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PALM VEIN RECOGNITION

A Thesis Submitted to the College of Science at Al-Nahrain University as a Partial Fulfillment of the Requirements for the Degree of Master in Computer Science

By

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

((..يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ
وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ
وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ))

صَدَقَ اللهُ العَليُ العَظيم

DEDICATED TO

My Parents

MY husband

MY Brothers and sisters

to Every person taught me a letter and everyone who helped me in difficult times

Acknowledgments

Praise God for the grace that He gave me to finish this project and the psychological strength that the Lord gave me so that I faced all difficulties and challenges, thanking you, my God.

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Liqaa

2017

Abstract

Biometrics is automated methods of recognizing an individual based on a physiological or behavioral characteristic. Biometric system consists of two subsystems; one for enrollment and the second is for recognition. In enrollment, used three biometric samples used to create user's main template. While, in the recognition phase, the system tries to identify who is the person (in the case of identification) or to verify is the person who claimed to be (in the case of verification).

In recent years, when normal fingerprints have failed in some skin conditions, research has turned towards veins and iris where results are guaranteed used for the identification/verification of individuals. The vein trace is hard to damaged, changed or forge since veins are immersed inside the human body.

In this thesis, a biometric system was developed for Palm Vein Recognition (PVR), the palm vein image is firstly preprocessed to simplify the task of isolating the vein from the background, apply region of interest extraction (ROI) to use only this useful and interest rectangle that using in the next steps. Then the image is enhanced to prepare it for segmentation process, in which separation of the vein pattern from the background that used for recognition to certain low percentage of errors. The final stage is the feature extraction the image is traced and divide it by blocks. For each block, Mean and standard deviation are extracted once depends on rows and others depends on columns. And then distance equations have been used to make a decision in matching stage. The presented system was tested using a CASIA Multi-Spectral Palm-print Image Database contains 7,200 palm images captured from 100 different people. The recognition system gives a percent of 91.6% of correct recognition. The proposed system needs software

requirements which was a program that written in a Visual C# programming language. It provides to the user a Graphical User Interface (GUI) to display the operating events of this system and make decisions.

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List of Abbreviations

Abbreviation	*Meaning*
CCD	Charged Coupled Device
DB	Data Base
DNA	Deoxyribonucleic Acid
GUI	Graphical User Interface
IBG	International Biometrics Group
MF	Multiplication Factor
MSE	Mean Square Error
NIR	Near-Infrared
PSNR	Peak Signal to Noise Ratio
PVR	Palm Vein Recognition
RMSE	Root Mean Square Error
ROI	Region of Interest
SD	Standard Deviation
SNR	Signal to Noise Ratio
SSIM	Structural Similarity Index
SW	Scanning Window
Thr	Threshold
TR	Thinning Rate

Chapter One

General Introduction

Chapter One
General Introduction

1.1 Overview

In the universal network society, where individuals can easily access their information anytime and anywhere, people are also challenged with the risk that others can easily access the same information anytime and anywhere. Because of this risk, individual identification technology which can distinguish between registered valid users and frauds is now generating interest. Currently, passwords, personal identification numbers (4-digit PIN numbers) or identification cards are used for individual 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 [Man13].

In biometric authentication, an account owner's body characteristics or behaviors (habits) are registered in a database and then compared with others who may attempt to access that account to see if the attempt is valid. Among these, because of its high accuracy, contact less palm vein authentication technology is being incorporated into various financial solution products for use in public places [Bha15].

Biometric recognition is based on physiological traits such as finger print, palm print, iris, face and behavioral traits such as gait or signature associated with the person. Biometric system consists of two subsystems; one for enrollment and the second one for recognition. In the enrollment stage, biometric data are acquired from the individuals, set of enhance operation apply to it, feature sets are extracted from the acquired data, and one or more templates per individual are calculated and stored in the database. In the recognition stage, biometric systems can operate in two modes, Verification or Identification. **Verification** refers to confirming or denying a person's claimed identity. In this mode, the system executes one to one comparisons of the template computed from the acquired biometric data with the individual's own biometric templates stored in the database. **Identification** refers to creating a person's identity. In this mode, template computed from the acquired user's biometric input is compared with the templates of all persons enrolled in the database to create an individual identity[Ani15]. Fig. (1.1) shows a biometric recognition system.

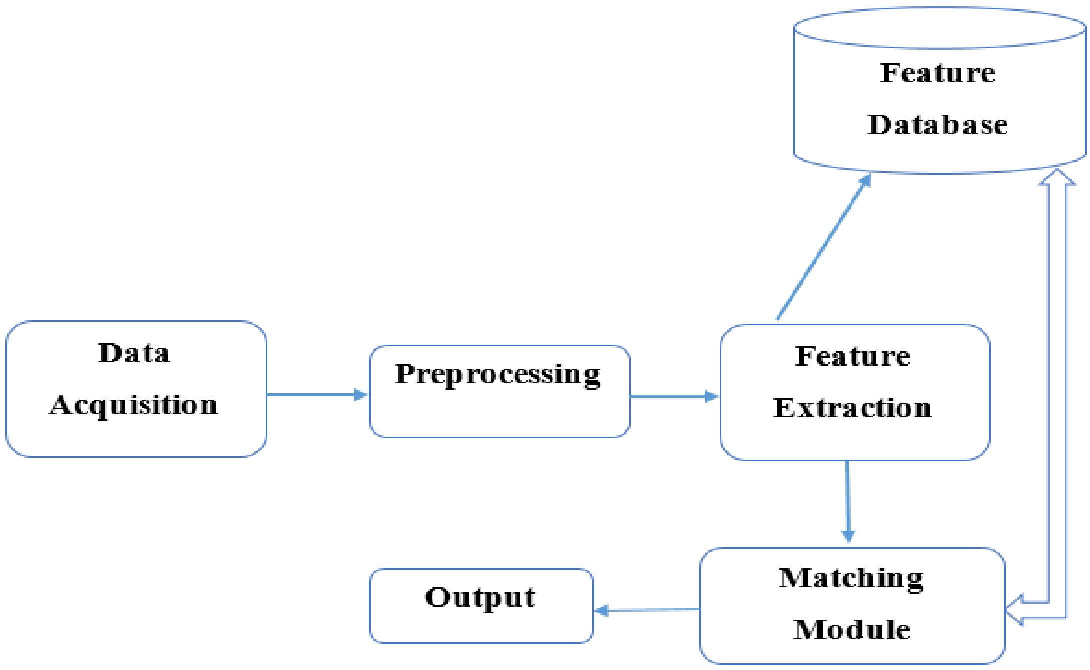


Fig. (1.1): A biometric recognition system[Ani15].

1.2 Palm Vein Recognition (PVR)

Academic and institution tried to develop a device that can catch the vascular patterns under the skin. Fujitsu has developed a palm vein pattern authentication technology that uses vascular patterns as personal identification data [Ahm13].

PVR recognition uses the vascular patterns of an individual's palm as personal identification data as shown in Fig. (1.2). Compared with a finger or the back of a hand, a palm has a broader and more complicated vascular pattern and thus contains a wealth of differentiating features for personal identification. PVR technology is secure because the authentication data exists inside the body and so it is very difficult to forge. It is highly accurate. This technology has many applications like: banking, hospitals, government offices, passport issuing, libraries, personal computer. Business growth will be achieved with these solutions by reducing the size of the palm vein sensor and shortening the authentication time [Dee13].

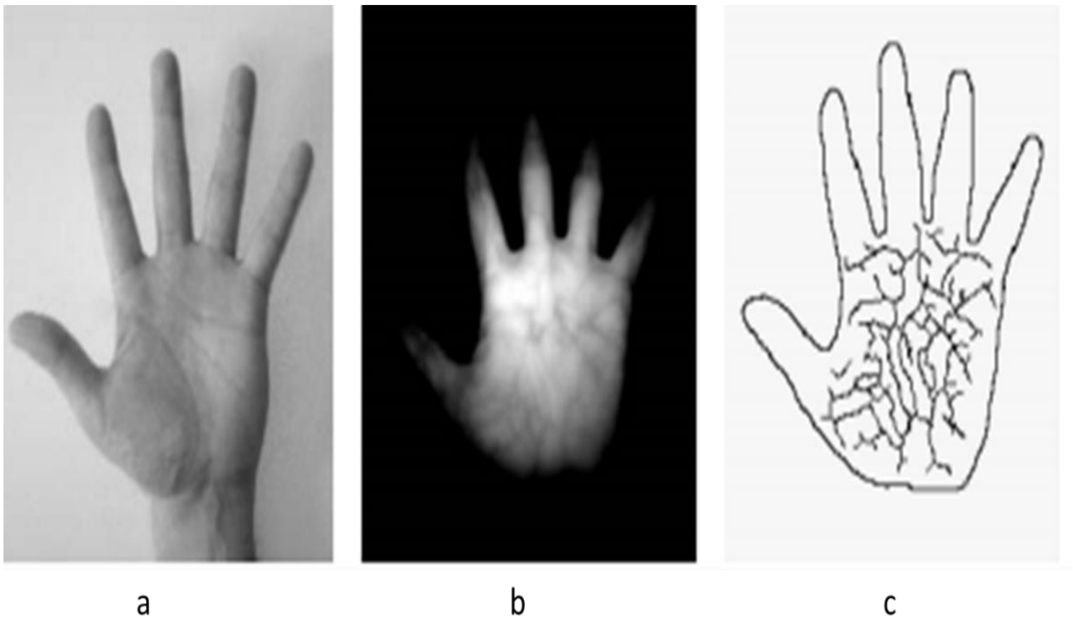


Fig. (1.2): Extracting a palm vein pattern (a) Visible ray image (b) Infrared ray image (c) Extracted vein pattern[Dee13].

1.3 Literature Survey

Many kinds of research have been conducted to study the problems of utilizing palm vein recognition methodology that consist of two parts listed below:

The first part: operations that used in the proposed system are

In 2011, Goyal, Megha [Goy11] has presented in-depth overview of the principles and applications of morphological image analysis, through a step by step process starting from the basic morphological operators and extending to the most recent advances which have proven their practical usefulness. This technique has shown that the morphological concepts constitute a powerful set of tools for extracting features of interest in an image, and a significant advantage in terms of implementation proved that dilation and erosion are primitive operations.

In 2013, Ray, Kasturika B. [Ray13] the approach to ROI extraction is based on the principle of selecting a region where rich texture patterns can be found. The acquired image has been divided into smaller horizontal and vertical strips and the statistical properties of the edginess of these regions have been used to either select or reject the strips from the ROI. Histogram techniques are used to check suitability of extracted region.

In 2013, Yogamangalam, R., and B. Karthikeyan. [Yog13] have presented a brief outline on some of the most common segmentation techniques like thresholding, Model based, Edge detection, clustering. mentioning its advantages as well as the drawbacks. They summarized various segmentation techniques. This segmentation is done to estimate the surfaces. That has proved that compared to other methods thresholding is the simplest and computationally fast.

In 2013, Karnea, A. S., and S. S. Navalgunda. [Kar13] have implemented a technique thinning operation on a binary image of size 128x128 pixels using Zhang Suen's thinning algorithm. The simulation results were obtained in terms of waveforms in ISim Xilinx simulator and the output text file of the hardware system is converted to an image format using MATLAB. Performance measurement is carried out between Zhang – Suen's thinning algorithm and MATLAB command for image thinning in terms of Thinning Rate (TR). The proposed algorithm designed in Verilog is more efficient because the complete frame of an image is read at once there by reducing the iteration by 128 times. The results obtained from the MATLAB and Xilinx should be compared. The performance of the thinning algorithm is also compared in terms of thinning rate.

In 2014, Mohanapriya, N., and B. Kalaavathi. [Moh14] were proposed a new algorithm called Multilevel contrast stretching and a noise smoothing technique for medical image enhancement, where the resultant image was showing more enhanced, sharpened, and edge preserved form, while the quality of the image is increased without distorting it. This technique result shows that PSNR, enhancement time was reduced and contrast level and image homogeneity are improved when compared to earlier techniques.

In 2014, Matta, Swati. [Mat14] discussed the various available segmentation techniques, showing the advantage and disadvantage of these different techniques, where various factors that affect the image segmentation process such as homogeneity of images, spatial characteristics of the image continuity, texture, image content.

In 2015, Anitha, M. L., [Ani15] the author suggested algorithm extract the ROI by segment the hand image from the background. After that finger tips and hand valley detection algorithm is used to find the tip points of little, ring, middle and index fingers and valley points between adjacent fingers. These tip points and valley points serve as base points to find palm print ROI location.

In 2015, Kumar, Prateek, and Sandeep Kumar Agarwal. [Kum15] have presented Hybridization of the median filter, Wiener filter and bilateral filter for de-noising of variety of noisy images The comparison between de-noised images is taken in terms of performance parameters such as MSE (mean square error), PSNR (peak signal to noise ratio), RMSE (root mean square error), SNR (signal to noise ratio) and SSIM (structural similarity index). He showed that Hybrid filter is able to recover much more detail of the original image and provides a successful way of image de-noising.

The second part: palm vein researches include

In 2013, Ahmed, Mona A., et al. [Ahm13] present the Analysis of palm vein pattern recognition algorithms, techniques, methodologies, and systems. They discussed some technical aspects of recent approaches for the following processes detection of ROI, segment a palm vein pattern, feature extraction and matching. Their result shows that there is no benchmark database exists for palm vein recognition. For all processes, there are many machine learning techniques with very high accuracy.

In 2014, Bhosale, Mr. Vishal U., et al. [Bho14] have used three different algorithms for processing Palm Vein Pattern Image of an individual taken by CCD CAMERA. This processed Image will be used later for authentication of a person. These algorithms for Biometrics are used for human recognition which consists of authentication, verification, and recognition.

1.4 Aim of Thesis

The proposed work aims to design and implement a PVR system that analyzes the palm and extract the features from the palm veins that used for recognition. Such system has two parts; the first part design a procedure (method) to discover the veins from palm and extract features from it, and the second part design a procedure (method) to apply the recognition process. This system needs two requirements that they are:

Software part which is a program that written in a Visual C# programming language. It provides to the user a Graphical User Interface (GUI) to simulated this system by observing the processes stages and make his/her actions on the system.

1.5 Thesis Organization

In addition to chapter one, the thesis contains four other chapters. Chapter one is an introduction to PVR and the aim of the present thesis. Other chapters are presented in the following:

Chapter Two: "Theoretical Background"

This chapter presents the background of the used technologies in the field of distinguishing individuals palm vein including biometric system and presents a brief description of basic tasks involved in the vein biometric system.

Chapter Three: "Proposed PVR Design"

This chapter contains the design and implementation steps of the proposed PVR, identification and verification system. It includes the algorithms used to perform preprocessing, feature extraction and matching stages. The implementation details about the system stages and steps are described with illustrating examples for clarifying the job of each step.

Chapter Four: "Experimental Results and Discussion"

This chapter presents the test results of analysis and classification stages to illustrate the performance of the suggested methods; identification and verification processes.

Chapter Five: "Conclusions and Future Works"

This chapter contains a list of some derived conclusions after analyzing the results of implementing the proposed methods. Some suggestions for future work to enhance the developed systems models are, also, listed in this chapter.

