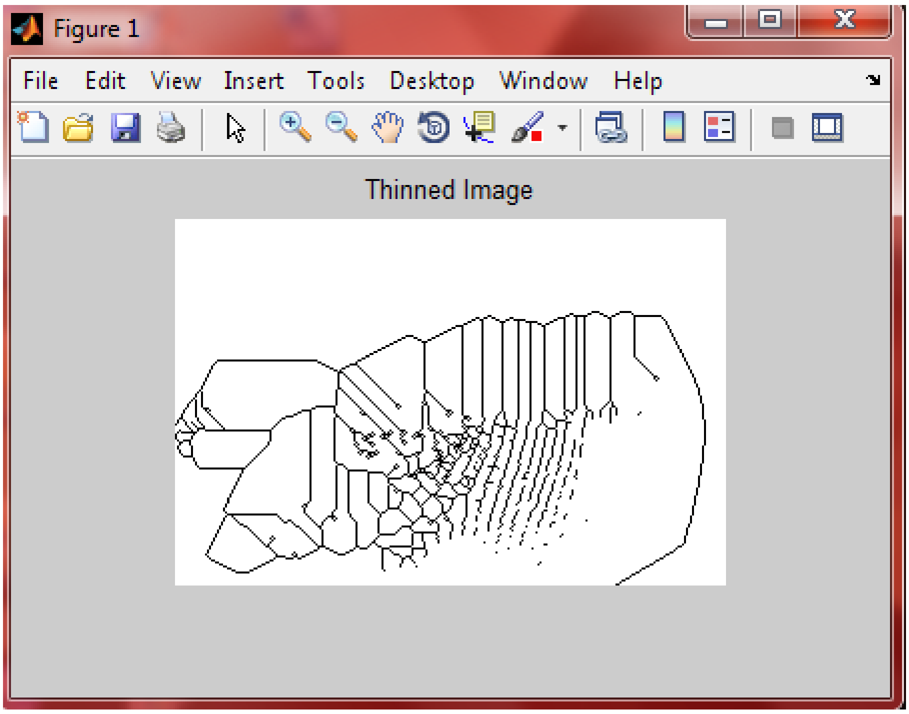


FIG 12: THINNED IMAGE

MATCHING PHASE

Cosine angle distance measure is adopted to measure the feature extracted. A fingerprint matching module computes a match score between two fingerprints, which should be high for fingerprints from the same finger and low for those from different fingers. The matching stage computes the Cosine distance between the template finger code and the input finger code.

