PVPAS: Palm Vein Pattern Authentication System

A End-semester project report submitted in partial fulfillment of the requirements for the award of

Bachelor of Technology

By

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Declaration

Project Title: **PVPAS: Palm Vein Pattern Authentication System**

Degree for which the End-Sem project report is submitted: **B.Tech.**

We declare that the presented End-sem project report represents largely our own ideas and work in our own words. Where others ideas or words have been included, we have adequately cited and listed in the reference materials. The documentation has been prepared without resorting to plagiarism. We have adhered to all principles of academic honesty and integrity. No falsified or fabricated method or data have been presented in the documentation. We understand that any violation of the above will cause for disciplinary action by the Institute, including revoking the conferred degree, if conferred, and can also evoke penal action from the sources which have not been properly cited or from whom proper permission has not been taken.

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CERTIFICATE

It is certified that the work contained in this project entitled **PVPAS: Palm Vein Pattern Authentication System** *submitted by* **Abhishek Bhowal(12-1-5-009), Shruti Datta Gupta(13-1-5-004), Utkarsh Jain(13-1-5-040), Abu Saleh Fahmid Islam(13-1-5-066), Muralidhar Nagalla(13-1-5-071), Anand Kumar(13-1-5-086)** *for the award of B.Tech is absolutely based on their own work carried out under my supervision and that this implementation has not been submitted elsewhere for any degree/diploma.*

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Finally, we believe this research cum real-life time implementation experience will greatly benefit our career in the future.

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Abstract

Authentication is a process in which the credentials provided are compared to those on file in a database of authorized users' information on a local operating system or within an authentication server. If the credentials match, the process is completed and the user is granted authorization for access. Palm Vein Pattern Authentication technology is one of the newest biometric techniques researched today. Biometrics, such as with vein recognition, refers to methods for recognizing individual people based on unique physical and behavioral traits. Vein recognition is a type of biometrics that can be used to identify individuals based on the vein patterns in the human palm. Vein recognition biometric devices can also be used for PC login, bank ATM identification verification, and many other applications such as opening car doors. The vein detection process consists of taking a snapshot of the subjects veins under a source of infrared radiation at a specific wavelength and processing the snapshot under certain algorithms and a system to provide user access.

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Chapter 1

Introduction

In the ubiquitous network society, where individuals can easily access their information anytime and anywhere, people are also faced with the risk that others can easily access the same information anytime and anywhere. Because of this risk, personal identification technology, which can distinguish between registered legitimate users and imposters, is now generating interest. Currently, passwords, personal identification numbers (4-digit pin numbers) or identification cards are used for personal identification. However, cards can be stolen, and passwords and numbers can be guessed or forgotten. To solve these problems, biometric authentication technology, which identifies people by their unique biological information, that is their physical and behavioral traits, is attracting attention. In biometric authentication, an account holders body characteristics or behaviors (habits) are registered in a database and then compared with others who may try to access that account to see if the attempt is legitimate. Palm vein authentication technology is one of the newest biometric techniques researched today.

1.1 Motivation

Vein information is internal to the human body and is very hard to duplicate, thereby providing a high level of security. Palm vein pattern authentication offers contact less authentication and provides a hygienic and non-invasive solution. Owing to its advantages over the other existing biometric technologies, palm vein pattern authentication has been a much researched technology in the past few years.

1.2 Scope

As often noted in literature, palm vein pattern based technology is an attractive branch of biometrics due to its following advantages:

- Uniqueness and permanence of the pattern.
- Anti-counterfeit: Vascular patterns are preset underneath the skin making it almost impossible to forge or copy.
- Active liveliness: Vein information disappears with biological tissues losing liveliness.
- Traceless technology: The biometric parameter is hidden from general view.
- Durable: Does not change in time like the face or iris.
- Non-contact detection procedure.
- FAR - False Acceptance Rate (people authenticated as someone else) is less than 0.00008 [1].

However, this method is still under extensive research, and still too recent to be properly assessed. The scanner is relatively bulky compared to fingerprint sensor.

1.3 Purpose

Our basic objective is to design a vascular pattern based biometric system which has two purposes: authentication and identification. We aim to design a system which consists of an easy to implement device that takes a snapshot of the subjects veins.

- This report gives an effective overview of a Palm Vein Authentication System. For this concern we have studied the related work on this through several research papers taken the outcomes of evaluation of experiments on those resources.

- Using the existing technologies we have tried an hardware as as well as an software implementation of how our system works and we further go through the ideas which have described on the research papers and evaluated proposed algorithms.

1.4 Organization

This report is organized as follows: Section 2 describes the literature review. Section 3 describes the Palm Vein Principles. Section 4 how the algorithms work. Section **??** contains the system design both hardware and software. Section 6 discusses the observations of our system algorithm and it contains the required results. Section 7 concludes our work and it presents what can be further done in future.

1.5 How Our Goal Is Achieved?

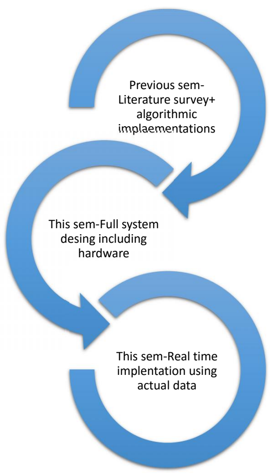

Figure 1.1: Our road-map.

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Chapter 2

Literature Review

2.1 Detailed Discussion

The below discussion gives a brief overview of why biometrics and to deep why palm biometrics is being preferred over other existing technologies and also our direction to algorithmic implementation.

2.1.1 Why Biometrics?

Biometrics authentication [2] is a growing and controversial field in which civil liberties groups express concern over privacy and identity issues. Today, biometric laws and regulations are in process and biometric industry standards are being tested. Automatic recognition based on who you are as opposed to what you know (PIN) or what you have (ID card). Recognition of a person by his body then linking that body to an externally established identity forms a very powerful tool for identity management biometric recognition.