Chapter Two

Theoretical Background

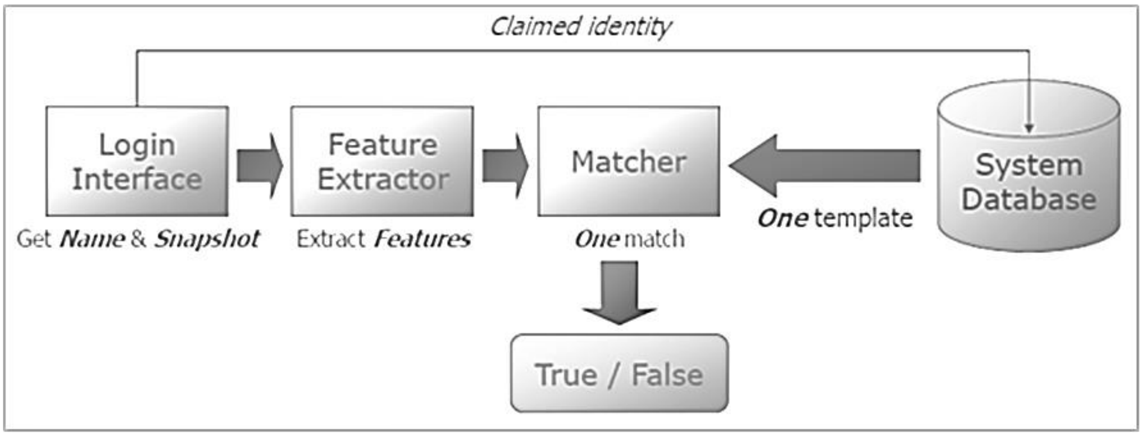
Chapter Two
Theoretical Background

2.1 Introduction

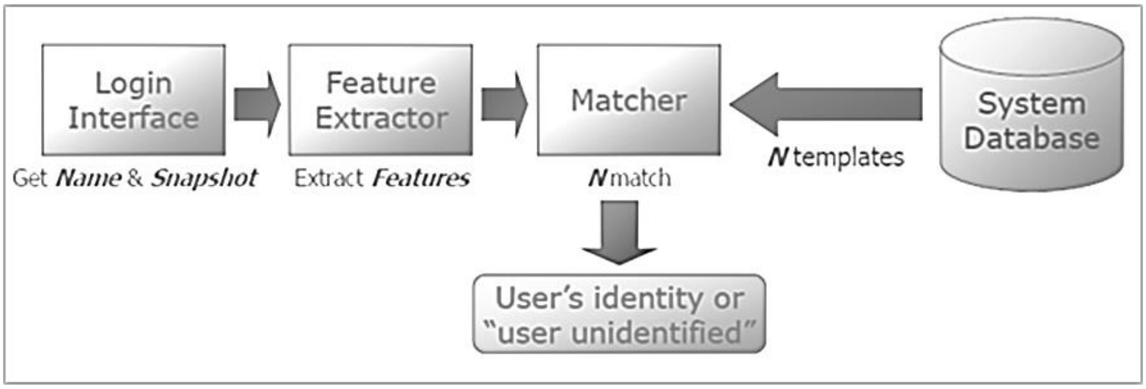
In this chapter, the basic theoretical sides of vein recognition system are discussed in details. A summarized introduction to biometrics system is given. This chapter presents the basic relevant issues about some of the used concepts in image processing field. Also, some of the widely used algorithms and techniques. Finally, the features extraction and matching stages are described.

2.2 PVR System

A biometric system is basically a pattern recognition system [Ani04]. Pattern recognition is the science for observing, distinguishing the patterns of interest and making correct decisions about the patterns. Thus, a biometric system applies pattern recognition to identify and classify the individuals by comparing it with the stored templates. Biometric systems can be used in two different manners. Identity *verification* occurs when the user claims to be already registered in the system. in this case, the verification biometric data gained from the user is compared to the user's data already stored in the database. *Identification* (also called search) identification occurs when the identity of the user is an intuition unknown. In this case, the user's biometric data is matched against all the records in the database as the user can be anywhere in the database or he/she actually does not have to be there at all as shown in Fig. (2.1) [Zde00].



(a)



(b)

Fig. (2.1): Block diagram shows the (a) verification (b) identification [Zde00].

It is obvious that identification is technically more challenging and costly [Zde00]. Unlike more public forms of identification, biometric measures contain no personal information and are more difficult to forge or steal [For98]. Before the user can be successfully verified or identified by the system (recognition stage), he/she must be enrolled with the biometric system. User's biometric data is captured, processed and stored. The process of the user's registration with the biometric system is called *enrollment* as shown in Fig. (2.2) [Zde00].

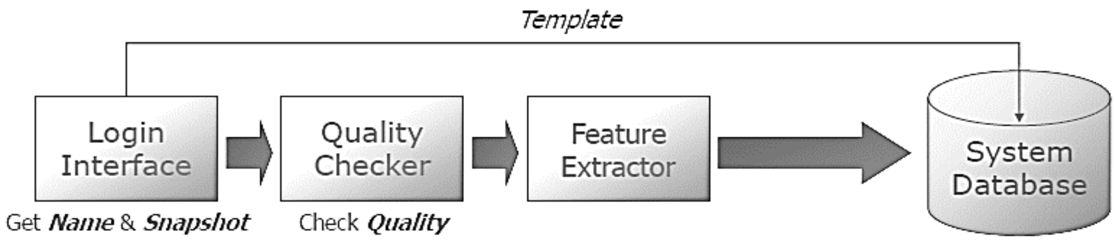


Fig. (2.2): Block diagram shows the enrollment stage [Zde00].

In enrollment, there are often several (usually 3 or 5) biometric samples used to create user's main template [Zde00].

A biometric system is designed using the following four main modules [Pan13]:

1- Sensor module: (encapsulating a quality checking module) It captures the biometric data of the individual.

2- Feature module: In this module captured biometric data is processed and set of features are extracted.

3- Matcher module: In this module a matching score is created during recognition, features are matched against the stored templates.

4- System database module: This module stores the templates of users. It stores the multiple templates of user to account for differences observed in biometric data and templates in database are updated over time [Pan13].

2.3 Vein Imaging Concepts

Veins are generally placed closer to the proximity of the skin than arteries. The patterns are normally extracted from images of the palm as seen in Fig. (2.3). The International Biometrics Group (IBG) in 6th report 2006 confirms the palm vein is between the iris and fingerprint. From security side, the vein looks like an iris, but from user-friendly side the palm vein looks like the fingerprint. An exciting aspect of vein recognition is the fact that the information is not visible, it is hidden inside the body. To capture the image, a near-infrared (NIR)-sensitive optical sensors are used to capture the image of the vein pattern [Xue08].

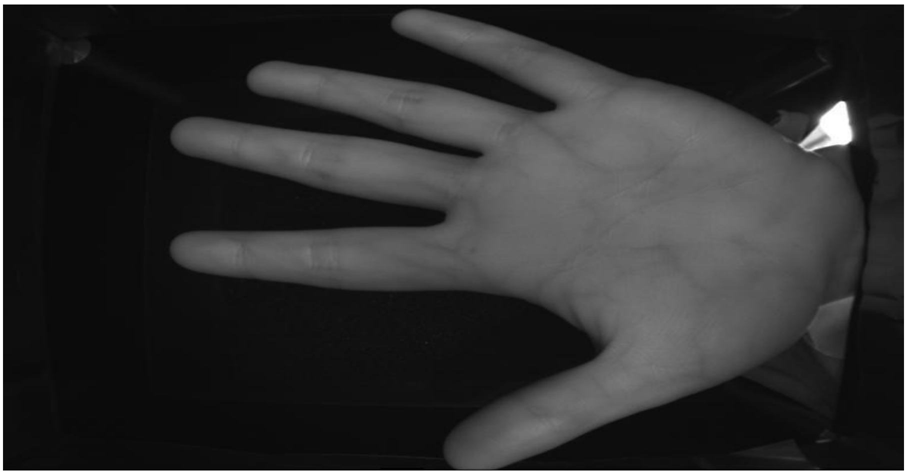


Fig. (2.3): Proposed palm vein image.

2.4 Image Preprocessing

Preprocessing stage of the image is to be the most fundamental stage in the biometric system. Some parts of the veins will be invisible in some images. The aim of preprocessing is to enhance some important features of the image for advanced processing or to improve the image data that contains undesired distortions [Ray13]. The vein image is prepared for feature extraction after several preprocessing stages that are below:

2.4.1 Region of Interest Extraction

The objective of the region of interest extraction (ROI) is to remove image areas that do not contribute to features that are useful in differentiating or classifying images. It tries to redefine the boundary within the acquired image. This smaller region becomes the focus area for applying various feature extraction and classification strategies. It is expected that the ROI will improve the accuracy of identification and authentication. The important step is ROI extraction that is rich in features and it is important factor for recognition performance to develop identification accuracy [Ray13].

2.4.2 Smoothing Spatial Filters

Smoothing filters are used for blurring and for noise reduction. Blurring is used in preprocessing steps, such as removal of small details from an image prior to (large) object extraction, and bridging of small gaps in lines or curves. Noise reduction can be accomplished by blurring with a linear filter and also by nonlinear filtering [Gon02].

A. Smoothing Linear Filters

The output of a smoothing, linear spatial filter is simply the average of the pixels contained in the neighborhood of the filter mask. These filters sometimes are called *averaging filters*. The idea behind smoothing filters is straightforward. By substituting the value of every pixel in an image by the average of the gray levels in the neighborhood defined by the filter mask, this process results in an image with reduced sharp transitions in gray levels. Because random noise normally consists of sharp transitions in gray levels, the clearest application of smoothing is noise reduction [Gon02].

B. Non Linear Filters

Order-statistics filters are nonlinear spatial filters whose response is based on ordering (ranking) the pixels contained in the image area included by the filter, and then replacing the value of the center pixel with the value determined by the ranking result. The best-known example in this type is the *median filter* [Gon02].

The median filter is a nonlinear signal processing technology based on statistics. The noisy value of the digital image or the sequence is replaced by the median value of the neighborhood (mask). The pixels of the mask are ranked in the order of their gray levels, and the median value of the group is stored to replace the noisy value. The median filtering output is

$$g(x, y) = \text{median}\{f(x - i, y - j), i, j \in W\} \qquad (2.1)$$

where $f(x, y)$, $g(x, y)$ are the original image and the output image respectively, W is the two-dimensional mask: the mask size is n x n (where n is commonly odd) such as 3x3, 5x5. the mask shape may be linear, square, circular, cross, and etc. [Zhu12].

Median filtering has a good edge preserving ability, and does not introduce new pixel values to the processed image [Kum15].

With non-linear filters, the noise is removed without any attempts to explicitly identify it. The median filter was one of the most popular nonlinear filter for removing Salt & Pepper noise [Mah10].

Median filters are quite popular because, for certain types of random noise, they provide excellent noise-reduction capabilities, with considerably less blurring than linear smoothing filters of similar size. Median filters are particularly effective in the presence of *impulse noise,* also called *salt-and-pepper noise* because of its appearance as white and black dots superimposed on an image. The principal function of median filters is to force points with distinct gray levels to be more like their neighbors. In fact, isolated clusters pixels that are light or dark with respect to their neighbors, and whose area is less than $n^2/2$ (one-half the filter area), are eliminated by a n*n median filter [Gon02].

2.4.3 Image Negative

The negative of an image with gray levels in the range [0, L-1] which is given by the expression:

$$s = (L - 1) - r \qquad (2.2)$$

Where $L=2^k$, k being the number of bits in the image being considered. So, for instance, for an 8-bit image, the range of pixel values will be [0, 255] and r is a pixel value in the input gray image. Reversing the intensity levels of an image in this manner produces the equivalent of a photographic negative. This type of processing is particularly suited for enhancing white or gray detail embedded in dark regions of an image, especially when the black areas are dominant in size [Gon02].

2.4.4 Contrast Stretching

In some digital images, the features of interest occupy only a relatively narrow range of the gray scale. One might use a point operation to expand the contrast of the features of interest so that they occupy a larger portion of the displayed gray-level range. This is called contrast enhancement or contrast stretching. The notion contrast refers to the amplitude of the differences for the gray-level within an image. The contrast of a grey scale image indicates how easily objects in the image can be distinguished [Pal14].

In linear contrast enhancement, there are different methods such as min-max linear contrast stretching, percentage linear contrast stretching and piecewise linear contrast stretching [Kot13].

In the minimum-maximum linear contrast stretching, a newly specified set of values that utilize the full range of available brightness values are used to assign the original minimum and maximum values of the data to be fall within the new range. The applied mapping function for this type can be found in equation (2.3); it maps the minimum grey level *Gmin* in the image (*I*) to zero and the maximum grey level *Gmax* to 255, the other grey levels are remapped linearly between 0 and 255 [Moh14]:

$$I_{Bri}(x, y)=255\left(\frac{I(x.y)-Gmin}{Gmax-Gmin}\right) \qquad (2.3)$$

The percentage linear contrast stretching uses the same idea of the min-max linear contrast stretching; with one exception, this method uses percentage from the mean of the histogram to determine values of the minimum and maximum [Kot13].

It is also possible to apply the contrast-stretching operation on a regional basis using the histogram from a region to determine the appropriate limits for the algorithm [You07].

2.4.5 Image Segmentation

Segmentation refers to the operation of partitioning an image into component parts, or into separate objects [McA04]. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments that collectively cover the entire image or a set of contours extracted from the image. Each of the pixels in a region is similar with respect to a certain characteristic or computed property, such as color, intensity, or texture [Lin01].

Segmentation is the most important part in image processing. Fence off an entire image into several parts which is something more meaningful and easier for further process. These several parts that are rejoined will cover the entire image. Segmentation may also depend on various features that are contained in the image. It may be either color or texture. Segmentation is also useful in Image Analysis and Image Compression. In the following subsections, a brief explanation for famous technique of image segmentation is given [Yog13]:

-Thresholding

Thresholding is a vital part of image segmentation, where in which the objects has been isolated from the background [McA04]. It is the simplest method of image segmentation. This method is based on a clip-level (or a threshold value) to turn a gray-scale image into a binary image. The key of this method is to select the threshold value (or values when multiple-levels are selected) [Bat09]. Depending on the thresholding value there are two techniques described:

a. Global Threshold:

Intensity distribution of object and background pixel are sufficiently distinct, then it is possible to use a global (single) Thr on the entire image.

When Thr depends only on the gray-level value of image and Thr is solely related to the properties of a pixel in the image, this technique is called global thresholding [Lan12]. It consists of setting a fixed threshold value Thr, all the pixels that are below Thr refers to the background and those above the fixed value are considered to be the foreground. Mathematically it can be given as

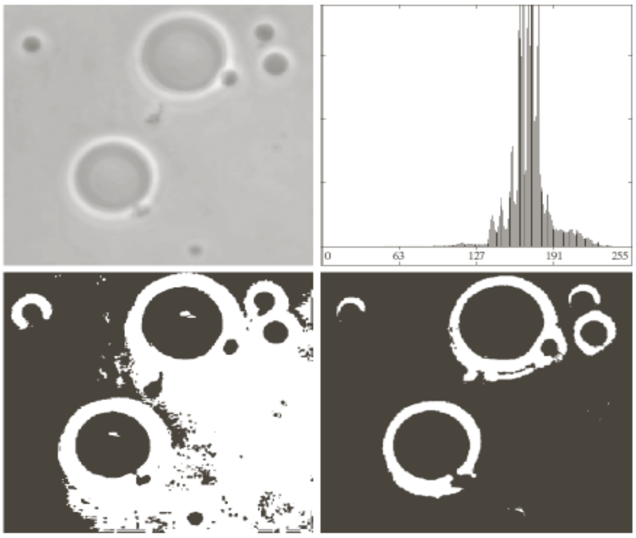
$$g(x, y)= \begin{cases} 1 \ \ if\ f(x.y) > \ Thr \\ 0 \ \ if\ f(x.y) \leq Thr \end{cases} \qquad (2.4)$$

Where g (x, y) is the output after thresholding. The examples of global thresholding are Otsu thresholding [Mat14].

Otsu's method is aimed in finding the optimal value for the global threshold. It is based on the interclass variance maximization. Well, thresholded classes have well-discriminated intensity values. 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.

Strategy Steps:

1. Compute histogram and probabilities of each intensity level.
2. Set up initial class probability and initial class means.
3. Step through all possible thresholds maximum intensity.
4. Update q_i and μ_i.
5. Compute between class variance.
6. Desired threshold corresponds to the maximum value of between class variance. Otsu's method: an example [Fer11]:



a	b
c	d

(a) original image;
(b) histogram of (a);
(c) global threshold: $T = 169$, $\eta = 0.467$;
(d) Otsu's method: $T = 181$, $\eta = 0.944$.

Fig. (2.4): Otsu thresholding [Fer11].

1. Local Thresholding

In the case of isolate vein from background where global thresholding doesn't work, local thresholding methods use different threshold values for pixels at different location in the images, the image is divided into sub images and then they are thresholded individually. Here the threshold (Thr) for each pixel depends on the location of the pixel within an image. So in this case multiple thresholds are selected to compensate for the uneven illumination. Hence various Thr's are selected for each of the sub-images [Mat14].