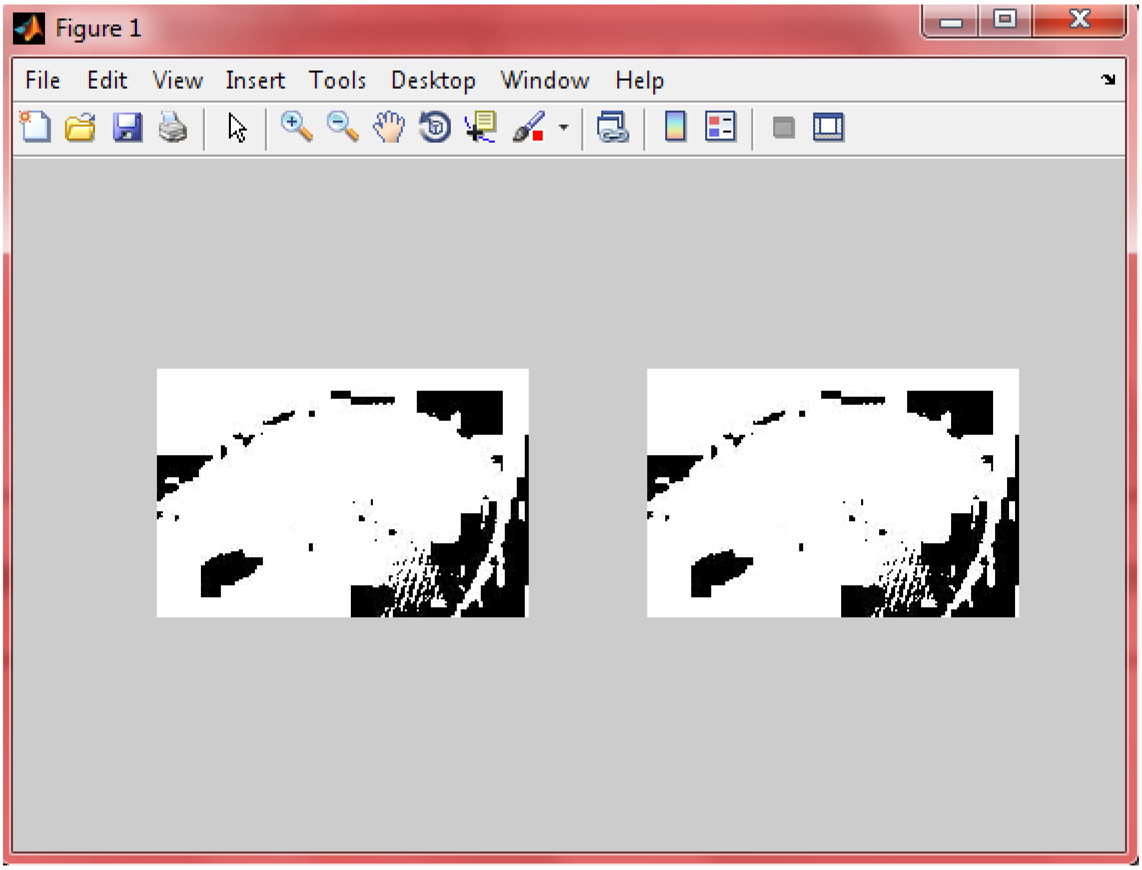


FIG 13: TWO IMAGES MATCHED AND ENHANCED

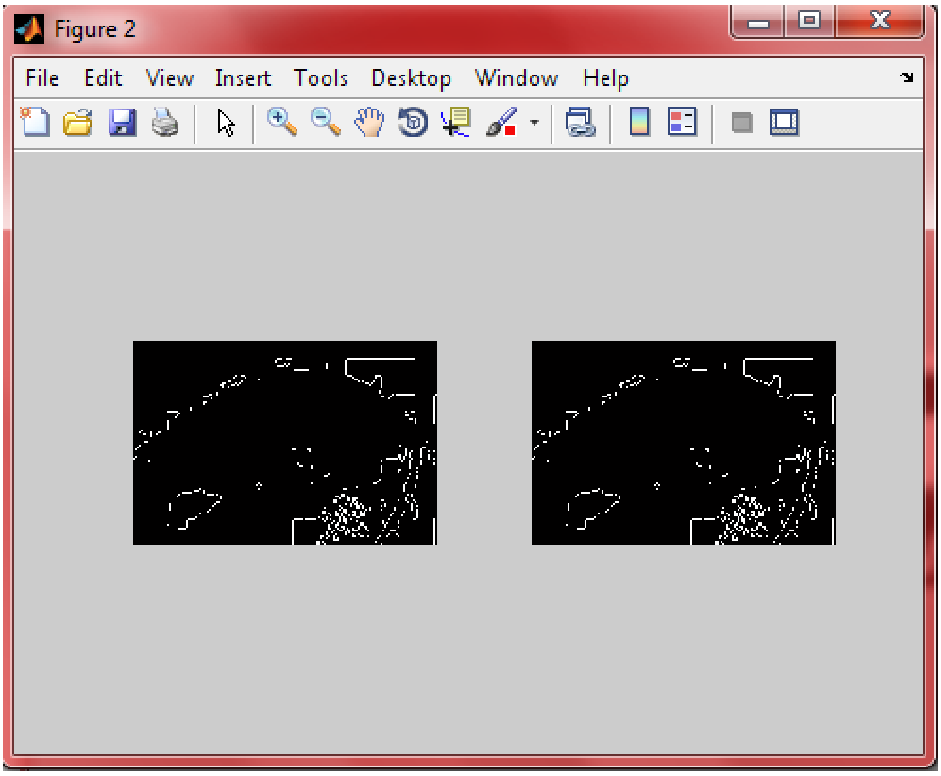


FIG 14: IMAGES THINNED AND MATCHED.

The images are hence matched by calculating their matching scores. Here we calculate the FMR (False Matching Ratio) and FNMR (False Non Matching Ratio) and get an equation to calculate the Matching Score.

FINGERPRINT IDENTIFICATION

The matlab code browses the image from the given array. The selected image is stored in a separate array that could be later used for identification. The captured image is browsed and by using matlab inbuilt functions it is stored as a separate id in an array. When a person logs in the binary image of the users fingerprint and the binary image of the fingerprints in the array are matched. Binary mapping takes place. If the binary values of the captured image matches with the binary values of the stored image then the user is given the access. Else a message is displayed invalid user.

