UNIVERSITY OF TURKISH AERONAUTICAL ASSOCIATION
INSTITUTE OF SCIENCE AND TECHNOLOGY

PALM VEIN PRINT TO RECOGNITION AND MATCHING BETWEEN THE PEOPLE

MASTER THESIS

Abeer Adnan ABDULRAHMAN

DEPARTMENT OF INFORMATION TECHNOLOGY

PROGRAM OF INFORMATION TECHNOLOGY

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Abeer Adnan Abdulrahman, having student number 1406050018 and enrolled in the Master Program at the Institute of Science and Technology at the University of Turkish Aeronautical Association, after meeting all of the required conditions contained in the related regulations, has successfully accomplished, in front of the jury, the presentation of the thesis prepared with the title of: "PALM VEIN PRINT TO RECOGNITION AND MATCHING BETWEEN THE PEOPLE".

Supervisor: Asst. Prof. Dr. Yuriy ALYEKSYEYENKOV
University of Turkish Aeronautical Association

Jury Members: Asst. Prof. Dr. Abdül Kadir GÖRÜR
cankaya University

Asst. Prof. Dr .Shadi AL SHEHABI.
University of Turkish Aeronautical Association

Asst. Prof. Dr. Yuriy ALYEKSYEYENKOV
University of Turkish Aeronautical Association

Thesis Defense Date :22.12.2017

UNIVERSITY OF TURKISH AERONAUTICAL ASSOCIATION
INSTITUTE OF SCIENCE AND TECHNOLOGY

I hereby declare that all the information in this study I presented as my Master's Thesis, called: Palm Vein Print to Recognition and Matching Between The People, has been presented in accordance with the academic rules and ethical conduct. I also declare and certify with my honor that I have fully cited and referenced all the sources I made use of in this present study.

22.12.2017

Abeer Adnan ABDULRAHMAN

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December 2017 Abeer Adnan ABDULRAHMAN

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BV	:	Blood Vessel
PV	:	Palm Vein
VP	:	Vein Patterns
2-D	:	2-Dimensional
IR	:	Infrared
NIR	:	Near- Infrared Rays
PINS	:	Personal Identification Numbers
ATM	:	Automated Teller Machine
ROI	:	Region of Interest
GS	:	Grey Scale
FE	:	Feature Extraction
I P	:	Image Processing
LC	:	Low-Contrast
GL	:	Gray Levels
SD	:	Standard Deviation
CS	:	Cross Sectional
LDP	:	Local Derivative Patterns
LBP	:	Local Binary Patterns
GIR	:	Genuine Identification Rate
DOG	:	Difference of Gaussians
SIFT	:	Scale-Invariant Feature Transform
EERs	:	Equal Error Rates
PCA	:	Principle Component Analysis
LDA	:	Linear Discernment Analysis
AHE	:	Adaptive histogram equalization
CLAHE	:	Contrast-limited adaptive histogram equalization
BGM	:	Biometric Graph Matching

ABSTRACT

PALM VEIN PRINT TO RECOGNITION AND MATCHING BETWEEN THE PEOPLE

Abeer Adnan Abdulrahman
Master, Department of Information Technology
Thesis Supervisor: Asst. Prof. Dr. Yuriy ALYEKSYEYENKOV
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With the rapid increase of technology, pattern recognition studies increased vastly. Due to several reasons that make fingerprints are not always the accepted solutions such as the age or the disease of the individuals we highlight the use of palm vein technology which can overcome these obstacles. In addition, it can be utilized for distinguishing the vein patterns (VP) in a person's palm.

Although many studies proposed vast range of methods for VP recognition, in this study we used maximum-curvature algorithm to detect VP. I improved the used techniques in term of matching and choosing reference points.

In this study there are two phases used training phase and testing phase (the system identifies a specific person). Both the training and testing phases share in the images enhancement stage and feature extraction stage.

The role of pre-processing phase prepares and improve the veins to be extracted in the feature extraction phase since the datasets are not identical due to the variety of quality, brightness and contrast that’s because these images were captured by near infra-red (NIR) light source.

The feature extraction stage cares about extracting palm veins, for this purpose we used max curvature algorithm for the extraction. The novel approach in this study is finding an accurate method to locate a reference point based on the lowest contrast region within the images. The reference point helped to correct the error between the images for each individual.

The second approach of this study is finding a way to get rid of the dark boundaries without losing any information of the image.

The training images used in this study are (50) images belong to (10) different people where each person has (5) images. Our study shows good results in term of matching and the accuracy.

Keywords: Palm vein, vein patterns, near infra-red, image processing.

ÖZET

AVUÇİÇİ DAMAR YAPISI İLE KİŞİ TANIMLAMA VE EŞLEŞTİRME

Abeer Adnan Abdulrahman
Yüksek Lisans, Bilişim Teknolojileri Anabilim Dalı
Tez Danışmanı: Doç. Dr.Yuriy ALYEKSYEYENKOV
Aralık 2017, 56 sayfa

Teknolojinin hızla artmasıyla kalıp tanıma çalışmaları büyük ölçüde arttı. Birkaç nedenden ötürü, parmak izleri, bireylerin yaşı veya hastalığı gibi her zaman kabul gören çözümler değildir, bu engellerin üstesinden gelen avuç içi damarı teknolojisinin kullanımını vurguluyoruz. Buna ek olarak, kişinin avuç içlerinin (VP) ayırt edilmesinde kullanılabilir.

Birçok çalışma VP tanıma yöntemi için geniş bir yelpaze önermişse de, bu çalışmada biz VP algılamak için maksimum eğri algoritması kullandık. Referans noktalarını eşleme ve seçme açısından kullanılan teknikleri geliştirdim.

Bu çalışmada iki aşama kullanılmaktadır; eğitim aşaması ve test aşaması (sistem belirli bir insanı tanımlar). Hem eğitim hem de test aşamaları, görüntü iyileştirme aşamasında ve özellik çıkarma aşamasında paylaşılıyor.

Ön işleme aşamasının rolü, veri özetleri kalite, parlaklık ve kontrastın çeşitliliği nedeniyle özdeş olmadığından, bu görüntülerin yakın kızıl ötesi VP ışık kaynağı tarafından yakalanması nedeniyle, öznitelik çıkarma safhasında çıkarılacak damarları hazırlar ve iyileştirir.

Öznitelik çıkarma aşamasında avuç içi damarlarının çıkartılması dikkat çekiyor, bu amaçla ekstraksiyon için maksimum eğri algoritması kullandım. Bu çalışmadaki yeni yaklaşım, görüntüler içindeki en düşük kontrast bölgeye dayanan bir referans noktasını bulmak için doğru bir yöntem bulmaktır. Referans noktası, her birey için görüntüler arasındaki hatanın düzeltilmesine yardımcı oldu.

Bu çalışmanın ikinci yaklaşımı, görüntünün hiçbir bilgisi kaybolmadan karanlık sınırlardan kurtulmanın bir yolunu bulmaktır.

Bu çalışmada kullanılan eğitim görüntüleri, her birinin (5) görüntüsünün olduğu (10) farklı kişiye ait toplam (50) görüntüdür. Çalışmamız, eşleşme ve doğruluk açısından iyi sonuçlar göstermektedir.

Anahtar Kelimeler: Avuçiçi damar, kişinin avuç içlerinin, yakın kızılötesi, görüntü işleme

CHAPTER ONE

1. GENRAL INTRODUCTION

1.1 Introduction

In different societies nowadays, technological development is very important in our life, which makes it dramatically easier.

As well as theft of personal data, fraud and security threats are developed, so it is very important to secure them completely from manipulation [1].

Why do we use palm vein print?

As we know by using" password "could be identified as personal identification numbers (PINC). However, their limitations restrict their use. Token or passwords (Student ID Card) similarly (ATM pin or Mail ID) for example can be stolen or forgotten [2].

The main reason that led to the developing Biometric system is the conflict between the stolen personal data and the duplication struggles of securing data [1]. And the most important reason that pulled in the consideration of specialists today in Biometric system, that it has better services than the ancient one. These systems have many options, it is hard to break and give anti spoofing capacities completely. Extra utilization of these frameworks has expanded in life today having a place with the breaking security frameworks spread, as another method for illicit points [3].

The biometric countenance extracted from human biological organs such as different patterns of hand like fingerprint, hand geometry, palm vein print, palm print, finger knuckles pattern, in addition to the face patterns including, iris, retina etc. grouped are classified as physiological characteristics. Others are called behavioral characteristics such as gait, voice signatures and gesture etc. [2].

So, the characteristics of biometric patterns can be classified into two categories. As in Figure 1.1 illustrated Samples of some of biometric patterns the physiological and behavioral characteristics [1].

1.1.1 The Physiological Characteristics Including

a) Fingerprint: it depends on the surface of the fingertip of ridges and furrows and so on.

b) Face recognition: consists of measuring the characteristics of face from video or still images.

c) Vein patterns: it is unique across the persons and not change over time, even in the status of identical twins.

d) Iris scan: the main characteristic of the iris is that information among individuals is unique, it does not change over time.

e) DNA: an acronym for deoxyribonucleic acid is present in each and every human cell (and in other organisms).

1.1.2 The Behavioral Characteristics Include

a) Keystroke: keystroke dynamics is related to the way people type characters on keyboards.

b) Signature: the handwriting of a given individual can be thought as representing his/her own characteristics.

c) Voice: the characteristics of voice are related to the appendages that form its sound that include the vocal tracts, mouth, nasal cavities, and lips. On the other hand, also related to the emotional and physical states of the speaker [4, 1].

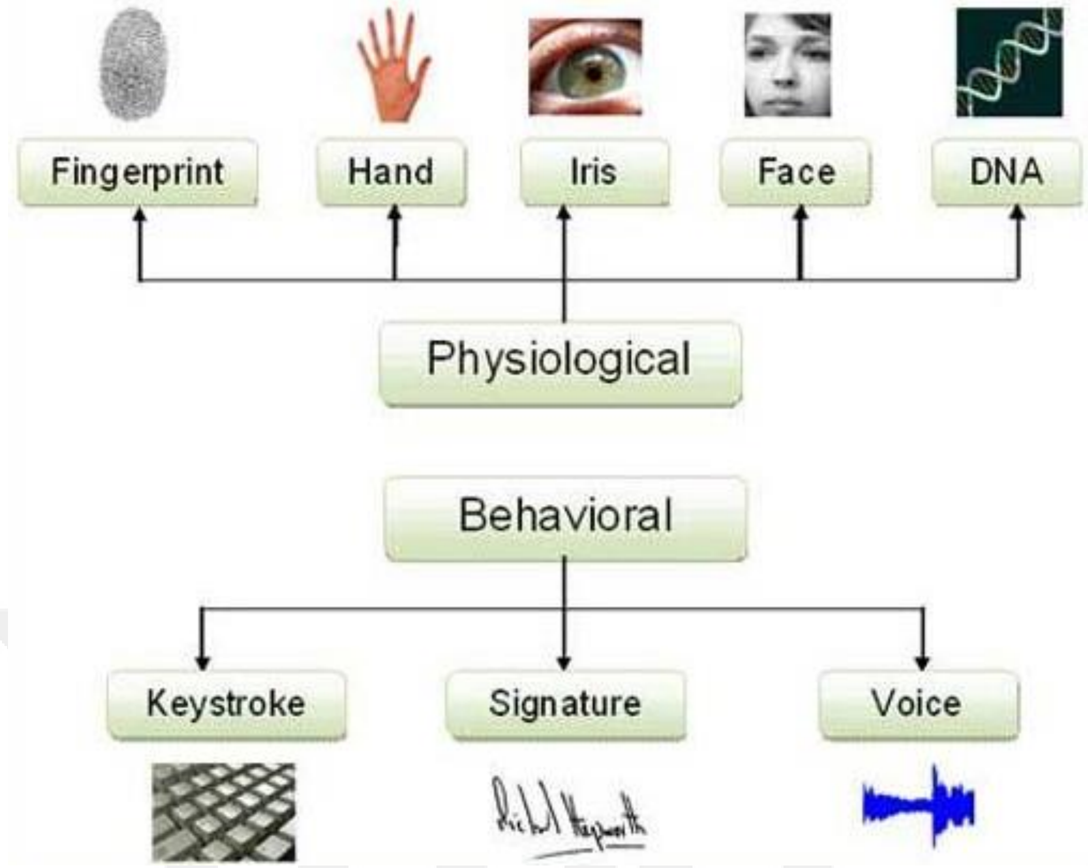


Figure 1.1: Samples several of biometric patterns [4].

1.2 Palm Vein Pattern

Palm vein authentication represents a new approach for the personal identification, it is one of the most reliable authentication. This technique uses the palm vein (PV) instead of the "password”, which contain physiological body characteristics that can be used to verify and distinguish between the users.

It is representing the contactless palm verification gadget that takes blood vessel (BV) pattern as an individual identification. It is representing the contactless palm verification gadget that takes BV pattern as an individual identification. It is one of the most ticklish and defy task to meet upcoming demand for strict security [5]. PV pattern is identified as the safer and easiest system in the work of biometric systems comparing with the other techniques [1].

Where the palm territory is free of hair and skin shading variations along these lines lessening capture noise. Additionally, the PV design is extremely point by point and complex and spreads a bigger region than the other vascular biometrics like the dorsal vein, finger vein and wrist vein [6].

Although each type of biometric systems has its utility and disadvantage, for example the recognition by fingerprint system is most public between biometric technologies that are accurate and very easy to gain.