In this case, the grey level allocation for object as well as for background overlaps each other considerably. Hence, no single grey level threshold can segment the image properly. In this local thresholding, this problem is conquering by isolating the whole image into smaller one; then each sub image is segmented separately. Finally, each segmented sub image collectively arrange in proper order to obtain segmented output of original image [Lan12].

2.4.6 Morphological Operation

Morphology is a branch of image processing which is particularly useful for analyzing shapes in images. Basic morphological tools applied for investigation of binary images, and then show how to extend these tools to greyscale images. Morphological methods include filtering, thinning and pruning. All morphological functions are defined for the binary image, but most have a natural extension to grayscale images. Dilation and Erosion are the basic operations of morphology, in the sense that all other operations are built from a combination of these two [McA04]. They are defined in terms of more elementary set operations, but are employed as the basic elements of many algorithms. Both dilation and erosion are produced by the interaction of a set called a structuring element with a set of pixels of interest in the image. The structuring element has both a shape and an origin [Goy11]. The operations are:

A. Dilation

let A be a set of pixels and let B be a structuring element. Let $(B^{\wedge})$ s be the reflection of B about its origin and followed by a shift by s. Dilation, as shown in Fig. (2.5) written $A \oplus B$, is the set of all shifts that satisfy the following:

$$A \oplus B = \{s | (B^{\wedge})\, s \cap A\} \qquad (2.5)$$

Fig. (2.5): Dilation process [Goy11].

Equation (2.5) is based on the reflecting B about its origin and shifting this reflection by s. The dilation of A and B then is a set of all displacement. As before, it is assumed that B is a structuring element and A is the set to be dilated or it can say that the B is flipping about its origin and slides over the set (image) A. Dilation is used for repairing breaks and intrusions [Goy11]. Dilation has the effect of increasing the size of an object [McA04].

B. Erosion

Let A be a set of pixels and let B be a structuring element as shown in Fig. (2.6) and its equation is:

$A \Theta B = \{s|(B)s \leq A\}$ (2.6)

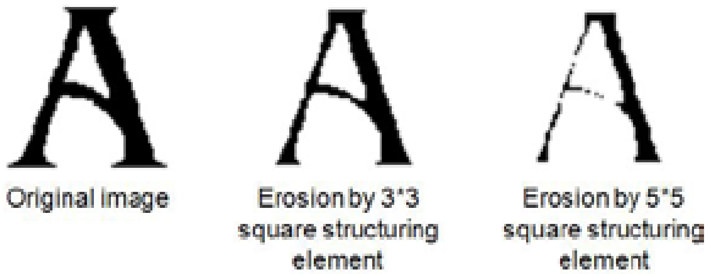


Fig. (2.6): Erosion process.

Erosion can split apart joined objects and can strip away extrusions. Erosion is used for shrinking or thinning operation whereas dilation grows and thickens the objects in a binary image [Goy11]. If the image kept on eroding, it ends up with a completely black result [McA04].

C. Boundary Extraction

To detect the boundary of a set A, denoted by *B*(A), can be obtained by first eroding A by B and then performing the set difference between A and its erosion. That is

B(A)=A- (A Θ B) (2.7)

where B is a suitable structuring element. Fig. (2.7) illustrates the mechanics of boundary extraction. It shows a simple binary object, a structuring element B, and the result of using Eq. (2.7) [Gon02].

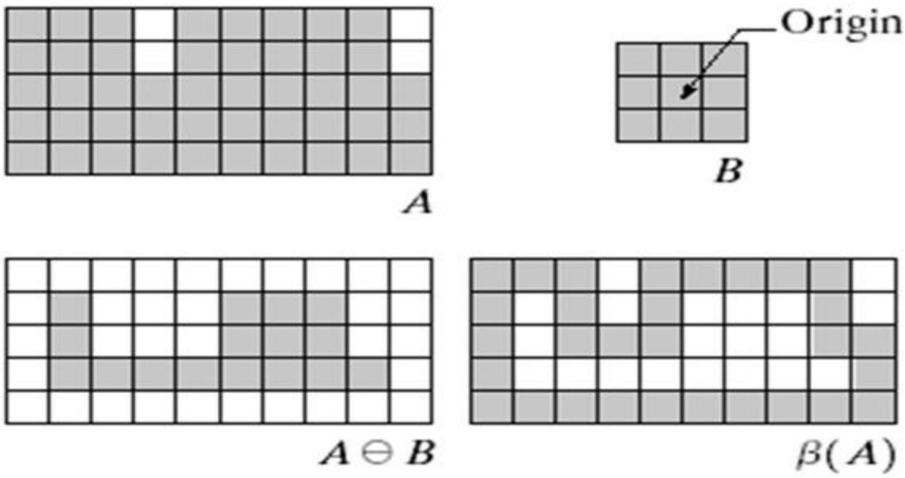


Fig. (2.7): Boundary Extraction [Gon02].

2.4.7 Thinning

thinning operation is done by iteratively eroding away nonessential pixels from the image until one is left with a stick figure, or skeleton, which describes the object. Thinning algorithms are the need to compute a reduced amount of data or to simplify the shape of an object in order to find features for recognition algorithms and classifications. The result of thinning operation must have the following properties:

As thin as possible, Connected and Centered.

All the thinning algorithms are classified into two broad categories:

1. Iterative thinning algorithm
2. Non-iterative thinning algorithm

In iterative methods, thinning algorithms produce a skeleton by examining and deleting contour pixels through an iterative process in either sequential or parallel way.

Non-iterative (non-pixel based) thinning is not based on examining individual pixels. These algorithms produce a certain median or center line of the pattern to be thinned directly in one pass, without examining all the individual pixels.

The **Zhang-Suen's** thinning algorithm is an iterative algorithm, fast and simple to be implemented. It is a parallel method consisting of two sub-iterations, first iteration serves to erase boundary point of south-east and vertex of north-west while the other one serves to erase boundary point of north-west and vertex of south-east. The following is sub-iterations presence in Zhang-Suen method [Sud14]:

1. Sub-iteration 1

a. $2 < N(P1) < 6$

b. $S(P1) = 1$

c. $P2 * P4 * P6 = 0$

d. $P4 * P6 * P8 = 0$

2. Sub-iteration 2

a. $2 < N(P1) < 6$

b. $S(P1) = 1$

c. $P2 * P4 * P8 = 0$

d. $P2 * P6 * P8 = 0$

where a contour point is any pixel with value '1' and having at least One 8-neighbor valued '0'. With reference to the 8-neighborhood definition shown in Fig. (2.8), the first step flags a contour point p for deletion if the following conditions are satisfied:

(a) 2< = N (P1) < = 6.

(b) S (P1) = 1.

(c) P2 * P4 * P6 = 0.

(d) P4 * P6 * P8 = 0.

where N (p1) is the number of nonzero neighbors of p1 that is, N (P1) = P2+ P3+ ……. P8+ P9 and S(p1) is the number of 0-1 transition in the ordered sequence of p2, p3, ..., p8, p9. For example, N (p1) = 4 and S (p1) = 3 in Fig. (2.8).

P9	P2	P3	0	0	1
P8	P1	P4	1	P1	0
P7	P6	P5	1	0	1

Fig. (2.8): Neighborhood arrangement and Illustration of conditions (a) and (b) [Kar13].

In the second step, conditions (a) and (b) remain the same, but conditions (c) and (d) are changed to:

(c’) P2 * P4 * P8 = 0 and (d’) P2 * P6 * P8 = 0

Step 1 is applied to every border pixel in the binary region under consideration. If one or more of the conditions (a) through (d) area violated, the value of the point in question is not changed. If all conditions area satisfied the point is flagged for deletion. It is important to be considered, that the point is not deleted until all border points have been processed. This prevents changing the structure of the data during execution of the algorithm. After step 1 has been applied to all border points, those that were flagged are deleted, changed to '0' for example. Then, step 2 is applied to the resulting data in exactly the same manner as step 1 [Kar13].

2.5 Feature Extraction

The feature extraction process is the most important stage during recognizing any palm vein image. Is starting from a captured vein image sample [Xue08]. Feature extraction module processes the biometric data. The output of the module is a set of extracted features suitable for the matching algorithm. During the feature extraction process, the module may also evaluate the quality of the input biometric data. In order to provide accurate recognition of individuals, the most discriminating information present in a pattern must be extracted. Only the significant features of the pattern must be extracted so that comparisons between templates can be made [Mat02]. It must be extracted mathematically into a numerical representation of the unique features extracted from the pattern that depends on divide the image to a number of blocks, and then calculate the mean and standard deviation of each block. "Mean" The expected value of the variate x is also called the mean value. It can be visualized as the center of gravity of the distribution. Usually it is denoted by the Greek letter µ.

$$\mu = \frac{1}{N}\sum_{i=1}^{N} X_i \qquad (2.8)$$

Where the N is the number of pixels in the block, X_i is the value of pixel in the block. It is called sample mean [Boh10]. The variance σ^2 measures the spread of a distribution, defined as the mean quadratic deviation of the variate from its mean value. Usually, not only the mean value of a stochastic quantity has been knowing, but require also information on the dispersion of the individual random values relative to it. The square root σ of the variance is called standard deviation and is the standard measure of stochastic doubts which can be expressed as follows [Boh10]:

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(X_i - \mu)^2 \qquad (2.9)$$

Where the N is the number of pixels in the block, X_i is the value of pixel in the block, μ is the mean value.

2.6 Feature Normalization

The goal of feature normalization is to independently normalize each feature component to the [0,1] range. A linear scaling normalization method is preferred over the others according to the empirical retrieval results. There are five normalization procedures: Linear scaling to unit range, Linear scaling to unit variance, Transformation to a Uniform [0,1] random variable, Rank normalization, Normalization after fitting distributions [Aks01]. In this thesis, use the first procedures that lead to good results. Given a minimum value min and maximum value max for a feature component x,

$$x' = \frac{x - \min(x)}{\max(x) - \min(x)} \qquad (2.10)$$

Where x is' is the normalized value and being in the [0,1] range [Aks01].

2.7 Feature Matching

After computing and normalizing the feature vectors for all images in the database given a query image that decides which images in the database are relevant to it and retrieve the most relevant ones as the result of the query [Aks01].

The biometric matching algorithm compares the current biometric features with the stored template. The desired security threshold level may be a parameter of the matching process. In verification case the result of the matching will be a yes/no answer. Otherwise in identification representing the similarity between the template and the current biometric sample is returned [Mat02]. In this thesis, using four distance equations that lead to good result. The first one is city block distance measure. It is computed as [Hyu07]:

$$1\text{- } D_{CB}(i) = \sum \left| V(j) - T_{avg}(i, j) \right| \qquad (2.11)$$

The second equation is Squared Euclidian distance. It is computed as [Hyu07]:

$$2\text{- } D_{Euc}(i) = \sum (V(j) - T_{avg}(i, j))^2 \qquad (2.12)$$

The third equation is normalized city block distance. It is computed as [Hyu07]:

$$3\text{- } D_{CBN}(i, j) = \sum \left| \frac{V(j) - Tavg(i,j)}{Tstd(i,j)} \right| \qquad (2.13)$$

The fourth equation is normalized Squared Euclidian distance. It is computed as[Hyu07]:

$$4\text{- } D_{EucN}(i, j) = \sum \left(\frac{V(j) - Tavg(i.j)}{Tstd(i.\ j)} \right)^2 \qquad (2.14)$$

Where D_{CB} is the City block distance, D_{Euc} is the Squared Euclidian distance, D_{CBN} is the Normalized City block distance, D_{EucN} is the Normalized Squared Euclidian distance, (i, j) the width and height of T_{avg} two-dimension array, V is the one-dimension array after normalization, T_{avg} is the average of template, T_{std} is the SD of templates.

Chapter Three

Proposed PVR Design

Chapter Three
Proposed PVR Design

3.1 Introduction

In this chapter, the design and implementation of proposed palm vein recognition will be presented. It contains all the details of each stage and each process of applied system.

3.2 System Layout

The proposed system is designed to distinguish individuals from palm vein pattern. Just like any pattern recognition systems, the introduced system includes two main phases: an enrollment phase and a recognition phase. In the enrollment phase, the features extracted from the palm images of the system users are stored in a database, the system passes through the following processing stages:

1. Preprocessing: it consists of three parts:
   a. ROI extraction: it includes five stages:
      i. Noise removal
      ii. Binarization
      iii. Boundary extraction
      iv. Determining the joints
      v. Drawing a rectangle around the ROI
   b. Image enhancement: it includes three stages:
      i. Image negative

ii. Brightness

iii. Noise removal

c. Segmentation: it includes four stages:

i. Local threshold

ii. Binarization

iii. Dilation

iv. Thinning

2. Feature extraction: three sets of features are extracted from each image:

i. mean based on rows and columns

ii. standard deviation based on rows

iii. standard deviation based on columns.

The extracted features are manipulated to construct templates that are saved in the system database. In the recognition phase a vector of the given palm image is constructed using the same steps of the enrollment phase then the vector will be matched with the templates stored in the database to make a decision.

3. Feature Matching and decision-making steps depend on the type of the required recognition action. It contains a two stages: identification and verification. In identification, the system should match the input palm vein feature vector with all feature vectors of palm vein images in the database and then return the identity of the person. While in verification, the system should match the input palm vein feature with its template and return the decision yes or no that verify the claim of that person. The proposed structure of palm vein recognition is shown in Fig. (3.1):

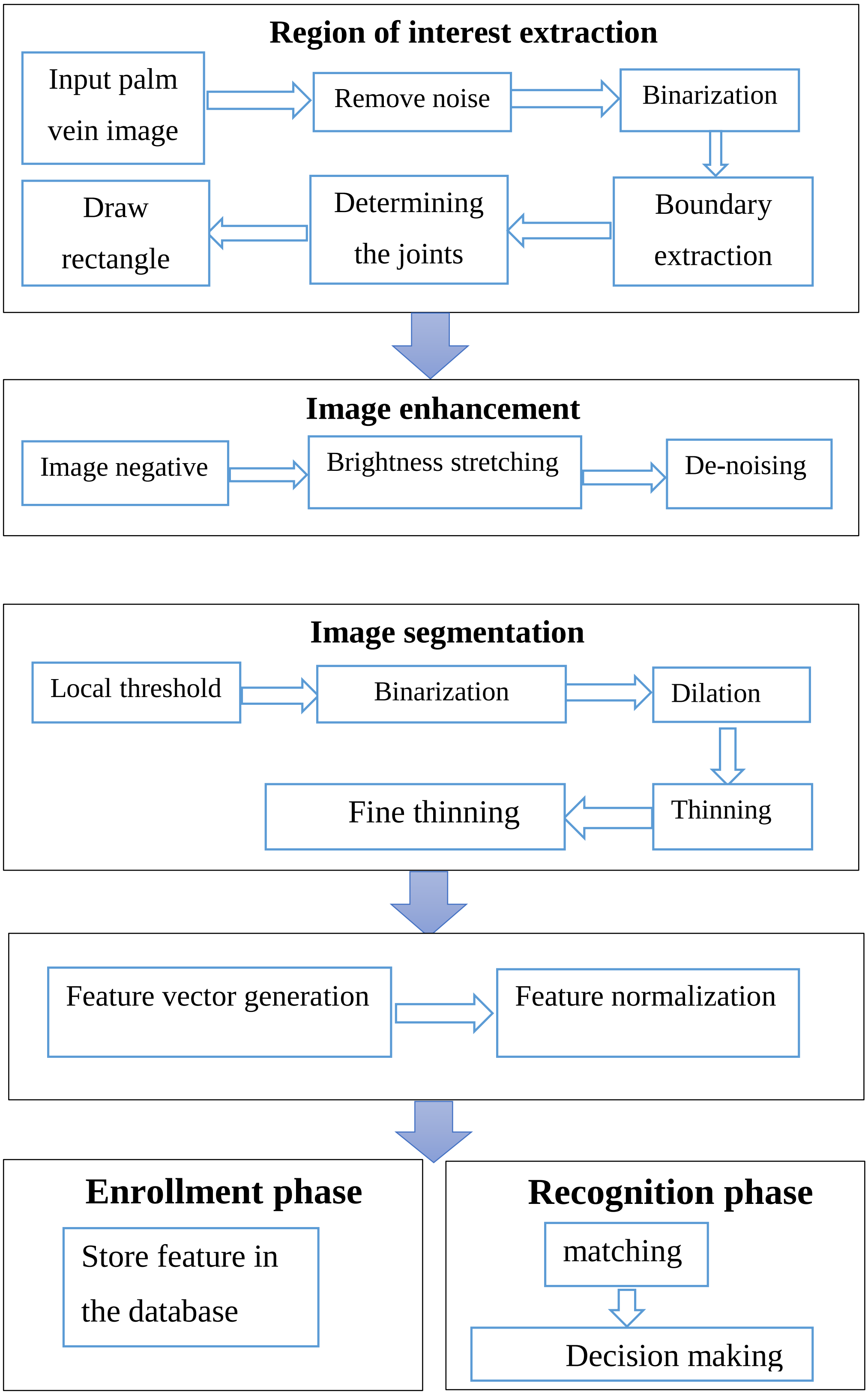


Fig. (3.1): The proposed structure of palm vein recognition.

