IITB Summer Internship 2013

Project Report

Attachment for Aadhar Authentication on Aaksh

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Summer Internship 2013
Project Approval Certificate

Department of Computer Science and Engineering

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Participants

Abstract

Aadhar authentication is the process wherein the Aadhar number, along with other attributes (demographic/biometrics/OTP) is submitted to UIDAI's Central Identities Data Repository (CIDR) for verification; the CIDR verifies whether the data submitted matches the data available in CIDR and responds with a yes/no. No personal identity information is returned as part of the response. The purpose of authentication is to enable residents to prove their identity and for service providers to confirm that the residents are who they say they are' in order to supply services and give access to benefits. The purpose of the project is to make an optical assembly for Aakash tablet so that it can be used in place of the current fingerprint scanning devices and to get a clear image of a fingerprint by using the tablets camera itself, and this fingerprint is in turn used for the authentication of the Aadhar Id, taking into consideration the cost of the optical device. Also an Image Enhancement Software is developed which will optimize the provided image. More specifically the system is designed in order to reduce the cost and to use the camera on the Aakash tablet for the purpose of fingerprint scanning. Once completed we will try for its application on other tablets and phones as well.

List of Figures

1.1 Block diagram for Aadhar Authentication Process 2

2.1 Image Enhancement Workflow 5
2.2 Sharpened image 6
2.3 Convolution technique 7
2.4 Original Image 9
2.5 Thresholded Image 9
2.6 From left to right: original fingerprint image, binarized image and corresponding thinned image. 10

3.1 Optical assembly attachment for Aakash tablet (Side view) 14
3.2 Optical assembly attachment for Aakash tablet (Top View) 14

4.1 Fingerprint Image 15
4.2 Fingerprint Image 15
4.3 Input Image 16
4.4 Histogram 16
4.5 Histogram 17
4.6 Cropped Image 18
4.7 Histogram 18
4.8 Histogram 18
4.9 Grayscaled Image 19
4.10 Histogram 19
4.11 Resized Image 20
4.12 Histogram 20
4.13 Equalized Image 21
4.14 Histogram 21
4.15 Sharpened Image 22
4.16 Histogram 22
4.17 Thresholded Image 23
4.18 Histogram 23
4.19 Thinned Image 24
4.20 Histogram 24
4.21 Input Image. 25
4.22 Histogram. 25
4.23 Cropped Image. 26
4.24 Histogram. 26
4.25 Grayscaled Image. 27
4.26 Histogram. 27

4.27 Resized Image. 28
4.28 Histogram. 28
4.29 Equalized Image. 29
4.30 Histogram. 29
4.31 Sharpened Image. 30
4.32 Histogram. 30
4.33 Thresholded Image. 31
4.34 Histogram. 31
4.35 Thinned Image. 32
4.36 Histogram. 32
4.37 Histogram. 33
4.38 Histogram. 33
4.39 Histogram. 34
4.40 Histogram. 34
4.41 Histogram. 35
4.42 Histogram. 35
4.43 Histogram. 36
4.44 Histogram. 36
4.45 Histogram. 37
4.46 Histogram. 37

Contents

1 Introduction **1**
- 1.1 Fingerprint Recognition System for Aadhar . . . 1
- 1.2 Aadhar Authentication . . . 2
- 1.3 Workflow of Aadhar authentication . . . 3

2 Image Processing **5**
- 2.1 Conversion of RGB to Gray scale . . . 5
- 2.2 Rescaling . . . 6
- 2.3 Adaptive Histogram equalization of Grey scale . . . 6
- 2.4 Sharpening . . . 6
- 2.5 Thresholding . . . 8
- 2.6 Thinning . . . 10
- 2.7 Brightness . . . 10
- 2.8 Contrast . . . 10
- 2.9 Scilab . . . 11

3 Hardware **13**

4 Experimentation and Results **15**
- 4.1 Experiment 1-With NOKIA 5530 . . . 16
  - 4.1.1 Input RGB Image . . . 16
  - 4.1.2 Cropped Image (Manual) . . . 18
  - 4.1.3 Image Grayscaling . . . 19
  - 4.1.4 Image Resizing . . . 20
  - 4.1.5 Image Adaptive Histogram Equalization . . . 21
  - 4.1.6 Image Sharpening . . . 22
  - 4.1.7 Image Thresholding . . . 23
  - 4.1.8 Image Thinning . . . 24
- 4.2 Experiment 2-With the Aakash Tablet . . . 25
  - 4.2.1 Input RGB Image . . . 25
  - 4.2.2 Cropped Image (Manual) . . . 26
  - 4.2.3 Image Grayscaling . . . 27
  - 4.2.4 Image Resizing . . . 28
  - 4.2.5 Image Adaptive Histogram Equalization . . . 29
  - 4.2.6 Image Sharpening . . . 30
  - 4.2.7 Image Thresholding . . . 31
  - 4.2.8 Image Thinning . . . 32
- 4.3 Experimental Results With Different Number of Leds ON . . . 33

4.3.1 With all LEDs on 33

4.3.1.1 Cropped Image (Manual) 33

4.3.2 With 3 Leds on 34

4.3.2.1 Cropped Image (Manual) 34

4.3.3 With 2 Leds(adjacent) on 35

4.3.3.1 Cropped Image (Manual) 35

4.3.4 With 2 Leds(diagonal) on 36

4.3.4.1 Cropped Image (Manual) 36

4.3.5 With 1 Led on 37

4.3.5.1 Cropped Image (Manual) 37

5 Conclusion and Future Scope **39**

Chapter 1

Introduction

1.1 Fingerprint Recognition System for Aadhar

Aadhar authentication means the process wherein Aadhar Number, along with other attributes, including biometrics, are submitted to the Central Identities Data Repository (CIDR) for its verification on the basis of information or data or documents available with it.

Aadhar authentication service only responds with a yes/no and no personal identity information is returned as part of the response.

Authentication User Agency (AUA): An organization or an entity using Aadhar authentication as part of its applications to provide services to residents. Examples include Government Departments, Banks, and other public or private organizations.

Sub-AUA (SA): An organization or a department or an entity having a business relationship with AUA offering specific services in a particular domain.

Authentication requests emerging from an AUA contains the information on the specific SA. For example, a specific bank providing Aadhar enabled payment transaction through NPCI as the AUA becomes the SA.

Authentication Service Agency (ASA): An organization or an entity providing secure leased line connectivity to UIDAIs data centres for transmitting authentication requests from various AUAs.