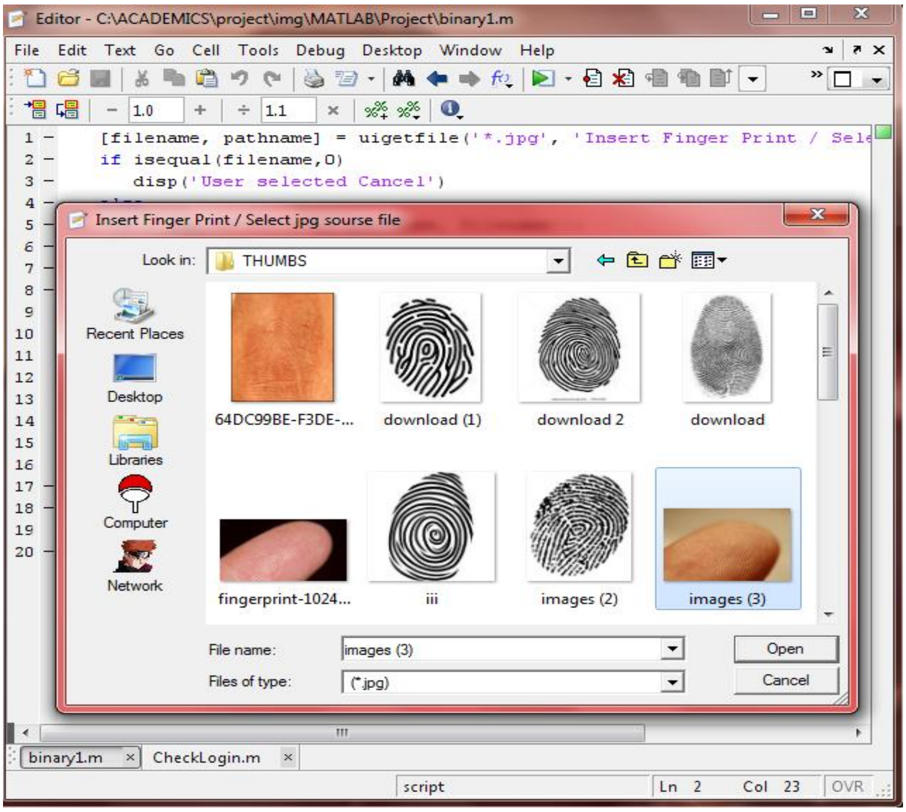


FIG 15: BROWSING THE CAPTURED IMAGE

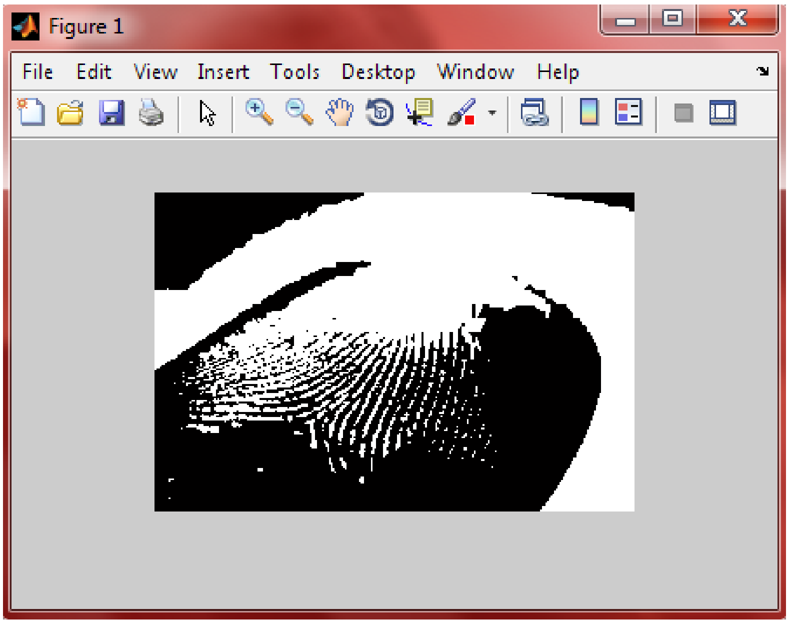


FIG 16 : THE CAPTURED IMAGE IN CONVERTED TO BINARY AND IS STORED IN THE ARRAY

THE CAPTURED IMAGE IS THEN COMPARED WITH THE IMAGES IN THE ARRAY AND THE RESULT IS SHOWN ON THE SCREEN.