3.3 Preprocessing Stage

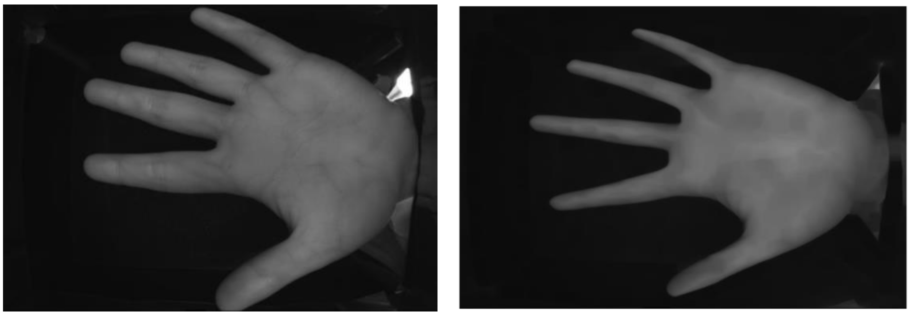
The preprocessing stage is important to simplify the task of isolating the vein from the background. In spite of many devices used to capture the palm veins, some pictures are bad or some are good or some capture for all the hand with their surroundings and with what surrounds the veins that are fingers and noisy background. To ensure the performance of an algorithm that is used for feature extraction and isolate the vein from palm must apply a set of processes to enhance and manipulate for these cases of the input image. A set of enhancement tasks has been applied to improve the clarity of the vein pattern structure and localize the region of interest (ROI) of veins.

3.3.1 ROI Extraction

ROI is the region that is rich in features and it is important for recognition performance to develop identification accuracy. A ROI extracting scheme for palm vein images must be extremely effective and efficient. There are five sub-stages to get the ROI:

1. **Noise Removal**

The input image was taken to all hand with some undesirable things that should be eliminated before moving to the next stage. In this stage, this noise is reduced to convert the image to the binary that leads to ROI extraction. The best-known order-statistics and the nonlinear spatial filter is the median filter. The median filter can lead to better result using equation (2.1). In this thesis, use the median filter for two purposes. First, use in this stage for removing the output noise (output of ROI) and the other to remove the input noise in the palm to clear the veins as described in next section as shown in Fig. (3.2).

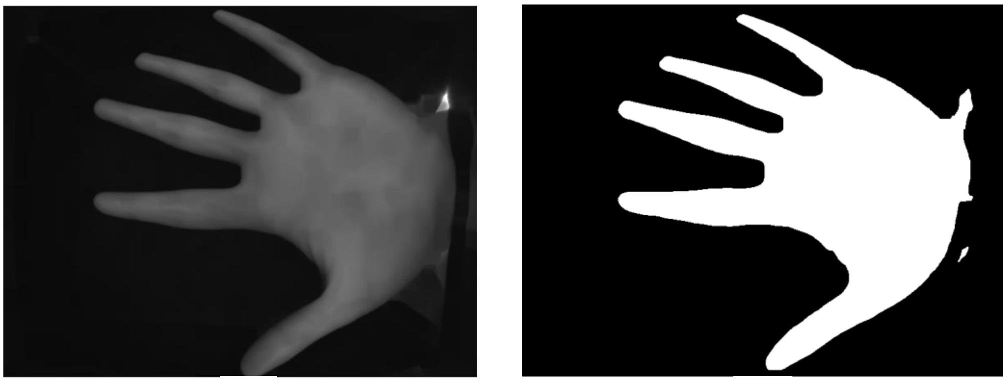


a b

Fig. (3.2): Image de-noising result; (a) The input noisy image (b) applying the Median filter on the original image.

2. **Binarization**

In this step, the image is converted to a binary image using Otsu's method is a global thresholding. After applying a median filter, apply Otsu thresholding and the result of implementing this method as shown in Fig. (3.3):



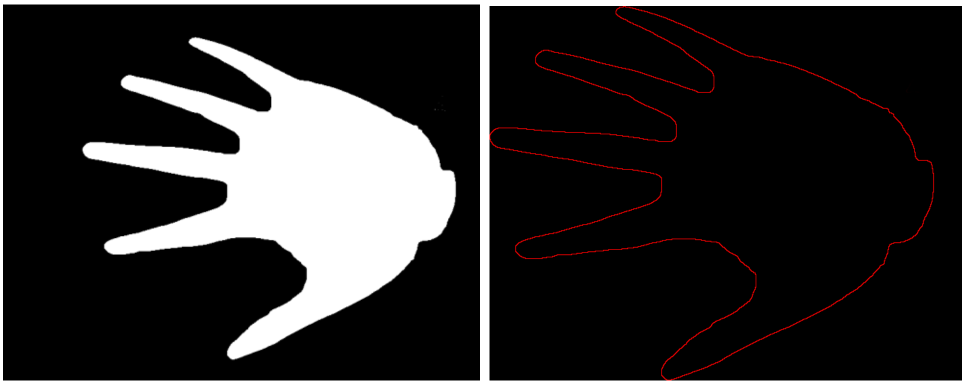
a b

Fig. (3.3): Otsu threshold (a) image after median filter (b) binary image.

3. **Boundary Extraction and Crop Process**

The boundary extraction of palm area is required for the next coming steps to determine the reference points that extracted the ROI. To apply boundary extraction using morphology boundary extraction in equation

(2.7). Then, apply crop process that makes the end of the fingers touch the edge of the image as shown in Fig. (3.4).



a b

Fig. (3.4): Boundary extraction and crop process (a) binary image (b) boundary extraction and crop process.

4. Determine the Joints of Palm

In order to extract the ROI from the palm image, there is a requirement to find suitable key points in the image, the following steps are implemented for that purpose:

1. Determine the joints by scanning the image vertically row by row until reach nine (or more) consecutive pixels vertically, when gaining these pixels, must put green circle in this place and regarded one of the joints and same way for other joints as shown in Fig. (3.5)

2. Determine the location of the thumb end then start from the opposite direction and determine the first joint horizontally as the first point (p1) that is shown in Fig. (3.5).

3. The two reference points which will be used to draw the ROI are the first point between the little finger and ring finger as (p1), the second point is the point between the middle finger and index finger as (p3). These points are considered as connecting points.

4. Determine the second point through the third joint and draw a straight line between the two points (p1, p3).
5. Rotate the image to draw the line of ROI correctly.
6. From these connected points draw the rectangle (ROI).

The above steps implementations are explained in (algorithm 3.1)

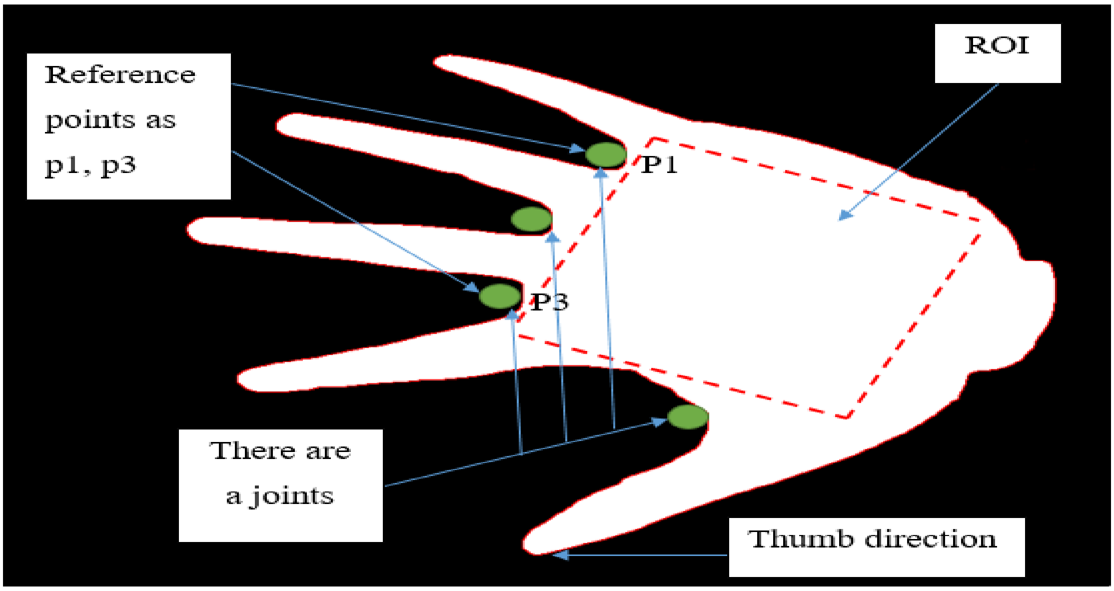


Fig. (3.5): Diagram of the important parts in the palm.

Algorithm (3.1): ROI extraction
Input: Img ///Bitmap image after boundary extraction W, H /// The image width & height, respectively
Output: ROI extraction ///cut the ROI part from palm
Begin **Step1:** ///Determine thumb direction Set c=0 **For** all i **Do** {where $0 \leq i \leq W$}

For all j **Do** {where 0 ≤ j ≤H}

If Img (i, j) =green **&** the i>point **Then set** point=i: **stop**

End For

End For

Step2: ///Determine reference points

For all i, j **Do** {where 0 ≤ i ≤ point-1, 0 ≤ j ≤ H}

If Img (i, j) = green **&** c =0 **Then set** p1x = i, p1y = j, increment c: **stop**

Else If Img (i, j) =green **&** c=1 **Then set** p1x = i, p1y = j,increment c: **stop**

Else If Img (i, j) =green **&** c=2 **Then set** p2x = i, p2y = j,increment c: **stop**

Else If Img (i, j) =green **&** c=3 **Then set** p3x = i, p3y = j,increment c: **stop**

End for

Step 3: /// draw line between two reference points

while p1y! = p3y

rotate (Img)

End while

draw line (p1, p3): **stop**

Step 4: /// draw rectangle (ROI)

set h = line – Distance (green_point, End_line)/2

set w = h

draw rectangle (p1, p3, w, h): stop

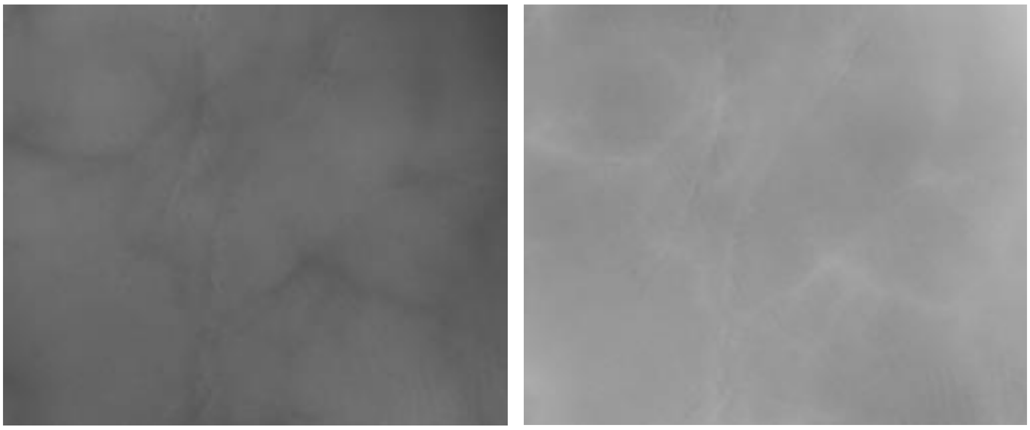
Step 5: End

3.3.2 Image Enhancement

This part contains three stages that develop and enhance the image to get the vein in the best case and prepare it for segmentation part. These enhancement stages are:

A. Image Inverse

In this stage, the input images are 8-bit gray-level JPEG files, apply the inverse to the gray image. The purpose of this stage is to invert the vein to make it more clear it is important for the next stages. Fig. (3.6) palm image (ROI), and its variant after the image passed through the inverting stage.

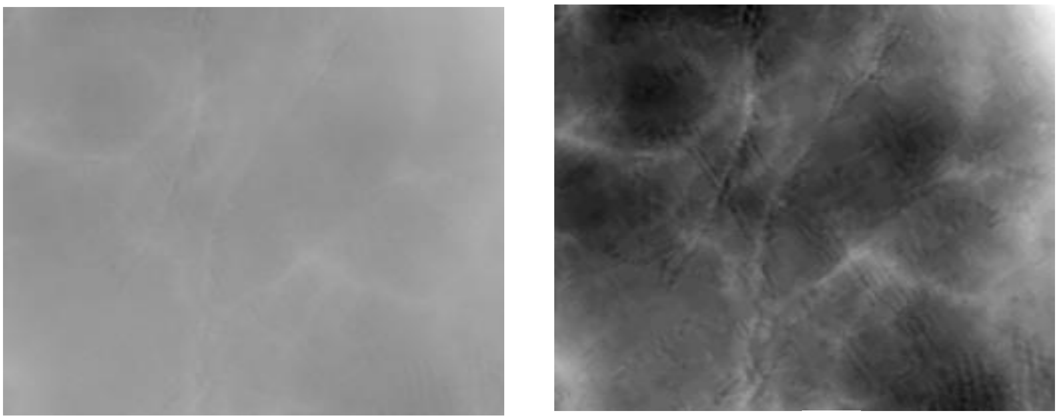


a b

Fig. (3.6): Inverse preparation (a) ROI of palm vein (b) The inverse.

B. Brightness Stretching Stage

To achieve better image features the image brightness is set to cover the whole dynamic range. Linear contrast stretching is applied to stretch the image pixel values to be within a determined range [0,255]. The stretching process is accomplished using the linear equation (2.3). Fig. (3.7) presents a negative image and its brightness stretched version.

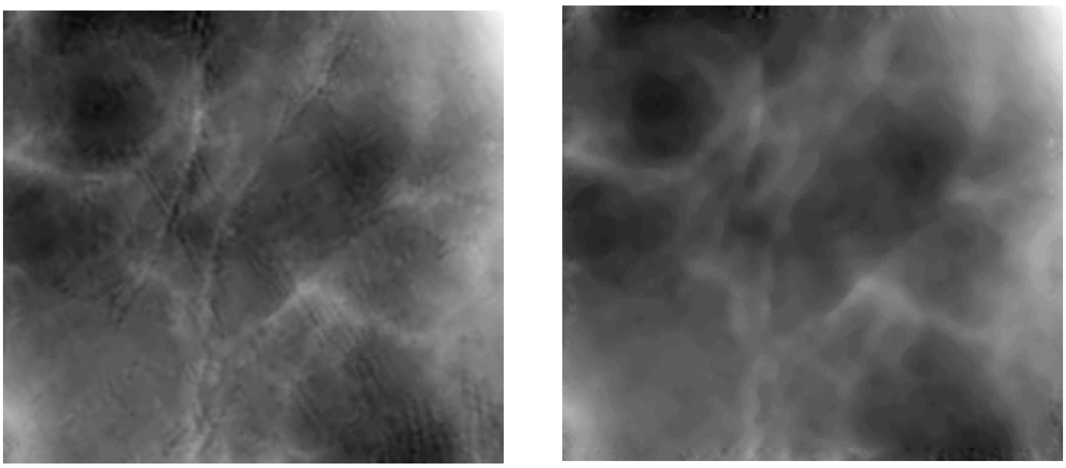


a b

Fig. (3.7): Brightness stretching (a) negative image (b) image after brightness stretching.

