REPUBLIC OF IRAQ

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

UNIVERSITY OF AL-QADISIYAH

COLLEGE OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

PERSONAL IDENTIFICATION BASED ON PALM VEIN

BY

STUDENT NAME

Hussein Hasan Hussein

Mustafa Muayad Raheem

Athman Dhiya Abdulsatar

SUPERVISOR

ASSIST PROF DR. ALI MUHSIN AL-JUBOORI

A graduation project submitted to the Multimedia department in partial fulfillment of the requirements for the degree of Bachelor in Information Technology in Multimedia

APRIL - 2019

Contents

Abstract

Biometric authentication has been widely studied for many years and attracted much attention due to its large ability security application. Palm vein is more immovable and more difficult to fake than other biometrics such as fingerprint, palm print and face. Since palm veins exist inside of the body, it is exceedingly hard to be forged. Palm vein authentication uses the unique patterns of the palm vein to identify individuals at a high level of accuracy.

In the proposed work: we first acquire the hand image then, we extract the region of interest (the middle of the palm) then, the resulting image will be enhanced using a Gaussian matched filtering algorithm, and then the output of Gaussian algorithm will be convoluted using the Gabor filter then, we extract palm features based on the Gabor filter. The output features will be kept in a template. Finally, the K-Nearest Neighbor with cosine similarity metric used as a matching method for matching between the database template and the testing samples. As a final matching result we got **94 %**.

Chapter 1

Introduction

Biometrics is the science of identifying a person using their physiological or behavioral features. Recently, vein pattern biometrics has attracted increasing interest from both research communities and industries. A vein pattern is the physical structure of the vast network of blood vessels underneath a person's skin [1]. Recently, a new biometric technology based on human palm vein patterns has attracted the attention of biometrics based identification research community. Compared with other traditional biometric characteristics (such as face, iris, fingerprint, etc.), palm vein exhibits some excellent advantages in application. For instance, apart from uniqueness, universality, permanence and measurability [2]. Palm vein hold the following merits [3]:

• The human palm vein pattern is extremely complex and it shows a huge number of vessels.

• The biometric information is located inside the human body, and therefore it is protected against

forgery and manipulation.

• The position of the palm vein vessels remains the same for the whole life and its pattern is absolutely unique.

• Skin color, skin dirtying, surface wounds, skin humidity, skin temperature, aging do not have major influence to enroll and to authenticate the palm vein pattern correctly.

The aim of this work is trying to find a method that gets highest results that is possible to implement this proposed method on other future work to create an authentication system based-on veins or maybe create an identification system used for many recognition applications.

Chapter 2

2.1 Biometrics

The need for reliable user authentication techniques has increased in the wake of heightened concerns about security and rapid advancements in networking, communications and mobility. Biometrics, described as the science of recognizing an individual based on his or her legitimate method for determining an individual's identity [4]. Biometric authentication or simply biometrics refers to establishing identity based on the physiological and behavioral characteristics shown in Figure 1.1 (also known as traits or identifiers) of an individual such as face,
fingerprints, hand geometry, iris, keystroke, signature, voice, etc. Biometrics systems offer several advantages over traditional authentications schemes. They are inherently more reliable than password – based authentication as biometric traits cannot be lost or forgotten; biometric traits are difficult to copy, share and distribute; and they require the person being authenticated
to be present at the time and point of authentication. Thus, a biometrics – based authentication scheme is a powerful alternative to traditional authentication schemes. A number of biometric characteristics have been in use for different applications [4, 5].