2.1.2 Existing Technologies

- **Face Recognition Technology:** Human individuality is often identified using faces, advancements in computing capability over the past few decades now enable similar recognitions. Recognition process has now matured into a science of sophisticated mathematical representations and matching processes from geometric model. Face recognition can be used for both verification and identification (open-set and closed-set). Facial recognition is achieved by means of comparing the rigid features of face, which do not change over a period of time.It can also be achieved by comparing other parameters such as skin tone against the information that are stored in the facial database.

- **Iris Recognition Technology:** Iris is a muscle within the eye that regulates the size of the pupil, controlling the amount of light that enters the eye. It is the colored portion of the eye with coloring based on the amount of melanin pigment within the muscle. Although the coloration and structure of the iris is genetically linked, the details of the patterns are not. The iris develops during prenatal growth through a process of tight forming and folding of the tissue membrane. Prior to birth, degeneration occurs, resulting in the pupil opening and the random, unique patterns of the iris. Although genetically identical, an individuals irides are unique and structurally distinct, which allows for it to be used for recognition purposes.

- **Voice Recognition Technology:** Speaker, or voice, recognition is a biometric modality that uses an individuals voice for recognition purposes. The speaker recognition process relies on features influenced by both the physical structure of an individuals vocal tract and the behavioral characteristics of the individual. A popular choice for remote authentication due to the availability of devices for collecting speech samples and its ease of integration, speaker recognition is different from some other biometric methods in that speech samples are captured dynamically or over a period of time, such as a few seconds. Analysis occurs on a model in which changes over time are monitored, which is similar to other behavioral biometrics such as dynamic signature, gait, and keystroke recognition. The unique patterns of an individuals voice is then produced by the vocal tract. The vocal tract consists of the laryngeal pharynx, oral pharynx, oral cavity, nasal pharynx, and the nasal cavity. It is these unique patterns created by the vocal tract which is used by voice recognition systems. Even though people may sound alike to the human ear, everybody, to some degree, has a different or unique annunciation in their speech.

2.2 Comparison To Palm Vein

While other types of biometric scanners are more popular for security systems, Vascular scanners are growing in popularity. Fingerprint scanners are more frequently used, but they generally do not provide enough data points for critical verification decisions [10]. Since fingerprint scanners require direct contact of the finger with the scanner, dry or abraded skin can interfere with the reliability of the system. Skin diseases, such as psoriasis can also limit the accuracy of the scanner, not to mention direct contact with the scanner can result in need for more frequent cleaning and higher risk of equipment damage. Vascular scanners do not require contact with the scanner, and since the information they read is on the inside of the body, skin conditions do not affect the accuracy of the reading. Vascular scanners also work with extreme speed, scanning in less than a second. As they scan, they capture the unique pattern veins take as they branch through the hand. Compared to the Retinal Scanner, which is more accurate than the vascular scanner, the retinal scanner has much lower popularity, because of its intrusive nature. People generally are uncomfortable exposing their eyes to an unknown light, not to mention retinal scanners are more difficult to install, since variances in height and face angle must be accounted for.

2.3 Review Of Main Algorithms Used

Papers	Description	Research Direction
ORB: An efficient alternative to SIFT and Surf [5]	Developed an effective key-points selector compared to other ones	Key-points detection to image matching using image matchers.
CLAHE algorithm [8] and binarization of images using otsus algorithm [6]	The first one developed a method for distribution of histogram in limited color space and the second one, automatic selection of threshold .	Efficient histogram equalization and adaptive thresholding respectively.

2.4 Currently Implemented

Fujitsu has developed a palm vein pattern based authentication system which has been implemented in a few banks in Japan. They tested their system using the data of 140,000 palms from 70,000 individuals and the results revealed a false acceptance rate of less than 0.00008 and a false rejection rate of 0.01 [1]. In addition, the devices ability to perform authentication was verified using the following:

- Data from people ranging from 5 to 85 years old.
- People from different occupations.
- Data taken from foreigners in Japan.
- Data taken in various situations in daily life, including after drinking alcohol, taking a bath, going outside, waking up etc.

Chapter 3

Palm Vein Principles

3.1 Principles of Vascular Pattern Authentication

Hemoglobin in the blood is oxygenated in the lungs and carries oxygen to the tissues of the body through the arteries. After it releases its oxygen to the tissues, the de oxidized hemoglobin returns to the heart through the veins. These two types of hemoglobin have different rates of absorbency. De oxidized hemoglobin absorbs light at a wavelength of about 760 nm in the near-infrared region. When infrared ray image is captured, the de oxidized hemoglobin in the palm veins absorbs this light, and appears as a series of black lines. Based on this feature, the region used for authentication is photographed with near-infrared light, and the vein pattern is extracted by image processing and registered. The vein pattern of the person being authenticated is then verified using authenticated pattern.

3.2 Advantages of Using The Palm

- Since each individual has a unique vascular pattern, vein authentication can be done by using the pattern on the back of the hand or a finger as well.

- However, the palm is the most accessible part of the human body, and the palm vein pattern is the most complex and covers the widest area.

- The palm has no hair and has no significant variations in complexion, making it easier to capture the vein pattern.

3.3 Methods of Capturing Veins

There are two methods of photographing veins:

- Reflection
- Transmission

3.3.1 A Comparison

- While the former illuminates the palm and photographs the light that is reflected back from the palm, the latter method photographs light that passes straight through the hand. When the body cools down due to a lowered ambient temperature, the blood vessels contract, decreasing the flow of the blood through the body. This increases the hands light transmittance, which, if too high, will result in a lighter, less contrasted image using transmission photography in which it is difficult to see the vessels. But a high light transmittance does not affect the level or contrast of the reflected light, due to which, with the reflection method, the vessels can be easily seen even when the hand/body is cool.