However, in some events the fingerprints fade and cause low performance according to wrinkles in fingers or hand of old people etc. While the retina or iris's recognition systems provide high accuracy, they are more expensive, in addition, when the eye approaches the scanner, it provides bad feeling for the user, in turn, affects the accuracy of the system which makes it an intrusive system. As well as, the 3D hand-shape recognition system, which is used more but it does not ensure the uniqueness or guarantee its functional quality in case of the change of the hand-shape due to some diseases like rheumatism as well as hand amputation due to a particular illness for example (diabetes) leading to performance degradation of the system [1].

Palm vein pattern system in comparison with the mentioned biometric systems:

a) Uniqueness: PV is different and unique of a kind for every person (even twins).
b) Accuracy: it is invisible and difficult to fake, forgery or theft because the veins are internal.
c) Contactless: easy to capture the image using proper imaging sensor which guarantees comfort and purity for user.
d) Robust: Skin problems have no effect to the recognition operation.
e) Speed: the identification execution is fast enough, Synchronizing with the real time.
f) Cost: it costs less compared with the iris recognition system for example.

1.2.1 The Reasons to Use Vein as a Recognition System

From the important features, that is, the veins are inside in the body and have abundance of differentiating features, accordingly that false identity through fraud is more difficult, thereby enabling a rising level of outer security [5]. Furthermore, a recent research showed that is unique to each person, even in the case of identical twins, it also varies between the right and the left hand. Also keep in mind that the vein patterns (VP) does not change with growth, it maintains the same pattern.

The combination of these factors make identifying people with this method is one of the most reliable methods on the market for different reasons.

1- A part is non-contact in the body is a vein.

2- Less affected by the surface conditions.

3- Palm vein recognition confer for a relatively high grade of security.

4- Vein patterns in the body are inside features, and are hence hard to counterfeit it.

5- Vein patterns are exceptional for each person. Different patterns even the identical twins have.

6- Vein can just can be perceived from a living body, and in this manner veins can be applied to live-body identification [7].

As for the disadvantages of applying this system, are:

1- High temperatures that affect the vein's width by increasing blood flow in the body.

2- Palm amputation due to a particular illness for example (diabetes).

The thermal images are used to extract PV and obtain good results. But the camera is extremely costly [8].

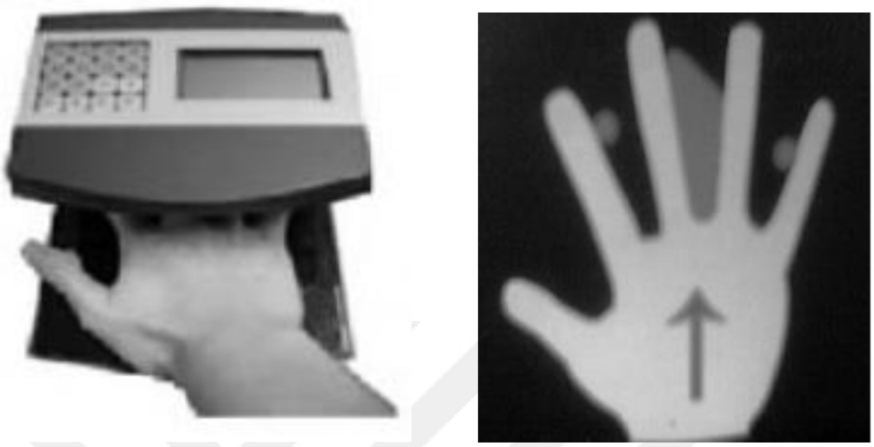
1.3 Infrared Rays

Infrared rays (IR) are electromagnetic radiation that wavelength is lengthy than that of the noticeable light, and IR light has a scope of wavelength that lies in the vicinity of 760nm and 1mm, like obvious light having wavelengths extending from red light to violet. IR light is generally partitioned into 3 ghostly areas: close near infrared (NIR), mid infrared rays and far infrared rays light [9].

1.4 Infrared Images and Extract the Feature

The palm vein is secure through work by capturing a person’s vein pattern image and get the details of the palm by NIR scanning to capturing the vein image. Where The palm secure detects the structure of the pattern of veins on palm of the human hand with most precision. by using The scanner, it is consisting small area for palm vein. That is easy and the nature for use, is fast and highly accurate. As in Figure 1.2 illustrated (a) scanner device, (b) the hand outside of the device.

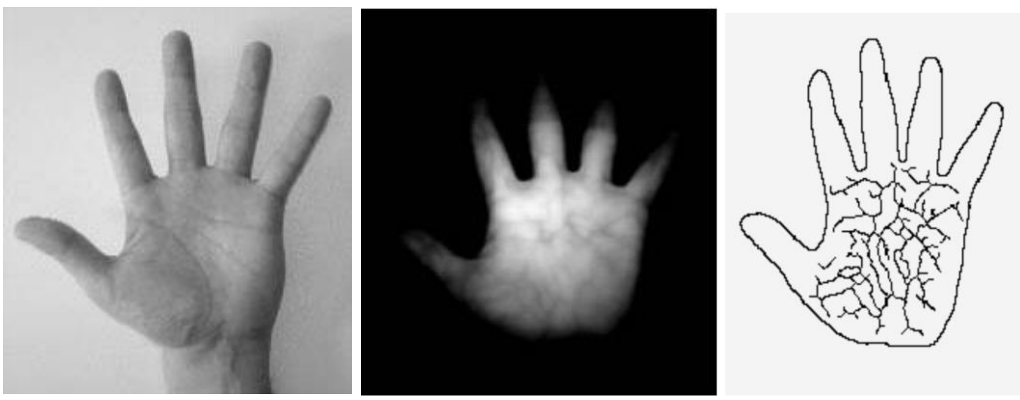
When the palm passes NIR the non-oxidized blood that is flowing through the veins absorbs the IR, which leads to the appearance of clear areas looks like a black pattern on the scanner. This pattern is registered by the sensor and is stocked in encrypted from in a database, on a smart card or in a token. Arteries and BV, which contain hemoglobin oxidized blood, which does not absorb the NIR light, is invisible to the sensor, so the veins are known as "veins".



a) Scanner Device. b) The Hand Out Side the Device.

Figure 1.2: Capture device [8].

The non-oxidized hemoglobin blood in the vessels absorbs light having a wavelength of about 7.6×10^{-4} mm within the near infrared rays area. When near NIR image is captured, like represented in Figure 1.3 three images (a) Visible X-ray (b) capturing IR image (c) blood vessel pattern image. Where figure (c) containing the non-oxidized hemoglobin is visible as a series of dark lines. Based on this feature, the vein authentication device interprets the dark lines of the infrared ray image as the blood vessel pattern of the palm, and afterward matches it with the prior registered blood vessel pattern of the person [5].



a) Visible X-ray b) Capturing ((IR)) Image c) Pattern Image blood vessel (BV)

Figure 1.3: Before and after (NIR) image captured [5, 9].

1.5 Aim of the Thesis

The aim of this thesis is to build a personal recognition system based on the PV, because PV authentication has an abnormal state of exactness and safety since it is situated inside the body and does not change through life and can't be stolen or lost.

Achievement of the system of PV print: The passwords will become past, and no fear of losing it. The use of stolen identity cards and passports will be greatly reduced, will prevent the misuse of stolen credit cards, access to computers will be possible for people without conventional identity verification" Passwords", will greatly reduce unnecessary costs, and it will Achieve and develop a high secure level and comfortable precise system.

1.6 Organization of Thesis

In this thesis: addition to the first chapter, organized it of includes four chapters regular as follows:

a) Chapter Two: "Related Work": This chapter transact with the previous studies tasks and processes within the PV biometric system, including pre-processing operations, features extraction, and so on down to the result of matching execution.

b) Chapter 3:" Design and Implementation of the System Architecture": This chapter transact with the design and implementation of the proposed the PV recognition and matching system and which algorithms used for each phase of this biometric system.

c) Chapter 4: "Experimental Tests and Evaluation": This chapter describes and illustrates the empirical results of this work for the recognition operation and discussion all the results.

d) Chapter Five: "Conclusions and Recommendations": This chapter transact with this present the conclusions of this thesis and provides a list of points proposed and suggestion the future work.

CHAPTER TWO

2. RELATED WORK

2.1 Introduction

In the following literature review, we present the previous studies of palm vein print and the implement of the algorithm of PV print for the recognition and verification between people.

2.2 Literature Review

a) Yi-Bo Zhang1, Qin Li, Jane You and Prabir Bhattacharya in 2007 [8]. In the subject of, Palm Vein Extraction and Matching for Personal Authentication.

The proposed system includes:

1) Infrared palm images capture.
2) Detection of Region of Interest.
3) Palm vein extraction by Gaussian shaped lines.
4) Matching: the similarity can be calculated between two images by using template matching.

In this work the data set: a low cost (CCD) camera and a set of IR light source are used to capture the IR palm images.

The results achieved: 98.8% recognition rate where the false acceptance rate is 5.5%.

b) Leila Mirmohamadsadeghi and Andrzej Drygajlo in 2011 [11]. In the subject of Palm Vein Recognition with Local Binary Patterns and Local Derivative Patterns.

The proposed system includes:

The two feature extraction operators Local Binary Patterns (LBPs) and Local Derivative

Patterns (LDPs) were investigated in terms of their ability to adapt to PV description.

In this work the data set: Extend- sieve experiments on CASIA Multi-Spectral Palm Print Image Database V1.0.

The results achieved**:** The tests on this dataset also show that the best adapted

LDPs descriptors consistently outperform the IR Local Binary Patterns match in both PV identification and verification.

c) Dipali Patalau Gaikwad, Sandipan Pralhad Narote in 2013 [3]. In the subject of, Multi-Modal Biometric System using Palm Print and palm vein Palm Vein Features.

The proposed system includes:

In this paper, the algorithm is offered, which contain basic processes: Preprocessing, enhancement, feature extraction and matching. Detailed descriptions of these steps are put in following sections

1. Preprocessing: Segmentation method is performed using thresholding technique where a suitable threshold is applied to separate the image from its background.
2. Region of Interest: using adaptive histogram equalization (AHE).
3. Feature extraction: Feature Extraction by using 2d Gabor Filter, Feature Extraction by using Contour let Transform
4. Matching: for matching purpose we apply the normalized Euclidean distance algorithm.

In this work the data set: CASIA Palm Print Image Database contains 7,200 palm images captured from 100 different people. The results achieved: out of 270 images 263 images were found to be matched correctly thus giving us a genuine identification rate (GIR) of 97.40 %.

d) Wenxiong Kang, Yang Liu, Qiuxia Wu, Xishun Yue, may in 2014 [12]. In the subject of, Contact-Free Palm-Vein Recognition Based on Local Invariant Features.

The proposed system includes:

1. Preprocessing:

1.1. Palm region extraction.

1.2. Hierarchical enhancement

1.2.1. Difference of Gaussian (DOG).

1.2.2. Histogram equalization.

2- Feature extraction and matching: We adopt the Scale-Invariant Feature Transform Root SIFT algorithm here for feature extraction and matching in contact-free palm-vein images by using the: Hellinger kernel, Euclidean distance.

3. Hierarchical mismatching removal algorithm:

3.1 Neighbor-based mismatching removal

3.2 LBP-based mismatching removal.

In this work the data set: experiments using the CASIA multi-spectral palm print Image Database V1.0.

The results achieved: rigorously evaluated the proposed approach using two different databases and obtained 0.996% and 3.112% Equal Error Rates (EERs).

e) Gaurav Jaswal, Ravinder Nath and Amit Kaul in 2015 [2]. In the subject of, Texture Based Palm Print Recognition Using 2-D Gabor Filter and Sub Space Approaches.

The proposed system includes:

A. Region of Interest Segmentation: segmentation algorithm is used.
B. Feature Extraction: Gabor filters works as band pass filters for 1D and 2D signals.
C. Dimension Reduction: applied the Principle Component Analysis (PCA) algorithm and then Linear Discernment Analysis (LDA) on the obtained weights of PCA for best class separation.
D. Similarity Measure: Euclidean distance calculates the minimum distance between the test images.

In this work the data set: two standard palm print databases namely IIT Delhi and CASIA.

The results achieved: higher accuracy (91%) in terms of correct recognition rate and low computation time.

f) S. Mohammadi, and A. Rahmani in 2016 [13]. In the subject of, Palm Vein Identification Using Weighted Multi-Scale Local Binary Patterns.

The proposed system includes:

1- PREPROCESSING

A. Extraction of Region of Interest: First eliminate noise and reduce details, a low pass filter such as Gaussian smoothing was applied to the original image. Then threshold Otsu was used to convert the image to a binary one. Edge detection is performed by applying Laplacian of Gaussian filters.

B. Image Enhancement: contrast-limited adaptive histogram equalization (CLAHE).

2- Feature Extraction:

A. Local Binary Pattern: The Local binary pattern (LBP) operator.

B. Circular Local Binary Patterns.

C. Uniform Local Binary Patterns.

In this work the data set: used CASSIA database.

The results achieved: the proposed method has produced an identification rate of 99.67%on 100 different palms from the CASSIA database.

g) Arathi Arakala, Hao Hao, Stephen Davis and K. J. Horadam in 2016 [6]. In the subject of**,** The Palm Vein Graph Feature Extraction and Graph".

The proposed system includes:

The PV image captured from an infra-red camera is converted into a spatial graph.

After image enhancement and analyzation, the PV features are extracted from the skeleton using a novel two stage spur removal technique.

The location of the features and the connections between them are used to define a Palm

Vein Graph. PV graphs are compared using the Biometric Graph Matching (BGM) Algorithm. We propose a graph registration algorithm that improves over existing state of the art algorithms for graph registration.

We introduce 10 graph topology-based measures for comparing PV graphs.

In this work the data set: CIE BIOMITRICS, PUT Vein Database Description Images in database have 1280x960 resolution and are saved as 24-bit bitmap, PV database where each PV has 12 samples captures across 3 sessions for 50 people.