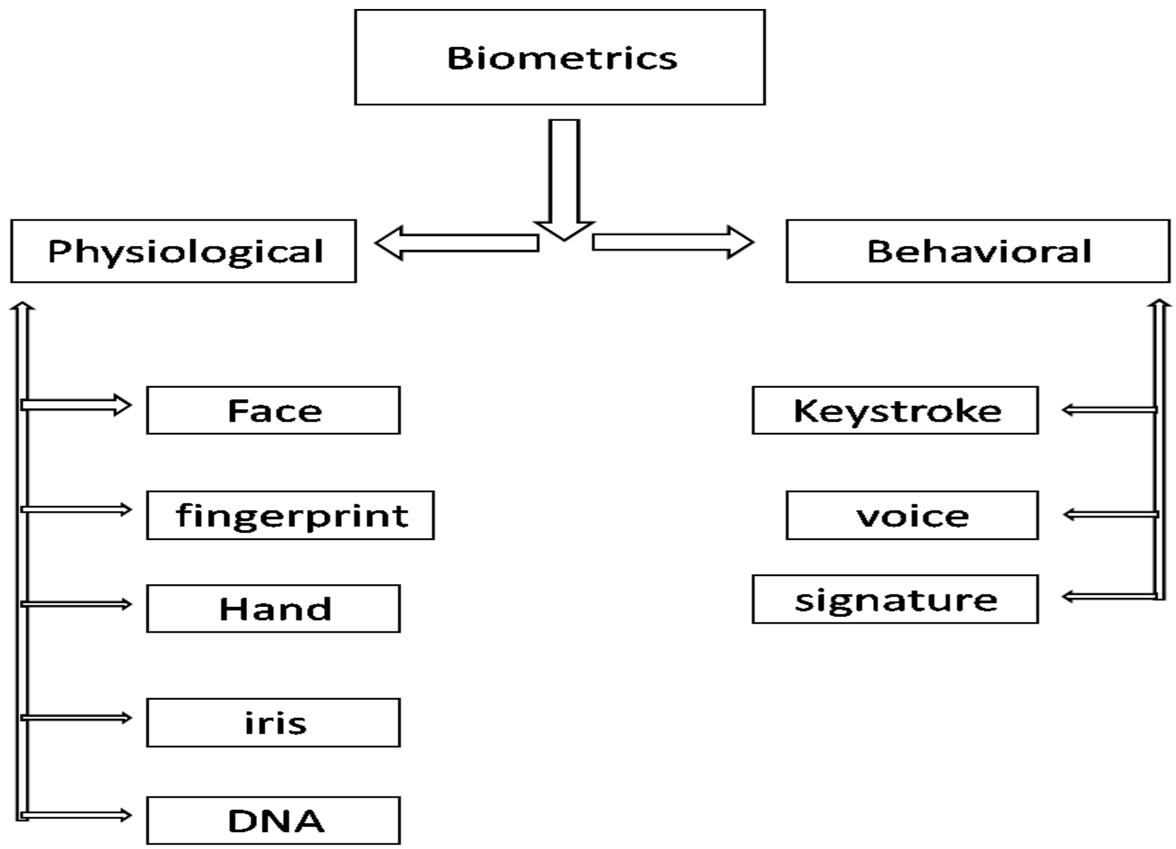

Figure 1: Classification of Biometric traits

Biometrics is the automated use of physiological or behavioral characteristics to determine or verify identity. Several aspects of this definition require elaboration. All biometric identifier scan be divided into two big groups:
1) Physiological.
2) Behavior.
Physiological or behavioral characteristics: Biometrics is based on the measurement of distinctive physiological and behavioral characteristics. Finger-scan, facial-scan, iris-scan, hand-scan, and retina-scan are considered physiological biometrics, based on direct measurements of a part of the human body. Voice-scan and signature-scan are considered behavioral biometrics; they are based on measurements and data derived from an action and therefore indirectly measure characteristics of the human body. The element of time is essential to behavioral biometrics-the characteristic being measured is tied to an action, such as a spoken or signed series of words, with a beginning and an end. The physiological/behavioral

classification is a useful way to view the types of biometric technologies, because certain performance- and privacy-related factors often differ between the two types of
biometrics. However, the behavioral/physiological distinction is slightly artificial. Behavioral biometrics is based in part on physiology, such as the shape of the vocal cords in voice-scan or the dexterity of hands and fingers in signature-scan. Physiological biometric technologies are
similarly informed by user behavior, such as the manner in which a user presents a finger or looks at a camera.

- Fingerprints scanning: - Today fingerprints consider being one of the oldest and popular among other bio-metric technologies. Fingerprint identification is also known as hand identification is the process of comparing two examples of friction ridge skin impression from human fingers, palm or toes.

- Face Recognition :- During the whole history of humanity, people used face to distinguish one person from the other. Facial (face) recognition is a computer application that automatically identifies or verifies a person with the help of a digital image or a video frame from a video source. One of the ways to do this is to compare the given example with the samples in the database.
- DNA: - Not long ago Russian show business was full of rumors that one of the popular Russian singers has two fathers and each father tried his best to influence on the son. Special programmers were created and the situation was discussed but only one thing was interested to public: who was the real father of the singer. The singer himself was confused. In one of the programs the singer and both of his father's decide to take DNA test.
- Hand Geometry: - Hand geometry is the use of geometric shape of the hand for recognition purposes. This method was rather popular 10 years ago but nowadays it is seldom used. The method is based on the fact that the shape of the hand of one person differs from the shape of the hand of another person and does not change after certain age. But it is not unique.
- Iris Recognition: - The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye. The iris is perforated close to its center by a circular aperture known as the pupil. The function of the iris is to control the amount of light entering through the pupil, and this is done by the sphincter and the dilator muscles, which adjust the size of the pupil [6]. Iris is the elastic, pigmented, connective tissue that surrounds the pupil of the

eye. Iris biometric is more reliable and accurate as compared to other biometric trait such as finger print. Iris texture is stable throughout life and is highly secure. Iris is less prone to attacks. Iris of the eye has different pattern for left and right eye. They are even unique for the identical twins. Iris is used for various authentication and security applications that include identity cards and passports, prison security, database access and computer login, border control and Government programmers [7]. Iris surface is divided into two in cooperative datasets, where as in non-cooperative major layers: papillary zones and the ciliary zone. Papillary dataset iris region is normally close to the corner of left zone is the inner part that forms boundary of the pupil. and right eye. To recognize the image, iris is divided in to An outer ciliary zone is the remaining part of the iris, and multiple regions and detection of single region can these are separated by the collarets – shows a pattern recognize a person. Color information is another important flower or zigzag [8]. Not to be confused with another, less prevalent, ocular-based technology, retina scanning and iris recognition uses camera technology with subtle infrared illumination to acquire images of the detail-rich, intricate structures of the iris. Digital templates encoded from these patterns by mathematical and statistical algorithms allow the identification of an individual or someone pretending to be that individual. Databases of enrolled templates are searched by matcher engines at speeds measured in the millions of templates per second per (single core) CPU, and with infinitesimally small False Match rates [9]. Iris Normalization is a Process in image processing that changes the range of pixel intensity values. Applications include photographs with poor contrast due to glare, for example. Normalization is sometimes called contrast stretching. In more general fields of data processing, such as digital signal processing, it is referred to as dynamic range expansion [9]. The purpose of dynamic range in the various applications is usually to bring the image, or other type of signal, into a range that is more familiar or normal to the senses, hence the term normalization. Often, the motivation is to achieve consistency in dynamic range for a set of data, signals, or images to avoid mental distraction or fatigue. Researchers have proposed different algorithm for iris detection. Processing iris image is a challenging task and that's for the iris region can be occluded by eye-lids or eye-lashes. This will cause a difference between intra and inter class comparisons. Therefore, we decided to isolate the effects of the eye-lid and the effects of the eye-lashes by using only the left and right part of the iris area for the iris recognition. Most of the method extracts the complete iris image, but we extract part of the iris image for the recognition **[10]**. Extraction is done by trimming the iris area above the upper boundary of the pupil and the area below the lower boundary of the pupil. Then we apply histogram equalization for enhance normalized iris image in order to compensate for the effect of image contrast and illumination. Usually good features must satisfy the following requirement. First, intra-class variance must be small, that means features derived from different samples of the same class should be closed. Second, the inter-class separation should be large [10].