- In reflection method, the illumination and photography components can be positioned in the same place although in transmission method they have to be placed in different locations.

- The system configurations of the two methods are also different. The reflection method illuminates the palm and takes photographs reflected back from the palm, so the illumination and photography components can be positioned in the same place. Again, because the transmission method photographs light that passes through the hand, the illumination and photography components must be placed in different locations. This makes it difficult for the system to be embedded into smaller devices such as notebook PCs or cellular phones.

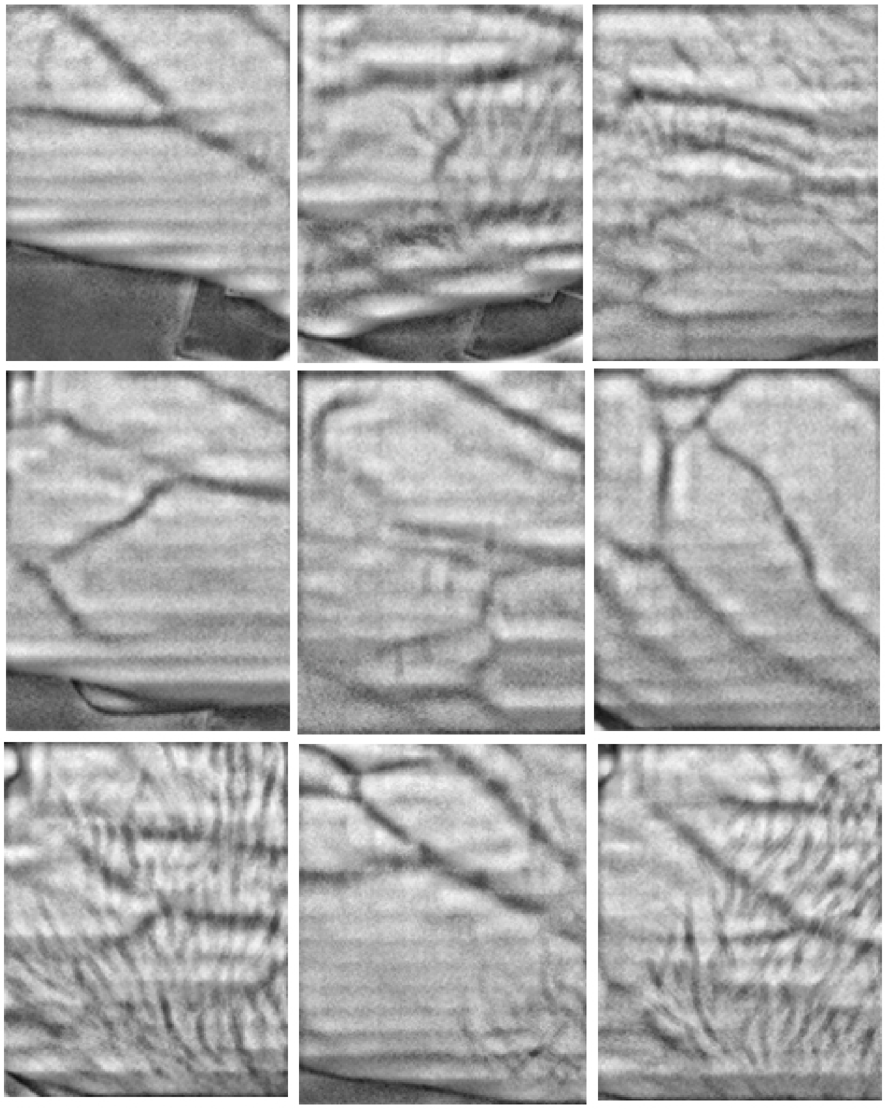

Figure 3.1: Dorsal palm vein patterns for different persons using IR-imaging(reflection photography).

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Chapter 4

Algorithms

This chapter primarily focuses on the various algorithms used in the process, a detailed discussion of how it works. But first, we need to know what are key points in an image and what is feature extraction in our image matching authentication process.

4.1 Key Points and Feature Extraction

An interest point or key point is a point in the image which in general can be characterized as follows:

- It has a clear, preferably mathematically well-founded, definition.
- It has a well-defined position in image space.
- The local image structure around the interest point is rich in terms of local information contents (e.g.: significant 2-D texture), such that the use of interest points simplify further processing in the vision system.
- It is stable under local and global perturbations in the image domain as illumination/brightness variations, such that the interest points can be reliably computed with high degree of repeatability.
- Optionally, the notion of interest point should include an attribute of scale, to make it possible to compute interest points from real-life images as well as under

scale changes.

Feature extraction a type of dimensionality reduction that efficiently represents interesting parts of an image as a compact feature vector. This approach is useful when image sizes are large and a reduced feature representation is required to quickly complete tasks such as image matching and retrieval. Image descriptors are used to compare key-points between two different images.

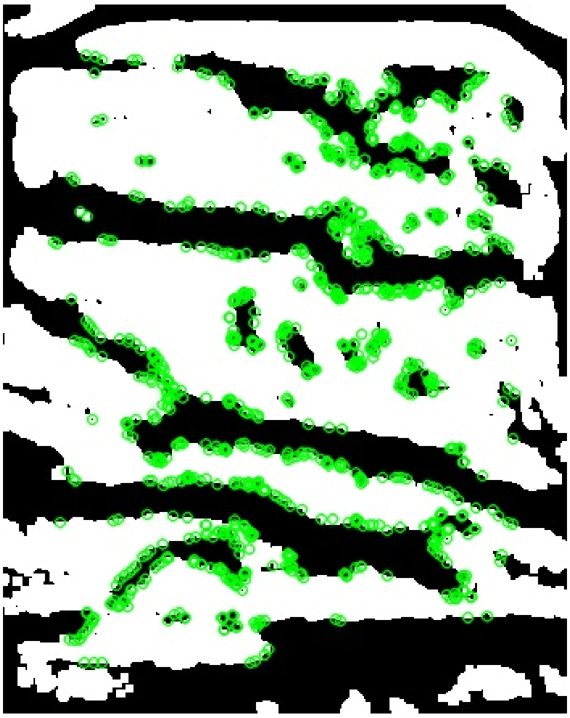

Figure 4.1: Illustrative figure showing valuable points(key-points) in vein-extracted image.