The results achieved: introduced measures, gave a definite improvement in matching accuracies over other published results on the same database, especially for samples with only a small common overlap area due to displacement, so this study demonstrates a further improvement in matching accuracy.

h) Shashi Balaa, Nidhi in 2016 [14]. In the subject of, Comparative analysis of palm print recognition system with Repeated Line Tracking method.

The proposed system includes:

A. Apply the Contrast-limited adaptive histogram equalization CLAHE to enhance the contrast of the image.

B. Apply segmentation technique to the obtained image to increase the precision.

C. In segmentation apply Global thresholding scheme is used.

D. Log Gabor filter is used for filtering the undesired noise from the desired information.

E. Chain code is used to represent the boundary of the image. Line tracing is used in chain code.

F. Maximum Curvature method is used to extract the curvature patterns of the palm.

G. Broken Line tracking algorithm is used to handle the lines of palm which are in this work the data set: load the palm print image from the CASIA database which is to be enhanced.

The results: the matching score of 100% are achieved in this technique.

i) Zahra Naji Razoqi, Yossra Hussain Ali in 2017 [1]. In the subject of, PV Recognition Using Centerline Extraction.

The proposed system includes**:**

1. Pre-processing.

1.1. Image enhancement.

1.1.1. Intensity Image Gray scale (GS).

1.1.2. Contrast Stretching.

1.1.3. De-noising.

1.2. Vein segmentation.

1.2.1. Smoothing Images.

1.2.2. Thresholding.

2. Post-processing.

2.1. Morphological Operations.

2.2. Centerline Extraction.

3. Features Extraction.

4. Matching and Vein Recognition.

In this work the data set: the images captured by the CCD camera to a computer.

The results achieved: the maximum recognition rate (identification) of the system was 100%. The high performances of verification task that representing by the error rate that was equal 0.333 %.

CHAPTER THREE

3. DESIGN AND IMPLEMENTATION OF PREPOSED SYSTEM (METHOD ALGORTHIM)

3.1 Introduction

The proposed palm vein recognition system includes two main phases: enrollment, and recognition. In the enrollment phase the system is programmed to verify specific users (authorized), while in the recognition phase, the system tries to recognize people who are trying to enter the system. These two phases are involved in pre-processing, post processing and features extraction stages. This chapter deals with the explanation of stages of the proposed recognition system, showing the methods of programming that have been used to design this system.

The program has been written in MATLAB (R2016b) programming language, the computer on which the work was performed is laptop computer (HP), Windows-7 operating system, processor: Intel Core i5 CPU (2.50) GHz and memory: (4GB) RAM.

3.2 The Dataset

The dataset of vein image has been captured using (PUT Vein Pattern Database) in the Organization of control and Information Engineering for Poznan University of Technology has been actively conducting investigate in the fields of picture handling and analysis of the biometrics for a long time.

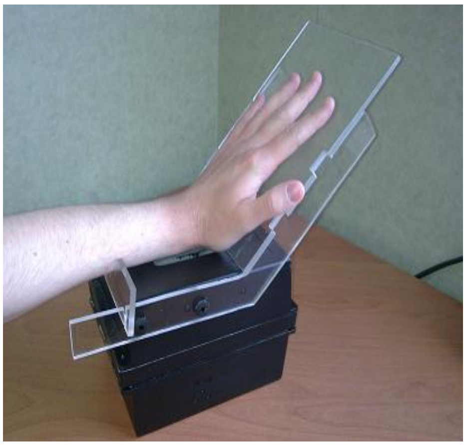
During our work we gathered databases, that can have valuable assets for image processing (IP) and biometrics community. On (Put. Poznan) these databases can be obtained for research purposes for free.

The research team work focuses on evolving of IP algorithms applications for biometrics system, in medical imaging, robotics and controller of security systems. The close IR image capture system (PUT Vein Pattern Database) by using it, based on low charge standard (USB) camera in modular construction and changeable lightning section for that is convenient for palm, and wrist acquisition of semi-rigid positioning systems.

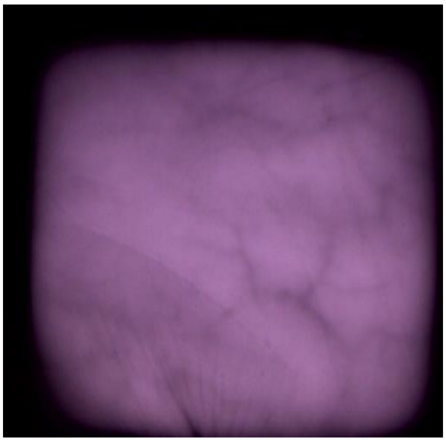
Where the database of PUT is consisted of 240 images offer human VP, Half of images (120 images) contains a PV pattern. As shown in Figure 3.1.b, and the other half (another 120 images) contains a wrist VP. Data were obtained from both hands of 10 volunteer students in this University with means of 20 different patterns for palms area. The images were taken in three session series, with four images each series, for at least one week between one session and another. In the case of the palm area, the volunteers were asked to put their hands on the machine to cover the capture window, in order of matching the line under their fingers with the edge.

Not to use additional positioning systems, when they capture the images to construction, the system allows the palm and wrist to be in a comfortable manner when the hand is positioned. As shown in Figure 3.1.a put the hand in a comfortable way.

Images in database of PUT have 1024× 768 resolutions and are saved as 24-bit bit map [10].



a) Put the Hand in a Comfortable Way.



b) palm vein (PV)Pattern.

Figure 3.1: View infrared image acquisition system [10].

3.3 Proposed System Structure

The proposed system workflow contains two main phases: training phase (including, region of interest (ROI) extraction, pre-processing, feature extraction(FE)) and testing phase (including ROI extraction, pre-processing, FE) and matching between two main phases to recognition and identification of people. Figure 3.2 illustrates the diagram of the propose system architecture.

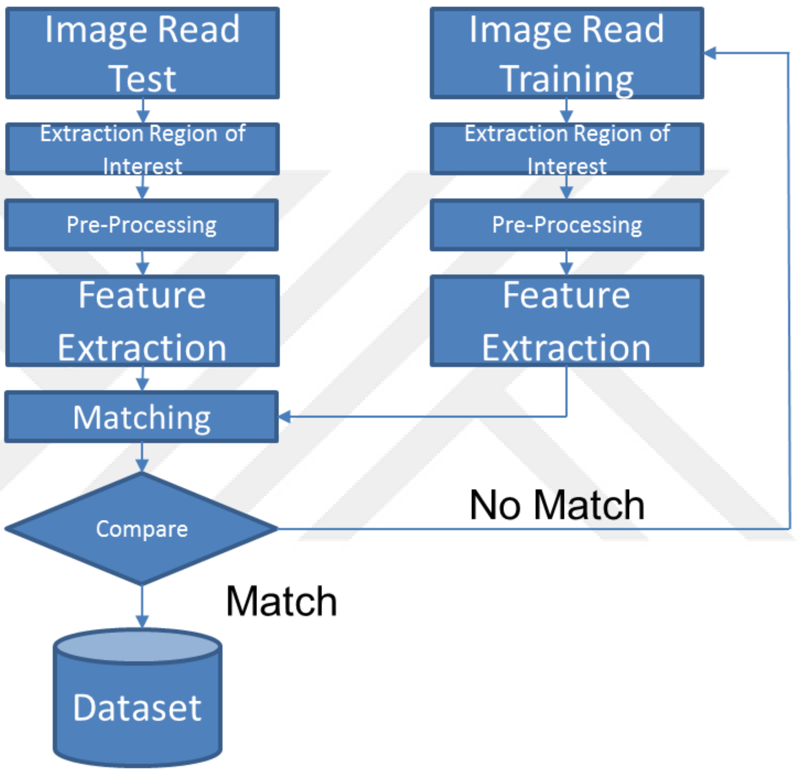


Figure 3.2: The diagram of the proposed system.

3.4 Region of Interest (ROI)

ROI determination can lessen the data amount during feature extraction process and matching. In addition, it can minimize the effect of rotation and translation of the palm, thus it is an essential to be fixed in the same condition in different images to include constancy of the main extracted vein features since the investigation process relays on comparing the features of VP extracted in the same region from two or more different images, so accurate and reliable investigation [1].

In term of image partition, operations are proposed to acquire the ROI of palm from the hand-scanned image in the pre-processing phase.

The first step is of the hand-partition to obtain the hand region from the background of an image, the next phase is to apply the valley detection algorithm to detect the reference-points in hand. After these steps, the vertices and edges were obtained of Region of Interest established on the reference-points [15].

To extract the ROI of the palm, either a circular or square area can be used. The square area is the best choice due to several benefits such as removing noise and reducing details [13], moreover the false texture appears near the wrist that is like to the vein texture which results in side effects when extracting and matching [12].

3.4.1 ROI Selection

To select ROI of PV automatically and reliably, segment a small region from the seized PV image, the PV extraction is to obtain the PV from a ROI. This can be considered as one of the significant steps in these four steps because of its big impacts, that it includes the accuracy of identification and the speed processing of the system [9]. The previous studies presented a PV, region of interest extraction algorithm which combined:

a) Otsu thresholding scheme.
b) Morphological opening operation.
c) Sobel edge detector.
d) Reference points.
e) Line construction.
f) Palm vein image alignment [9].

A. Otsu thresholding scheme:

Algorithm 3.1: Threshold otsu.

Input	x= original image level= default threshold
Output	bw_img= binary image (thresholding image)

x = imread (image.tif);
level = graythresh (x);
bw_img= im2bw (x,level);
imshow(bw_img)	

B. Morphological opening operation:

Morphology, is a branch of IP which is particularly helpful for examining shapes in image. Matlab has many option tools for binary morphology in the IP toolbox; a large portion of which can be utilized for grey-scale morphology.

The morphological method produced a gray-scale image by starting with a binary image, the opening Morphological for the most part smoothies the shape of a question breaks limit isthmuses and wipes out thin bulges [17] the morphological opening operation method is illustrating in algorithm (3.2).

Algorithm 3.2: Morphological opening operation.

Input	x= original image level=value of thresholding by default st= Create a disk-shaped with a radius of (5) pixels.
Output	Im_open= Morphological open image

x = imread(image.tif);
figure, imshow(x);
level=graythresh(x);
x1 = im2bw (x, level);
st= strel('disk',5);
im_open = imopen (x1, st);
figure, imshow (im_open, []);	

C. Sobel Edge Detector:

Edge detection can be achieved by applying different filters, this ability be conquered by smoothing the outcome the other way; these filters give clear edges, and it performs rationally well within the entity of noise, Sobel filter is probably the best filter [16] The Sobel edge detection illustration is in algorithm (3.3).

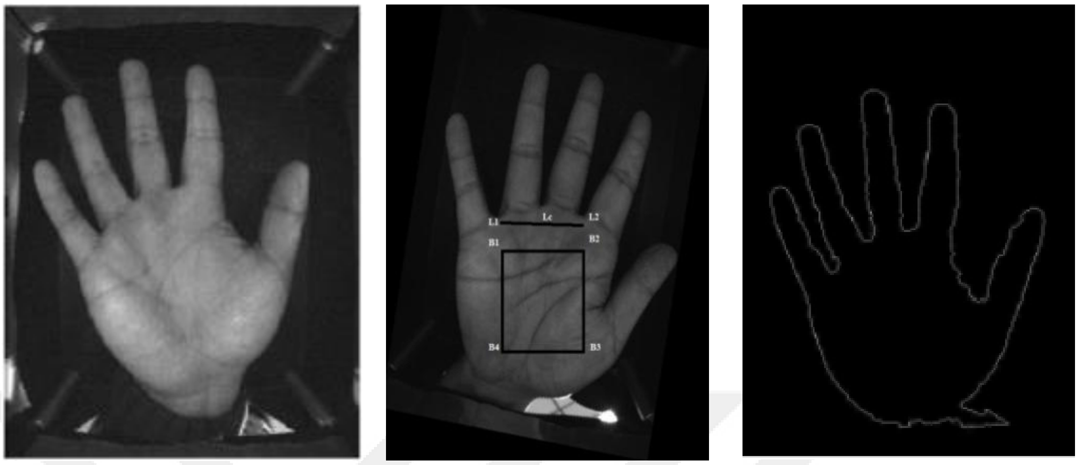
Algorithm 3.3: Sobel edge detection.

Input	x= original image
Output	x1=image after Sobel edge detection

x = imread('image.tif);
imshow(x)
x1 = edge(x,'sobel');
figure;
imshow(x1,'montage'); title ('Sobel Filter’);	

D&E. Reference points detection and alignment of the PV image:

Reference point is very important for determining the region of interest as shown in Figure3.3with (a, b, c) [3].



a) image alignment b) Reference Points c) Detected Palm Boundary

Figure 3.3: Reference point is very important for determining the region of Interest [3].

3.5 Pre-Processing

The fulfillment of the overall system depends intensely on the nature of the information input for the images, and the raw image probably contains poor contrast, noise and varying brightness. Therefore, some basic tasks must be performed in order for the resulting image to be more suitable for the job to be pursued, therefore pre-processing is an important phase in the biometric system that prepares and enhances the vein image. The pre-processing phase workflow contains the following steps:

3.5.1 Image Enhancement

The major objective of this stage is to process an image so that the result is more proper than the original image for a specific application with the enhancement of the wanted VP and reduction of any unwanted information in order to extract common features from images.

Image enhancement is one of the most important and visually appealing phases of IP. This is done by applying the following steps:

A. Intensity Image (Gray Scale):

The grayscale image (or gray level image) this image is the only one that has colors in which are shades of gray. And that means gray's intensity is stocked as an 8-bit integer, resulting in 256, so zero represents black, and 255 is white, and the all values between them represent different shades of gray.