Terminal Devices: Terminal devices are devices employed by SAs/AUAs (both government and non-government) to provide services to the residents.

Authentication Factors:

Demographic data (name, address, date of birth etc.)
Biometric data (fingerprint image)
PIN
OTP
Possession of mobile

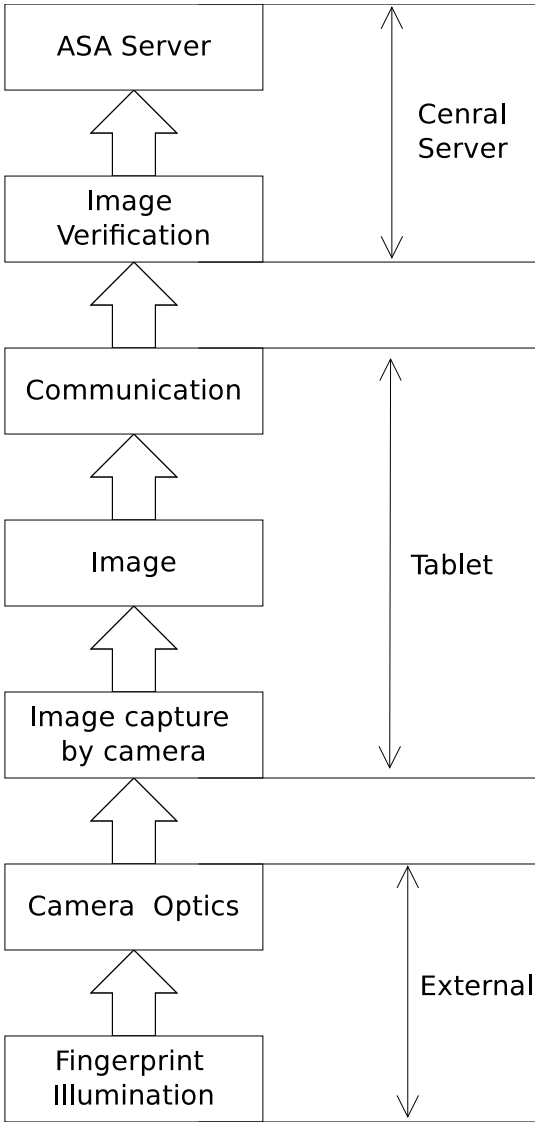

Figure 1.1: Block diagram for Aadhar Authentication Process

1.2 Aadhar Authentication

Aadhar Number

The Unique Identification (Aadhar) Number, which identifies a resident, will give individuals the means to clearly establish their identity to public and private agencies across the country. Three key characteristics of Aadhar Number are:

1. Permanency (Aadhar number remains same during lifetime of a resident)

2. Uniqueness (one resident has one ID and no two residents have same ID)

3. Global (same identifier can be used across applications and domains)

Aadhar Number is provided during the initiation process called enrolment where a residents demographic and biometric information are collected and uniqueness of the

provided data is established through a process called de-duplication.

Post reduplication, an Aadhar Number is issued and a letter is sent to resident informing the details.

1.3 Workflow of Aadhar authentication

1. The hardware attached on the top of tablets camera takes the clear image for fingerprint authentication (biometric detail).

2. Resident provides Aadhar Number, necessary demographic and biometric details to terminal devices belonging to the AUA/SA (or merchant/operator appointed by AUA/SA) to obtain a service offered by the AUA/SA.

3. Aadhar authentication enabled application software that is installed on the device packages these input parameters, encrypts, and sends it to AUA server over either a mobile/broadband network using AUA specific protocol.

4. AUA server, after validation adds necessary headers (AUA specific wrapper XML with license key, transaction id, etc.), and passes the request through ASA server to UIDAI CIDR.

5. Aadhar authentication server returns a yes/no based on the match of the input parameters.

6. Based on the response from the Aadhar authentication server, AUA/SA conducts the transaction. [1]

Chapter 2

Image Processing

The steps involved in image processing are

1. Conversion of RGB to Gray scale
2. Rescaling
3. Adaptive Histogram equalization of Grey scale
4. Sharpening
5. Thresholding
6. Thinning

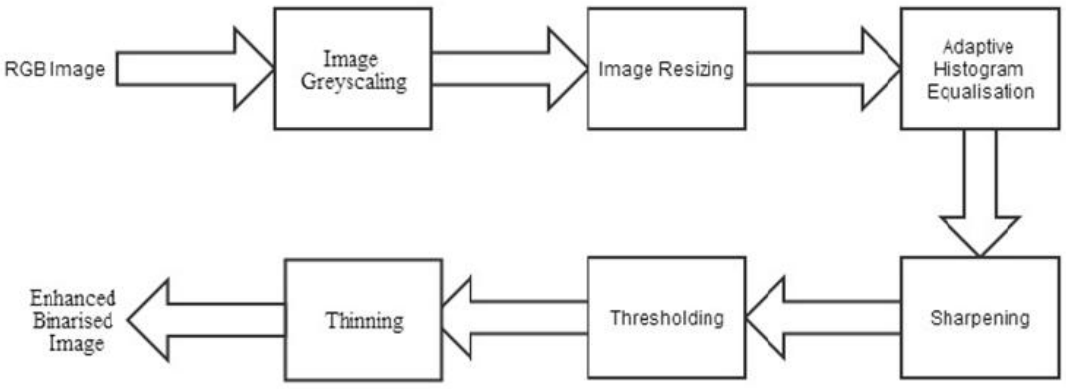

Figure 2.1: Image Enhancement Workflow

2.1 Conversion of RGB to Gray scale

(a) The R, G and B values for each pixel are obtained.
(b) The average of these three values is calculated.
(c) Each pixel is reassigned this average value.

2.2 Rescaling

It is a process of resizing of the image.

2.3 Adaptive Histogram equalization of Grey scale

Adaptive histogram equalization(AHE) is a computerimage processingtechnique used to improvecontrastin images. It differs from ordinaryhistogram equalizationin the respect that the adaptive method computes severalhistograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image. It is therefore suitable for improving the local contrast of an image and bringing out more detail.

2.4 Sharpening

Sharpening an image means to make the differences between the neighboring pixels more noticeable. Sharpening brings out the details of an image. Sharpening can be done by kernel based convolutions.

In image processing a kernel, is a small matrix which is useful for blurring, sharpening, embossing, edge-detection, and more. A kernel is a 2D matrix of numbers that can be used as coefficients for numerical operations on pixels.

Figure 2.2: Sharpened image

The third picture is a sharpened version of the original (first) image.