4.2 ORB: Oriented FAST and rotated BRIEF

Ethan Rublee, Vincent Rabaud , Kurt Konolige and Gary Bradski in [5] developed an efficient algorithm for key point selector. ORB is basically a fusion of FAST(which itself is an another algorithm) key point detector and BRIEF(again another algorithm) descriptor with many modifications to enhance the performance. First it uses FAST to find key points, then applies Harris corner measure to find top N points among them.

It also uses pyramid to produce multi-scale-features. But in our process we have taken the hamming distance as the similarity measure. So in a nutshell ORB is composition of two algorithms which are:

4.2.1 FAST

Features from Accelerated Segment Test(FAST) algorithm is used here for corner detection in the images. The method for corner detection using FAST algorithm was proposed by Edward Rosten and Tom Drummond in [11]. A basic summary of the FAST algorithm is presented below.

- Select a pixel ρ in the image which is to be identified as an interest point or not. Let its intensity be ß.
- Select appropriate threshold value γ.
- Then we consider a circle of 16 pixels around the pixel under testing.
- Now the pixel ρ is a corner if there exists a set of 'n' contiguous pixels in the circle (of 16 circles) which are all brighter than ß+γ, or all darker than ß-γ. (shown as white dashed line)

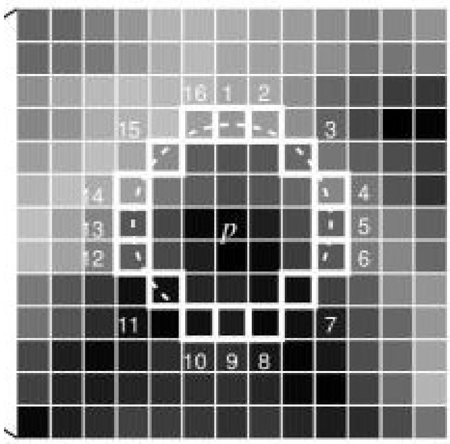

Figure 4.2: Corner detection using FAST.

4.2.2 Rotated BRIEF

Michael Calonder, Vincent Lepetit, Christoph Stecha and Pascal Fua in [12] developed a easy method for calculating binary strings within image patch(patch is an arbitrary shaped region). ORB uses BRIEF(Binary Robust Independent Elementary Features) descriptors. It provides a shortcut to find the binary strings directly without finding descriptors. It takes smoothened image patch and selects a set of n (x,y) location pairs in an unique way. Then some pixel intensity comparisons are done on these location pairs. For eg, let first location pairs be p and q. If the intensity of p is less than that of q, then its result is 1, else it is 0. This is applied for all the n location pairs to get a n-dimensional bit-string.

Using these two mentioned algorithms ORB computes the intensity weighted centroid of the patch with located corner at center. The direction of the vector from this corner point to centroid gives the orientation. To improve the rotation invariance, moments are computed with which should be in a circular region of radius r, where r is the size of the patch.

4.3 Otsu

Otsu algorithm is used for image binarization. Neeraj Bharghava, Dr.Ritu Bharghava and Anchal Kumawat in [6] developed an algorithm for automatic optimum threshold calculation for an image using otsu. In simple words, it automatically calculates a threshold value from image histogram for a bimodal image. (For images which are not bimodal, binarization wont be accurate.) The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal, or equivalently (because the sum of pairwise squared distances is constant), so that their inter-class variance is maximal.

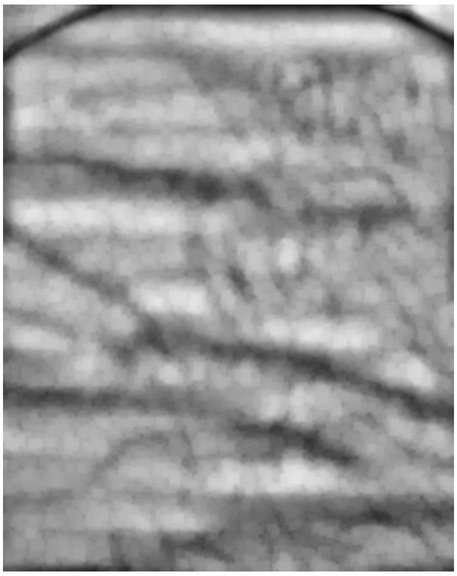

Figure 4.3: Extracted vein image(IR-imaging) before thresholding.

Figure 4.4: After thresholding using otsu.

4.4 CLAHE

CLAHE stands stands for contrast adaptive limited histogram equalization. M.Sasi and V.K Jayshree in [8] developed an efficient histogram equalization technique. Normal histogram equalization considers the global contrast of the image. In many cases, it is not a good idea because most of the information is lost due to over brightness. So to solve this problem, adaptive histogram equalization is used. In this, image is divided into small blocks called "tiles". Then each of these blocks are histogram equalized as usual. So in a small area, histogram would confine to a small region (unless there is noise). If noise is there, it will be amplified. To avoid this, contrast limiting is applied. If any histogram bin is above the specified contrast limit, those pixels are clipped and distributed uniformly to other bins before applying histogram equalization. After equalization, to remove artifacts in tile borders, bilinear interpolation is applied.

Figure 4.5: Extracted vein image(IR-Image) showing region of interest.