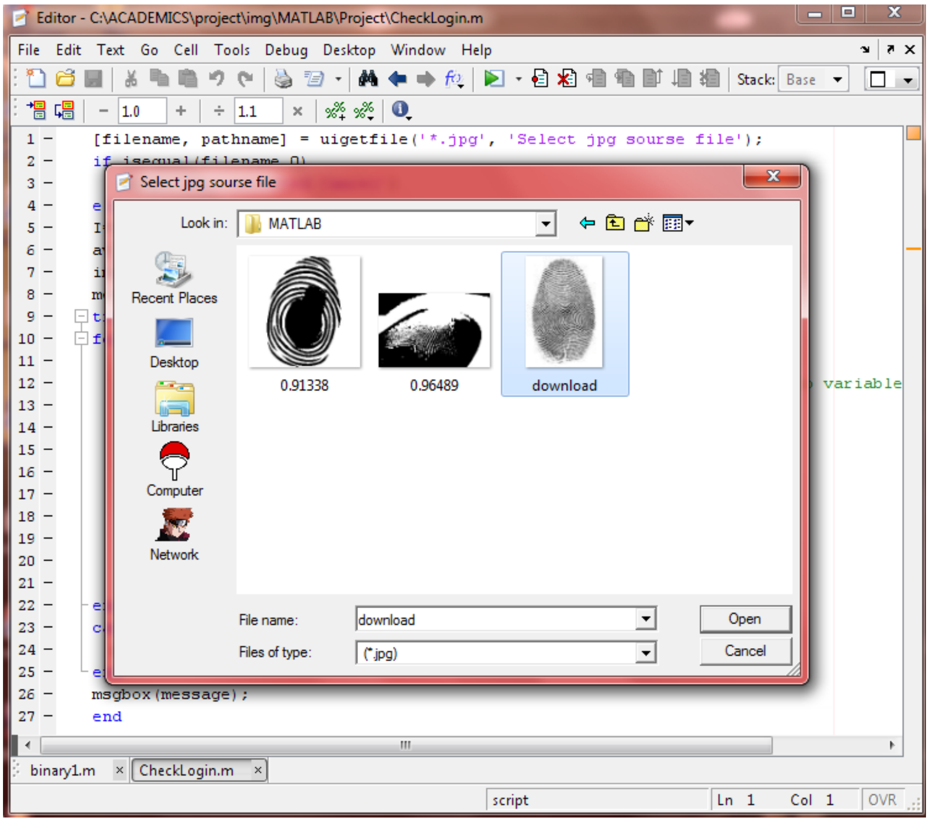


FIG 17 : THE IMAGE IS MATCHED

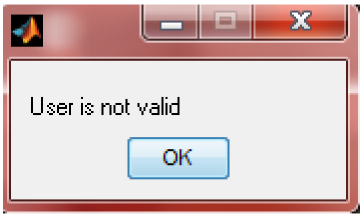


FIG18 : THE RESULT IS DISPLAYED.

Chapter 5 : CODE IMPLEMENTATION

5.1 RGB to Grayscale conversion

Gray.m

```
RGB = imread('D:\kurtis\images.jpg');
image(RGB)
I = rgb2gray(RGB)
image(I)
imshow(I)
```

5.2 Normalisation of Grayscale image

Norm.m

```
RGB = imread('D:\kurtis\images.jpg');
image(RGB)
I = rgb2gray(RGB)
image(I)
m=imshow(I)
originalMinValue = double(min(min(m)))
originalMaxValue = double(max(max(m)))
originalRange = originalMaxValue - originalMinValue;
desiredMin = 0;
desiredMax = 1;
desiredRange = desiredMax - desiredMin;
dblImageS1 = desiredRange * (double(grayImage) - originalMinValue) / originalRange +
desiredMin;
```

5.3 Skin color Detection

Colordetection.m

```
I=imread('D:\kurtis\images.jpg');
I=double(I);
[hue,s,v]=rgb2hsv(I);
cb =  0.148* I(:,:,1) - 0.291* I(:,:,2) + 0.439 * I(:,:,3) + 128;
```

```
cr =  0.439 * I(:,:,1) - 0.368 * I(:,:,2) -0.071 * I(:,:,3) + 128;
[w h]=size(I(:,:,1));
for i=1:w
    for j=1:h
        if  140<=cr(i,j) && cr(i,j)<=165 && 140<=cb(i,j) && cb(i,j)<=195 && 0.01<=hue(i,j)
&& hue(i,j)<=0.1
            segment(i,j)=1;
        else
            segment(i,j)=0;
        end
    end
end
% imshow(segment);
im(:,:,1)=I(:,:,1).*segment;
im(:,:,2)=I(:,:,2).*segment;
im(:,:,3)=I(:,:,3).*segment;
figure,imshow(uint8(im));
```