The main reasons that made the grayscale images very common and distinguishable is that those images have other type of colored images, because a lot of image capturing hardware’s can only support 8-bit images. In addition, grayscale images are totally sufficient for many tasks and so there is no need to use more complex processes (color images). Therefore, grayscale image provides less information per pixel [18].

In RGB space All components have equal intensity which means, the intensity of “gray" color is impartial to the intensity of the other colors including, red, green and blue.

So it is only necessary to determine the value of one density per pixel, rather than three intensities, that is necessary to define each pixel in entire color image. Therefore, most of the availability of converting a colored image (RGB) to a grayscale domain is that to have less data because the grayscale domain has one channel instead of three channels of (RGB)domain, as shown in the equation (3.1) Where R= red, G=green, and B= blue [1].

$$\text{Grayscale}(i,j)=0.2989 * R + 0.5870 * G + 0.1140 * B \tag{3.1}$$

One of other methods for this purpose is applying equation (3.2) done by a set of values less than minimum value of input image into (0.0) (black), and values greater than maximum value of input image into (1.0) (white) and the Algorithm (3.4) shows the procedure steps of converting original image into gray intensity image [1].

$$\text{Grayscale}(i,j)=\frac{1}{(MAX-MIN)*(I(i,j)-MIN)} \tag{3.2}$$

Where, appear the maximum and minimum of input image for original image.

Algorithm 3.4: Intensity Image (Gray Scale)

Input	I= original image(RGB)
Output	Img_out= Gray Scale Image

```
I =imread (image. tif);
min=min (I (:));
max=max (I (:));
img_out(i,j)= 1/ (max – min) * (Img (i, j) – min))
figure,imshow(img_out,[]);
```

the Syntax in(MATLAB)
I = rgb2gray(RGB)

B. Contrast Stretching:

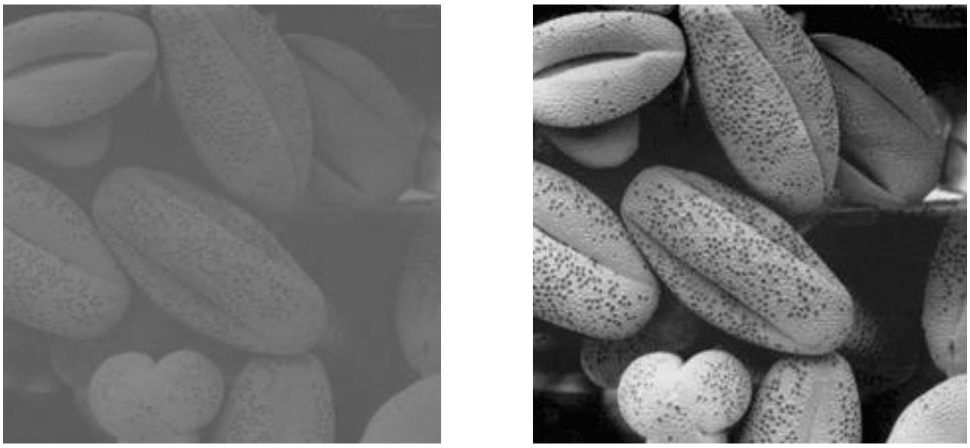
A contrast-stretching is one of the easiest piecewise linear functions. and it is transformation. The incorrect setting of a lens a slot and lack dynamic range in the imaging sensor, during image capture, lead to result of low contrast (LC) images in weak illumination. The idea of this step in image processed is to raise the dynamic range of the gray levels. Figure 3.4 (a, b) shows a typical transformation used for contrast stretching.

As well, the goal of contrast stretching is to set the contrast of image to be more intense, thus that the gray level histogram from the input image is charted onto a uniform histogram. For this work, the contrast normalization is executed by computing a two-element of pixel value for that vector, that common range of [0, 255] that can be used for stretching the contrast of the image may be done using:

1- by applying the equation (3.3), the stretching method is illustrating in algorithm (3.4) [1].

$$stretch\big(I(r,c)\big) = \left[\frac{\boldsymbol{I(r,c)-I(r,c)_{MIN}}}{\boldsymbol{I(r,c)_{MAX}-I(r,c)_{MIN}}}\right][MAX - MIN] + MIN \qquad (3.3)$$

Wherever I (r,c) MAX and I (r,c) MIN refer to the maximum and the minimum gray levels (GL) values in the gray image, MAX and MIN refer to the greatest and smallest GL values [0 255] [19].



a) Low-Contrast Image. b) Result of Contrast Stretching.

Figure 3.4: Shows a typical transformation used for contrast stretching [19].

Algorithm 3.5: Contrast stretching.

Input	Img_in= original image(RGB)
output	Img_out=Image after stretching

```
img_in =imread (image. tif);
I=rgb2gray(img_in)
figure, imshow(I);
figure, imhist(I);
I=im2double(I);
I_min=min (I (:));
I_max=max (I (:));
Img_out=255*(I- I_min)/(I_max-I_min);
Img_out=uint8(img_out);
figure,imshow(img_out);
figure,imhist(img_out);
```

2- Histogram Processing:

As shown in this section the histograms are fundamental for numerous spatial domain processing techniques, so making them a widespread instrument for the real-time in IP. In addition, that it supplies useful image statistics. Histogram manipulation can be used to adjust the contrast by raising the dynamic domain of the GL that is effective for image enhancement. The histogram of a digital image to GL in the domain between [0, L-1] .is distinguished:

Adaptive histogram equalization (AHE):

It enhances the contrast of the gray scale (GS) image by converting the values by utilizing contrast limited adaptive histogram equalization (CLAHE).

CLAHE works on little areas in the image, called tiles, as opposed to the entire image. Each tile's contrast is enhanced, thus that the histogram of the output area approximately matches the histogram, defined by the 'Distribution' parameter. The connecting tiles are then combined utilizing bilinear fulfillment to expel falsely prompted limits. The differentiation, particularly in homogeneous regions, the advantage of CLAHE contrast is enhanced, and 'Distribution' ability be bounded to bypass amplifying every noise that can be occur in the image.

To Apply CLAHE method is illustrate in algorithm (3.6). The syntax of adaptive histogram equalization in Matlab:

J = adapthisteq (I)

Algorithm 3.6: Histogram equalization.

Input	x= original image
Output	Im_histeq=Image after stretching by histogram equalization

```
x= imread('image.tif');
Im_histeq = adapthisteq(x);
figure, imshow(x);
figure, imshow(Im_histeq);
figure, imhist(Im_histeq);
```

C. De-Noising:

We may had comprehended the noise that is a corruption in the image signal, caused by outer unsettling influence.

In the event that an image is being sent electronically starting with one place then onto the next, by means of satellite or remote transmission, or through link of cable networked, we may anticipate that blunders will happen in the image signal. These mistakes will show up on the image yield in various courses relying on the kind of unsettling influence in the signal.

Typically, we comprehend what sort of mistakes to expect, and the kind of noise on the image; subsequently we can pick the most suitable technique for diminishing the viability of the commotion affect, cleaning a tainted picture by commotion is along these lines a critical region of image rebuilding.

In this segment we will research a portion of the diverse methods of taking out or diminishing noise impacts on the image [16].

So the order-statistical filters are usually non-linear filters, in which the kernel mask slip over the image in the same way as the linear status, the only difference entity that the filtered rate will be the outcome of some nonlinear operations on the neighboring pixels [1].

IP with Standard Spatial Filters:

In this section we discuss linear and nonlinear spatial filters.

1- Linear Spatial Filters:

It bolsters a various of predefined 2-D linear spatial filters, obtained by using a special function, which creates a filter mask, (w), utilizing the general syntax of special is:

w = fspecial ('type', parameters)

where 'type' indicates the filter type, and parameters further define the specified filter [20].

Gaussian Filter:

Gaussian is a very important filter, its low pass filter, then continuous 2-D Gaussian function which can be defined as equation (3.4):

$$g(x, y) = 1/\sigma \sqrt{2\pi} \exp(-(x^2 + y^2)/2 \sigma^2) \tag{3.4}$$

x: in the horizontal axis the distance from the origin point.

y: in the vertical axis the distance from the origin point.

σ: the standard deviation of the Gaussian distribution [1].

the syntax of gaussian filter in Matlab is:

h = fspecial ('gaussian', hsize, sigma) B

Gaussian low pass filter of size $(r \times c)$ hsize with standard deviation (SD) of sigma (positive). H size may be a vector determined the number of rows and columns in h, or it may be a scalar, in which status h is a square matrix. The default value for matrix size is [3 3], and (σ) is 0.5.

2- Nonlinear Spatial Filters:

A commonly- utilized tool for creating nonlinear spatial filters functions ordfilt2, which makes order-statistic filters (as well called rank filters).

These are nonlinear spatial filters whose reaction is based on ordering (ranking) the pixels that are contained in an image neighborhood and then substituting the value of the center pixel in the neighborhood with the value particular by the best-known order-statistic filter in digital IP is the median- filter to make a median filter:

Median filtering:

Median filtering, seems a roughly tailor-made to sweep the noise (salt and pepper). A median filtering is an example of a non-linear spatial filter: recall that, if there is an even number of values, or median of a set is the middle value when they are isolate.

The output value is the median of the values in the mask, by using mask (3×3), for example in Figure 3.5:

50	65	52
63	255	58
61	60	57

$\longrightarrow$ 50 52 57 58 [60] 61 63 65 255 $\longrightarrow$ 60

Figure 3.5: Represent example of mean filter.

The process of obtaining the median means that, very small or very large values, noisy values will end up at the top or bottom of the isolated list. Thus the median will in common substitute a noisy value with one closer to its surroundings. [16] In MATLAB, median filtering is implemented by the medfilt2 function:

B = medfilt2(A, [m n]);

median filtering is performed, where each output pixel contains the median value in the m-by-n neighborhood around the corresponding pixel in the input image. Then medfilt2 still does a remarkably good outcome, to eliminate noise entirely, there for, there is two-element numeric vector Neighborhood size, specified as a two-element numeric vector, [m n], of real positive integers. [m n] Neighborhood size3-by-3 (default).

B=medfilt2(A, [3,3]);

OR

B=medfilt2(A, [5,5]);

Illustrate in algorithm (3.7) apply median filter

Algorithm 3.7: De-noising image.

Input	Input _Img=image after stretching
Output	Out_ Img=de noising image
Input_Img=Image after stretching; Out_Img= medfilt2(Img_input,[m n]); Figure, imshow(out_Img)	

D. Smoothing:

To reduce the blur and the noise, smoothing filter is used, Blurring is utilized in preprocessing phase, like the removing of small specifics from an image before the extraction of a (large) object, noise dilution can be accomplished by blurring [19].The concept of filtering has been used in frequency range or in the spatial range where it refused some frequency components and accepted others in frequency range, however the spatial domain filtering is operating in a pixel neighborhood [1].In the linear filters, a new (filtered) value of the base pixel is specified as some linear set of the pixel's values in its neighborhood, the commonly used linear filters are:

Mean filter:

The mean filter is one of the simplest, and it locale for operations that make blurring images. The concept of the mean filter is to change the center pixel value in the output image with the mean value of a $(M \times N)$ neighboring pixels of input image as shown in equation (3.5) by using filter mask example of $(3x3)$ window size.

$$h = \frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \tag{3.5}$$

The window size (M × N) pixels is used for performance the mean filter which is selected based on test, thus, the degree of blurring relies on the volume of the mask [1]. The algorithm (3.8) is illustrating the steps of apply mean filter on image.

Algorithm 3.8: Mean filter.

Input	[a b]= size of original image
output	z=Image after mean filter

```
[a,b]=size(a5);
z=zeros(a-2,b-2);
for i=1:a-2
   for j=1:b-2
      z(i+1,j+1)=mean2(a5(i:i+2,j:j+2));
   end
end
colormap(z(256));
figure, imshow(z),title('mean filter’)
```

3.6 Feature Extraction (FE)

FE is an essential step in the biometric recognition systems the features must be extracted since the biometric characteristics cannot be immediately compared but require fixed and distinguishing features to be extracted from sensor outputs [1].

So, the main idea is to get all the features of the PV image in a mathematical equation rather than the original palm image after preprocessing it, by using mathematical transforms. To execution of the proposed algorithm in PV print [18] The Selection of suitable FE way is perhaps the single most substantial factor in obtaining high recognition performance [21].

There are different methods used to extract features of PV from the palm images such as what have been reported in a previous study. The widely used feature extraction methods are: Gabor features, maximum curvature, line tracing

The FE process is starting from an obtained vein image sample. The pattern of veins structure, to be extracted from the noisy vein image, a sample is shown in Figure 3.7. Features used for recognition and identification is localized in the extracted VP. Published in various algorithms with various studies based on line tracing, local thresholding, curve lets and neuronal networks, as well as maximum curvature points. The algorithms of those released all have the same result: VP for authentication aim, which needs to be stocked and processed [22].

3.6.1 Maximum Curvature Method

This part describes our algorithm for extracting finger VP from finger images. There are three steps in this algorithm:

[Step 1] Extraction of the center positions of veins:

When extract the centerline of veins with different widths and brightness', the procedure checks the cross sectional (CS) profile of a vein that appeared to an extent the main reason the vein is gloomier than the surrounding region, as presented in Figure 3.6. These concave curves own great curvatures. shown the (wide & narrow) or (dark &bright) veins in the position (A, B, C) Fig 3.6 & in (position C) the center status of veins do not have a native minimum brightness, thus, the center status of veins may be gained by computing local maximum curvatures in CS profiles.