C. Image De-Noising Stage

Because of noise in the image, in this stage, the noise is reduced to make the vein clear more. A simple median filter is applied to the brightness image to reduce the noise. The median filter lead to a good result. Fig. (3.8) present the noisy image and remove this noise.



a b

Fig. (3.8): Remove noise (a) Noisy image after brightness (b) Image after median filter.

3.3.3 Image Segmentation

Segmentation is probably the hardest and the most important step in the proposed system because the segmentation permits to separate the vein pattern from the background that used for recognition to the certain low percentage of errors. One of the problems that may face this operation is selecting optimal threshold value that could give the best result.

A. Local Thresholding

Local adaptive thresholding is used to separate the desirable vein from the background; the separation process is based on the difference in pixel's intensities of each block or region. The selection of local thresholding is due to: (i) the vein images contain a background noise, and (ii) there is variation in contrast and illumination gradient. So, the local thresholding is more suitable to be used than the global thresholding, as shown in Fig. (3.9).

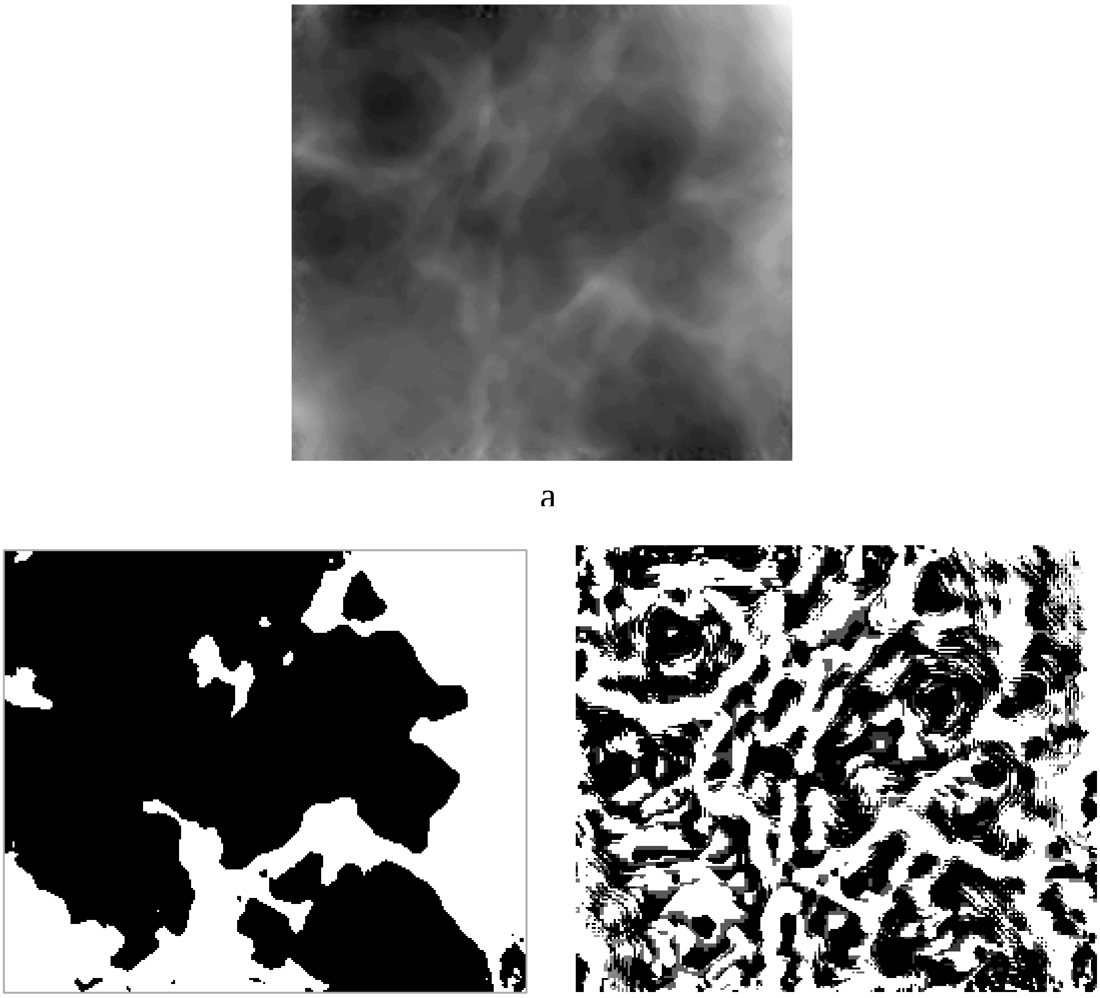
Local thresholding algorithm could be implemented by using different threshold value at different places. This needs a measurement of a local region of image intensity. Global thresholding is applied in the value of image where it is greater or less than a specific threshold. In this project, local thresholding is applied. The applied local mapping process for indemnity the brightness variation consists of the following mapping steps:

i. Partition the image, into small square blocks, each has size (bxb).

ii. For each block, a scanning window (SW) is applied (with area nxn; where n>b) covers the block area and extends to the surrounding area.

iii. The mean (μ) and standard deviation (SD) of the pixel's values located inside the window (nxn) are determined

iv. Then for each pixel, the following mapping criterion is applied [ASM14]:



a

b c

Fig. (3.9): Local Thresholding (a) Image without noise (b) Global thresholding (c) Local thresholding.

$$Arr_{thr}(x, y) = \begin{cases} 255 \quad if\ arr_{noise} > mean + (factor * SD) \\ 0 \quad if\ arr_{noise} < mean - (factor * SD) \\ mean \quad otherwise \end{cases} \quad (3.3)$$

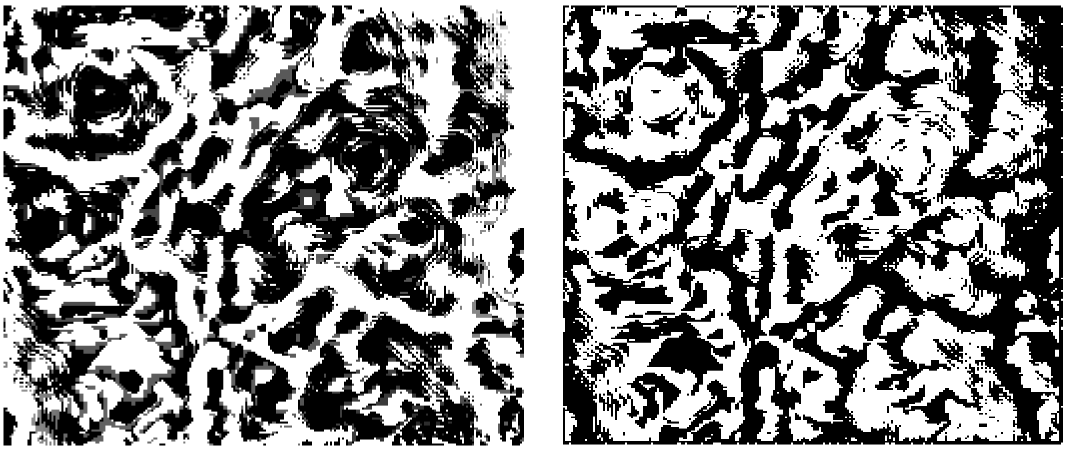
This algorithm from [ASM14] but with some changes that led to best result according to the input image, the multiplication factor is constant to all image.

B. Binarization

A binary process converts the image from grayscale level to binary black and white level. After local thresholding, the image contains gray regions (mean value). This process makes the image black and white which helps for thinning process that led to the extraction of the veins. In this proposed system, the proper threshold value is determining as shown in Fig. (3.10):

$$Thr = (max + min) / 2 \qquad (3.4)$$

$$Arr_{binary}(x, y) = \begin{cases} 0 \; if \; arr_{thr} < Thr \\ 1 \quad otherwise \end{cases} \qquad (3.5)$$

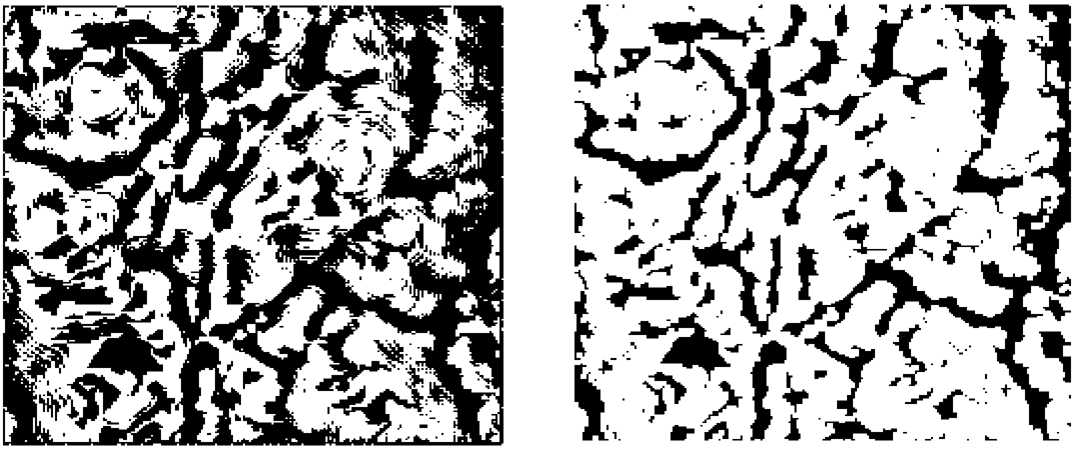


a b

Fig. (3.10): Binarization process (a) Local thresholding (b) Binarization.

C. Dilation

In this proposed system, there is a need to fill the small gaps and bridge nearest veins to achieve more accurate facial segments. Dilation is a morphological image processing that can be used in such situation. In dilation process, a filter (structuring element) is opened around each black pixel in the binary image and the number of white pixels within structuring element is counted, if the number of white pixels is equal or greater than a given threshold (Thr) then the original pixel value is converted into white color. This process is shown in Fig. (3.11).

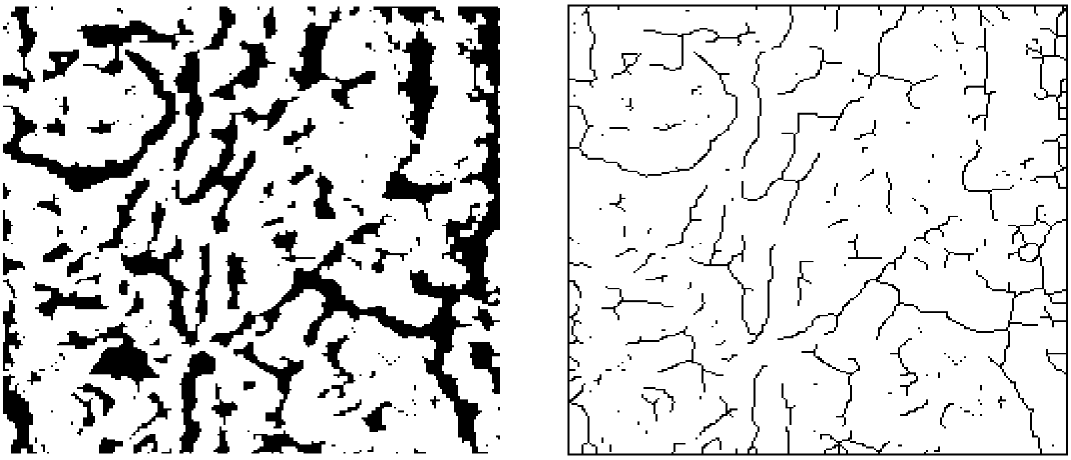


a b

Fig. (3.11): Gaps filling (a) Binary image (b) Dilation process.

D. Thinning

It is one of the important stages in palm vein recognition that convert the veins to the thinnest case that enables to extract the features from it. In this thesis, the two step thinning Zhang-Suen’s algorithm is used. It is fast and simple to be implemented. It makes the vein thickness contains from one pixel as shown in Fig. (3.12). the Zhang-Suen’s thinning is illustrated in the algorithm (3.2).



a b

Fig. (3.12): Thinning algorithm (a) Image after dilation (b) Result of two step thinning.

Algorithm (3.2): Zhang-Suen's thinning
Input: Img ///Bitmap image after dilation process W, H /// The image width & height, respectively S[,] /// Boolean array
Output: Img_thin ///The last stage to extract the vein

Begin
Step1: ///Convert image to Boolean array
For all i **Do** {where 0 ≤ i<W}
For all j **Do** {where 0 ≤ j ≤H}
Set s [j, i] = Img (i, j): **stop**
End For
End For
Step2: /// Determining the value of Boolean array
Set count=0
For all i **Do** {where 0 ≤ i <W}
For all j **Do** {where 0 ≤ j ≤H}
Set p2 = s [j] [i - 1]

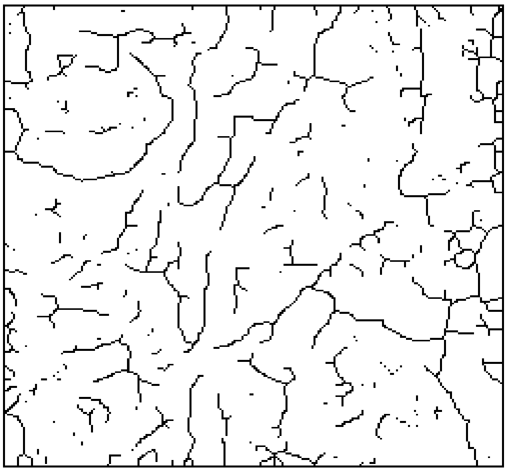
```
Set p3 = s [j + 1] [i - 1]
Set p4 = s [j + 1] [i]
Set p5 = s [j + 1] [i + 1]
Set p6 = s [j] [i + 1]
Set p7 = s [j - 1] [i + 1]
Set p8 = s [j - 1] [i]
Set p9 = s [j - 1] [i - 1]

If p2 = s [j] [i - 1] Then count=count+1
If p3 = s [j + 1] [i - 1] Then count=count+1
If p4 = s [j + 1] [i] Then count=count+1
If p5 = s [j + 1] [i + 1] Then count=count+1
If p6 = s [j] [i + 1] Then count=count+1
If p7 = s [j - 1] [i + 1] Then count=count+1
If p8 = s [j - 1] [i] Then count=count+1
If p9 = s [j - 1] [i - 1] Then count=count+1
    a = (! p2 && p3) + (! p3 && p4) +(! p4 && p5) +(! p5 &&p6)
    +(! p6 && p7) + (!p 7 && p8) +(!p8 && p9) + (!p9 && p2)
    If count >=2 and count<=6 Then
        If a=1 Then
            If (! ((p2 && p4) && p8) Then
                If (! ((p2 && p6) && p8)) Then
                    s [j, i] =false
                End If
        End If
        If (! ((p2 && p4) && p6)) Then
            If (! ((p4 && p6) && p8)) Then
                s [j, i] =false
```

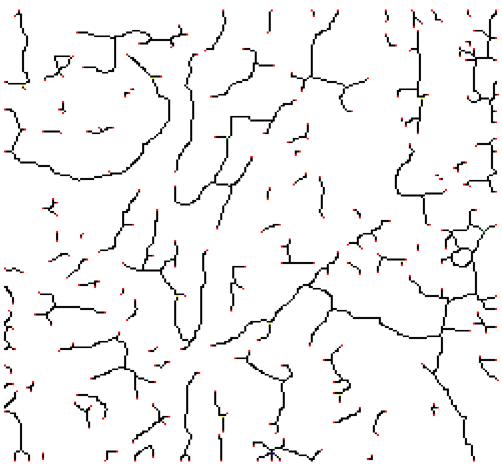
```
                End If
            End If
    End For
Step3: ///convert Boolean array to image
    For all i Do {where 0 ≤ i<W}
        For all j Do {where 0 ≤ j ≤H}
            If (s[j][i]) Then Img_thin= Img (i, j): stop
        End For
    End for
Step4: End
```

E. Fine Thinning

In the two-step thinning, there are some points that not belong to the veins. It is scattered in the image. This points must remove to get the veins in the last case of thinning and extract only the important feature. In this thesis, has removed one, two and three points by using 3x3 and 5x5 filter when finding them alone and not connected to any vein as shown in Fig. (3.13).



a



b

Fig. (3.13): Fine Thinning (a) Two step thinning (b) Last thinning.