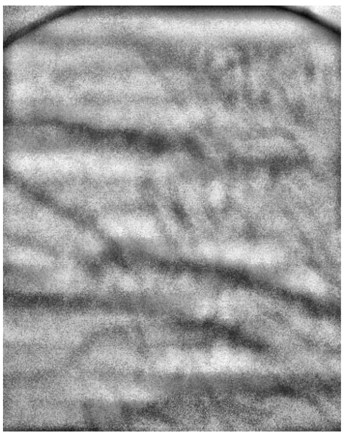

Figure 4.6: Histogram equalization after using CLAHE.

4.5 Gaussian Blur

Gaussian blur [13] or gaussian filter is applied in image processing as a smoothening filter. Basically its the result of blurring an image by a gaussian function. This approach is a widely used effect in graphics software, typically to reduce image noise and reduce detail.

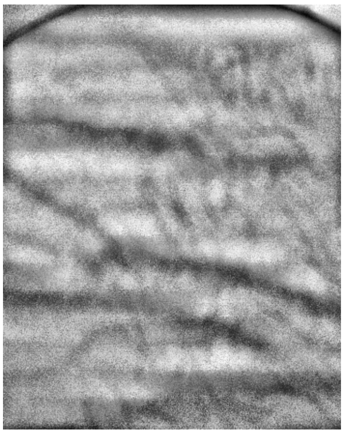

Figure 4.7: Extracted vein image(IR-Image) before gaussian blur .

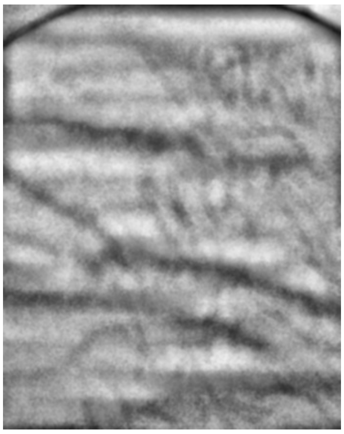

Figure 4.8: Extracted vein image(IR-Image) after gaussian blur.

4.6 KNN Matcher

KNN matcher is a subset of brute force matcher. Brute force matcher is simple and easy to implement. It takes the descriptor of one feature in first set and is matched with all other features in second set using some distance calculation. And the closest one is returned. For brute force matcher, first we have to create the matcher object. It takes two optional parameters. First one is normal type. It specifies the distance measurement to be used. For binary string based descriptors like BRIEF, hamming distance is to be used. Second parameter is a boolean variable, which is false by default. If it is true, matcher returns only those matches with value (i,j) such that i-th descriptor in set A has j-th descriptor in set B as the best match and vice-versa. Once the optional parameters are created, two important methods are used. First one returns the best match. Second method returns k best matches where k is specified by the user. It can be useful when we need to do additional work on that.

Chapter 5

System Design

This chapter focuses on the whole system design which is primarily composed of hardware design cintaining modules as well as console-based software system. In the below sections this is discussed in details.

5.1 Hardware Design

The basic hardware modules that are used in this implementation are Raspberry Pi module and Raspberry Pi NoIR Camera module. The NoIR camera module is used to capture the infrared image of the subjects veins. This image is then processed in the Raspberry Pi using various image processing algorithms as discussed and the result gets stored in the database for further use.

5.1.1 Raspberry-Pi

It is a single board computer which is very easy to implement and to work with. Also it works as a central module of the whole embedded image capturing and processing system of our syatem. Its main parts include:

- Main Processing chip (Broadcom BCM2837 SOC)
- Memory : 2GB

- Internal Storage : 32GB
- OS : Debian 8 Jessie
- Power supply, HDMI out, Ethernet port, USB Ports and other interfaces.

In the whole process we have used the V3 B+ model of raspberry-pi. An authentication system using raspberry pi is fast enough to run the image scanning algorithms and the data stream can flow smoothly between the camera and the raspberry pi board.

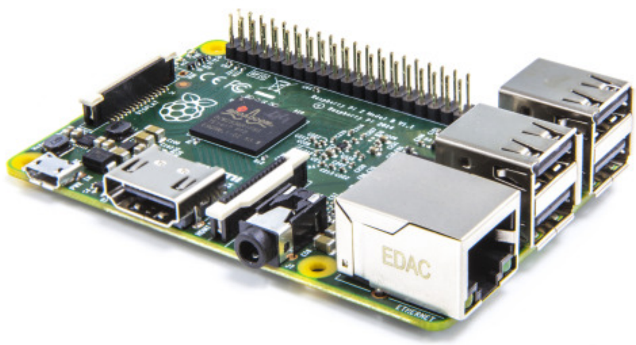

Figure 5.1: Our raspberry pi module.

5.1.2 Raspberry Pi NoIR Camera V2:

The V2 Pi NoIR has a Sony IMX219 8MP Sensor and can connect to the Raspberry Pi directly with Camera Serial Interface(CSI). The Pi Cam is used to capture the infrared image of the palm vein pattern of the individual, which can then be processed further.

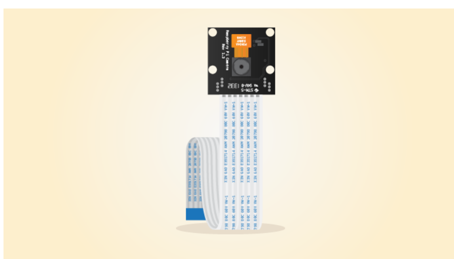

Figure 5.2: Our pi camera module.

5.1.3 IR LEDs:

The IR LEDs that are used are of 180mW power output and the range of the radiation is between 750-890nm.

5.1.4 Full Hardware Design

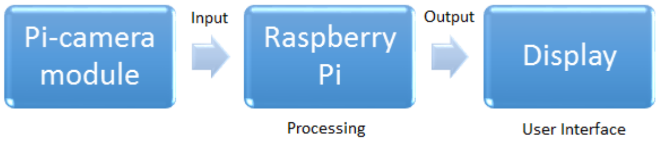

Figure 5.3: Our connecting modules.