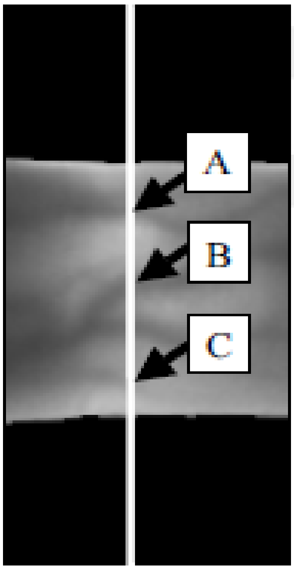


Figure 3.6: Cross sectional (CS) profile of vein [23].

The method for extracting vein center lines is viewing in Figure 3.7. To make Feature extraction active versus vein width variation.

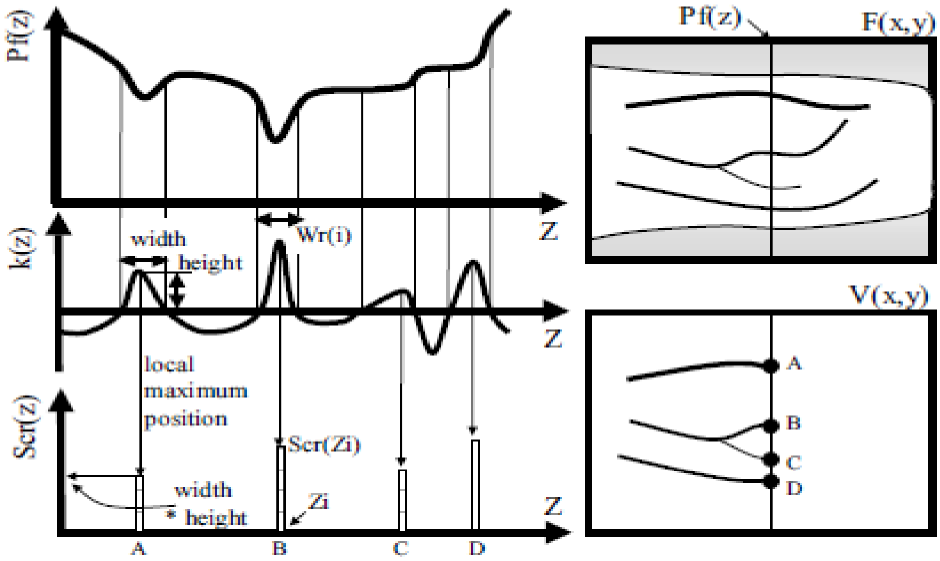


Fig 3.7: Relationship among profile, curvature, and probability score of vein [23].

[Step 1-1] Calculation of the curvatures of profiles:

$P_f\,(z)$ is obtained from $F(x,y)$at a vertical direction, where $F(x,y)$is the intensity of pixel (x,y). As shown in Fig. 2. To relate a position of $P_f\,(z)$ to that of (x,y) , the mapping function T_{rs} is realize as $F(x,y)$=$T_{rs}\left(P_f\,(z)\right)$

The curvature, K_z, can be represented as(3.6):

$$k(z) = \frac{d^2\,P_f\,(z)/dz^2}{\left\{1+\left(d\,P_f\,(z)/dz\right)^2\right\}^{\frac{3}{2}}} \tag{3.6}$$

[Step 1-2] Detection of the centers of veins:

The classified of profile as convex or concave relied on whether $\boldsymbol{K_z}$ is positive or negative Fig. 3.7 If $\boldsymbol{K_z}$ is positive, the profile $\boldsymbol{P_f\,(z)}$ is a dent "concave". In this step, the local maximums of $\boldsymbol{K_z}$ in each concave region are computing. These points indicate the center positions of the veins. The status of these points are represented accordingly $\boldsymbol{Z_{\frac{1}{i}}}$

$\boldsymbol{i = 0, 1, \ldots.\ , N-1}$ where $\boldsymbol{N}$ Is the maximum number of local points in the profile.

[Step 1-3] Assignment of scores to the center positions:

Results mention that the possibility of placing central centers on veins is assigned to each center status.

A Scores $\boldsymbol{S_{cr}}(Z)$ define as (3.7) :

$$\boldsymbol{S_{cr}}(\boldsymbol{\acute{Z}}) = \boldsymbol{K}(\boldsymbol{\acute{Z}}) \times \boldsymbol{W_r}\ (\boldsymbol{i}), \quad (3.7)$$

Where $\boldsymbol{W_r}\ (\boldsymbol{i})$ is the width of the area where the curvature is the positive one of $\boldsymbol{Z}_{\frac{1}{i}}$ is located (Figure 2). If $\boldsymbol{W_r}\ (\boldsymbol{i})$ represents a large vein width, the vein may also be large. Moreover, the curvature in the center of the vein is great when it appears clearly. Therefore, the width and curvature areas Are considered in their grades. scores are assigned to the plane, V, a result of confirm on the veins. This is, Assignment of scores to the center positions:

$$\boldsymbol{V}(\boldsymbol{\acute{x}_\iota}, \boldsymbol{\acute{y}_\iota}) = \boldsymbol{V}(\boldsymbol{\acute{x}_\iota}, \boldsymbol{\acute{y}_\iota}) + \boldsymbol{S_{cr}}\ (\boldsymbol{\acute{z}_\iota}) \quad (3.8)$$

Where $(\boldsymbol{\acute{x}_\iota}, \boldsymbol{\acute{y}_\iota})$ represents the points defined by $\boldsymbol{F}(\boldsymbol{\acute{x}_\iota}, \boldsymbol{\acute{y}_\iota}) = \boldsymbol{T_{rs}}\left(\boldsymbol{P_f}\ (\boldsymbol{\acute{z}_\iota})\right)$

[Step 1-4] Calculation of all the profiles:

To get the VP pervasion in an entire image, all the profiles in four directions also it is analyzed. The directions applied are horizontal, vertical, and the two oblique directions intersecting the horizontal and vertical at 45° thus.

[Step 2] Connection of the center positions:

To link the centers of veins and remove noise, the depended on filtering operation. First, two neighboring pixels are checked on two side (right & left side).

The line is drawn horizontally if the value of $(x, y)$and the pixel on both side are large . The line is drawn with a gap at (x, y)When the value of the pixle large in both side and the value of pixel$(x, y)$is small thus, the value of(x, y)must increase to connect the line. The point of noise is at (x, y)When the pixels on both sides of (x, y)have small values and (x, y)has a large value , thus, to remove the noise should be reduced the value of (x, y) . This process can be via as follows in (3.9).

$$Cd_1(x, y) = min\{max(V(x + 1, y), V(x + 2, y)) + max(V(x - 1, y), V(x - 2, y))\} \quad (3.9)$$

Second, in the same way calculation is made for each of the four directions and $Cd_2\ Cd_3\ Cd_4$ gained. Finally $G = max(Cd_1, Cd_2, Cd_3\ , Cd_4)$

[Step 3] Labeling of the image:

VP, using a threshold for binarized $\boldsymbol{G}(\boldsymbol{x}, \boldsymbol{y})$, labeled as section of the background when the pixels with values smaller than the threshold. labeled as section of the vein area when the pixels with values equal or greater than the threshold. An example of VP extraction is represented in Figure 3.8 [23].

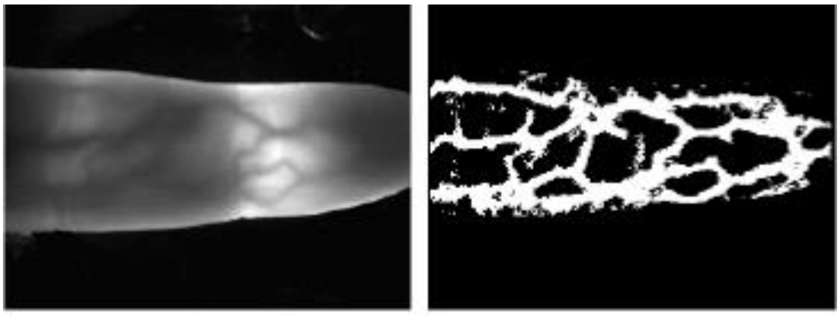


Figure 3.8: An example of vein patterns (VP) [23].

3.7 Matching

Matching is a process that includes scaling the degree of resemblance between two templates. thus, extracting the features and storing it in training database, matching process that takes place by calculating the degree of resemblance between VP (i.e. That input test PV image by feature stored with feature template), The distance measures are often used to measure the difference between two feature vectors.

There are two matrices commonly used to measure the distance, which are: (Euclidean Distance, City Block Distance) [1].

The process of matching phase, the data of VP is converted into matching data, and compared these data with register data. For matching line shaped VP there are Two methods commonly used:

1- Structural matching: while a finger VP in the hand has little of feature points, and this method is requiring additional extraction of feature points like bifurcations and line endings.

2- template matching: based on comparison of pixel values is more convenient to apply matching step for palm VP.

The classical technique of template-matching against pattern distortion is not robust. To solve this problem, the "ambiguous area" surrounding the veins are identified, and the tenuous mis-alignments between VP in the palm regions are negligent. Robust achieved by apply template-matching [24].

CHAPTER FOUR

4. EXPERIMENTAL TESTES AND EVALUATION

4.1 Introduction

This system has been prepared to recognize individual based palm vein patterns, with utilizing the connotation of maximum- curvature method to extracted better realize of the vein status. The task of matching is depending on scales function to generate key points position from the vein's in the palm.

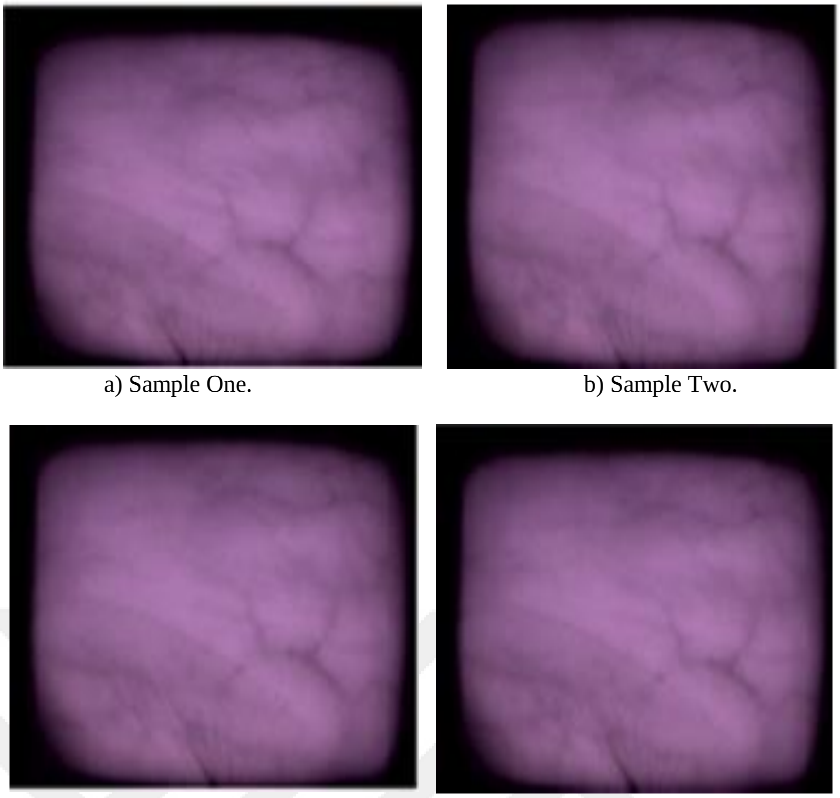
In this chapter, the results of experimental tests show the results of detection of BV images after extract region of ROI with features extraction, verification and matching the result are presented and discussed.

4.2 Dataset Enrollment

The database is taken from (PUT Vein Pattern Database) consists of 240 images presenting human VP by using based on low cost standard USB camera in modular construction.

Half of the images include PV pattern (120 images) and another half contains a wrist VP (120), the images capture in three a session so we have in this data set three series and four images each series, with at least one week between each a session, Images in database have (1024× 768) resolutions and are saved as 24-bit bitmap.

Where The data set used to construct the system of PV print, for the training and testing the algorithm from (PUT) database, this data set consists the PV printing images for 10 people. Five samples per person, four training images (4 * 10 = 40 images) and one for test (1 * 10 = 10 images) so we have 50 images have been used in our tests as training samples for both of identification and verification tasks, respectively. IN figure 4.1 shows the samples of PV images for person (no1) right hand in one a session.



a) Sample One. b) Sample Two.

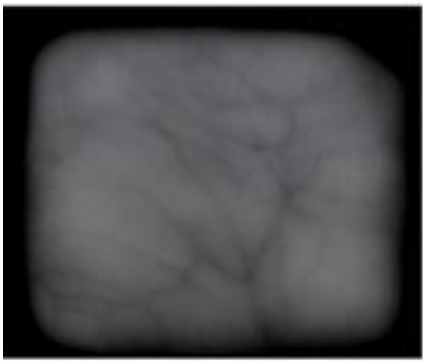
c) Sample Three. d) Sample Four.

Figure 4.1: Shows the samples of palm vein (PV) images for person number one for right hand in one a session.

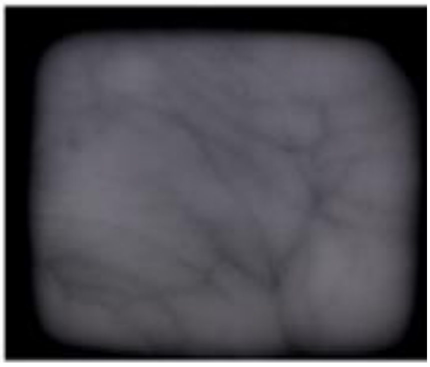
4.3 ROI Extraction

The experimental results show that the proposed algorithm is effective and efficient in PV of ROI segmentation and is robust for noises surrounding PV images. In this paper we used the (PUT data set of VP) database.