5.4 Conversion to Binary Image

Binary.m

```
RGB = imread('D:\kurtis\images.jpg');
BW = im2bw(RGB, 0.6)
image(BW)
imshow(BW)
%BW1 = gpuArray(imread('D:\kurtis\images.jpg'));
%figure, imshow(BW1)


%BW2 = bwmorph(BW1,'remove');
%figure, imshow(BW2)


%BW3 = bwmorph(BW1,'skel',Inf);
%figure, imshow(BW3)
```

5.5 Morphological Processing on Binary Image

Morph.m

```
RGB = imread('D:\kurtis\images.jpg');
BW = im2bw(RGB, 0.6)
image(BW)
imshow(BW)
BW1 = imread(BW);
SE = strel('arbitrary',eye(5));
BW2 = imerode(BW1,SE);
imshow(BW2)
BW3 = imdildate(BW2,SE);
imshow(BW3)
imwrite(BW3,'morph.jpg');
```

5.6 Combining of normalized image and binary image after morphological processing

Combine.m

```
A = imread('C:\Users\sakshi\Documents\MATLAB\binary.jpg');
B = imread('C:\Users\sakshi\Documents\MATLAB\morph_remove.jpg');
C = imfuse(A,B,'blend','Scaling','joint');
imwrite(C,'C:\Users\sakshi\Documents\MATLAB\blend_overlay.jpg');
imshow(C);
```

5.7 Cropping of image

Crop.m

```
I = imread('D:\kurtis\images.jpg');
I2 = imcrop(I,[75 68 130 112]);
imshow(I2)
```

5.8 Enhancement of image

Enhance.m

```
I = imread('D:\kurtis\images.jpg');
imshow(I)
background = imopen(I,strel('disk',15));
figure, surf(double(background(1:8:end,1:8:end))),zlim([0 255]);
set(gca,'ydir','reverse');
I2 = I - background;
figure, imshow(I2)
I3 = imadjust(I2);
figure, imshow(I3);
level = graythresh(I3);
bw = im2bw(I3,level);
bw = bwareaopen(bw, 50);
figure, imshow(bw)
cc = bwconncomp(bw, 4)
cc.NumObjects
grain = false(size(bw));
grain(cc.PixelIdxList{50}) = true;
figure, imshow(grain);
labeled = labelmatrix(cc);
RGB_label = label2rgb(labeled, @spring, 'c', 'shuffle');
figure, imshow(RGB_label)
graindata = regionprops(cc, 'basic')
grain_areas = [graindata.Area];
nbins = 20;
figure, hist(grain_areas, nbins)
title('Histogram of Rice Grain Area');
```

5.9 FEATURE EXTRACTION

```
close all;
clear all;
clc;
 % Parameter Setting
width = 45;
height = 45;
kmax = pi / 2;
f = sqrt( 2 );
delta =  pi/3 ;
 img_in = imread('C:\ACADEMICS\project\img\MATLAB\images.jpg');
img_in_gray = im2double(rgb2gray(img_in));
img_in_h = histeq(img_in_gray);


imshow(img_in_h);


img_out = zeros(size(img_in_gray,1), size(img_in_gray,2), 8);
for u = 0 : 7
 GW = GaborWavelet ( width, height, kmax, f, u, 2, delta ); % Create the Gabor wavelets
 figure( 2 );
 subplot( 1, 8, u + 1 ),imshow ( real(GW),[]);
 img_out(:,:,u+1) = imfilter(img_in_gray, GW, 'symmetric');
end
 % default superposition method, L2-norm
img_out_disp = sum(abs(img_out).^2, 3).^0.5;


img_out_disp = img_out_disp./max(img_out_disp(:));
% normalize


figure( 4 );
imshow(img_out_disp);
```