5.2 Software Design

Our software design consists as follows:

5.2.1 User Interface:

It is used for client side interaction. The user is first prompted to select the function that he/she wishes the system to perform, i.e., add a new data, login to the system, delete a record or exit. A new user enters his/her name, roll number and places their palm on the scanner for the camera to take the infrared photograph of the vein pattern. For login, the user again has to enter their name, roll number and get their vein pattern scanned, which is then used for authentication. The roll number of user is used as an index in the database) User Interface: It is used for client side interaction. The user is first prompted to select the function that he/she wishes the system to perform, i.e., add a new data, login to the system, delete a record or exit. A new user enters his/her name, roll number and places their palm on the scanner for the camera to take the infrared photograph of the vein pattern. For login, the user again has to enter their name, roll number and get their vein pattern scanned, which is then used for authentication. The roll number of user is used as an index in the database. The user interface is console based on the raspberry-pi.

Figure 5.4: Console based interface in raspberry pi.

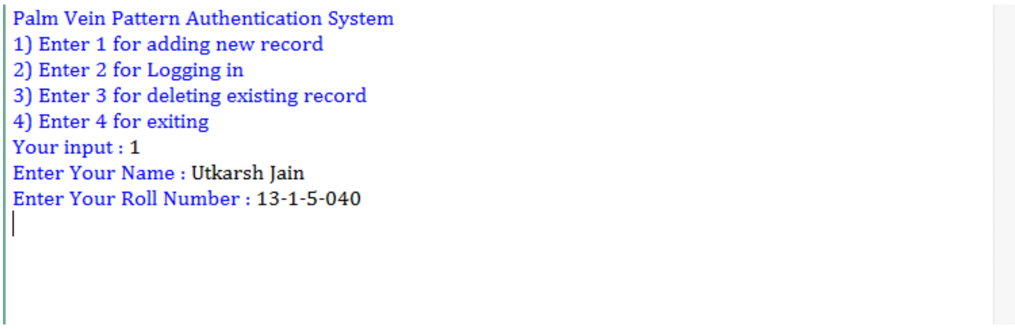

Figure 5.5: Console based interface in raspberry pi.

5.2.2 Image Processing: What Is Practically Happening?

This is the second step in our software design where algorithms used are coded in **python** for matching and storing the scanned image. The scanned images are matched with that stored in the database for authentication. We have used **OpenCV** which is an open source computer vision library. The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. The captured image is processed through the following serially followed steps that are depicted in the below figure.

- **CLAHE Histogram Equalizer:** Firstly, this increases the image contrast for better visibility of veins.

- **Gaussian Blur:** Then after the second step, this method is used to reduce the noise in the image.

- **Otsu Binarization:** Now, this method is used to convert the image to black and white image.

- **ORB:** Lastly, this method is used to extract the key-points and descriptors for the image. The descriptors are then stored in the database.

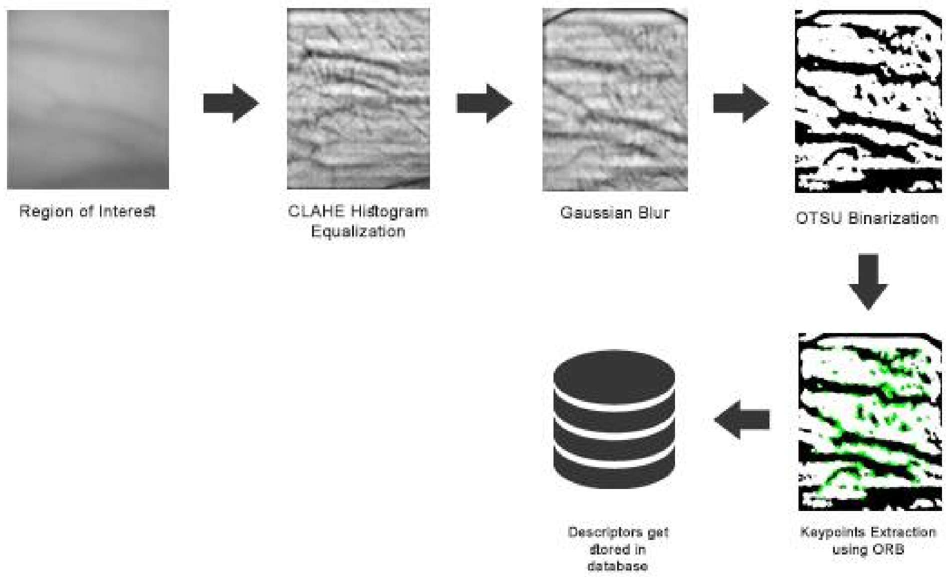

Figure 5.6: Our image processing technique.

5.2.3 User Repository

It stores the personal details for the user and descriptors for the palm vein image.

- **MongoDB:** MongoDB is an open-source document database and leading NoSQL database.

- **PyMongo:** PyMongo is a python distribution containing tools for working with MongoDB, and is the recommended way to work with MongoDB from Python.

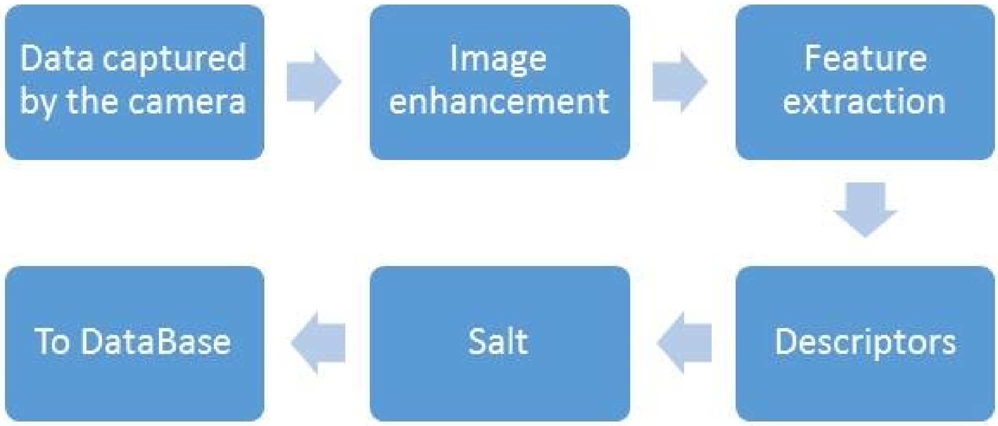

Figure 5.7: How the data flows.