- Voice recognition: - Voice, like many other characteristics that are used for biometric methods, is unique. Like style of gait, it takes quite little time to analyze the voice and to identify the person. Voice in biometrics or “voice print” is presented as a numerical model of the sound.
- Key stroke :- The keystroke is the behave of the human mean to say that the different humans have the different techniques of pressing keys on such basis the identification takes place.

- Signature scanning: - Another behavioral biometric is signature by which the data can be extract by the signature of that particular person.

Biometric system may operate either in verification mode or identification mode

a) verification mode

“Dose this biometric data belong to Bob?”

b) identification mode
“Whose biometric data is this”

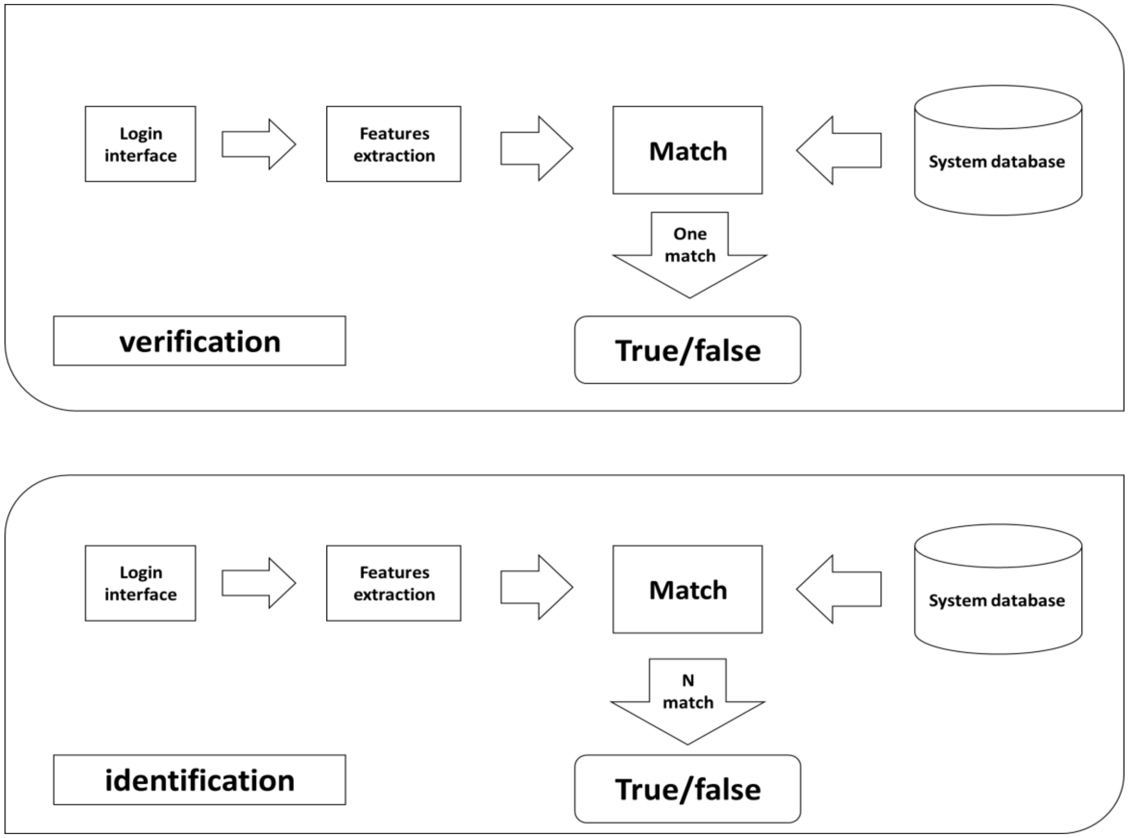

Figure 2: verification mode and identification mode.

2.2 Pattern recognition

Pattern recognition**[11]** is the scientific discipline whose goal is the classification of objects into a number of categories or classes. Depending on the application, these objects can be images or signal waveforms or any type of measurements that need to be classified. We will refer to these objects using the generic term patterns. Pattern recognition has a long history, but before the 1960s it was mostly the output of theoretical research in the area of statistics. As with everything else, the advent of computers increased the demand for practical applications of pattern recognition, which in turn set new demands for further theoretical developments. As our society evolves from the industrial to its postindustrial phase, automation in industrial production and the need for information handling and retrieval are becoming increasingly important. This trend has pushed pattern recognition to the high edge of today's engineering applications and research. Pattern recognition is an integral part in most machine intelligence systems built for decision making.