Sharpening involves the following steps:

1. Read the original image.
2. Choose the image processing technique-sharpening.
3. Choose the corresponding kernel to do the sharpening.
4. Apply the above kernel to the image matrix using convolution.
5. Display the sharpened image.

The advantages of sharpening are that it brings out the details of an image, it makes the picture smudge free and it emphasizes on the texture of the image.

The disadvantages of sharpening are that over-sharpening can spoil the originality of an image and by sharpening the smoothness of the image is lost.

For sharpening one of the most commonly used methods is Laplacian kernel.

The advantages of using laplacian kernel is that since the kernel is usually much smaller than the image, this method usually requires far fewer arithmetic operations and also, the Laplacian kernel is known in advance so only one convolution needs to be performed at run-time on the image.

The disadvantage of Laplacian kernel is that it is sensitive to noise.
To reduce the noise, the image is often Gaussian smoothed before applying the Laplacian filter.

How convolution is done:

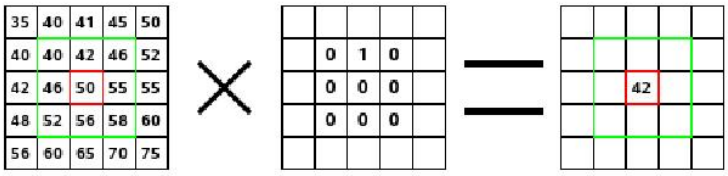

Figure 2.3: Convolution technique

Complexity of Laplacian Kernel:

Time Complexity=O(27 x m x n^2)

m=size of the image

n^2 = *multiplicationcomplexity*

Space Complexity=O (m x 24)

m=size of the image

Another technique for doing sharpening is unsharp masking.

The general algorithm is for unsharp masking is:

1. Blur the original.
2. Subtract the blurred image from the original (the resulting difference image is called the "mask").
3. Amplify the difference.

4. Add the mask to the original.
5. The resulting image (original plus mask) will appear "sharper"

Blurring can be done in different ways:
1. Using bilateral filter
2. Using median filter
3. Using mean filter

The general algorithm is the same for all of the above techniques.
They vary in their method of blurring.

The disadvantages of unsharp masking is that there are many steps and choices so the complexity is more. If we want to sharpen the edges then convolution is better since in unsharp masking everything is sharpened, not just the edges where sharpening is most needed. Also by doing unsharp masking the noise is amplified. One convolution has to be applied to blur the image. In unsharp masking the number of multiplication steps is more because there are more steps in unsharp masking, as first we have to blur the image and then we multiply again to enhance the details. Hence multiplication complexity increases.

2.5 Thresholding

Otsu Thresholding

Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for thepixel levels each side of the threshold, i.e. the pixels that either fall inforeground or background. The aim is to find the threshold value where the sum of foreground and background spreads is at its minimum.

Find the threshold that minimizes the weighted within-class variance depending upon the weight,mean and variance of the background and foreground pixels and it gives better results than any other thresholding technique.

Algorithm:

1.Compute histogram and probabilities of each intensity level.
2.Set up initial weights and mean.
3.Step through all possible thresholds maximum intensity.
a.Update weight and mean.
b.Compute variance.
c.Compute within class variance.
4.Desired threshold corresponds to the minimum within class variance.

Results:

Figure 2.4: Original Image

Orignal Image
(300*336)pixels
Size:47 kb

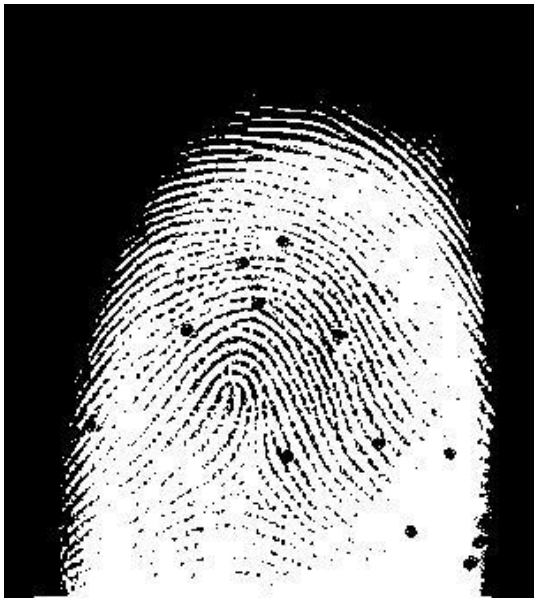

Figure 2.5: Thresholded Image

After Otsu Thresholding
(300*336)pixels
Size:29.9 kb

The advantage of Otsu method is that it produces more accurate results.

The disadvantages of Otsu method is that it has lots of calculation involved in calculating weight,mean and variance.The histogram (and the image) are bimodal. The method assumes stationary statistics and cannot be modified to be locally adaptive. It assumes uniform illumination so the bimodalbrightness behavior arises from object appearance differences only.

2.6 Thinning

Fingerprint image thinning is a very important step in fingerprint recognition algorithms. In this step the ridge lines of the fingerprint image are transformed to a one-pixel thickness. This process is fundamental for finger- print recognition algorithms, as thinned images are easier to process, and reduce operations processing time.

As thinning does not change the structure of the finger- print image and preserves the locations of the fingerprint ridge and valley features, it makes easier to identify the global and local features of the fingerprint image (such as Core, Delta, Minutiae points) that are used for finger- print classification, recognition and matching. [6]

Figure 2.6: From left to right: original fingerprint image, binarized image and corresponding thinned image.

2.7 Brightness

Brightness can be calculated as:

Brightness=(0.2126*r) +(0.7152*g) +(0.0722*b)

2.8 Contrast

(Maximum Brightness-Minimum Brightness) / (Maximum Brightness+Minimum Brightness)

2.9 Scilab

Scilab is an open source; cross-platform numerical computation package. It can be used for signal processing, image and video processing, numerical optimization and modeling and simulation of explicit and implicit systems. We made use of Scilab because it is an open source platform and provides good processing results.Image processing and enhancement needs packages like IPD and SIVP needed to installed separately. [7]

Chapter 3

Hardware

It is the optical assembly mounted over the camera of the Aakash tablet.

Apparatus used:

Black acrylic (3 mm thick)
Transparent acrylic (3 mm thick, 32.5mm x 35 mm)
PCB
LEDs (4 quantity, 3 mm thick)
Resistors (4 quantity, 220 ohms)
Wires
Driller
Soldering gun
Soldering wire
Hack saw
File
Polishing paper
Adapter (Output voltage: 5V DC)

Assembly consists of 3 parts-

1. Clamp: To fix the assembly, with the tablet over the camera and also to hold the spacer.

2. Spacer: To maintain a certain distance between the camera and fingerprint, such that a clear and consistent image is taken.