5.3 An overview

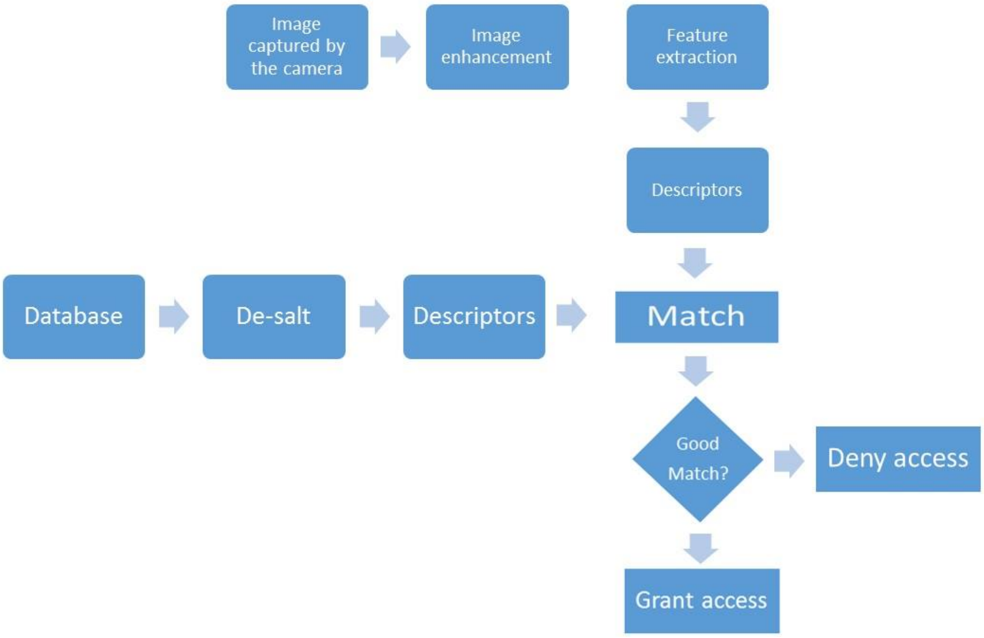

Figure 5.8: All functional modules.

Chapter 6

Results

This chapter is based on the real obsevations obtained based on the false-acceptance rate(FAR) and the false-rejection rate(FRR). But before going to that we need to know what actually they are and few more parameters.

6.1 FAR

The false acceptance rate, or FAR, is the measure of the likelihood that the biometric security system will incorrectly accept an access attempt by an unauthorized user. A system's FAR typically is stated as the ratio of the number of false acceptances divided by the number of identification attempts.

6.2 FRR

The false rejection rate is the measure of the likelihood that the biometric security system will incorrectly reject an access attempt by an authorized user. A system's FRR typically is stated as the ratio of the number of false rejections divided by the number of identification attempts.

The FRR and FAR can be adjusted in accordance with the image threshold and security level requirements.

6.3 Threshold

It is the minimum number of good matches that should exists between a training image and testing image.

6.4 Ratio

The probability that a match is correct can be determined by taking the ratio of distance from the closest neighbor of the key point to the distance of the second closest neighbor is known as ratio test.

6.5 Observed FAR and FRR

SL NO	RATIO	THRESHOLD	FAR (%)	FRR (%)
1	0.5	75	0	100
2	0.6	75	0	100
3	0.65	75	0	100
4	0.70	75	0	100
5	0.75	75	0	100
6	0.80	75	0	20
7	0.80	100	0	70
8	0.85	100	100	0
9	0.85	150	40	20

Figure 6.1: FRR and FAR calculation using suitable threshold.

Chapter 7

Conclusion & Future works

7.1 Conclusion

Thus we conclude our report that we have implemented an Palm Vein Pattern Authentication System using dorsal vein imaging using the hardware described above and basic console based system. We have taken into account the combination of various algorithms which we thought would be the best in our whole project work. The combination process is our own idea and based on that the findings are written.

7.2 Future Works

In future we will try to implement a proper GUI based system which can be used an IoT device so that it can be implemented in our institute for student attendance.

7.3 Discussion

It is observed from the above results that the above system is efficient for small database systems, however the effect of this system on large-scale database is yet to be known.