Machine vision is an area in which pattern recognition is of importance, A machine vision system captures images via a camera and analyzes them to produce descriptions of what is imaged. A typical application of a machine vision system is in the manufacturing industry, either for automated visual inspection or for automation in the assembly line. For example, in inspection, manufactured objects on a moving conveyor may pass the inspection station, where the camera
stands, and it has to be ascertained whether there is a defect. Thus, images have to be analyzed on line, and a pattern recognition system has to classify the objects into the "defect" or "non-defect"c1ass. After that, an action has to be taken, such as to reject the offending parts. In an assembly line, different objects must be located and "recognized," that is, classified in one of a number of classes known a priori. Examples are the "screwdriver class," the "German key class," and so forth in a tools' manufacturing unit. Then a robot arm can place the objects in the right place.
Character (letter or number) recognition is another important area of pattern recognition, with major implications in automation and information handling.
Optical character recognition (OCK) systems are already commercially available and more or less familiar to all of us. An OCR system has a "front end" device consisting of a light source, a scan lens, a document transport, and a detector.
At the output of the light-sensitive detector, light intensity variation is translated into "numbers" and an image array is formed. In the sequel, a series of image processing techniques are applied leading to line and character segmentation. The pattern recognition software then takes over to recognize the characters-that is, to classify each character in the correct "letter, number, punctuation" class. Storing the recognized document has a twofold advantage over storing its scanned image.
First, further electronic processing, if needed, is easy via a word processor, and second, it is much more efficient to store ASCII characters than a document image. Besides the printed character recognition systems, there is a great deal of interest invested in systems that recognize handwriting. A typical commercial application of such a system is in the machine reading of bank checks. The machine must be able to recognize the amounts in figures and digits and match them. Furthermore, it could check whether the payee corresponds to the account to be credited. Even if only half of the checks are manipulated correctly by such a machine, much labor can be saved from a tedious job. Another application is in automatic mail sorting machines for postal code identification in post offices. On-line handwriting recognition systems are another area of great commercial interest. Such systems will accompany pen computers, with which the entry of data will be done not via the keyboard but by writing. This complies with today's tendency to develop machines and computers with interfaces acquiring human-like skills. Computer-aided diagnosis is another important application of pattern recognition, aiming at assisting doctors in making diagnostic decisions. The final diagnosis is, of course,

made by the doctor. Computer-assisted diagnosis has been applied to and is of interest for a variety of medical data, such as X-rays, computed tomographic images, ultrasound images, electrocardiograms (ECGs), and electroencephalograms(EEGs). The need for a computer-aided diagnosis stems from the fact that medical data are often not easily interpretable, and the interpretation can depend very much on the skill of the doctor. Let us take for example X-ray mammography for the detection of breast cancer. Although mammography is currently the best method for detecting breast cancer, 10%-30% of women who have the disease and undergo mammography have negative mammograms. In approximately two thirds of these cases with false results the radiologist failed to detect the cancer, which was evident retrospectively. This may be due to poor image quality, eye fatigue of the radiologist, or the subtle nature of the findings. The percentage of correct classifications improve at a second reading by another radiologist. Thus, one can aim to develop a pattern recognition system in order to assist radiologists with a “second” opinion. Increasing confidence in the diagnosis based on mammograms would, in turn, decrease the number of patients with suspected breast cancer who have to undergo surgical breast biopsy, with its associated complications.

Speech recognition is another area in which a great deal of research and development effort has been invested. Speech is the most natural means by which humans

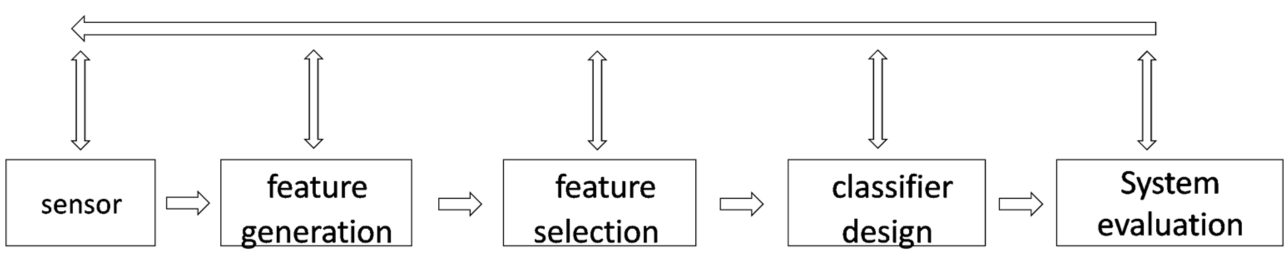

Figure 3: The basic stages involved in the design of a classification system.

2.3 Digital image processing

Digital image processing is a field that continues to grow, with new applications being developed at an ever increasing pace. It is a fascinating and exciting area to be involved in today with application areas ranging from the entertainment industry to the space program.

The Internet, with its ease of use via the World Wide Web browsers, combined with the advances in computer power and network bandwidth has brought the world into our offices and into our homes. One of the most interesting aspects of this information revolution is the ability to send and receive complex data that transcends ordinary written text.

Visual information, transmitted in the form of digital images, has become a major method of communication for the twenty-first century.

Digital image processing, also referred to as computer imaging, can be defined as the acquisition
and processing of visual information by computer. The importance of digital image processing is derived from the fact that our primary sense is our visual sense. Our vision system allows us to gather information without the need for physical interaction; it enables us to analyze all types of information directly from pictures or video. It provides us with the ability to navigate about our environment, and the human visual system is the most sophisticated, advanced neural system in the human body. Most of the scientific discoveries and advancements have relied on the visual system for their development—from the discovery of fire to the design of a cell phone.

The information that can be conveyed in images has been known throughout the centuries to be extraordinary—one picture is worth a thousand words. Fortunately, this is the case, because the computer representation of an image requires the equivalent of many thousands of words of data, and without a corresponding amount of information the medium would be prohibitively inefficient. The massive amount of data required for images is a primary reason for the development of many subareas within the field of computer imaging, such as image segmentation and image compression.