3. Optical: To illuminate the finger, while fingerprint image has to be taken.

Clamp : It is made of black acrylic (opaque) which fits directly onto the camera of the Aakash tablet and there is also spacer holding capability of the clamp.

Spacer : To get better focusing of the image, there should be a certain distance between the finger and the camera. I have taken distance as 30 mm. I got this value by making cardboard prototypes of different heights of the spacer. Spacer is mounted on the clamp.

Optical : This part is to actually implement the FTIR (frustrated total internal re-

flection) principle for fingerprint recognition. This consists of two parts-

1. PCB : On this, leds are mounted just next to the acrylic plate on which fingerprint has to be kept. When we need to take the fingerprint image, LEDs glow and due to FTIR principle we get a fingerprint image which differentiates between the ridges and valleys of the finger.

2. Lid : To cover the PCB so that outside light does not affect the fingerprint image.

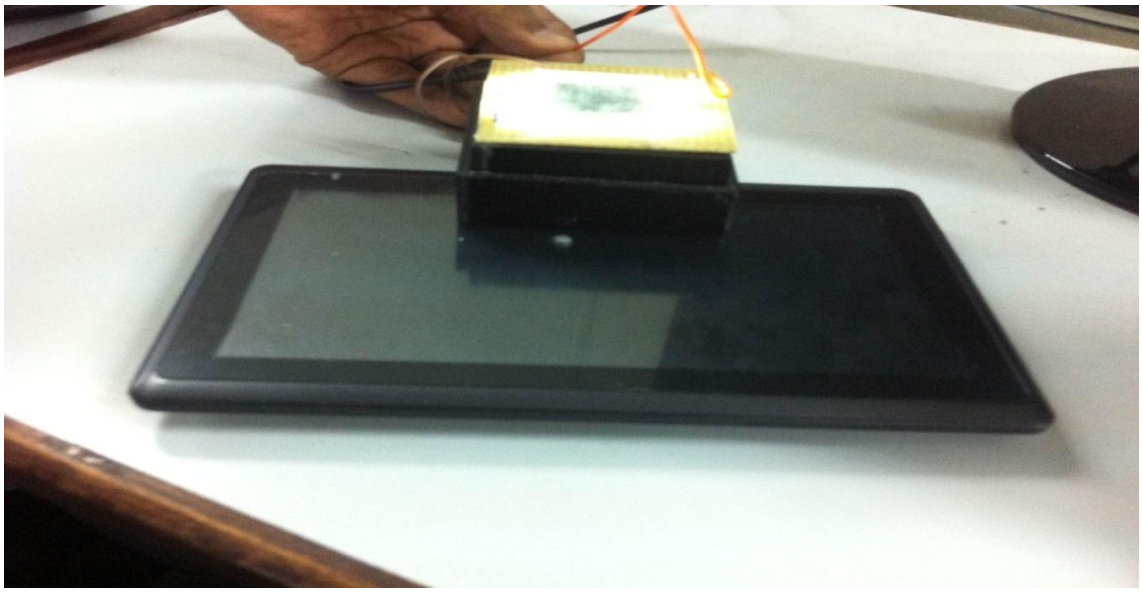

Figure 3.1: Optical assembly attachment for Aakash tablet (Side view)

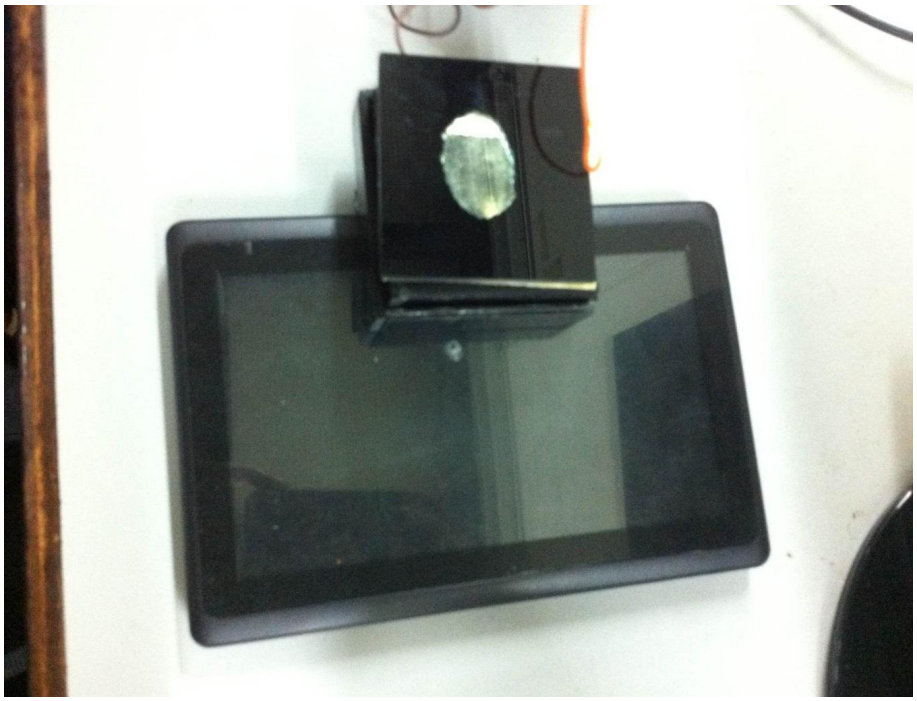

Figure 3.2: Optical assembly attachment for Aakash tablet (Top View)

Chapter 4

Experimentation and Results

Comparison of fingerprint image taken with optical assembly and without optical assembly:

Without Optical assembly:

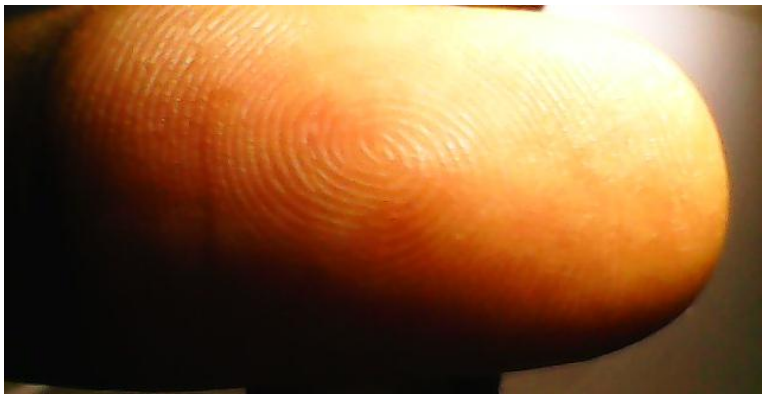

Figure 4.1: Fingerprint Image

With Optical Assembly:

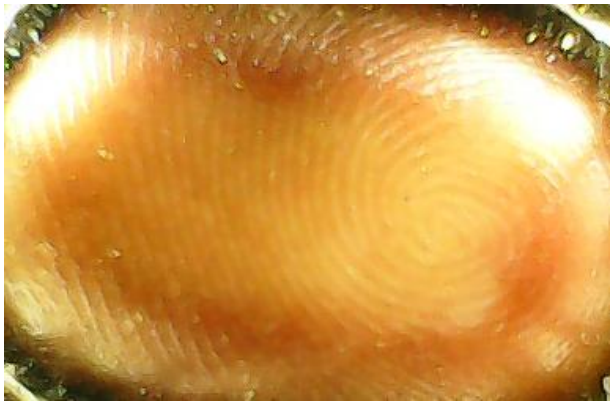

Figure 4.2: Fingerprint Image

4.1 Experiment 1-With NOKIA 5530

4.1.1 Input RGB Image

Figure 4.3: Input Image

Specifications:

Dimension:2048x1536
Size:233 KB
DPI:300
Filetype:.jpg
Colour Representation:RGB(values from 0 TO 255)
Exposure time:1/167 SECONDS
Focal Length:4 mm
Camera Specification:3.0 Megapixel

Image Histogram:

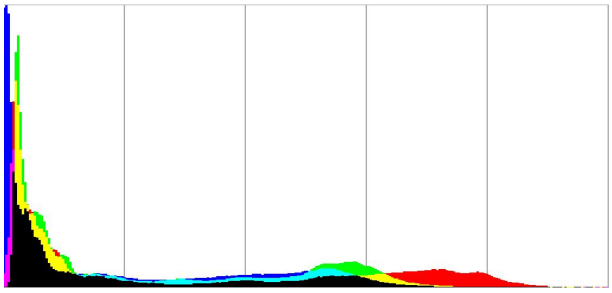

Figure 4.4: Histogram

Brightness Histogram:

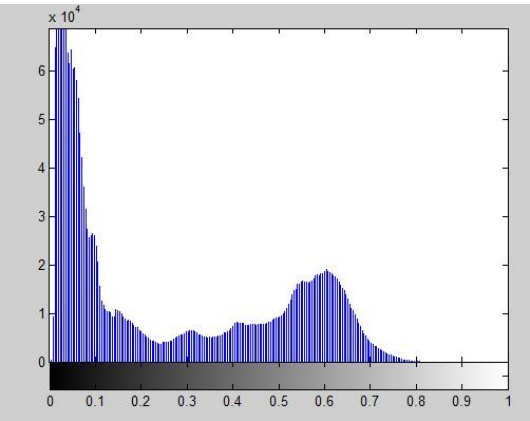

Figure 4.5: Histogram

4.1.2 Cropped Image (Manual)

Figure 4.6: Cropped Image

Specifications:

Dimension:836x639
Size:64.2 KB
DPI:300
Filetype:.jpg
Contrast:0.8822

Image Histogram:

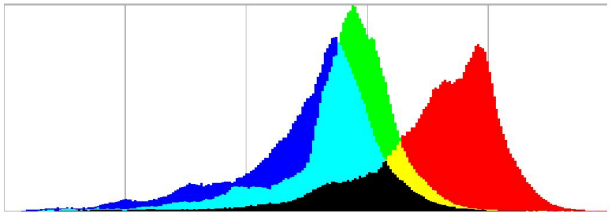

Figure 4.7: Histogram

Brightness Histogram:

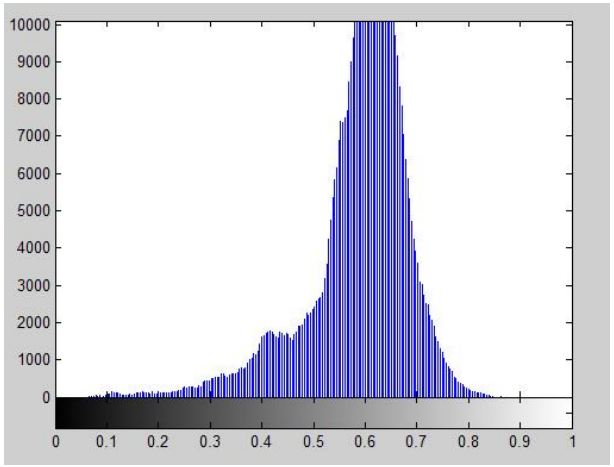

Figure 4.8: Histogram

4.1.3 Image Grayscaling

Figure 4.9: Grayscaled Image

Specifications:

Dimension:836x639
Size:46 KB
DPI:300
Filetype:.jpg

Image Histogram:

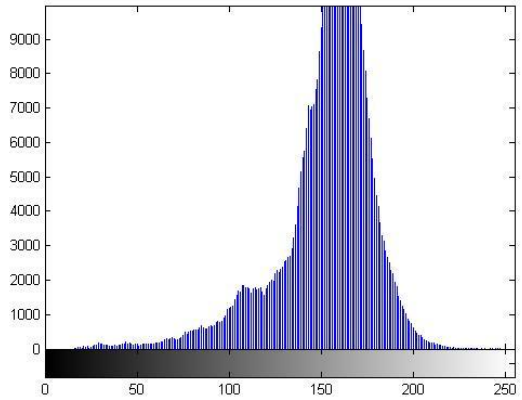

Figure 4.10: Histogram

4.1.4 Image Resizing

Figure 4.11: Resized Image

Specifications:

Dimension:300x200
Size:6.02 KB
DPI:300
Filetype:.jpg

Image Histogram:

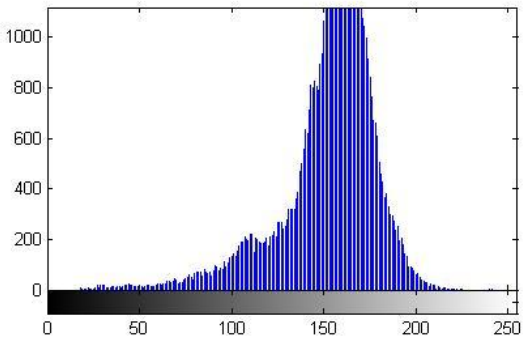

Figure 4.12: Histogram

4.1.5 Image Adaptive Histogram Equalization

Figure 4.13: Equalized Image

Specifications:

Dimension:300x200
Size:12.1 KB
DPI:300
Filetype:.jpg

Image Histogram:

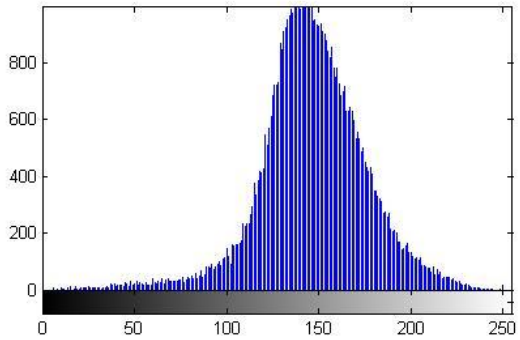

Figure 4.14: Histogram

4.1.6 Image Sharpening

Figure 4.15: Sharpened Image

Specifications:

Dimension:300x200
Size:22.4 KB
DPI:300
Filetype:.jpg

Image Histogram:

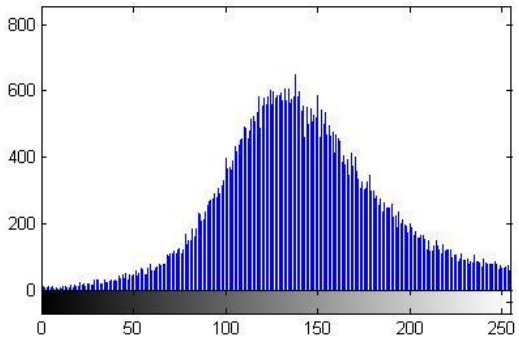

Figure 4.16: Histogram

4.1.7 Image Thresholding

Figure 4.17: Thresholded Image

Specifications:

Dimension:300x200
Size:37.1 KB
DPI:300
Filetype:.jpg

Image Histogram:

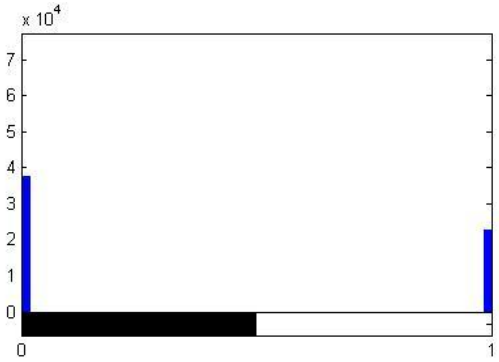

Figure 4.18: Histogram

4.1.8 Image Thinning

Figure 4.19: Thinned Image

Specifications:

Dimension:300x200
Size:36.6 KB
DPI:300
Filetype:.jpg

Image Histogram:

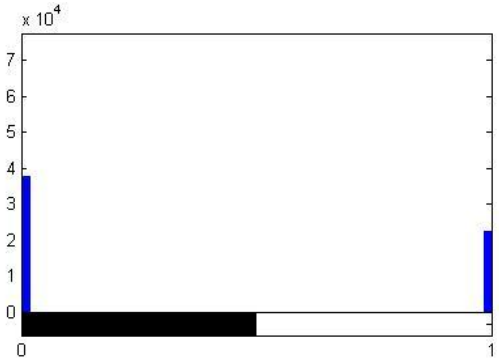

Figure 4.20: Histogram

4.2 Experiment 2-With the Aakash Tablet

4.2.1 Input RGB Image

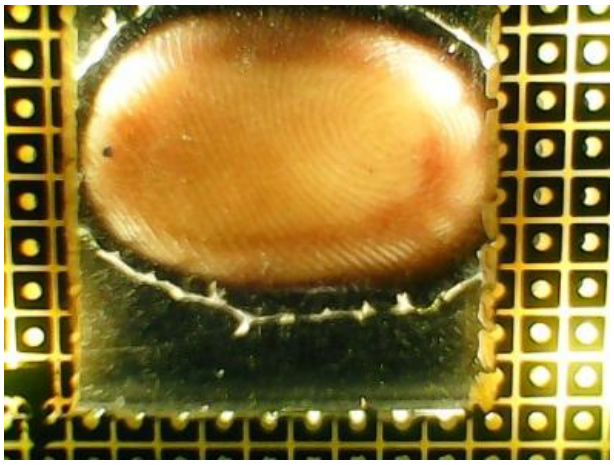

Figure 4.21: Input Image.

Specifications:

Dimension:640x480
Size:159 KB
DPI:96
Filetype:.jpg
Colour Representation:RGB(values from 0 TO 255)
Camera Maker: MID 001
Focal Length:3 mm
Camera Specification:0.3 MEGAPIXELS VGA

Image Histogram:

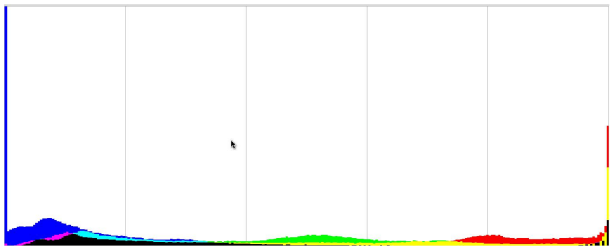

Figure 4.22: Histogram.

4.2.2 Cropped Image (Manual)

Figure 4.23: Cropped Image.

Specifications:

Dimension:334x222
Size:16.1 KB
DPI:96
Filetype:.jpg
Contrast:0.7853

Image Histogram:

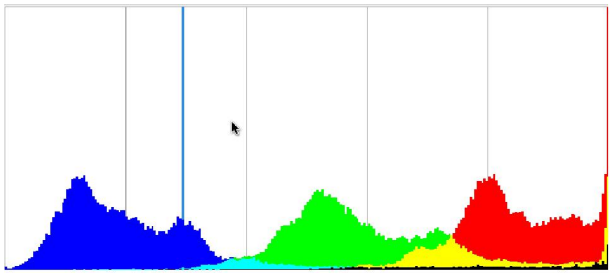

Figure 4.24: Histogram.