So between the sessions viewing large displacements in captured images. In fact, the area in one image may only be partly present in another. In addition, if the ROI is too small, it restricted the number of features that can be extracted from the image. This paper selects the entire captured image region as the ROI. Figure 4.2 shows the samples of PV images for one person with different session. the position of captured first image is different than the second image that causes obstacles with features that extracted from both of them with the extraction and matching the features, so that have been decided to get the image without cropping small region ROI.



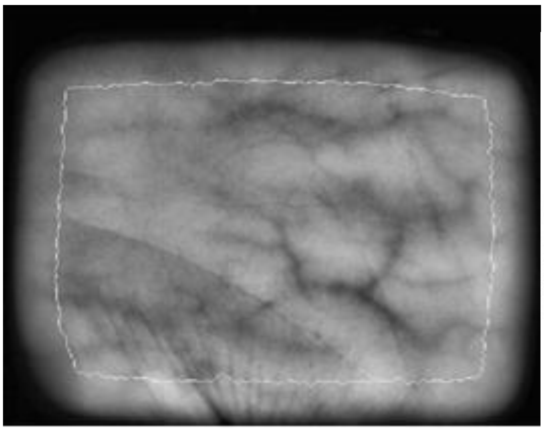
a) The Image in First Session.



b) The Image in the Third Session.

Figure 4.2: Show two palm vein (PV) images at different sessions from the same person a large displacement is attracting attention between two images.

Therefore, to extract PV from the original image we performed that extraction by bounding the ROI automatically as we shown in Figure 4.3, which is was done by writing a code which used to detect the out edge of the palm then determine an inner bound as shown in the figure below the second figure represents the cropping image after getting rid of the out boundaries of the image. We tried to extract the ROI by using fixed square or rectangle templet but we notice that we loss some important information, that’s why we preferred to use automatic framing for the ROI. The idea of this extraction relays on the pixels located in the edges of the palm, where the white frame that shown in the first figure was conducted based on edge pixels with suitable shifting to get rid of the dark places that surround the image. We did this step since our algorithm used to detect the veins where their colors are dark and similar to the background of the image.



a) Before (ROI) Automatically.

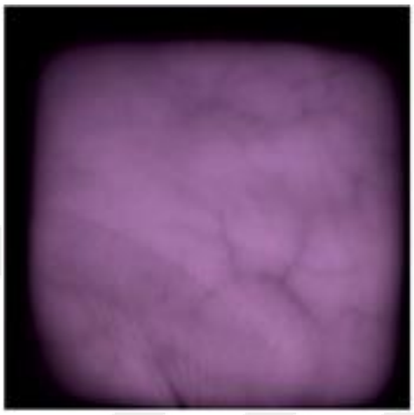
b) After (ROI) Automatically.

Figure 4.3: Shows the samples of palm vein (PV) images before& after cropped region of interest ROI automatically.

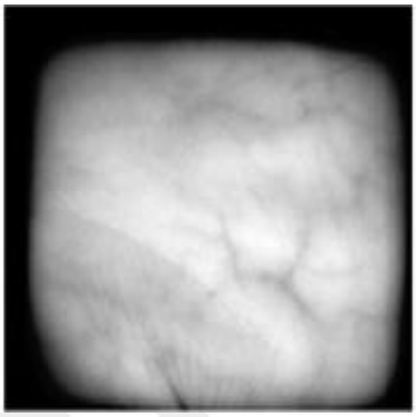
4.4 Pre-Processing

A. Gray intensity image:

In this phase, the input image (original image) is converted to GS density image. This inversion phase will create bright veins relative to the background. Figure 4.4 shows a sample of the IR palm image (a) .and the image in (b) represents the GS image.



a) RGB Image.



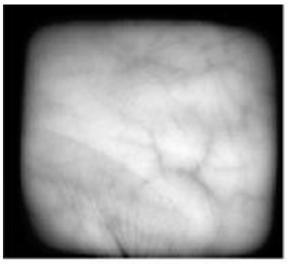
b) Gray Scale Image.

Figure 4.4: Sample of captured RGB image and converted it to gray scale intensity.

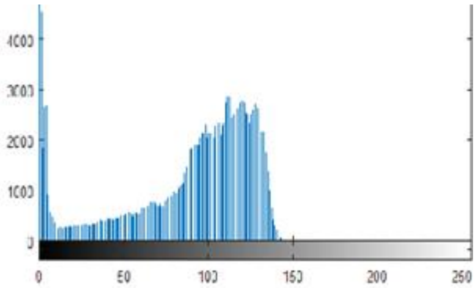
B. Contrast Stretching:

By applying adapt histogram equalization method AHE, the contrast stretching increases the dynamic extend of an image to cover the full brightness extend. Figure 4.5 (a, b, c, d) illustrated the histogram of two samples images before and after apply stretching step before extract ROI.

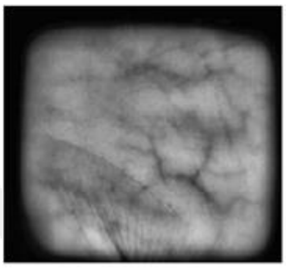
Sample 1



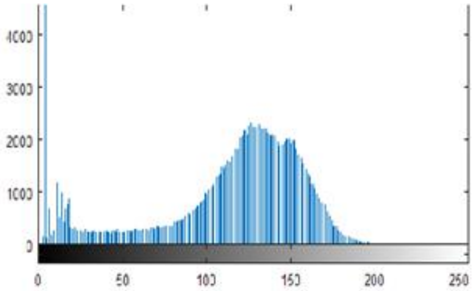
a) Gray Scale Intensity Image.



b) Histogram for Gray Scale Intensity Image.



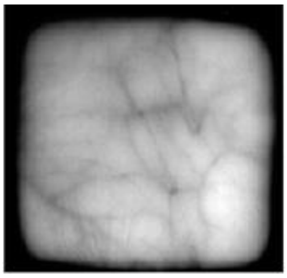
c) Apply (AHE).



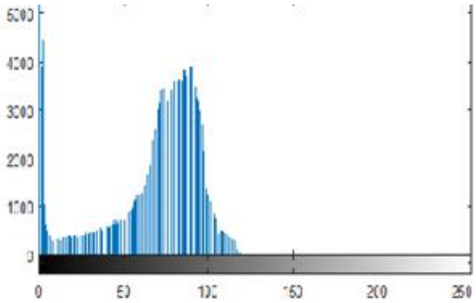
d) Histogram after AHE.

Figure 4.5: Input image for sample (1) with represented the histogram. After apply adapt histogram equalization (AHE) method with represented the histogram.

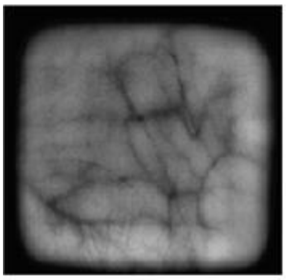
Sample 2



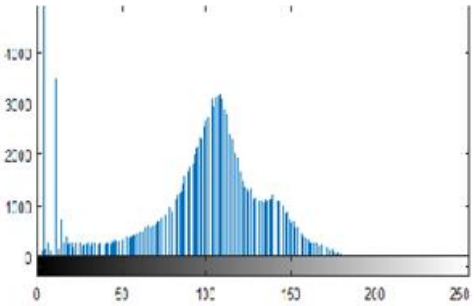
a) Gray Scale Intensity Image.



b) Histogram for Gray Scale Intensity Image.



c) Apply (AHE).



d) Histogram after AHE.

Figure 4.6: Input image for sample (2) with represented the histogram. After apply adapt histogram equalization method (AHE) with represented the histogram.

The contrast stretching increases the dynamic extend of an image to cover the total brightness extends, after apply stretching step before extract ROI. As shown in Figure 4.5 (sample1) and Figure 4.6 (sample2) and illustrates in Figure 4.7 contrast stretch by applying adapt histogram equalization method after extract the ROI.

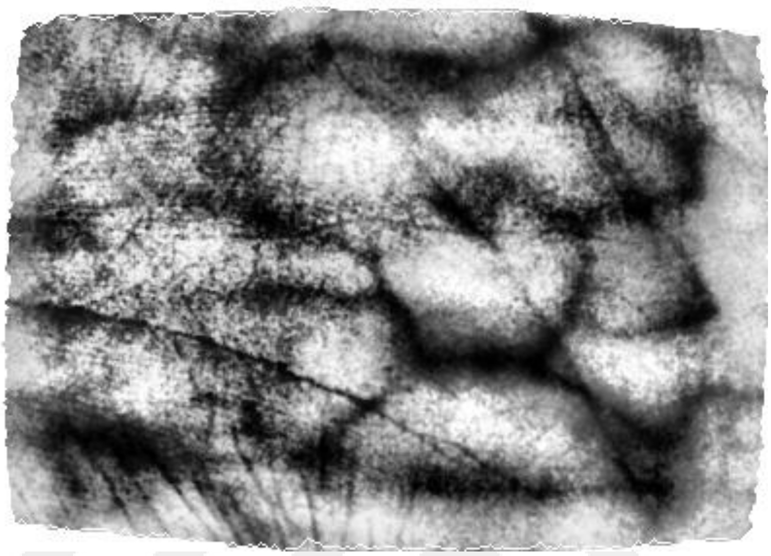
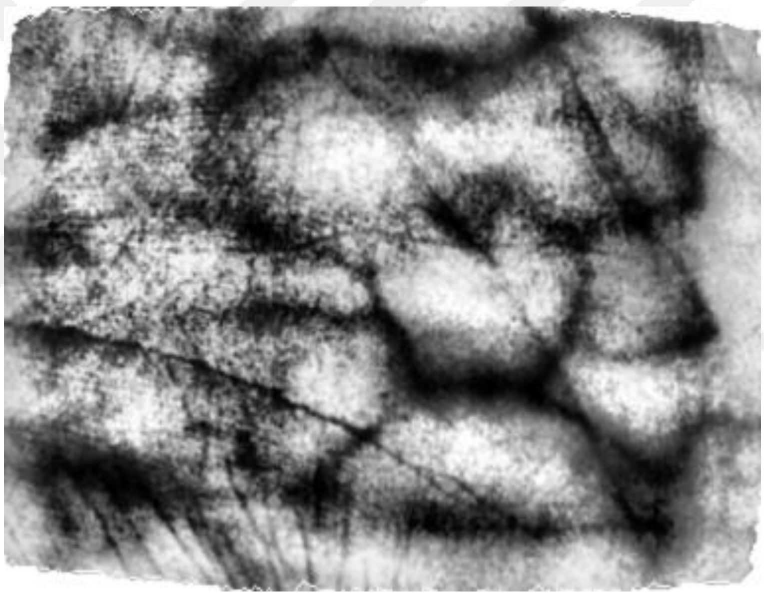


Figure 4.7: Illustrates contrast stretch by applying adapt histogram equalization method after extract region of interest (ROI).

C. De-noising:

Gaussian fitter leads to good result in term of reducing image noise. Gaussian low pass filter in which case h is a square matrix. The value for h size is [7 7]; and use the default value for sigma is (0.5) As showing the Figure 4.8 (a, b) illustrates before and after applying Gaussian fitter to remove the noises.

a) Before Image De-Noising



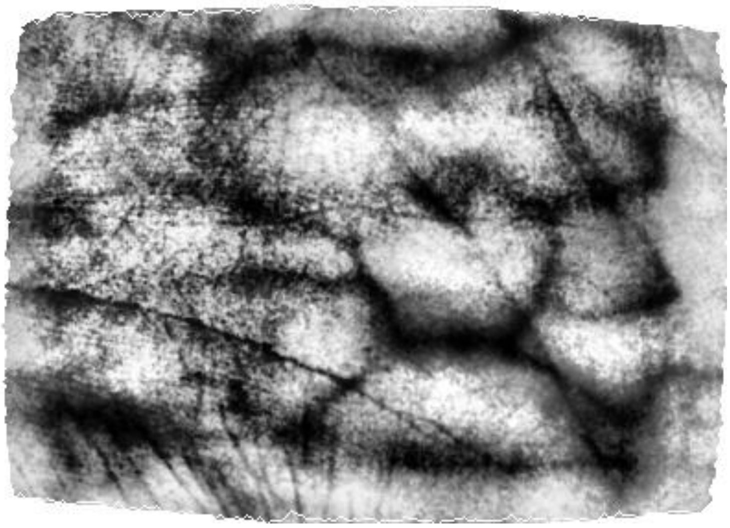
b) After Image De-Noising.

Figure 4.8: Before and after applying gaussian fitter to remove the noises.