Another important aspect of computer imaging involves the ultimate “receiver” of the visual information—in some cases the human visual system, in others the computer itself. This distinction allows us to separate digital image processing into two primary application areas: (1) computer vision applications, and (2) human vision applications, with image analysis being a key component in the development and deployment of both (Figure 4). In computer vision applications the processed (output) images are for use by a computer, while in human vision applications the output images are for human consumption. The human visual system and the computer as a vision system have varying limitations and strengths, and the computer imaging specialist needs to be aware of the functionality of these two very different systems. The human vision system is limited to visible wavelengths of light,

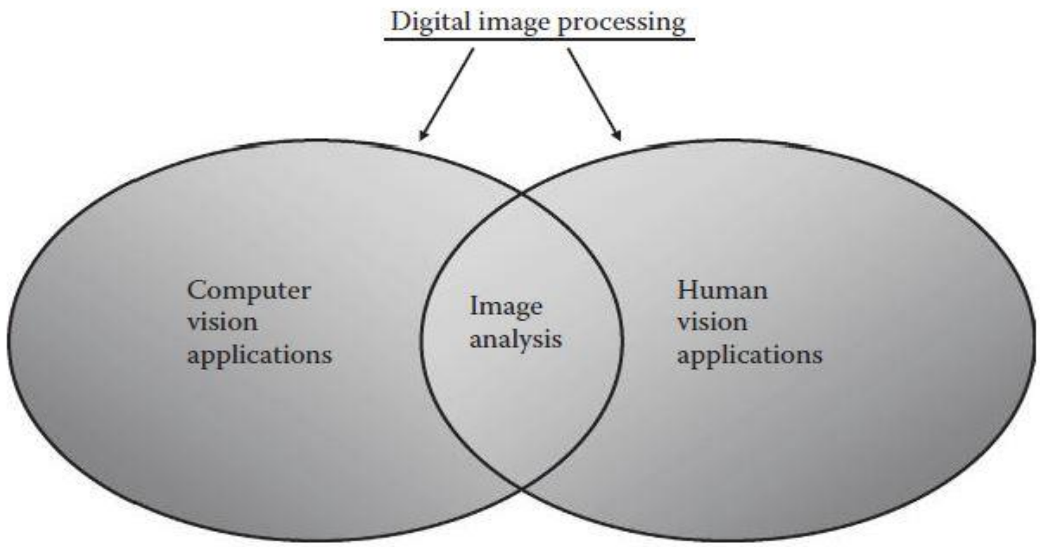

Figure 4: digital image processing.

2.3.1 Image Enhancement

Image enhancement [12] techniques are employed to emphasize, sharpen, and/or smooth image features for display and analysis. Image enhancement is the process of applying these techniques to facilitate the development of a solution to a computer imaging problem.

Consequently, the enhancement methods are application-specific and are often developed empirically. Figure 8.1-1 illustrates the importance of the application by the feedback loop from the output image back to the start of the enhancement process, and models the experimental nature of the development. In this figure we define the enhanced image as E (r, c). The range of applications includes using enhancement techniques as preprocessing steps to ease the next processing step or as post processing steps to improve the visual perception of a processed image, or image enhancement may be an end in itself. Enhancement methods operate in the spatial domain, manipulating the pixel data, or in the frequency domain, by modifying the spectral components.

Some enhancement algorithms use both the spatial and frequency domains. The type of techniques includes point operations, where each pixel is modified according to a particular equation that is not dependent on other pixel values, mask operations, where each pixel is modified according to the values in a small neighborhood (sub image), or global operations, where all the pixel values in the image are taken into consideration. Spatial domain processing methods include all three types, but frequency domain operations, by nature of the frequency (and sequence) transforms, are global operations. Of course, frequency domain operations can become “mask operations,” based only on a local neighborhood, by performing the transform on small image blocks instead of the entire image.

Enhancement is used as a preprocessing step in some computer vision applications to ease the vision task, for example, to enhance the edges of an object to facilitate guidance of a robotic gripper. Enhancement is also used as a preprocessing step in applications where human viewing of an image is required before further processing. For example, in one application, high-speed film images had to be correlated with a computer simulated model of an aircraft. This process was labor intensive because the high speed film generated many images per second and difficult due to the fact that the images were all dark. This task was made considerably easier by enhancing the images before correlating them to the model, enabling the technician to process many more images in one session.

2.3.2 Edge/Line Detection

The edge and line detection [12] operators presented here represent the various types of operators in use today. Many are implemented with convolution masks, and most are based on discrete approximations to differential operators. Differential operations measure the rate of change in a function, in this case, the image brightness function. A large change in image brightness over a short spatial distance indicates the presence of an edge.

Some edge detection operators return orientation information (information about the direction of the edge), while others only return information about the existence of an edge at each point.

2.4 **Feature Analysis and Pattern Classification**

Feature analysis and pattern classification [12] are often the final steps in the image analysis process. Feature analysis involves examining the features extracted from the images and determining if and how they can be used to solve the imaging problem under consideration.

In some cases, the extracted features may not solve the problem and the information gained by analyzing the features can be used to determine further analysis methods that may prove helpful, including additional features that may be needed. Pattern classification, often called pattern recognition, involves the classification of objects into categories.

For many imaging applications this classification needs to be done automatically, via computer. The patterns to be classified consist of the extracted feature information, which are associated with image objects and the classes or categories will be application dependent.

Feature extraction [12] is a process that begins with feature selection. The selected features will be the major factor that determines the complexity and success of the analysis and pattern classification process. Initially, the features are selected based on the application requirements and the developer's experience. After the features have been analyzed, with attention to the application, the developer may gain insight into the application's needs that will lead to another iteration of feature selection—extraction and analysis.

The overall process 1 will continue until an acceptable success rate is achieved for the application.

When selecting features for use in a computer imaging application, we want to consider the following desirable attributes. A good feature is

• Robust—It will have similar results under various conditions, such as lighting, cameras, lenses, and so on.
• Discriminating—It is useful for differentiation of classes (object types) of interest.
• Reliable—It provides consistent measurements for similar classes (objects).
• Independent—It is not correlated to other features.

For example, if we are developing a system to work under any lighting conditions, we do not want to use features that are lighting-dependent—they will not provide consistent results in the application domain and are not robust. If a feature has similar values for different objects, it is not a discriminating feature; we cannot use it to separate the different classes.

A feature that has different values for similar objects is not reliable. Features that are correlated have redundant information that may confuse the classifier and waste processing time.

A specific type of robustness, especially applicable to object features, is called RST invariance, where the RST means rotation, size, and translation. A very robust feature will be RST-invariant, meaning that if the image object is rotated, shrunk or enlarged, or translated (shifted left/right or up/down), the value for the feature will not change. As we explore the binary object features, consider the invariance of each feature to these simple geometric operations.