5.1.0 MATCHING PHASE

```
%Program for Fingerprint Feature Extraction

%Program Description
%This program extracts the ridges and bifurcation from a fingerprint image

%Read Input Image
binary_image=im2bw(imread('C:\ACADEMICS\project\img\MATLAB\images.jpg'));

%Thinning
thin_image=~bwmorph(binary_image,'thin',Inf);
figure;imshow(thin_image);title('Thinned Image');

%Minutiae extraction
s=size(thin_image);
N=3;%window size
n=(N-1)/2;
r=s(1)+2*n;
c=s(2)+2*n;
double temp(r,c);
temp=zeros(r,c);bifurcation=zeros(r,c);ridge=zeros(r,c);
temp((n+1):(end-n),(n+1):(end-n))=thin_image(:,:);
outImg=zeros(r,c,3);%For Display
outImg(:,:,1) = temp .* 255;
outImg(:,:,2) = temp .* 255;
outImg(:,:,3) = temp .* 255;
for x=(n+1+10):(s(1)+n-10)
for y=(n+1+10):(s(2)+n-10)
e=1;
for k=x-n:x+n
f=1;
for l=y-n:y+n
mat(e,f)=temp(k,l);
```

```
f=f+1;
end
e=e+1;
end;
if(mat(2,2)==0)
ridge(x,y)=sum(sum(~mat));
bifurcation(x,y)=sum(sum(~mat));
end
end;
end;

% RIDGE END FINDING
[ridge_x ridge_y]=find(ridge==2);
len=length(ridge_x);
%For Display
for i=1:len
    outImg((ridge_x(i)-3):(ridge_x(i)+3),(ridge_y(i)-3),2:3)=0;
    outImg((ridge_x(i)-3):(ridge_x(i)+3),(ridge_y(i)+3),2:3)=0;
    outImg((ridge_x(i)-3),(ridge_y(i)-3):(ridge_y(i)+3),2:3)=0;
    outImg((ridge_x(i)+3),(ridge_y(i)-3):(ridge_y(i)+3),2:3)=0;

    outImg((ridge_x(i)-3):(ridge_x(i)+3),(ridge_y(i)-3),1)=255;
    outImg((ridge_x(i)-3):(ridge_x(i)+3),(ridge_y(i)+3),1)=255;
    outImg((ridge_x(i)-3),(ridge_y(i)-3):(ridge_y(i)+3),1)=255;
    outImg((ridge_x(i)+3),(ridge_y(i)-3):(ridge_y(i)+3),1)=255;
end

%BIFURCATION FINDING
[bifurcation_x bifurcation_y]=find(bifurcation==4);
len=length(bifurcation_x);
%For Display
for i=1:len
    outImg((bifurcation_x(i)-3):(bifurcation_x(i)+3),(bifurcation_y(i)-3),1:2)=0;
    outImg((bifurcation_x(i)-3):(bifurcation_x(i)+3),(bifurcation_y(i)+3),1:2)=0;
```

```
    outImg((bifurcation_x(i)-3),(bifurcation_y(i)-3):(bifurcation_y(i)+3),1:2)=0;
    outImg((bifurcation_x(i)+3),(bifurcation_y(i)-3):(bifurcation_y(i)+3),1:2)=0;

    outImg((bifurcation_x(i)-3):(bifurcation_x(i)+3),(bifurcation_y(i)-3),3)=255;
    outImg((bifurcation_x(i)-3):(bifurcation_x(i)+3),(bifurcation_y(i)+3),3)=255;
    outImg((bifurcation_x(i)-3),(bifurcation_y(i)-3):(bifurcation_y(i)+3),3)=255;
    outImg((bifurcation_x(i)+3),(bifurcation_y(i)-3):(bifurcation_y(i)+3),3)=255;
end
figure;imshow(outImg);title('Minutiae');
```

5.1.1 MINUTAE EXTRACTION

```
clc;

 clear all; close all;

pic1 = imread('C:\ACADEMICS\project\img\MATLAB\binary.jpg');
pic2 = imread('C:\ACADEMICS\project\img\MATLAB\binary.jpg');

figure
subplot(1,2,1);
imshow(pic1)
subplot(1,2,2);
imshow(pic2)

%so that we obtain white and black points and edges of the objects present
%in the picture.

edge_det_pic1 = edge(pic1,'prewitt');%applying edge detection on first picture


%so that we obtain white and black points and edges of the objects present
%in the picture.

edge_det_pic2 = edge(pic2,'prewitt');%%applying edge detection on second picture
```