4.2.3 Image Grayscaling

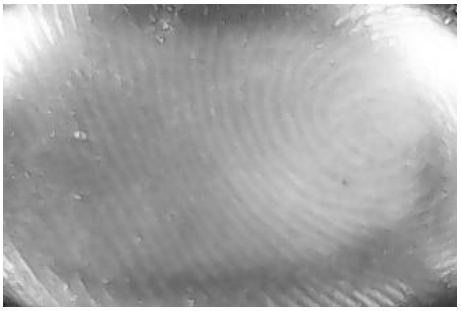

Figure 4.25: Grayscaled Image.

Specifications:

Dimension:334x222
Size:6.66KB
DPI:96
Filetype:.jpg

Image Histogram:

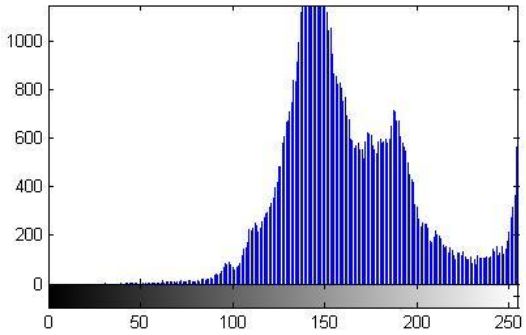

Figure 4.26: Histogram.

4.2.4 Image Resizing

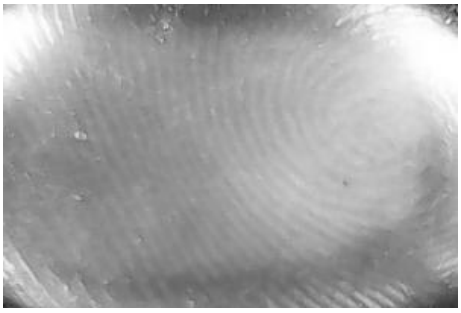

Figure 4.27: Resized Image.

Specifications:

Dimension:300x200
Size:5.77 KB
DPI:96
Filetype:.jpg

Image Histogram:

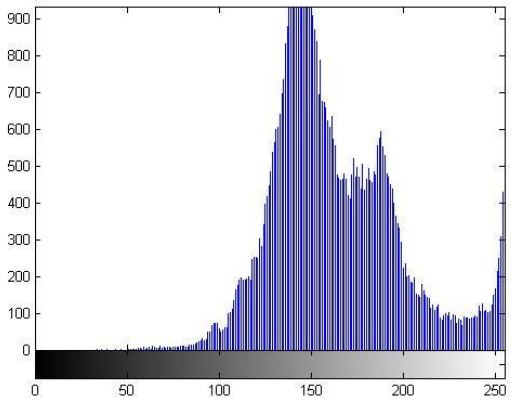

Figure 4.28: Histogram.

4.2.5 Image Adaptive Histogram Equalization

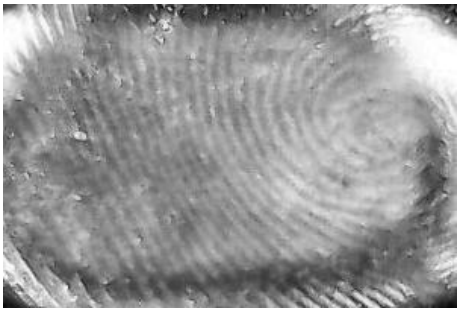

Figure 4.29: Equalized Image.

Specifications:

Dimension:300x200
Size:10.8 KB
DPI:96
Filetype:.jpg

Image Histogram:

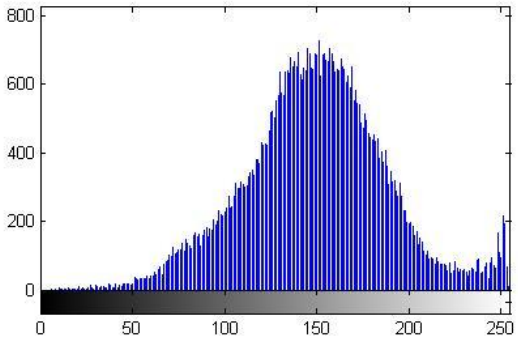

Figure 4.30: Histogram.

4.2.6 Image Sharpening

Figure 4.31: Sharpened Image.

Specifications:

Dimension:300x200
Size:19.2 KB
DPI:96
Filetype:.jpg

Image Histogram:

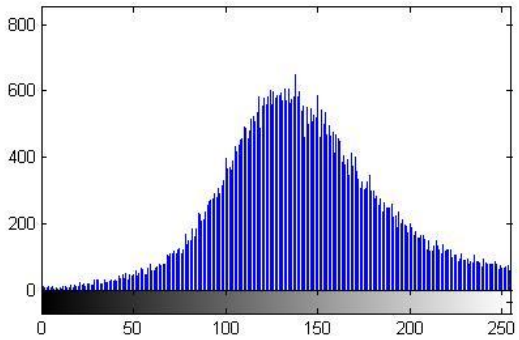

Figure 4.32: Histogram.

4.2.7 Image Thresholding

Figure 4.33: Thresholded Image.

Specifications:

Dimension:300x200
Size:31.9 KB
DPI:96
Filetype:.jpg

Image Histogram:

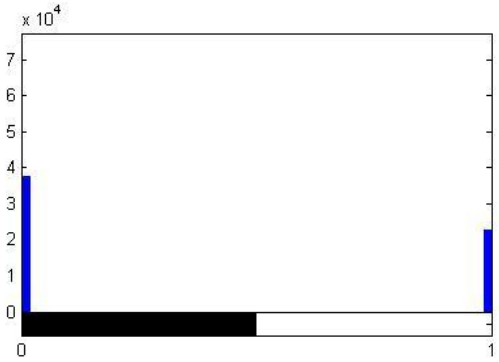

Figure 4.34: Histogram.

4.2.8 Image Thinning

Figure 4.35: Thinned Image.

Specifications:

Dimension:300x200
Size:31.0 KB
DPI:96
Filetype:.jpg

Image Histogram:

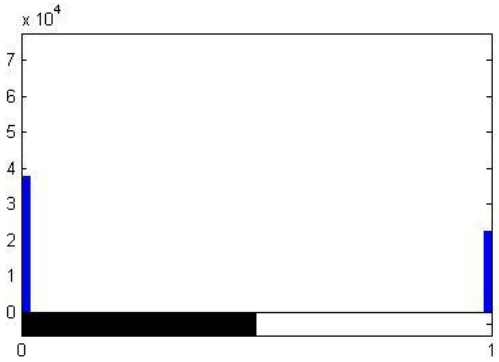

Figure 4.36: Histogram.