Chapter 3

3.1 Introduction about the project

In our system after acquiring the image and enhancing it with the Gaussian matching filter, a Gabor filter bank applied and then a set of features extracted for the results. In the training parts we used 400 images to create the template (database template), and 200 images used for testing, and finally a matching method applied to get the final results.

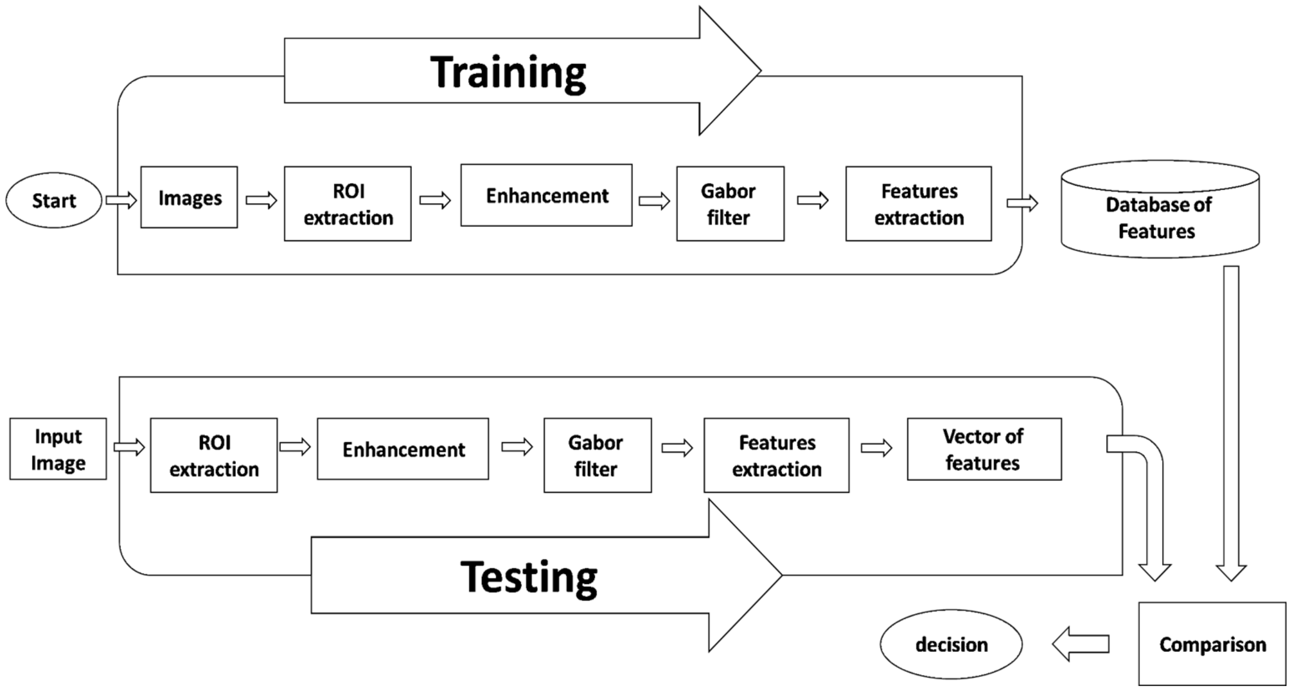

Figure 5: Flowchart of the project

3.2 ROI Algorithm

In this algorithm, we used the key points between the fingers to specify the middle part of the hand the problem was the rotation of the hand so we had to rotate each hand before extracting the region of interest to alien all regions for correct classification. The key points are the point in-between the pinky & ring finger, and the point in-between the index & middle finger. After rotation of the hand, we track the centroid of the palm then we acquire the region of interest

Input: row image

Output: ROI (Central part of the image)

- Step1. Apply: smoothing low-pass filter.
- Step 2. Binarize the image.
- Step 3. Extract: biggest object.
- Step 4. Obtain: boundary & center point coordinates.
- Step 5. Compute: distances between the center point and the boundaries.
- Step 6. Obtain the minima peaks.
- Step 7. Find the key-points.
- Step 8. Rotate the image.
- Step 9. Extract the Region of Interest(ROI).