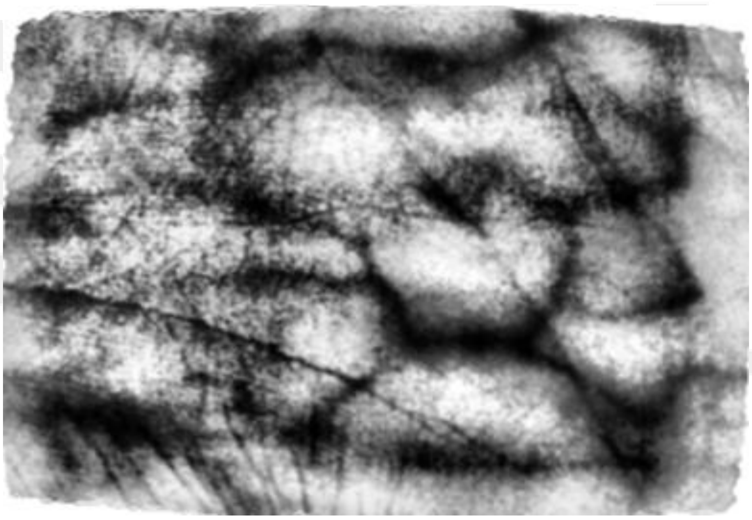
4.5 Vein Segmentation

A. Smoothing Image by Applied Mean Filter:

Mean filter used to reduce the blur and the noise by applying the algorithm 3.9, Blurring is used in preprocessing steps, like elimination of small details from an image before vein extraction, noise dilution can be achieved by blurring. As shown in Figure 4.9 illustrates the results of applying the mean filter on the image after blurring.



a) Original Image



b) Apply Mean Filter

Figure 4.9: Illustrates the results of applying the mean filter on the image after blurring.

4.6 Feature Extraction

In the proposed work before matching phase, we extracted the features from the palm by apply the algorithm of maximum curvature method. it has been applied to extract the features of vein clearly with use different values of sigma .as we observed in table 4.1 different value of sigma and noted change with clearly in veins.

Table 4.1: Different value of sigma and noted change with clearly of veins.

sig	Result
3	The valleys and the edges appears with the veins.
5	The valleys and the edge appears less with the veins.
7	The valleys and the edge appears less with the last value of sigma.
9	The veins appearance is more clear.
11	The disappearance of valleys and veins appearance is more obvious.
14	The veins appears very clear without valleys.

As we observe in Figure 4.10 when we apply maximum -curvature method with different value of Sigma (σ) We noted disappear the valley and appear the veins clearly when($\sigma = 14$) .

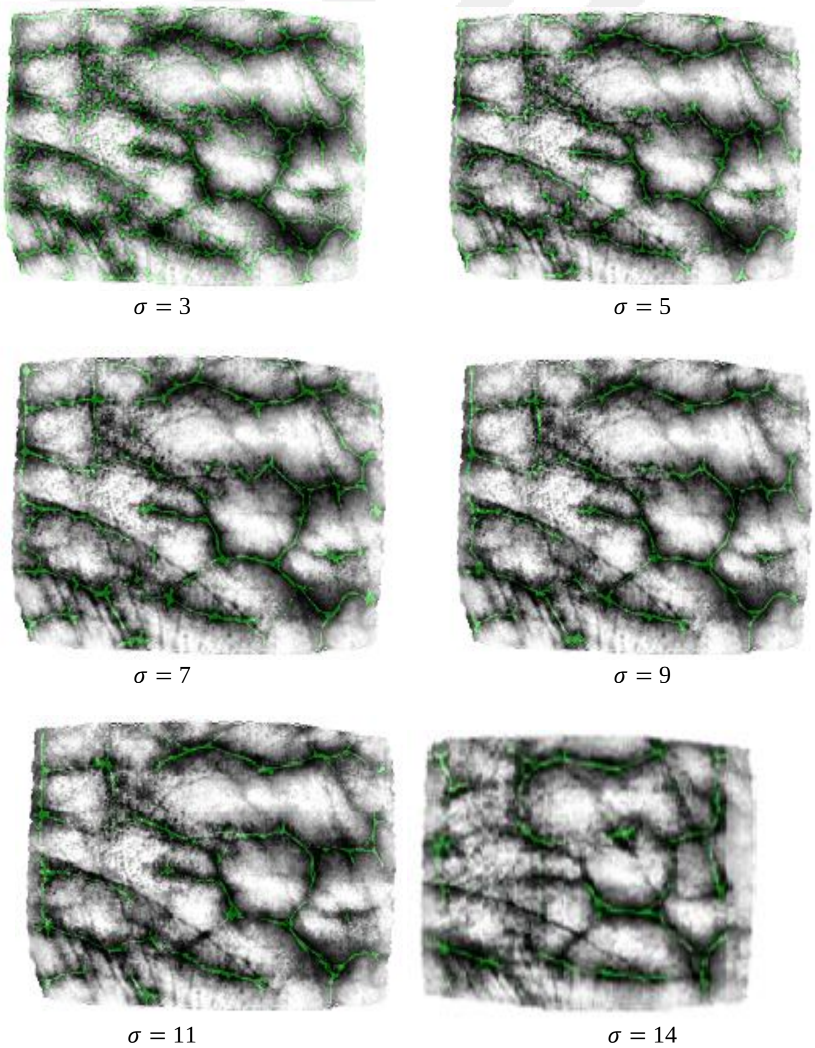
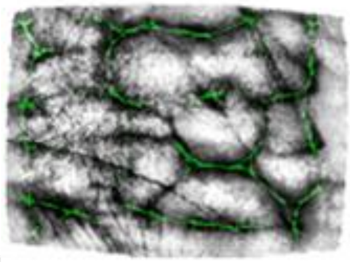
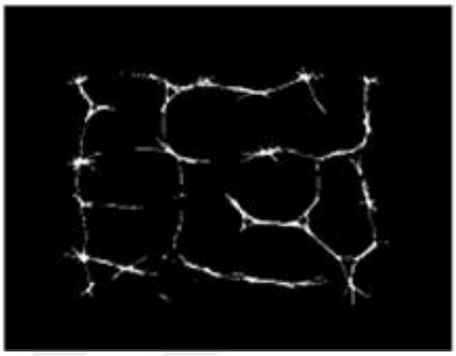


Figure 4.10: We use different value of sigma and we noted disappear the valley and appear the beans.

Preparing the image to the matching phase after converted the image that extracted from feature extraction phase to the binary image the white lines represents the vein extracted from the original image. As shown in Figure 4.11 (a, b) we used value of sigma (14) and we noticed the valley disappeared and the veins appeared clearly.



a) Extraction Feature with Value of $\sigma = 14$.

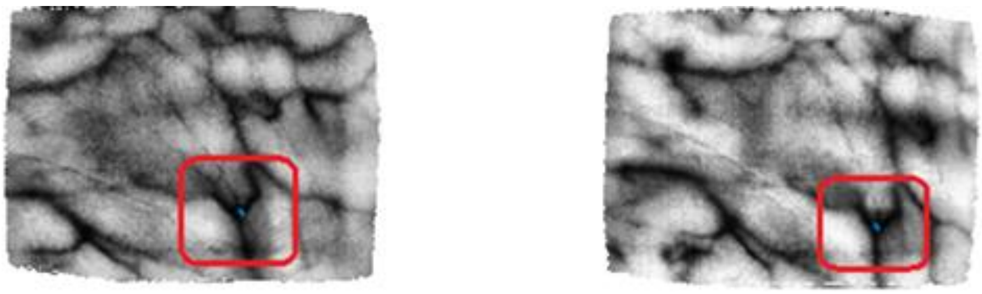


b) Preparing to Matching Phase by Converted the Image to Binary.

Figure 4.11: We use value of (σ =14) and we noted disappeared the valley the veins appear clearly after we converted it to the binary image to apply matching phase.

4.7 Finding Reference Point

One of the big challenges that we faced in this study was finding reference points for the dataset. As known many studies used dataset that contain fingers, in such dataset that will ease the process finding reference points. The importance of reference point appears during the matching process, since the training images and the test images are not identical in term of rotation angle and shifting that’s because the taken images for the same person were taken in different angels and different positions. In our dataset it is difficult to determine reference point since there are no fingers but only palms. Although the images have different intensities but these images for each person have something in common, which is regions with lowest intensities after detecting these points we cropped this region as a region of interest for the matching purposes. The reference point is the center point of the region that we cropped from these two images, the region as template with a square shape with value (150*150). After checking through the dataset, we noticed that most of the images have unique shape veins around these references point that awe detect and that’s defiantly the most important region in the palm, the Figure 4.12 below shows the detected reference points.

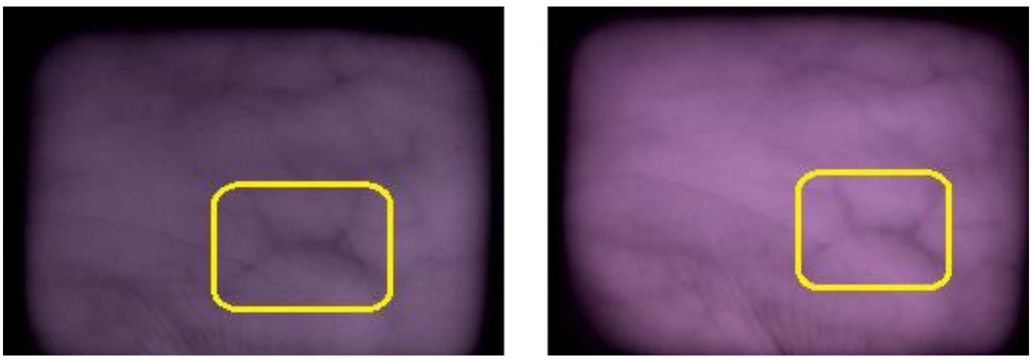


a) Test Image. b) Training Image.

Figure 4.12: Reference points detection.

4.8 Matching

As we mentioned previously that we cropped a small portion of the image (training and testing), the center of the cropped image is the reference point that by extracted the template with square shape (150×150) the center of these template is represent the reference point. We used this method because the difference of intensities of the images for each person effect on the used algorithm in this study because not all veins can be detected in all the images for the same person and because the region around the reference point more clear comparing with other region for the same palm as shown in the Figures 4.13 below.



a) Image in First Session. b) image in second session.

Figure 4.13: Regions with lowest intensities for the same person.

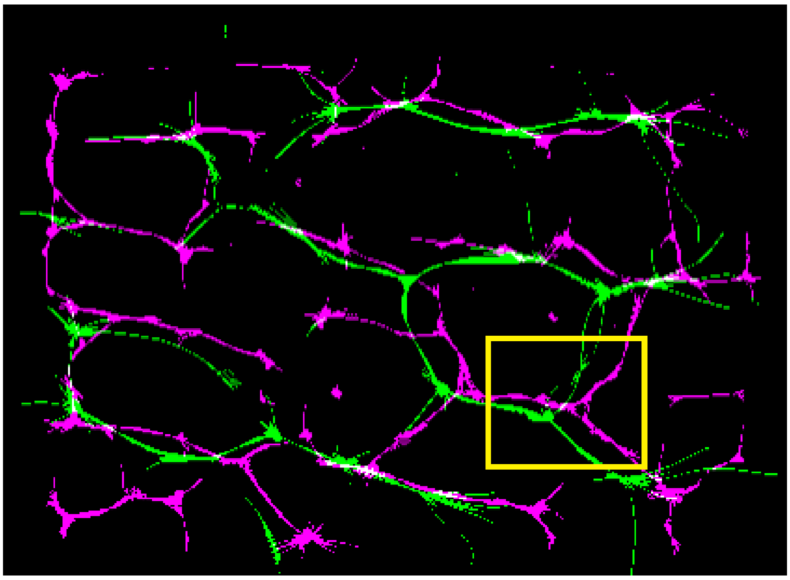


Figure 4.14: Two images (pairs).

It is clear to see in Figure 4.14 shifting between the two images (pairs), in our algorithm we corrected this shift based on the reference points that we found. We used three different methods for matching, First we tried to apply the matching for the whole image without cropping but the results were not that good illustrated the result in table 4.2, second after cropping the regions around reference points with template (150×150) we get higher results and the algorithm successes to recognize the veins for each person good illustrated the result in table 4.3. We stabilized the tested image and rotated the training image between [+10: -10] degree and for each degree we calculated the matching and then find out the highest matching for all the degrees as shown in Figure 4.15. The used equation during the matching stage is simply:

$$\text{TOTAL MATCHED PERCENTAGE} = \frac{\text{MATCHED DATA}}{\text{TOTAL DATA}} * 100\% \quad (5.1)$$

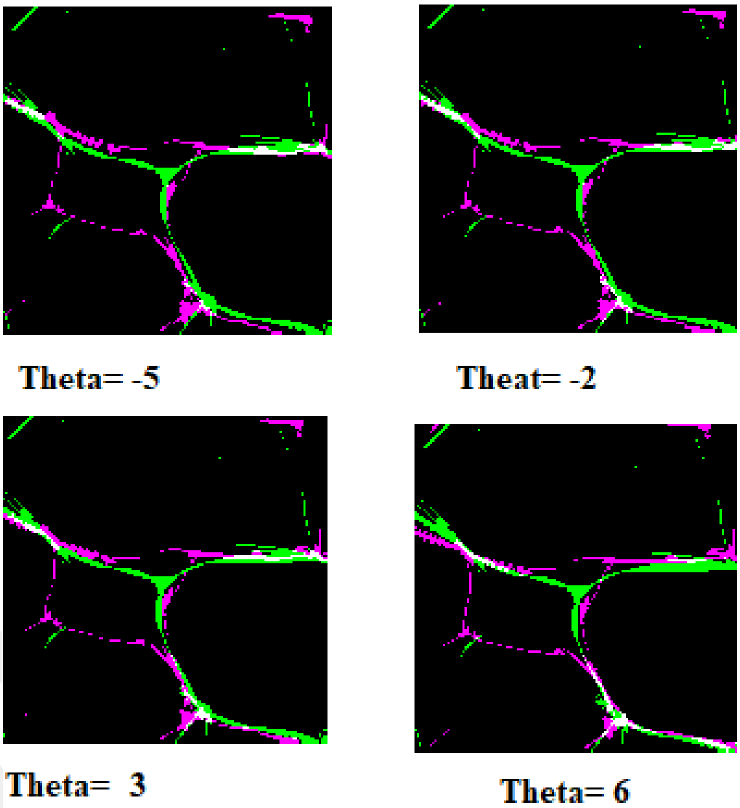
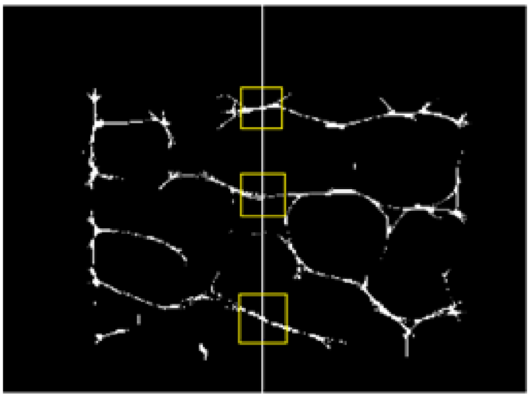
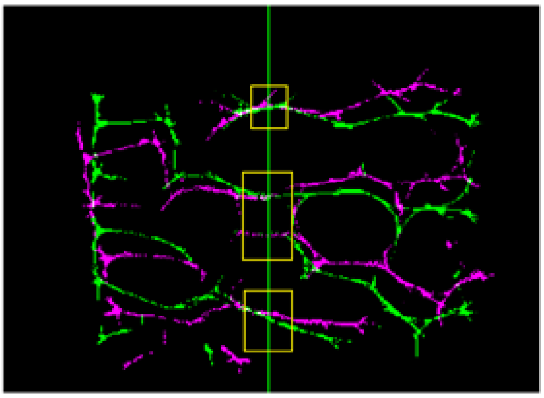