3.4 Feature Extraction Stage

In this stage, the features required to recognize different individuals. The features must have high discrimination ability for recognizing the individuals. The number of features used to achieve high recognition must be as small as possible. In this proposed system, feature extraction stage implies two main steps: (i) feature vector generation, (ii) feature normalization step.

3.4.1 Feature Vector Generation Step

In this step, the features that are used to represent a particular person, and distinguish it from other people are extracted with the error rate in the small discrimination. The method used in this system to extract the feature vector from palm vein can be determined using such method:

In this algorithm, trace the image and divide it by blocks. For each block, the μ has been extracted for whole block and SD for rows and SD for columns by using equation (2.8) and (2.9) for μ and SD. The size of the image is 250x250. The number of blocks in each row chosen 10 that lead to a good result and the same as for column. The size of the block becomes from divide the size of the image to a number of blocks. In this case is 25x25 height and width of the block. To calculate the features for one person from a number of blocks in the row and column multiply by a number of the feature in each block.

There are 300 features for each person. Using a file to store the feature and use a three-dimension array for restore the value from the file and the implemented steps for applying this generation task are listed in algorithm (3.3).

Algorithm (3.3): Feature Vector Generation

Input: Img ///Bitmap image after last thinning process

W, H /// The image width & height

arr ///array after thinning process

nx///number of block in width

ny///number of block in height

Output: vec[n] ///The feature vector array where n is number of feature

Begin

Step1: ///Extract the features from thinning image

```
    Set wb=W/nx ///width of block
    Set hb=H/ny ///height of block
    Set f=0
    For all iy Do {where 0 ≤ iy < nx}
        Set ys = hb * iy
        For all ix Do {where 0 ≤ ix < ny}
            Set xs = wb * ix
            For all y Do {where 0 ≤ y < hb}
                /// determine standard deviation based by
                rows and Mean for hole block
                Set county[y]=0
                For all x Do {where 0 ≤ x < wb}
                    Set county[y] = county[y]+ arr [x + xs, y + ys];
                End for
            End for
            For all i Do {where 0 ≤ i < countyLength}
                Set xmean [ix, iy] = xmean [ix, iy] + county[i]
            End for
            Set xmean [ix, iy] = xmean [ix, iy] / wb
```

```
For all i Do {where 0 ≤ i < ny}
    For all j Do {where 0 ≤ j < nx}
        Set xstd [ix, iy] =xstd [ix, iy]+(arr[i, j] - xmean[ix,
        iy])^2
    End for
End for
Set xstd [ix, iy] = Sqrt (xstd [ix, iy]/wb)
///in each block one value of mean and two values for SD
vec[f]= xmean [ix, iy]
increment f
vec[f]= xstd [ix, iy]
increment f
/// determine standard deviation based by columns
For all x Do {where 0 ≤ x < wb}
   ///countx array of summation black pixel in block based
   on columns
   Set countx[x]=0
   For all y Do {where 0 ≤ y < hb}
       Set countx[x] = countx[x]+ arr [x + xs, y + ys];
   End for
End for
For all i Do {where 0 ≤ i < countxLength}
    Set ymean [ix, iy] = ymean [ix, iy] + countx[i]
End for
Set ymean [ix, iy] = ymean [ix, iy] / hb
For all i Do {where 0 ≤ i < ny}
    For all j Do {where 0 ≤ j < nx}
        Set ystd [ix, iy] =ystd [ix, iy] + (arr [i, j] – ymean
```

```
                    [ix, iy])^2
                End for
            End for
            Set ystd [ix, iy] = Sqrt (ystd [ix, iy]/hb)
            /// in each block one value of mean and two values for SD
            vec[f]= ymean [ix, iy]
            increment f
            vec[f]= ystd [ix, iy]
            increment f
        End for
    End for
Step2: End
```

3.4.2 Feature Normalization Step

In this step, If the features are given in different scales then the large scaled features will override the features of small scale and unhelpful in final recognition. So, performing the normalization process is very important since the feature vector that is proposed in this system contains features of different scales. Features are normalized using equation (2.9), and the implemented steps after get the vector V normalize it listed in the algorithm (3.4).

Algorithm (3.4): Feature Vector Normalization
Input: Vec[] ///The feature vector array where n is number of feature
Output: Norm_Feat[n] ///The feature vector array after normalization within [0,1] range feature

```
Begin
Step1: ///Normalize the feature vector
        Set min=Vec [0]
        Set max=Vec [0]
        For all i Do {where 0< i < VecLength}
            If vec[i] < min
                Min=vec[i]
            End if
            If vec[i] > max
               Max=vec[i]
            End if
        End for
        For all i Do {where 0 ≤ i < VecLength}
           Set Norm_Feat[i] = (Vec[i] - min) / (max - min)
           Save this normalized feature vector in database
        End for
Step2: End
```

3.5 Feature Matching Stage

This stage measures the degree of matching between two vein patterns. The extracted vein patterns of the input image can directly be compared with the stored templates. A certain distance equations are used to calculates the degree between the template and the input patterns. After feature extracting step, the distance equations are applied using four equations (2.11-2.14) and the implemented steps for applying this matching task are listed in algorithm (3.5).

Algorithm (3.5): Feature Matching
Input: PNo///number of persons CNo ///Number of classes FNo /// Number of features Norm_Feat[n] ///The feature vector array after normalization for the input person FeatVec[,,] ///3D array of feature vector after normalization from database that holds PNo of persons within CNo of classes for FNo of features
Output: Person Identity

Begin
Step1: ///Calculate the Average and standard deviation for each person with his classes
For all i **Do {**where 0 ≤ i< PNo}
///Compute average of feature (k) within all classes in database
Set Mean = 0
For all k **Do** {where 0 ≤ k<FNo}
For all j **Do** {where 0 ≤ j< CNo}
Set Mean = Mean+ FeatVec [i, j, k]
End For
Set Mean = Mean/CNo
Set Avg [i, k] = Mean
Save the Avg in database
For all j **Do** {where 0 ≤j< CNo}
Set Std [i, k] = Std [i, k] + $(\text{FeatVec [i, j, k]}-\text{Mean})^2$
End For
Set Std [i, k] = Sqrt (Std [i, k] /CNo)
Save Std in database
End For

End For

Step2: ///Compute the distance between the input person with all stored templates

For all i **Do {**where 0 ≤ i< PNo}

For all k Do {where 0 ≤ k<FNo}

///apply four distance equations and all of these are correct

Set sum1 =sum1+Abs(norm_Feat[k] – Avg [i, k]);

Set sum2 = sum2 +(norm_Feat[k] – Avg [i, k])^2

Set sum3 = sum3+ Abs(((norm_Feat[k] – Avg [i, k]) / Std [i, k]))

Set sum4 =sum4+((norm_Feat[k] – Avg [i, k]) / Std [i, k])^2

End for

Set a[i]=sum1

Set b[i]=sum2

Set c[i]=sum3

Set d[i]=sum4

End for

Step3: Search for minimum Distance value in each array a, b, c, d

Step4: return the person identity for minimum Distance value

Step5: End

Chapter Four Experimental Results and Discussion

Chapter Four
Experimental Results and Discussion

4.1 Introduction

In this chapter, the performed test results of the implemented system are presented which is mentioned in the previous chapter to notify what best recognition results can be achieved to identify the individuals using the feature vectors acquired from the feature extraction stage. The system had been established using C sharp (Microsoft Visual Studio 2010) programming language. The tests have been conducted under the environment: Windows-10 operating system, laptop computer Sony Vaio (processor: Intel Core i3 CPU (2.40) GHz and (4GB) RAM.

4.2 Test and Implementation

The presented system was tested using a CASIA Multi-Spectral Palm-print Image Dataset contains 7,200 palm images captured from 100 different people. This will explain in details in Appendix A. The results of the implemented tests are given in the following sub-sections.

4.2.1 ROI Implementation and Result

To extract the features of a good performance to each person must be detected and extract the ROI that the veins are focused in this region. Apply a set of processes to achieve this result as shown in Fig. (4.1).

The first process is applying the median filter that important step to remove noise from input image for convert it to binary. The value of median filter is chosen depending on the result of removing the noise that depends on the size of the mask of median filter that affects to remove the noise after Otsu thresholding. The median mask values are started from 5x5, 6x6, 7x7 to 20x20, the best value that led to the good result that removes most of the noise is 20x20 as shown in the table (4.1) The size of the applied median filter is an important factor for reducing the noise from the image. For this reason, it chooses a large specific size to remove all the noise from the input image.

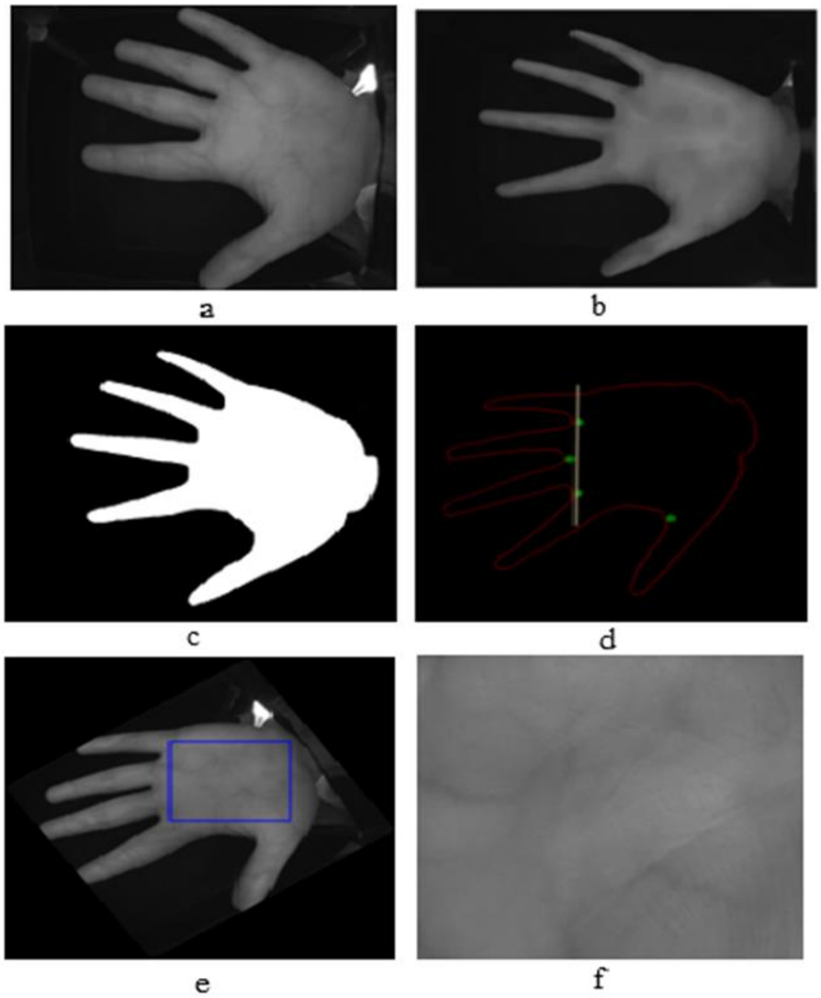
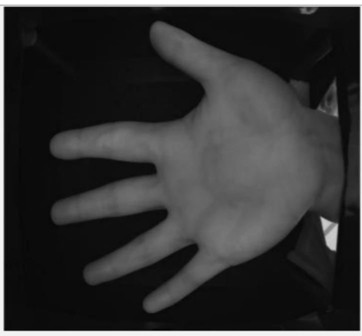
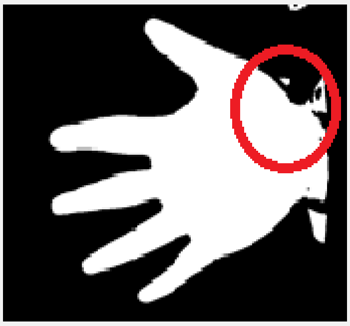
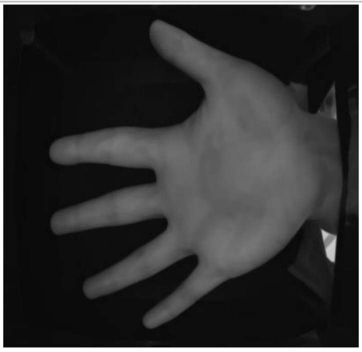
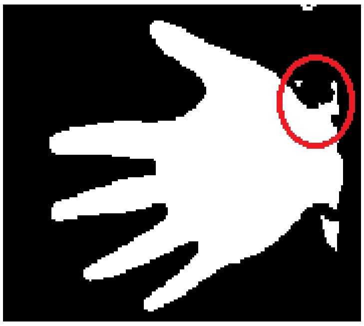
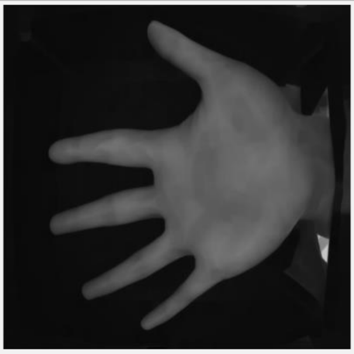
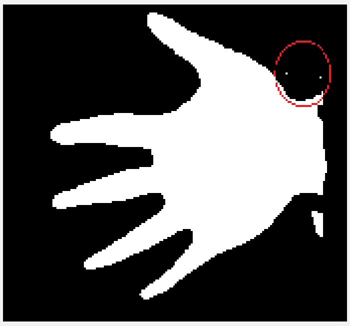
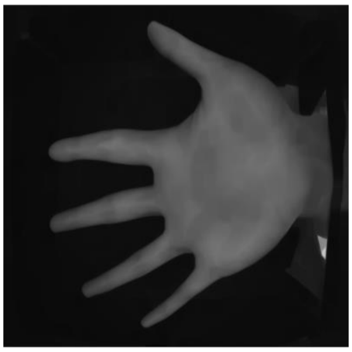
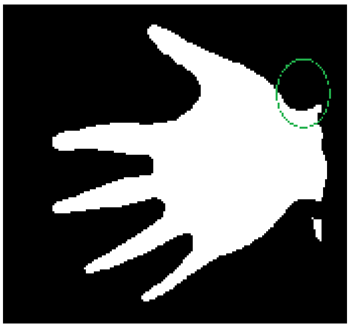


Fig. (4.1): The final ROI extraction result: (a) original image (b) apply median filter (c) apply Otsu threshold for binary (d) detect the boundary of palm and determine the references point then rotated image (e) draw rectangle around the ROI (f) extract the ROI

Table (4.1): Result of applying median filter and Otsu thresholding.

Size of median filter	De-noising Image(Median filter)	Binarization (Otsu thresholding)
5x5		
10x10		
15x15		
20x20		

4.2.2 Image Enhancement

It contains three stages as mention in section 3.2. in details. The first stage is converting the image to gray and inverse it. The second stage is stretching and normalization and the third stage is removing noise from the inside of palm vein by using a median filter and then tuning values of the mask of a median filter by using 5x5, 7x7 and 9x9. The 5x5 mask size not affects a lot in the input image and not remove all the noise. As for the 9x9 mask size, distorts the image a lot of need. The 7x7 mask size that leads to a good result and removes noise as needed as shown in Fig. (4.2).