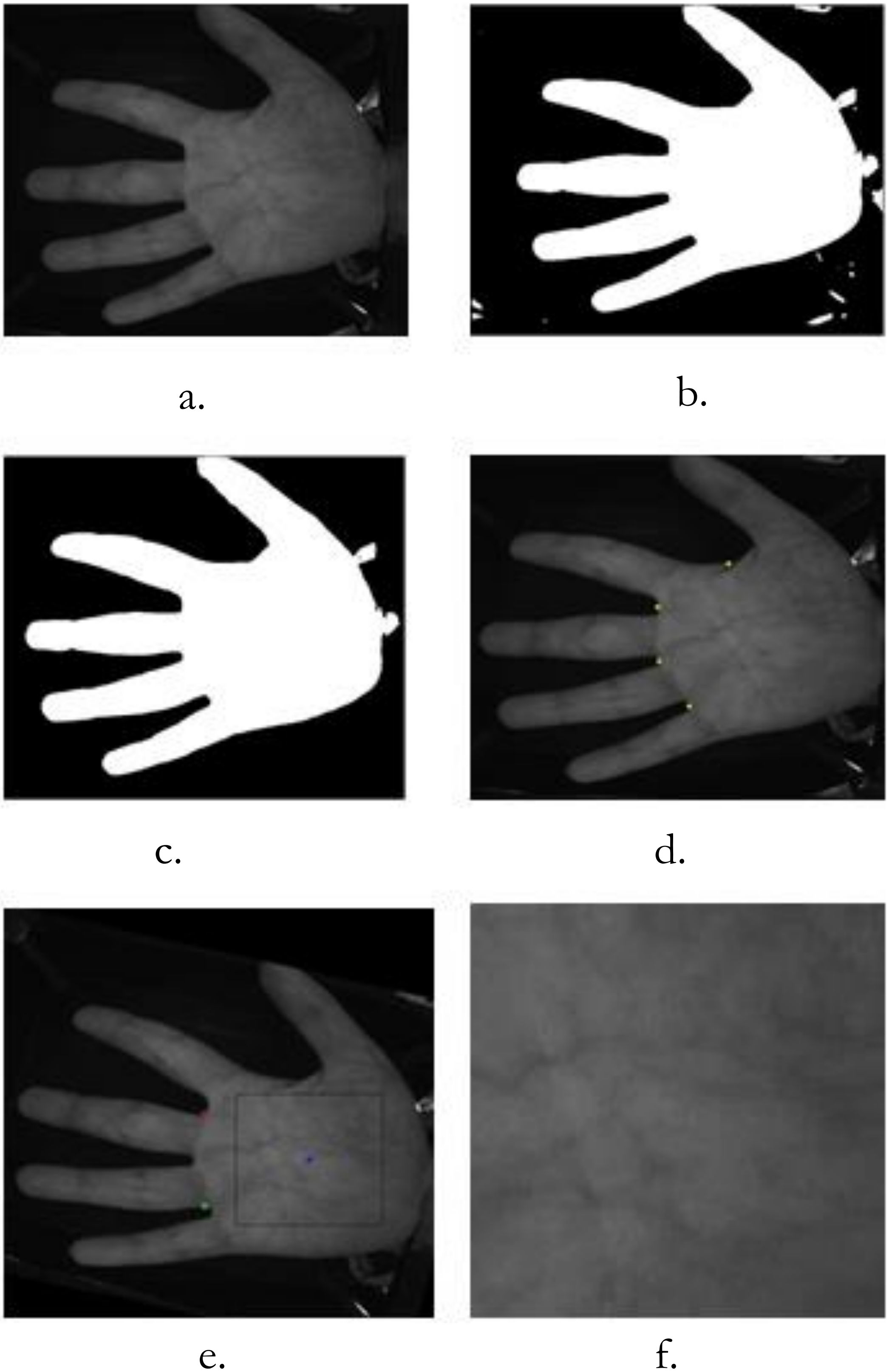

Figure 6. a. original image. b. binarized image. c. biggest object. d. minima peaks. e. normalized & rotated. f. ROI

3.3 Enhancement

The Gaussian **[13]** function shape is similar to the cross-sections of the palm vein. The Gaussian matched filters are widely used in retinal vessel extraction, due to that it can be a good technique to extract these palm veins. The Gaussian matched filters are Gaussian shaped filters along an angle:

$$\mathbf{g}_{\theta}^{\sigma}(\mathbf{x},\mathbf{y}) = -\,\mathbf{exp}\left(\frac{\mathbf{x}'^{2}}{\sigma^{2}}\right) - \mathbf{m} \quad \text{for } |\mathbf{x}'| \leq 3\sigma, |\mathbf{y}'| \leq \mathbf{L} / 2 \qquad \textbf{(1)}$$

Where $\mathbf{x}' = \mathbf{x}\cos\theta + \mathbf{y}\sin\theta$, $\mathbf{y}' = -\mathbf{x}\sin\theta + \mathbf{y}\cos\theta$, the standard deviation of Gaussian, m is the mean value of the filter, and L is the length of the filter in y-direction, which is set empirically. The filter is designed as a zero-sum to repress the background pixels. For each pixel, six different angle filters (j = j/6, where j = {0, 1, 2, 3, 4, 5}) are applied, and the maximal response among these six directions is kept as the final response for the given scale

$$\mathbf{R}_{\mathbf{F}}^{\sigma} = \mathbf{max}\left(\mathbf{R}_{\theta \mathbf{j}}^{\sigma}(\mathbf{x},\mathbf{y})\right) \qquad (2)$$

$$\mathbf{R}_{\theta \mathbf{j}}^{\sigma}(\mathbf{x},\mathbf{y}) = \mathbf{g}_{\theta \mathbf{j}}^{\sigma}(\mathbf{x},\mathbf{y}) * \mathbf{f}(\mathbf{x},\mathbf{y}) \qquad (3)$$

Where the original image and * denotes the convolution operation. The value of σ and L is set by experimental as shown in Figure 7 the result of palm vein enhancement.

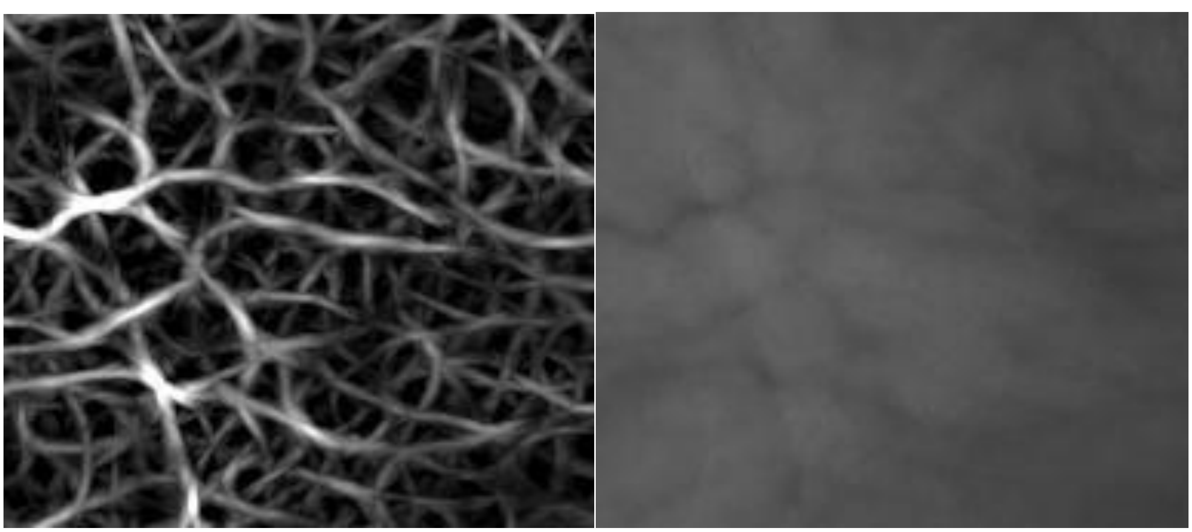

Figure 7: Palm Vein Enhancement

Gaussian algorithm

Input: normalized ROI.