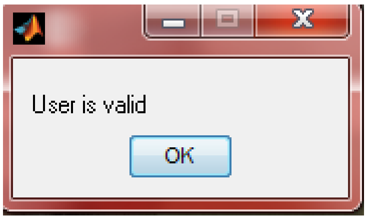
```
figure
subplot(1,2,1);
imshow(edge_det_pic1)
subplot(1,2,2);
imshow(edge_det_pic2)


OUTPUT_MESSAGE = ' Hence the pictures have been matched, SAME PICTURES ';

OUTPUT_MESSAGE2 = ' Hence the pictures have not been matched, DIFFERENT
PICTURES ';

%initialization of different variables used
matched_data = 0;
white_points = 0;
black_points = 0;
x=0;
y=0;
l=0;
m=0;

%for loop used for detecting black and white points in the picture.
for a = 1:1:256
for b = 1:1:256
if(edge_det_pic1(a,b)==1)
white_points = white_points+1;
else
black_points = black_points+1;
end
end
end

%for loop comparing the white (edge points) in the two pictures
for i = 1:1:256
```

```
for j = 1:1:256
if(edge_det_pic1(i,j)==1)&&(edge_det_pic2(i,j)==1)
matched_data = matched_data+1;
else
;
end
end
end


%calculating percentage matching.
total_data = white_points;
total_matched_percentage = (matched_data/total_data)*100;

%outputting the result of the system.
if(total_matched_percentage >= 90)          %can add flexability at this point by reducing the
amount of matching.

total_matched_percentage
OUTPUT_MESSAGE
else

total_matched_percentage
OUTPUT_MESSAGE2
end
```

Chapter 6 : OUTPUT

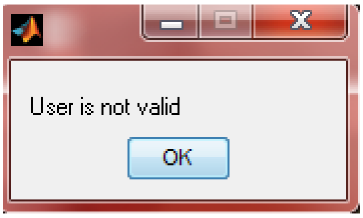
VALID RESULT

When the captured image matches with the Images stored in the array then the result displayed is “User is Valid”



INVALID RESULT

When the captured image does not match with the images stored in the array then the result is “User is not valid”



CONCLUSION AND FUTURE SCOPE.

The above implementation was an effort to understand how Fingerprint Recognition is used as a form of biometric to recognize identities of human beings. It includes all the stages from minutiae extraction from fingerprints to minutiae matching which generates a match score. Various standard techniques are used in the intermediate stages of processing.

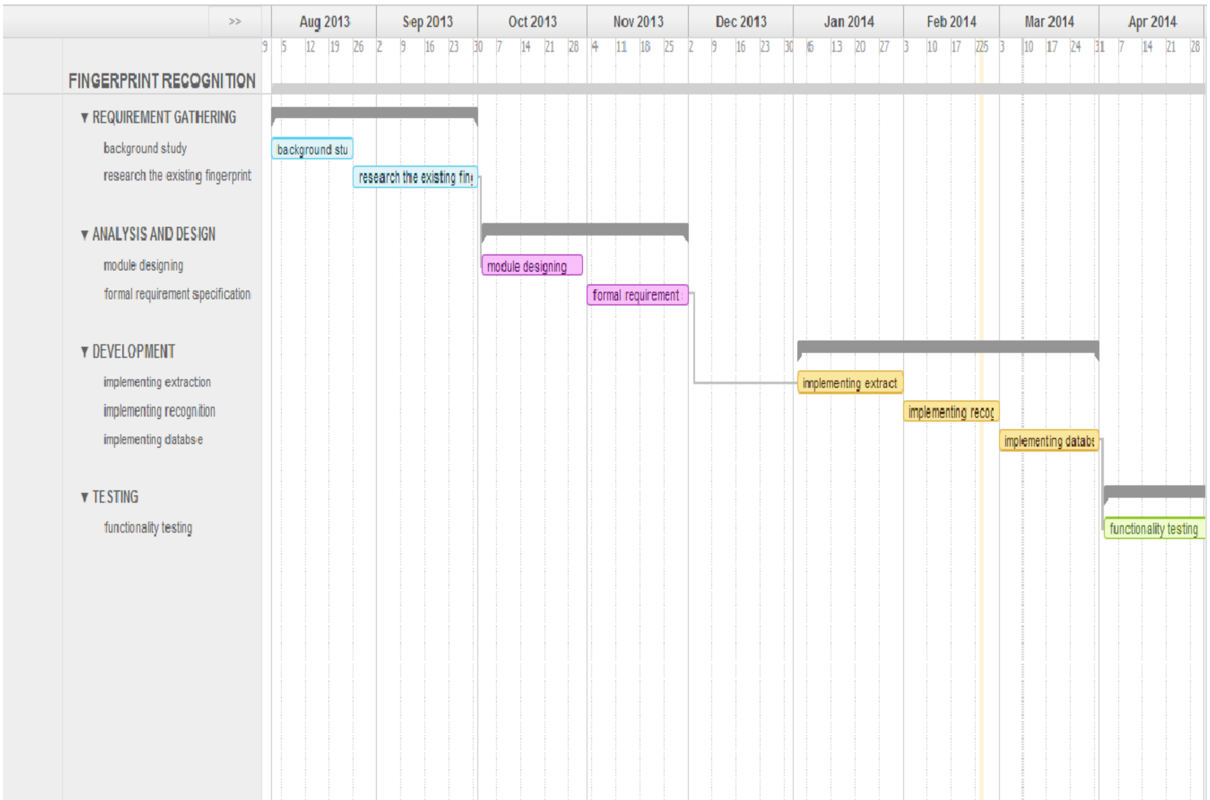
The relatively low percentage of verification rate as compared to other forms of biometrics indicates that the algorithm used is not very robust and is vulnerable to effects like scaling and elastic deformations. Various new techniques and algorithm have been found out which give better results.