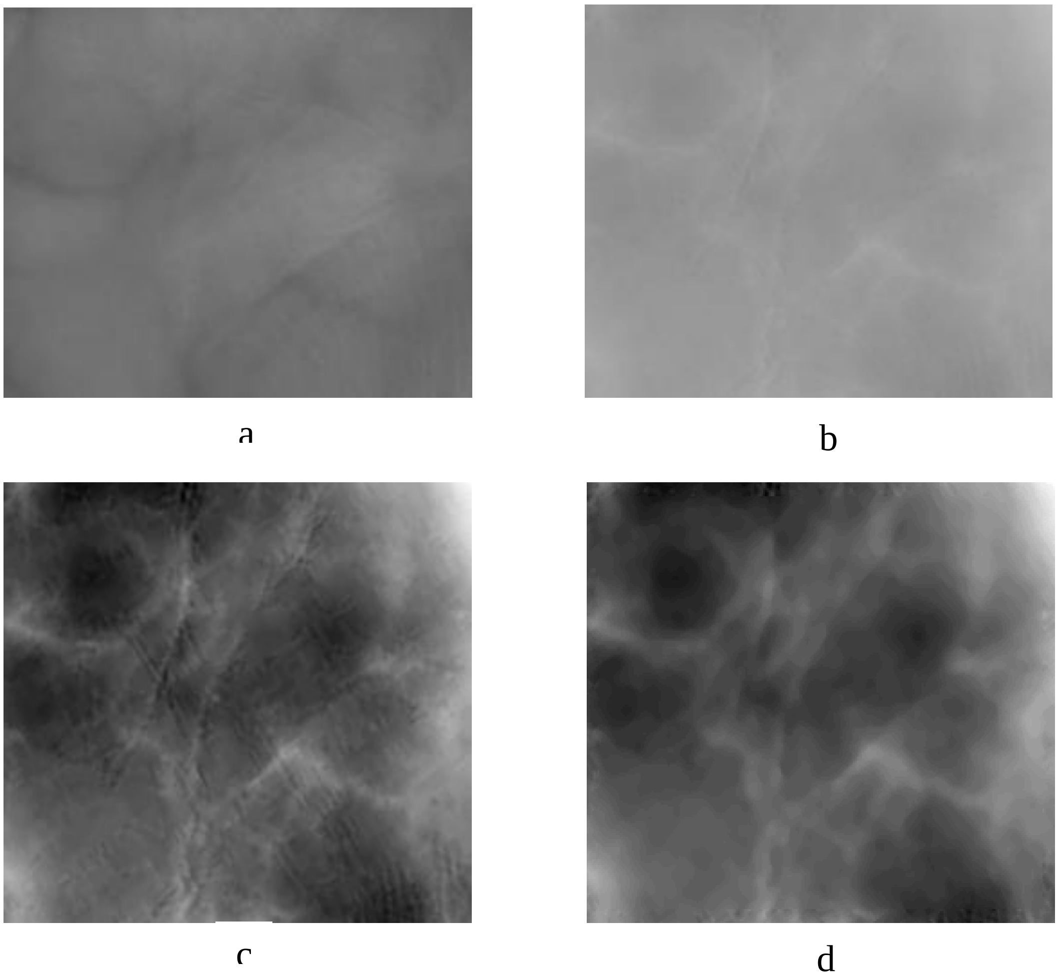
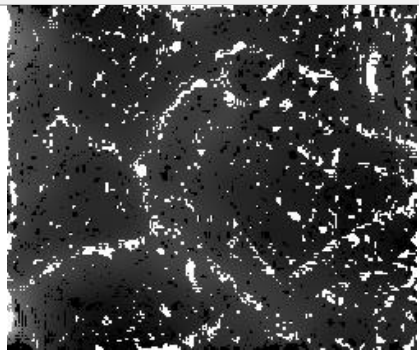


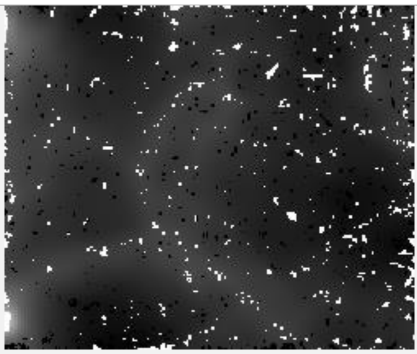
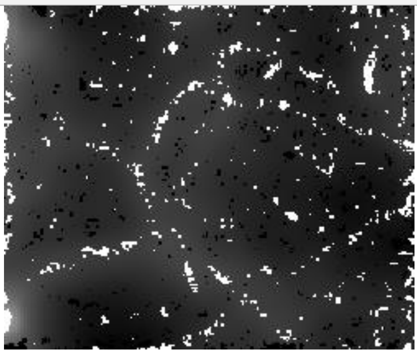
Fig. (4.2): Result of Image Enhancement (a) original ROI (b) Negative of a (c) Brightness and stretching (d) De-noising

4.2.3 Image Segmentation

It is the last stage a preprocessing module that isolates veins from image background. This stage is the main and the backbone of the presented system. It contains five stages: local thresholding, Binarization, dilation, thinning and final thinning as mention in previous sections. The important stage is local thresholding that contains three values (block size(BL), scanning window(SW) and a multiplication factor(MF)) in which they effect on the result. Each change in the three values lead to different results and the best values are in the sixth case that (BL=2, SW=7, and MF=0.05) will give the best result that from it can extract the veins as shown in the table (4.2).

Table (4.2): Result of applying local threshol.

BL	SW	MF	Description	Local thresholding
2x2	**5**	**0.2**	cannot extract the Veins because of noise in the veins	
2x2	**5**	**0.4**	MF enlargement but the image becomes dark.	

2x2	**5**	**0.6**	Notice that each increase in MF caused the image dark and the veins almost disappeared	
2x2	**7**	**0.6**	Increase the SW to 7 and the result is the same as its previous	
2x2	**7**	**0.04**	the result differ very much when decrease MF	
2x2	**7**	**0.05**	increase the MF by degree will give the best result that from it can extract the veins	

4.2.4 Dilation and Thinning

After local thresholding stage, the image contains some gray level because of local thresholding it applies depending on three levels (the value of mean among them) as mention in equation 3.3. The processes that applied to the image after thresholding are:

1- Convert the resulted image to a binary as mention in equation (3.4)

2- Apply dilation process as mention in section 2.4.6, this is also an important stage that facilitates the process of thinning and to repair breaks and intrusions as shown in Fig. (4.3 b)

3- Thinning is the last step in segmentation stage that make veins as thin as possible. Using two-step thinning as mention in section 2.4.7

4- Apply final thinning by removing any alone pixel or two or three by using a tripartite filter that traces each pixel as shown in Fig. (4.3 c, d) the green circles illustrate the deleted points.

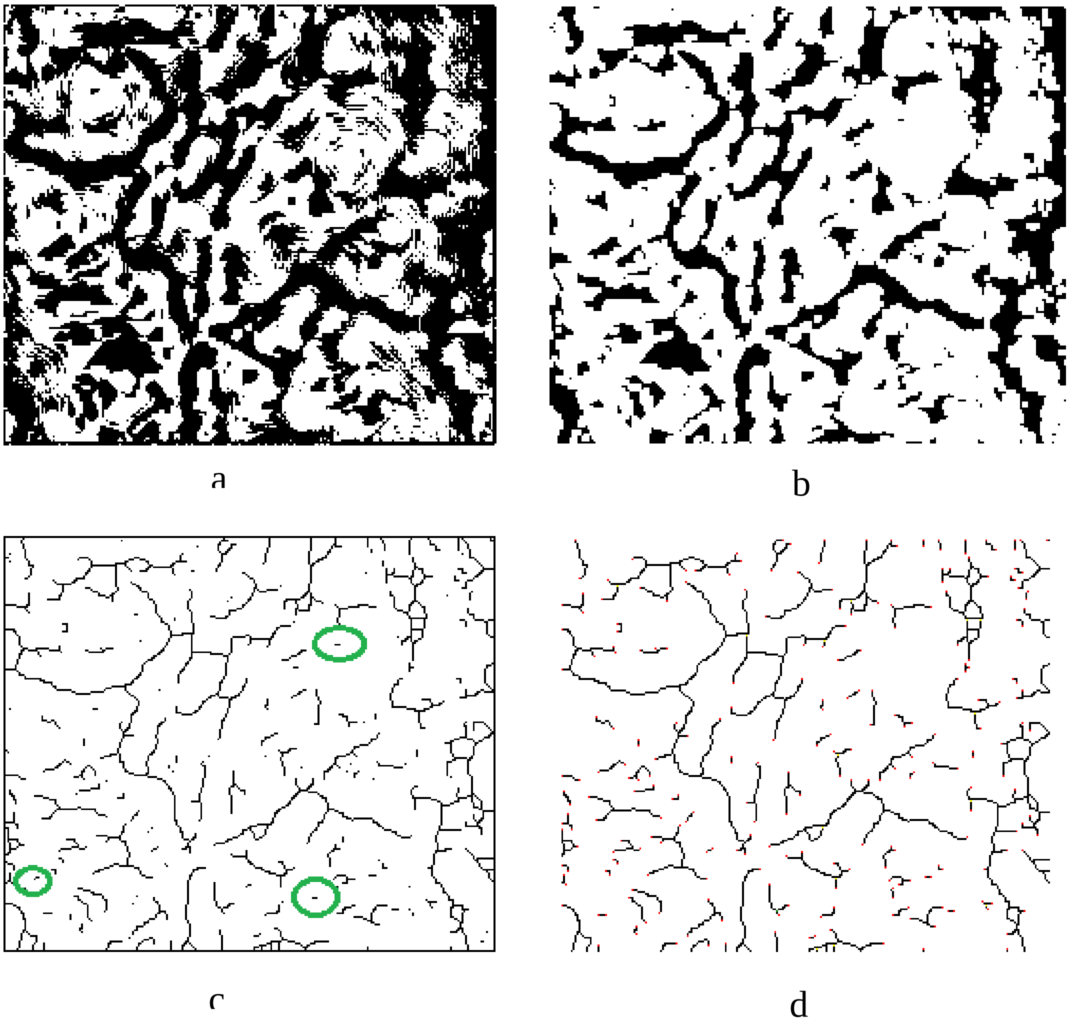


Fig. (4.3): Result of applying dilation and thinning (a) Image after thresholding (b) result of dilation (c) thinning (d) final thinning.

4.3 Feature Extraction

The features must be extracted from thinning image that the size of the image is 250x250. After the experience of drawing characteristics through the shape of the vein such as capital letter T, terminal point, +, and Y that led to failure, this lead to calculate the characteristics statistically. First, divide the image into the number of blocks. The number of blocks in each row is 10 that lead to a good result and the same number for the column. Each block has three features, first one the µ for the whole block, the second one the SD for row and the third one the SD for the column, for this reason, this number of blocks and features lead to a good result. To calculate the features for one person from a number of blocks in the row and column multiply by a number of the feature in each block that are 300 features for each image. After that, because of contrast in the value of features then apply feature normalization to scaling features in the range [0,1] as mentioned in equation (2.9) these methods lead to a good result.

4.4 Feature Matching

In verification, the system success without error. In identification, there are four distance equations that match the input person with the template that stored in DB. From the result of these equations, the recognition takes the minimum value that matches with the input image as shown in table 4.3 where the first column represents the persons that stored in database, the second column the result of applying the equation as mention in (2.11), the third column the result of applying the equation as mention in (2.12), the fourth column the result of applying the equation as mention in (2.13), the fifth column the result of applying the equation as mention in (2.14). In the table (4.3), the input person is the tenth person and each value is the rate of matching between the input person (10) and each person stored in the database.

Table (4.3): Feature Matching where input person is 10.

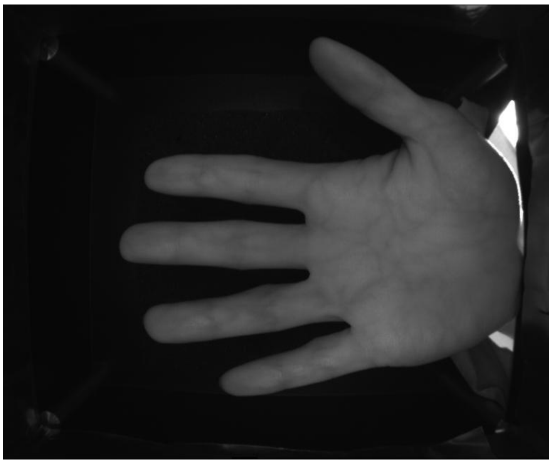
Persons	D_{CB}	D_{Euc}	D_{CBN}	D_{EucN}
1	10.2408	0.4142	7.2554	0.2663
2	10.9075	0.4652	7.5176	0.2741
3	10.217	0.4124	7.2044	0.2582

4	10.2592	0.4095	7.1157	0.2339
5	9.9332	0.3827	6.9635	0.2378
6	10.6136	0.4439	7.4462	0.2746
7	9.8614	0.374	7.0704	0.2484
8	9.998	0.3917	6.94	0.2375
9	11.4215	0.4977	8.0696	0.316
10	5.8393	0.1426	4.0938	0.0846
11	9.1126	0.3484	6.3066	0.2156
12	11.1141	0.4788	7.6733	0.272
13	10.0296	0.4048	7.0469	0.2496
14	10.7338	0.4282	7.4324	0.2488
15	9.8597	0.3731	6.8417	0.2293

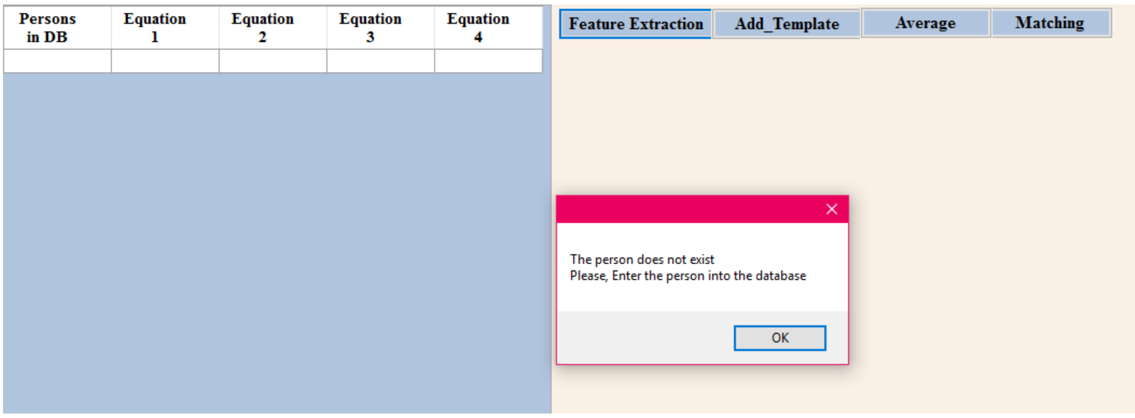
In some cases, the system distinguishes the wrong person and this problem has been solved by applying the four equations that are described in section 2.7 must be at least three equations valid until the discrimination is correct as shown in table (4.4) where the first equation is wrong that person 38 is the claimed person but the correct person is 48 as three other equations are correct, and some not execute correctly it considers in the error rate because no optical biometric system without error rate, and the system does not identify it and print message that explaining the error. For this reason, the identification rate according to this cases are 91.6 %. According to apply the Another example is shown in the Appendix B. If the person is not in the database (is not identify in PVR) the system requires to input this person and store him in the database as shown in Fig. (4.4).

Table (4.4): Feature matching where the input person is 48.

Persons	D_{CB}	D_{Euc}	D_{CBN}	D_{EucN}
34	11.2383	0.4895	7.7268	0.2914
35	10.7644	0.4621	7.7456	0.2954
36	11.3096	0.5207	8.0635	0.3276
37	10.5314	0.4374	7.6272	0.2866
38	9.2518	0.4536	7.5996	0.3216
39	11.2421	0.4987	8.2833	0.3502
40	10.2807	0.4393	7.3876	0.2793
41	10.5975	0.428	7.5537	0.2747
42	10.9495	0.446	7.7193	0.2713
43	10.8652	0.4624	7.6031	0.2748
44	10.2602	0.4063	7.194	0.2562
45	10.6914	0.4469	7.6097	0.2786
46	10.2081	0.4321	7.2911	0.2742
47	10.4454	0.4212	7.4283	0.2701
48	9.4826	0.3454	6.7788	0.2277
49	10.0846	0.4026	6.9982	0.2387
50	10.2476	0.4271	7.4679	0.2847



a



b

Fig. (4.4): The result of person not store in DB (a) the input palm vein (b) the result of system.