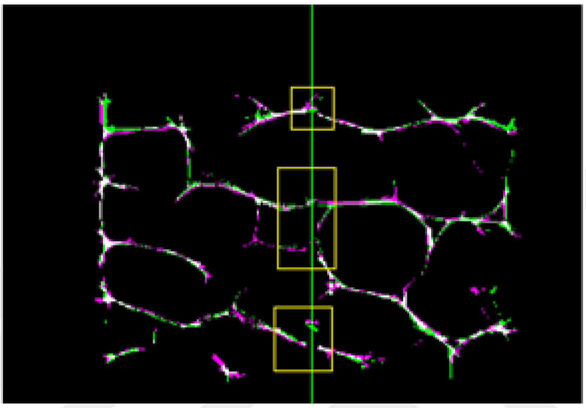
Figure 4.15.: Rotate training image with different degrees.

The third method used in this study is centerline which simply can be performed by passing a line through the image and find the intersections between the line and extracted features, these intersection points used in matching process between the two images (test image and train image). The yielded results are not that good due to the gabs of the curves founded in images due to the variety of contrast, illustrated the result in table 4.4. The Figure 4.16 (a, b, c) showed the result of applied centerlines over images.





a) Centerline &intersection point. b) Uncorrected image with centerline.



c) Correct images with centerline

Figure 4.16: After applying centerline method.

The tables below show the results between the three different methods used in matching.

Table 4.2: Matching (original images size for 10 people).

Person	Matching ratio	Correct person
1	12.674%	T
2	10.64%	F
3	7.54%	F
4	4.7%	F
5	7.37%	F
6	9.76%	T
7	13.21%	T
8	8.54%	F
9	9.74%	F
10	11.2%	F
		Accuracy= 30%

Table 4.3: Matching (templates).

Person	Matching ratio	Correct person
1	57.3 %	T
2	43.2%	T
3	51.4 %	T
4	23.54 %	T
5	15.35 %	F
6	47.6 %	T
7	32.5 %	T
8	37.6 %	T
9	44.3 %	T
10	48.3 %	T
		Accuracy = 90%

Table 4.4: Matching (centerline).

Person	Matching ratio	Correct person
1	7.4 %	F
2	23.2 %	T
3	19.4 %	T
4	16.4 %	F
5	14.8 %	T
6	5.6 %	F
7	8.2 %	F
8	16.01 %	F
9	17.9 %	T
10	21.6 %	T
		Accuracy = 50%

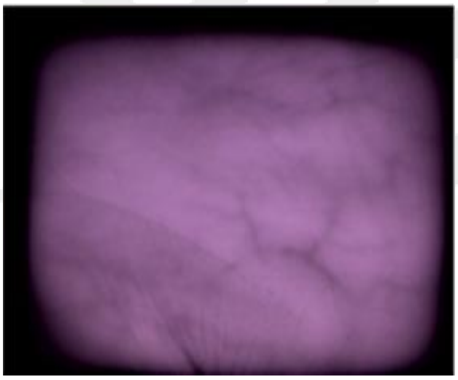
4.9 Evaluation of Propose System

1- When the work is started, the type of data set (PUT data set) is the main reason to depended the geometrically method to extract the ROI from the original image by geometrically calculating the center of the original image and depended in to extract the ROI. All the images are the same size (1024× 768) in (PUT data set), just the palm without fingers, so I preferred the geometrically cropped by calculating the center of the image through that determine the value of the main point (X Coordinate and Y Coordinate) to crop the requiring region square or rectangle according to the required size for instance (128×128) or (300×300).

Actually, I discovered that the region cropped in one image may only be partially present in another image. In addition, if the ROI is too small it is losing the information and limits the number of features that can be extracted from the image. That causes main obstacles with the accurate of extraction and matching the features.

There is clarity in the Figure 4.17 the first image (128×128) and second image (300×300) of the partially of the region cropped and loss of information and its limitation in the P V.

Thus, to extract vein from the original image I performed that had been decided to get the image without cropping small region extraction by extract the ROI automatically. I performed it and get better result.



a) Original Image.

b) Cropped 8 × 128 .

c) Cropped 300 × 300.

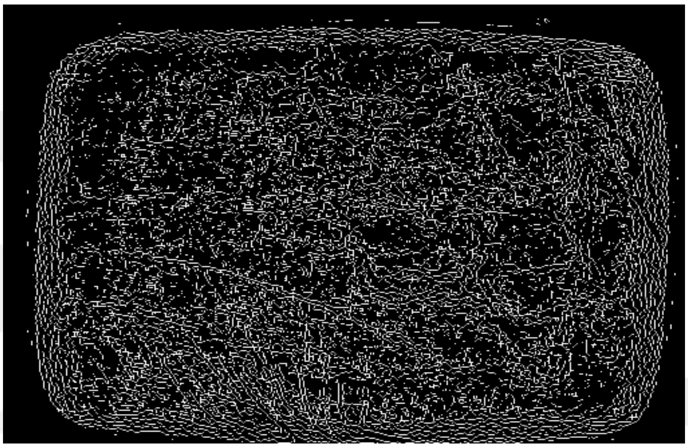
Figure 4.17: Depended the geometrically method to extract the region of interest (ROI).

2- Some processing should be adopted for refining the image and retaining the desired objects; before the processing phase including the “imdilate” method.

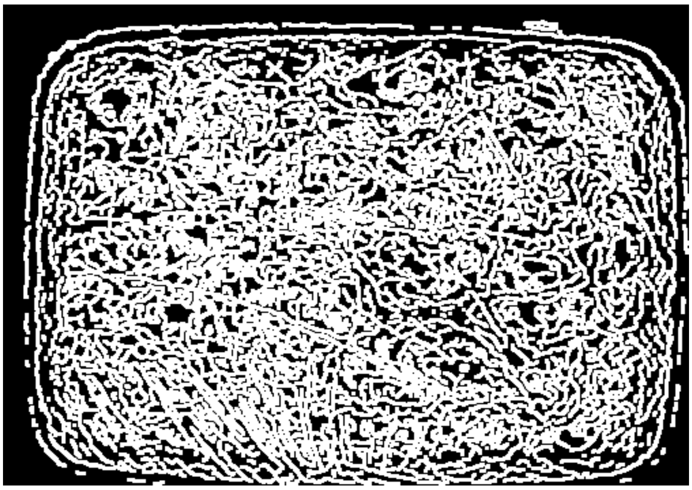
Apply function “imdilate” to segmentation and get rid of boundary and get ROI Detect Entire Cell grayscale, the argument setrel is a structuring element object, or array of structuring element objects, returned by the setrel or off setrel function.

With specifies two value of the angle are (0,90) of the line as measured in a counterclockwise direction from the horizontal axis, and approximately the distance between the centers of the structuring element members at opposite ends of the line is (3).

And with apply "sobel filter" to detector the edges best than apply "canny filter" that appearance Unwanted edges .AS shown in Figure 4.18 (a, b).



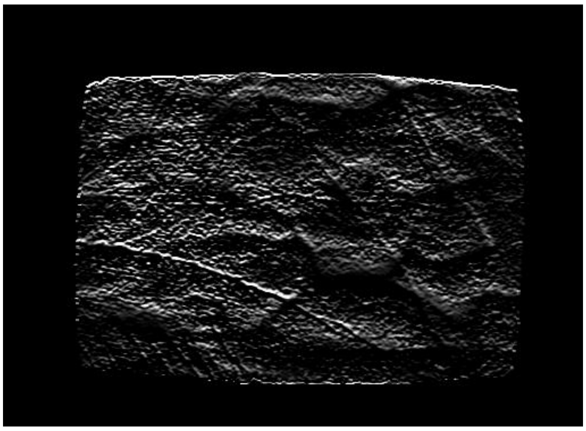
a) Sobel filter.



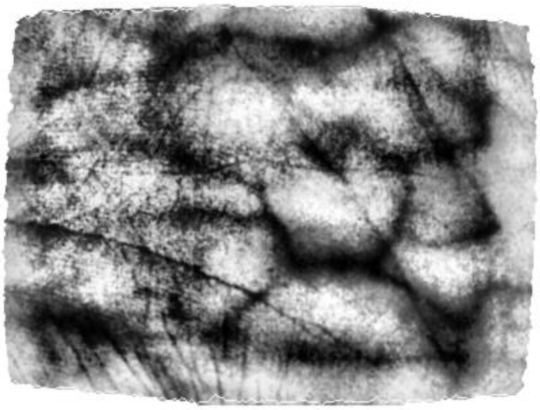
b) Canny filter.

Figure 4.18: Detector the edges with "sobel filter "best than apply "canny filter"

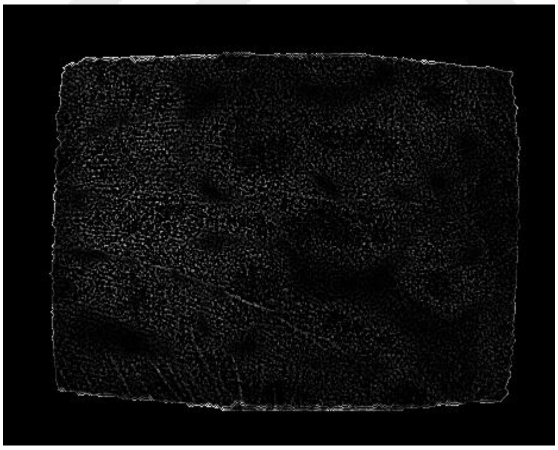
3- Result of applying of different filters in de-noising step. Gaussian filter leads to best result in term of reducing image noise as we shown in Figure 4.19.



a) Type Filter is Prewitt



b) Type Filter is Gaussian with the Parameter Value [7 7] & Sigma = (0.5)



c) Type Filter is laplacian the Parameter of Alpha =0.2

Figure 4.19: Gaussian filter best result in de-noising step.

4- In term of matching I tried to get batter results in different ways, for instance, I tried to match the whole image without any cropping but that was not sufficient. Another solution was used in the matching which is choosing key points. This method improved the results but increased the ratio of error.

I also used templates and I moved them over the tested image with different rotation angles but that’s take a very long time for the processing.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The extraction of veins palm is very important, since the common methods used nowadays for people identification cannot cover all the cases due to some sort of diseases such as diabetes and other factor that effect on the print of fingers and palms. The need for new way of verification appeared, vein patterns recognition can be used in this field. In our study we used 50 images for 10 different person I used a known algorithm for feature extraction which is (maximum-curvature). Finding reference points for the images helped me to determine the regions of interest and matching. Our results were very good in term of accuracy. Due to the sort of our dataset that don't contains the fingers but only palms, I found an accurate method to locate a reference points that were used for extracting the region of interest and correct the error occur between images in term of shifting and rotation. Image enhancement effect on the yielded results, in my study in preprocessing step I used Gaussian fitter leads to good result in term of reducing image noise and I used to adapt histogram equalization which improved the contrast of the images and lead to get a better result during feature extraction stage. Increasing the value of sigma improves the extracted veins. There are still problems with vein extraction due to the variety of contrast and brightness.

5.2 Recommendations for Future Works

a) I recommend using dataset of palms that contain fingers which can be used as reference points that in turn will ease the matching process.
b) Using more accurate algorithms that can be used for vein detections.

c) One of the most confusing obstacles that we faced in my study is the variety of intensities of the dataset which in turn will affect negatively on vein detection. So, I recommend generating dataset with similar intensities.
d) Using fixed template for extracting region of interest is not sufficient because some information might be lost.

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CURRICULUM VITA

PERSONAL INFORMATION

Name, Surname : Abeer Adnan Abdulrahman

Date and Place of Birth : / Iraq – Baghdad 4/1/1973

Marital Status : Married

Phone : 009647704220080-009053788738060

WhatsApp 00905378738060

Email : abeer.mtjmd@gmail.com

EDUCATION

High School : AL-KAWTHER 1989-1990

Undergraduate : University College of Madenat Al-Elem / Computer Technique Engineering/ Department of Computer Technique Engineering.

Work and skills:

Mayoralty of Baghdad since 2005 in the GPS unit.

Work in GPS unit in Municipality of AL-Kadhumya since 2012.

Computer skills: Windows 10, Matlab, MS Office, Prolog.