Also a major challenge in Fingerprint recognition lies in the pre-processing of the bad quality of fingerprint images which also add to the low verification rate.

As a future scope we can take a large database of images and then make a user interface and match the images accordingly. Such large systems are used in various fields like airlines and industries for employee or people verification.

APPENDICES

APPENDIX A: Work Plan



APPENDIX B : Tools Description

MATLAB is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, you can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java.

You can use MATLAB for a range of applications, including signal processing and communications, image and video processing, control systems, test and measurement, computational finance, and computational biology. More than a million engineers and scientists in industry and academia use MATLAB, the language of technical computing.

Add-on products extend MATLAB for:

- Math, Statistics, and Optimization
- Signal Processing and Communications
- Image Processing and Computer Vision
- Control System Design and Analysis
- C Code Generation

APPENDIX C : Quality Assurance

Quality assurance, or QA for short, is the systematic monitoring and evaluation of the various aspects of a project, service or facility to maximise the probability that minimum standards of quality are being attained by the production process. Two principles included in QA are “ Fit for Purpose” – the product should be suitable for the intended purpose; and “Right first time”- mistakes should be eliminated.

Fit for purpose:
This project is fit for the purpose of developing High security in areas like Airports, Banks, and Hotels etc. It is a step forward to increase the accuracy of touch based fingerprint recognition system to touch-less fingerprint recognition system.

Right first time:
Till now one can only achieve up to 95% of accuracy in figuring out the correct individual using his/ her fingerprints.

Failure Testing:
I will definitely consider the test cases on it so as to increase its accuracy and make it a better project than existing ones.

Programming style and testing:
I have only used Matlab for coding of all the algorithms.

REFERENCES

1.Pooja Gautam and Shubhra gautam Sharma," Touch-less Fingerprint Recognition System at Airports",in proceedings of the 5th National Conference; INDIACom-2011 Computing For Nation Development, March 10 – 11, 2011

2. T. Matsumoto, H. Matsumoto, K. Yamada, and S. Hoshino, "Impact of artificial "gummy" fingers on fingerprint systems", In Proceedings of SPIE Vol. Num.4677, Jan 2002.

3. Bazen, A.M. and Gerez, S.H., "Elastic minutiae matching by means of thin-plate spline models" Pattern Recognition, 2002. Proceedings. 16th International Conference on Vol. 2, pp. 985 - 988, Aug. 2002.

4. Derakhshani R., Schuckers S. A. C., Hornak L., and O'Gorman L. "Determination of vitality from a non-invasive biomedical measurement for use in fingerprint scanners." Pattern Recognition Journal, Vol.36, (2003) 383-396.

5. Hans J. Einighammer and Jens Elnighammer, "System for the Touchless Recognition of Hand and Finger Line", US6404904, 2002.

6. Pantazis Mouroulis, "Visual Instrumentation: Optical Design & Engineering Principles" McGraw-Hill Professional, 1999.

7. Angelopoulou Elli, "Understanding the Color of Human Skin. ", Proceedings of the 2001 SPIE conference on Human Vision and Electronic Imaging VI, SPIE Vol.4299, pp. 243-251, May 2001.

8. Jain A., Lin H. and Bolle R., "On-line Fingerprint Verification," IEEE Trans. On Pattern Analysis and Machine Intelligence, Vol. 19, no. 4, pp.302-314, Apr. 1997.

9. Huvanandana, S., Changick Kim and Jenq-Neng Hwang, "Reliable and fast fingerprint identification for security applications", IEEE International Conference on Image Processing, vol. II, pp. 503-506, Vancouver, Canada, October 2000.