4.5 Discussion

In the first stage in the system is ROI extraction and the best size of median filter to remove noise from the input image is 20x20. The process of converting the hand to binary is Otsu thresholding that leads to good result to detect the boundary of hand. After extract the ROI, the new image is the rectangle of ROI of palm vein applying on it several processes that inverse of image, brightness stretching, and then apply median filter to remove noise inside the palm vein and the best size of median is 7x7 because 5x5 does not remove all noise and 9x9 blurring the image. Then apply the backbone local thresholding to isolate the veins from the background and the best values are BL=2, SW=7, and MF=0.05 as described in 4.2.3 in details. Then the best values for feature extraction are no. of blocks=10 in the row and 10 for the column, the size of block= 25x25, and number of features are 300 for each person stored in DB. Because of the variance in feature values, applying normalization to rescaling the values and make it in the range between [0,1]. Then apply feature matching by using four distance equations that measure the distance between the input person with templates stored in DB these equations are mention in 2.7 in details and there are lead to the good result in the recognition process. From table 4.3 and table 4.4 notice that the value of first equation is larger from others because the equation is the summation of absolute value. The second equation is less than 1 because it is the power of values less than 1 such as 0.2 * 0.2 = 0.04. The third equation values are large than 1 because it is the summation of absolute value divided by SD. The fourth equation is less than 1 because it is the power of values less than 1 divided by SD (when multiplying the values that less than 1 by itself the result is less than the original number). The verification rate is 100% and the identification rate is computed from the law percentage that: (number of correct images/number of all images) *100 %. The identification rate is 91.6% .

Chapter Five
Conclusions and Future Works

Chapter Five

Conclusions and Future Works

5.1 Conclusions

According to the conducted analysis to evaluate the recognition performance of the proposed system, many conclusions have been stimulated, and they are:

1. The proposed PVR system can be used to recognize the individuals in rate 91.6 %.
2. The removal of noise from the palm Vein image has an important effect on ROI extraction that covers most area of palm.
3. Local thresholding with a specific value for multiplication factor and scanning block gives an important result that isolates the veins from the background.
4. Dilation and thinning operations give the vein the desired shape in the recognition process.
5. Using the palm vein image statistical method gave recognition rate better than that given by the shape (Terminal, Capital letter T, Plus +, and Capital letter Y).
6. When entering each person to the system, must take more than one capture of the palm vein (at least three) because of the movement that occurs in the hand at each palm vein print and stored in a specific way in a database so that one template of features represents the person and this led to good results in the process of recognition.

5.2 Future Works

1. Testing another data set type of vein images that suffer from the effect of higher scaling.
2. The quality of image data is important for the applications. So, the current image enhancement methods can be improved to provide better enhancement results with lower complexity.
3. The proposed system can be applied to any part in the human body that contain veins such as veins in finger and veins in wrist.
4. Another matching method can be used, such as neural network.
5. In some cases of the input image, need rotation in that moment of introduction.

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Appendix A
Multiple Spectral Image Details

The data set is using self-designed multiple spectral imaging devices, as shown in Figure (4.1). All palm images are 8-bit gray-level JPEG files. For each hand, capture two sessions of palm images. The time interval between the two sessions is more than one month. In each session, there are three samples. Each sample contains six palm images which are captured at the same time with six different electromagnetic spectrums. Wavelengths of the illuminator corresponding to the six spectra are 460nm, 630nm, 700nm, 850nm, 940nm and white light respectively. Between two samples, allow a certain degree of variations of hand postures. Through that, aim to increase the diversity of intra-class samples and simulate practical use. In this device, there are no pegs to restrict postures and positions of palms. Subjects are required to put his palm into the device and lay it before a uniform-colored background. The device supplies an evenly distributed illumination and captures palm images using a CCD camera fixed on the bottom of the device and design a control circuit to adjust spectrums automatically.

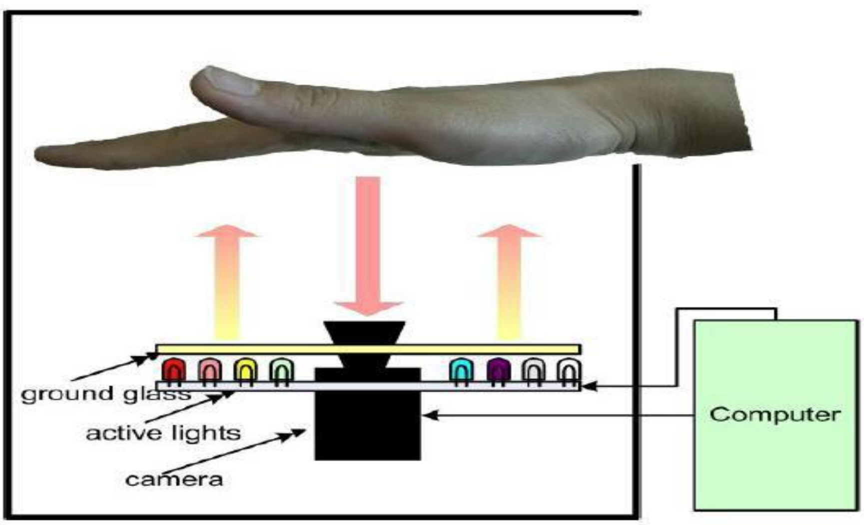

Fig. (0.1): Self-developed multi-spectral imaging device.

Appendix B

Feature Matching for Input Persons with Database

Table (B-1.1): Feature Matching where input person is 14

Persons	D_{CB}	D_{Euc}	D_{CBN}	D_{EucN}
1	9.7682	0.388	7.126	0.2702
2	9.6411	0.3649	6.7633	0.2213
3	11.2019	0.4789	7.9945	0.3077
4	10.8033	0.4385	7.6493	0.2739
5	11.1947	0.4441	7.9865	0.2875
6	10.7054	0.4359	7.6352	0.2861
7	9.6854	0.3521	6.9634	0.2357
8	9.3984	0.3577	6.6432	0.2275
9	10.6241	0.4348	7.5753	0.29
10	9.9759	0.389	7.0247	0.2452
11	11.0211	0.4413	7.7765	0.2777
12	10.7267	0.4662	7.5531	0.2942
13	10.0431	0.385	7.0515	0.2372
14	5.1741	0.1114	3.7369	0.0734
15	10.0292	0.3792	7.2168	0.2532
16	9.8792	0.3797	6.9732	0.2381
17	10.7632	0.456	7.7342	0.3002
18	11.3468	0.5049	7.9564	0.2967
19	10.0769	0.3873	7.2237	0.2549
20	10.9137	0.4965	7.6137	0.2897
21	10.7102	0.4258	7.671	0.281
22	10.2345	0.4019	7.3133	0.2569
23	10.7099	0.4551	7.6143	0.2941
24	10.1143	0.4234	7.0925	0.2586
25	10.2818	0.4249	7.3836	0.2819
26	11.3587	0.4738	7.8625	0.2846
27	10.9651	0.4709	7.6957	0.2853

28	10.2701	0.418	7.3389	0.2704
29	10.9683	0.4472	7.6815	0.2724
30	10.6302	0.4372	7.5092	0.2764
31	10.9918	0.4668	7.8998	0.2984
32	11.407	0.4877	7.9866	0.3029
33	9.7696	0.3659	7.0932	0.2381
34	10.4266	0.4404	7.5142	0.2804
35	11.124	0.478	7.8766	0.2984
36	11.0938	0.4544	7.6554	0.2686
37	10.9752	0.4604	7.82	0.2982
38	9.7184	0.3669	6.9854	0.2427
39	10.5312	0.4472	7.6022	0.2956
40	10.1823	0.3956	7.1579	0.2482
41	10.2626	0.4117	7.224	0.2583
42	9.3463	0.3638	6.5473	0.2248
43	10.4836	0.4279	7.3936	0.2667
44	9.8304	0.3878	6.9234	0.24
45	10.3829	0.4263	7.3685	0.2697
46	11.4668	0.4882	8.074	0.3016
47	10.1717	0.3985	7.3163	0.2641
48	10.42	0.4282	7.4566	0.276
49	11.0113	0.4602	7.7449	0.281
50	9.1875	0.337	6.6107	0.224

Table (B-1.2): Feature Matching where input person is 27.

Persons	D_{CB}	D_{Euc}	D_{CBN}	D_{EucN}
1	10.8293	0.4675	7.6319	0.2832
2	10.9201	0.4711	7.4638	0.265
3	10.8378	0.4725	7.5907	0.2956
4	11.0715	0.4894	7.6039	0.2784

5	11.15	0.4798	7.659	0.2739
6	11.6124	0.5309	8.109	0.3241
7	11.5862	0.5211	7.9856	0.3102
8	10.6348	0.4468	7.2869	0.2553
9	11.8531	0.5617	8.2146	0.3174
10	11.3035	0.4922	7.6493	0.2756
11	11.4278	0.5004	7.9449	0.2967
12	9.9006	0.4059	7.0137	0.2563
13	11.3039	0.4961	7.7578	0.2794
14	11.952	0.5673	8.1185	0.3168
15	11.5897	0.4968	7.8754	0.2855
16	10.9948	0.4796	7.6172	0.2847
17	11.1043	0.4816	7.7361	0.2843
18	12.5303	0.6191	8.5141	0.3428
19	10.4977	0.4295	7.0993	0.2377
20	11.3551	0.5132	7.9096	0.3091
21	10.9015	0.4749	7.4815	0.281
22	11.4405	0.5176	7.8555	0.2852
23	10.9137	0.4801	7.6048	0.2825
24	10.1608	0.4148	7.1465	0.2456
25	11.8242	0.5724	8.232	0.3428
26	10.2041	0.4203	7.056	0.2361
27	5.8731	0.1369	4.0891	0.0803
28	11.1741	0.4779	7.7009	0.2805
29	10.1946	0.4024	7.2407	0.2512
30	11.3275	0.486	7.8308	0.2843
31	11.7672	0.517	8.0263	0.2958
32	10.8996	0.4578	7.5174	0.2661

33	11.4033	0.4777	7.8988	0.2835
34	10.6926	0.4438	7.3055	0.2534
35	12.238	0.5793	8.2838	0.3167
36	10.8678	0.4813	7.5108	0.2779
37	10.5424	0.4331	7.3574	0.2544
38	10.909	0.4761	7.5615	0.2773
39	12.0026	0.5537	8.2691	0.3336
40	10.2928	0.4149	7.1075	0.241
41	10.8764	0.4756	7.4209	0.2713
42	11.6355	0.51	7.8959	0.2827
43	10.1457	0.4181	7.0595	0.2565
44	11.4332	0.4975	7.8392	0.2838
45	11.0243	0.4735	7.6227	0.2671
46	11.1071	0.4739	7.6781	0.2664
47	11.9041	0.5435	8.0995	0.3071
48	11.0813	0.4838	7.6724	0.2852
49	11.6133	0.5299	7.8428	0.2959
50	11.801	0.5362	8.1284	0.3081

Table (B-1.3): Feature Matching where input person is 35.

Persons	$\mathbf{D_{CB}}$	$\mathbf{D_{Euc}}$	$\mathbf{D_{CBN}}$	$\mathbf{D_{EucN}}$
1	10.171	0.4128	7.1374	0.257
2	11.0561	0.4851	7.6321	0.2839
3	10.6325	0.4499	7.4117	0.2805
4	10.2583	0.4237	7.1255	0.2451
5	11.1103	0.4672	7.7329	0.289
6	10.2686	0.4467	7.3428	0.2847

7	10.5034	0.4258	7.2986	0.2648
8	10.4096	0.4481	7.1178	0.2505
9	9.8093	0.4075	6.9489	0.2633
10	9.6773	0.3714	6.8235	0.2366
11	9.8659	0.403	6.8897	0.2378
12	11.7423	0.527	8.1153	0.3096
13	10.0237	0.4161	7.1239	0.2591
14	11.0049	0.4825	7.7311	0.2959
15	10.0468	0.3939	7.0452	0.2451
16	10.8894	0.4761	7.5002	0.2843
17	10.3812	0.4479	7.2168	0.2707
18	11.7202	0.5501	8.0236	0.3077
19	10.8625	0.4547	7.6877	0.2887
20	12.5179	0.6117	8.6237	0.3433
21	10.0838	0.4196	7.103	0.2664
22	8.6145	0.3269	6.0323	0.1927
23	10.9513	0.4915	7.5915	0.2947
24	10.8627	0.4719	7.3761	0.2629
25	9.9088	0.4114	6.882	0.2494
26	11.2639	0.513	7.9945	0.324
27	12.2075	0.5659	8.4129	0.3321
28	9.2423	0.3563	6.5595	0.2229
29	11.3923	0.4976	8.0015	0.3072
30	11.0984	0.4832	7.6312	0.2804
31	11.9036	0.5427	8.2762	0.3263
32	11.3672	0.5012	8.137	0.3196
33	9.9096	0.3987	6.9126	0.2377
34	10.9232	0.4532	7.495	0.2662

35	5.2852	0.1202	3.8554	0.0816
36	11.7514	0.5266	8.0632	0.3116
37	9.9742	0.3976	6.9194	0.2416
38	8.9496	0.3385	6.3662	0.2181
39	10.1066	0.4052	7.1478	0.251
40	9.6773	0.3862	6.7771	0.2368
41	10.9946	0.4814	7.787	0.3104
42	10.8553	0.4505	7.7837	0.2921
43	11.6822	0.5326	8.1266	0.3206
44	10.576	0.4429	7.2896	0.2665
45	9.6297	0.3844	6.7985	0.2386
46	10.661	0.4519	7.4498	0.2797
47	10.2103	0.4257	7.1591	0.2587
48	10.7892	0.44	7.572	0.2716
49	10.1993	0.4248	7.0591	0.26
50	8.9359	0.3501	6.3241	0.2143

الخلاصة

في السنوات الأخيرة، عندما فشلت بصمات الأصابع العادية في بعض الحالات الجلدية، تحولت البحوث نحو الأوردة والقزحية حيث يتم ضمان النتائج المستخدمة لتحديد التحقق من الأفراد. من الصعب تلف الأوردة او تغييرها أو تزويرها لانها مغمورة داخل جسم الإنسان. القياسات الحيوية هي الطرق الآلية لتمييز الفرد على أساس الخصائص الفسيولوجية أو السلوكية. يتكون النظام البيومتري من نظامين فرعيين: واحد للتسجيل والثاني للتمييز. في التسجيل، عادة تجمع ٣ او ٥ عينات بيومترية للشخص الواحد لانشاء قالب للمستخدم . وبينما يحاول النظام، في مرحلة التمييز، تحديد هوية الشخص (في حالة تحديد الهوية) أو التحقق من هوية الشخص المدعي (في حالة التحقق).

في هذا العمل يتم تطوير نظام البيومترية للتعرف على اوردة باطن الكف، يتم أولا معالجة صورة الاوردة لتبسيط مهمة عزل الوريد من الخلفية، وتطبيق استخراج منطقة الاهتمام لاستخدام فقط هذا الجزء المهم والمفيد من الاوردة. ثم يتم تحسين الصورة لإعدادها لعملية التجزئة، التي تفصل نمط الوريد من الخلفية والتي تستخدم للتمييز بنسبة مئوية معينة من الأخطاء. المرحلة النهائية هي استخراج الخصائص حيث يتم تتبع الصورة وتقسيمها الى اجزاء. لكل جزء، تم استخراج المتوسط والانحراف المعياري تارة يعتمد على الصفوف واخرى يعتمد على الأعمدة. ثم استخدمت معادلات المسافة لاتخاذ القرار في مرحلة المطابقة. تم اختبار النظام المقدم باستخدام مجموعة صور لاوردة باطن الكف من كاسيا متعددة الطيف حيث قاعدة البيانات تحتوي على ٧،٢٠٠ صورة اخذت من ١٠٠ شخص مختلف. هذا النظام يعطي نسبة مئوية ٩١,٦٪ من التمييز الصحيح. يحتاج هذا النظام إلى شرطين هما: جزء البرمجة الذي هو برنامج مكتوب بلغة C# حيث يوفر للمستخدم الواجهة الرسومية لمحاكاة هذا النظام من خلال مراقبة مراحل سير العمليات واتخاذ الإجراءات على النظام. والجزء الاخر هو جهاز الأشعة تحت الحمراء متصلة بجهاز الكمبيوتر، وهذا الجهاز يستخدم لمسح باطن كف الشخص.

جمهورية العراق

وزارة التعليم العالي والبحث العلمي

جامعة النهرين

كلية العلوم

تمييز الاشخاص بأوردة باطن الكف

رسالة

مقدمة إلى كلية العلوم في جامعة النهرين

كجزء من متطلبات نيل درجة الماجستير

في علوم الحاسوب

من قبل

لقاء جواد علوان

(بكالوريوس علوم حاسبات،٢٠١٤)

اشراف

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رجب ١٤٣٨ **نيسان ٢٠١٧**