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Appendix I

Source Code

file is indexMain.py

```
from pymongo import MongoClient
import numpy as np
import cv2
import re
import time
import os
import picamera
import base64
cv2.ocl.setUseOpenCL(False)
client = MongoClient('localhost', 27017)
db = client.userDatabase
collection = db.userData
captureImage = False

def rollIsCorrect(rollNo):
    matchObj = re.match(r'[0-9][0-9]-[0-9]-[0-9]-[0-9][0-9][0-9]',rollNo,
        re.I)
    if matchObj:
```

```
        return True
    return False


def alreadyExist(rollNo):
    cursor = db.userData.find({"roll_no": rollNo})
    if cursor.count() != 0:
        return True
    return False


def addData():
    name = raw_input("Enter␣Your␣Name␣:␣")
    while True:
        rollNo = raw_input("Enter␣Your␣Roll␣Number␣:␣")
        if rollIsCorrect(rollNo):
            break
        else:
            print "Roll␣No.␣is␣not␣in␣correct␣format!␣Please␣Enter␣again."
    if alreadyExist(rollNo):
        print "User␣with␣this␣roll␣number␣already␣exists!"
    else:
        startScan = raw_input("Place␣your␣hand␣on␣the␣scanner␣and␣press␣1␣
            :␣")
        if startScan == "1":
            print "Capturing␣Image!␣do␣not␣remove␣your␣hand!"
            with picamera.PiCamera() as camera:
                camera.resolution = (1280,720)
                camera.framerate = 32
                camera.iso = 100
                time.sleep(1)
                camera.capture('test.jpg')
            image_base = cv2.imread("test.jpg",0)
            image = image_base[240:600, 450:800]
```

```
        os.remove("test.jpg")
        print "Image␣Captured!␣You␣can␣now␣remove␣your␣hand!"
        cv2.imwrite("roi.jpg",image)
        #orb = cv2.ORB_create(nfeatures = 1000)
        clahe = cv2.createCLAHE(clipLimit=4.0, tileGridSize=(16,16))
        equ = clahe.apply(image)
        equ = clahe.apply(equ)
        cv2.imwrite("equalized.jpg",equ)
        blur = cv2.GaussianBlur(equ,(5,5),0)
        cv2.imwrite("gaussian.jpg",blur)
        kernel = np.ones((5,5),np.uint8)
        opening = cv2.morphologyEx(blur, cv2.MORPH_OPEN, kernel)
        cv2.imwrite("opening.jpg",opening)
        ret,th = cv2.threshold(opening,0,255,cv2.THRESH_BINARY+cv2.
            THRESH_OTSU)
        cv2.imwrite("threshold.jpg",th)
        string =cv2.imencode(".jpg",th)[1]
        b64 = base64.b64encode(string)
        post = {
            "user_name": name,
            "roll_no": rollNo,
            "image_str":b64,
        }
        collection.insert_one(post)
        cv2.destroyAllWindows()
        print "User␣Successfully␣Added!!"
    else:
        print "Wrong␣input!␣Start␣Again.."

def deleteData():
    name = raw_input("Enter␣Your␣Name␣:␣")
    while True:
```

```
        rollNo = raw_input("Enter␣Your␣Roll␣Number␣:␣")
        if rollIsCorrect(rollNo):
            break
        else:
            print "Roll␣No.␣is␣not␣in␣correct␣format!␣Please␣Enter␣again."
    if alreadyExist(rollNo):
        db.userData.delete_one({"roll_no":rollNo})
        print "User␣Deleted␣Successfully!"
    else:
        print "User␣Does␣not␣Exists!"

def login():
    name = raw_input("Enter␣Your␣Name␣:␣")
    while True:
        rollNo = raw_input("Enter␣Your␣Roll␣Number␣:␣")
        if rollIsCorrect(rollNo):
            break
        else:
            print "Roll␣No.␣is␣not␣in␣correct␣format!␣Please␣Enter␣again."
    if alreadyExist(rollNo):
        startScan = raw_input("Place␣your␣hand␣on␣the␣scanner␣and␣press␣1␣
            :␣")
        if startScan == "1":
            print "Capturing␣Image!␣do␣not␣remove␣your␣hand!"
            with picamera.PiCamera() as camera:
                camera.resolution = (1280,720)
                camera.framerate = 32
                camera.iso = 100
                time.sleep(1)
                camera.capture('test.jpg')
            image_base = cv2.imread("test.jpg",0)
            image = image_base[240:600, 450:800]
```

```
os.remove("test.jpg")
print "Image␣Captured!␣You␣can␣now␣remove␣your␣hand!"
cursor = db.userData.find({"roll_no": rollNo})
for results in cursor:
    img_str = results["image_str"]
string = base64.b64decode(img_str)
nparray=np.fromstring(string,np.uint8)
img_main = cv2.imdecode(nparray,cv2.IMREAD_COLOR)
cv2.imwrite("img_main.jpg",img_main)
img_main = cv2.imread("img_main.jpg",0)
orb = cv2.ORB_create(nfeatures= 1000)
clahe = cv2.createCLAHE(clipLimit=4.0, tileGridSize=(16,16))
equ = clahe.apply(image)
equ = clahe.apply(equ)
blur = cv2.GaussianBlur(equ,(5,5),0)
kernel = np.ones((5,5),np.uint8)
opening = cv2.morphologyEx(blur, cv2.MORPH_OPEN, kernel)
ret,th = cv2.threshold(opening,0,255,cv2.THRESH_BINARY+cv2.
    THRESH_OTSU)
key_points_1, des_main = orb.detectAndCompute(img_main, None)
key_points, des_query = orb.detectAndCompute(th, None)
bf = cv2.BFMatcher(cv2.NORM_HAMMING, crossCheck=False)
matches = bf.knnMatch(des_main, des_query, k=2)
print len(matches)
good = []
for m, n in matches:
    if m.distance < 0.85 * n.distance:
        good.append([m])
print len(good)
img3 = cv2.drawMatchesKnn(img_main,key_points_1,th,key_points,
    good,None,flags=2)
cv2.imwrite("matching.jpg",img3)
```

```
            if len(good) > 150:
                print "Login␣Successful!!"
            else:
                print "Login␣Failed!!"
        else:
            print "Wrong␣Input!Start␣Afresh.."
    else:
        print "User␣Does␣not␣Exists!"
while True:
    print "Palm␣Vein␣Pattern␣Authentication␣System"
    flag = raw_input("1)␣Enter␣1␣for␣adding␣new␣record\n2)␣Enter␣2␣for␣
        Logging␣in\n3)␣Enter␣3␣for␣deleting␣existing␣record\n4)␣Enter␣4␣
        for␣exiting\nYour␣input␣:␣")
    if flag not in ["1","2","3","4"]:
        print "Wrong␣Input!!"
    elif flag == "1":
        addData()
    elif flag == "2":
        login()
    elif flag == "3":
        deleteData()
    elif flag == "4":
        break
```