4.3 Experimental Results With Different Number of Leds ON

4.3.1 With all LEDs on

4.3.1.1 Cropped Image (Manual)

Figure 4.37: Histogram.

Specifications:

Dimensions:386 x 398
Size:219 KB
DPI:96
File Type:.jpg

Image Histogram:

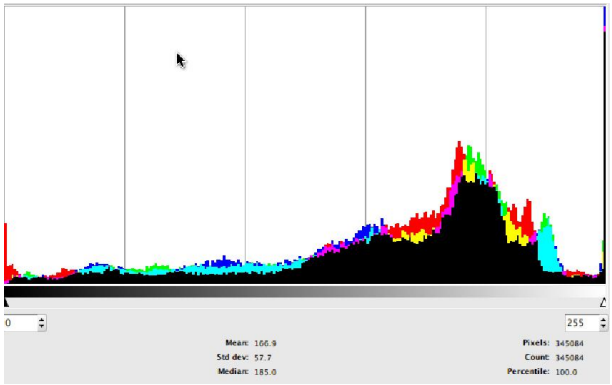

Figure 4.38: Histogram.

4.3.2 With 3 Leds on

4.3.2.1 Cropped Image (Manual)

Figure 4.39: Histogram.

Specifications:

Dimensions:447x 315
Size:29 KB
DPI:96
File Type:.jpg

Image Histogram:

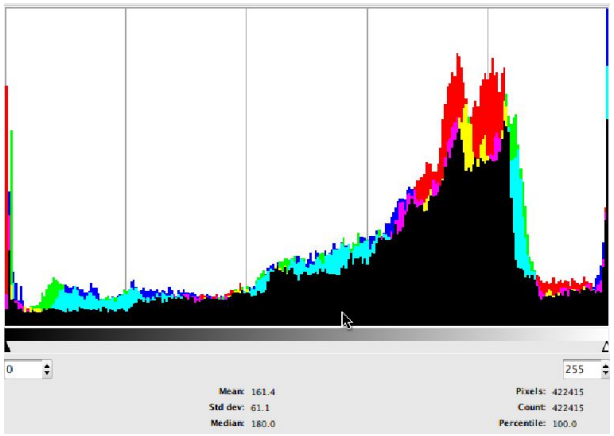

Figure 4.40: Histogram.

4.3.3 With 2 Leds(adjacent) on

4.3.3.1 Cropped Image (Manual)

Figure 4.41: Histogram.

Specifications:

Dimensions:452x323
Size:30.4 KB
DPI:96
File type:.jpg

Image Histogram:

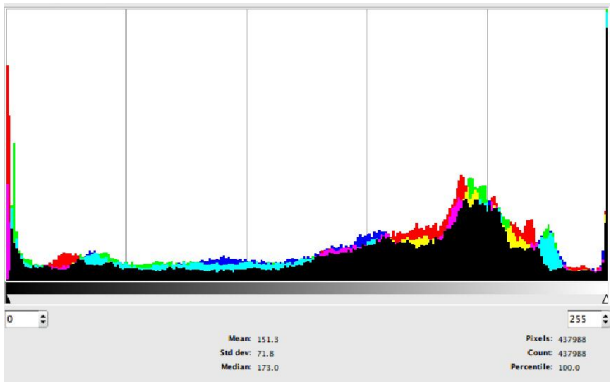

Figure 4.42: Histogram.

4.3.4 With 2 Leds(diagonal) on

4.3.4.1 Cropped Image (Manual)

Figure 4.43: Histogram.

Specifications:

Dimensions:427x291
Size:24.3 KB
DPI:96
File type:.jpg

Image Histogram:

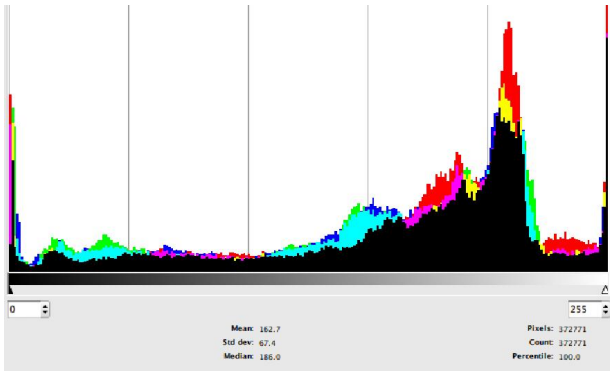

Figure 4.44: Histogram.

4.3.5 With 1 Led on

4.3.5.1 Cropped Image (Manual)

Figure 4.45: Histogram.

Specifications:

Dimensions:449x310
Size:27.8 KB
DPI:96
File type:.jpg

Image Histogram:

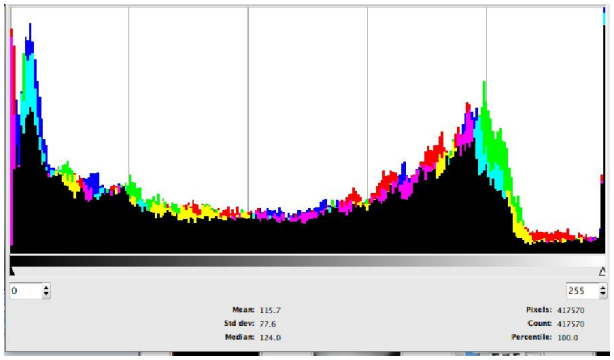

Figure 4.46: Histogram.

Chapter 5

Conclusion and Future Scope

In today's world, it is important to be secure from every possible area which has threads of being attacked. With emerging technology the security can be much effectively used.

The reliability of any automatic fingerprint system strongly relies on the precision obtained in the minutia extraction process. A number of factors are detrimental to the correct location of minutia. Among them, poor image quality is the most serious one. In this project, wehave combined many methods to build a minutia extractor and a minutia matcher. The following concepts have been used- segmentation using Morphological operations, minutia marking byespecially considering the triple branch counting, minutia unification by decomposing a branch into three terminations and matching in the unified x-y coordinate system after a 2-step transformation in order to increase the precision of the minutia localization process and elimination of spurious minutia with higher accuracy.

The proposed alignment-based elastic matching algorithm is capable of finding the correspondences between minutiae without resorting to exhaustive research.

There is a scope of further improvement in terms of efficiency and accuracy which can be achieved by improving the accuracy of the optical assembly by testing with IR and SMD LEDs so as to capture better image or by improving the image enhancement techniques so that the input image to the thinning stage could be made better which could improve the future stages and the final outcome.

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