Output: enhanced image.

- Step 1. Initializing all the variables.
- Step 2. Compute all the angles.
- Step 3. Compute $\mathbf{x'}, \mathbf{y'}$.
- Step 4. Generate the Gaussian filters.
- Step 5. Apply the filters on the image.
- Step 6. Obtain the enhanced image based-on the maximum response.

3.4 Gabor filter

The feature extraction is implement using Gabor filter. Gabor filter [14] is a band pass filter which have orientation-selective and frequency-selective features and optimal joint resolution in both spatial and frequency domains. Gabor filters have been extensively used for extracting texture information, that they were powerful in capturing some specific local features in the texture image. A two-dimensional Gabor filter is a combine function with two components: a complex plane wave and a Gaussian-shaped function. It is defined as following:

$$\mathbf{G(x,y) = k\,exp\left[-\frac{1}{2}\left(\frac{x_0^2}{\sigma_x^2}+\frac{y_0^2}{\sigma_y^2}\right)+j_{2\pi f_0}X_0\right]} \quad (4)$$

$$\mathbf{x_0 = x\cos\emptyset + y\sin\emptyset} \quad (5)$$

$$\mathbf{y_0 = -x\cos\emptyset + y\sin\emptyset} \quad (6)$$

Where $\mathbf{k = 1\,/\,(2\pi\sigma_x\sigma_y)}$, $\mathbf{j = \sqrt{-1}, \theta}$ is the orientation of Gabor filter, $\mathbf{f_0}$ represent the filter center frequency, $\mathbf{\sigma_x}$ **and** $\mathbf{\sigma_y}$ are the scale of the Gaussian shape, $\mathbf{x_0}$ **and** $\mathbf{y_0}$ are the two vertical Gaussian axes. The most important parameters $\mathbf{f_0}$, $\mathbf{\sigma_x}$ and $\mathbf{\sigma_y}$ in Gabor function that make the filter appropriate for some specific application. The Gabor filter can be split to imaginary part and real part. The imaginary part (odd symmetric) Gabor filter is used for edge detection. The real part (even symmetric) Gabor filter is used for detecting the ridge in the image. To analysis the Gabor filter in terms of real part and imaginary part, can be represented as following:

$$\mathbf{G_{mk}^{0}(x,y) = k\,exp\left\{-\frac{1}{2}\left(\frac{x_0^2}{\sigma_x^2}+\frac{y_0^2}{\sigma_y^2}\right)cos(2\pi f_{mk}x_{ok})\right\}} \quad (7)$$

$$\mathbf{G_{mk}^{0}(x,y) = k\,exp}\left\{-\frac{1}{2}\left(\frac{x_0^2}{\sigma_x^2}+\frac{y_0^2}{\sigma_y^2}\right)\sin(2\pi f_{mk}x_{ok})\right\} \quad (8)$$

where m is the scale index, k is the channel index and f_{mk} is represent the center frequency of the real part and imaginary part of Gabor filter at the k^{th} channel. After create a bank of Gabor filter, the enhanced palm image is convolved with the Gabor filter bank. The best output to the Gabor filter is depend on its parameters ($f_0\sigma_x\sigma_y$ and $\emptyset$)).In the propose method,π is begin from 0 to π by increment is equal to π / 8 and the center Frequency f_{mk} is change with the orientation. In [78] propose a method to determine the relation between σ and f_{mk} and we used it in the research which is defined as following

$$\sigma f_{mk} = \frac{1}{\pi}\sqrt{\frac{\ln 2}{2}\frac{2^{\Delta\emptyset mk}}{2^{\Delta\emptyset m_k}}\frac{+1}{-1}} \quad (9)$$

where $\Delta\emptyset mk(t[0.5,2.5])$ is represent the spatial frequency bandwidth to the Gabor filter in the

k^{th} channel and m scale. $\Delta\emptyset$ are put as

$\Delta\emptyset 1 > \Delta\emptyset 5 > \Delta\emptyset 2 > \Delta\emptyset 3 > \Delta\emptyset 4$, $\Delta\emptyset 2$
$= \Delta\emptyset 8$, $\Delta\emptyset 3 = \Delta\emptyset 7$, $\Delta\emptyset 4 = \Delta\emptyset 6$.

In the propose method we built a bank of Gabor filter with 2 channels and 8 orientations and the central frequency is change depending on

$$\sigma f_{mk} = \frac{1}{\pi}\sqrt{\frac{\ln 2}{2}\frac{2^{\Delta\emptyset mk}}{2^{\Delta\emptyset m_k}}\frac{+1}{-1}} \quad (10)$$

. Figure 8 shows some sample of the bank of Gabor filter. Assume that I(x, y) denote a palm-vein image, F(x, y) denotes a filtered I(x, y), we can obtain

$$F(x,y) = \sqrt{\left(G_{mk}^{0}(x,y) * I(x,y)\right)^2 + \left(G_{mk}^{0}(x,1) * I(x,y)\right)^2} \quad (11)$$

where * denotes convolution in two dimensions. Thus, for a palm-vein image, 16 filtered images are generated by a bank of Gabor filters.

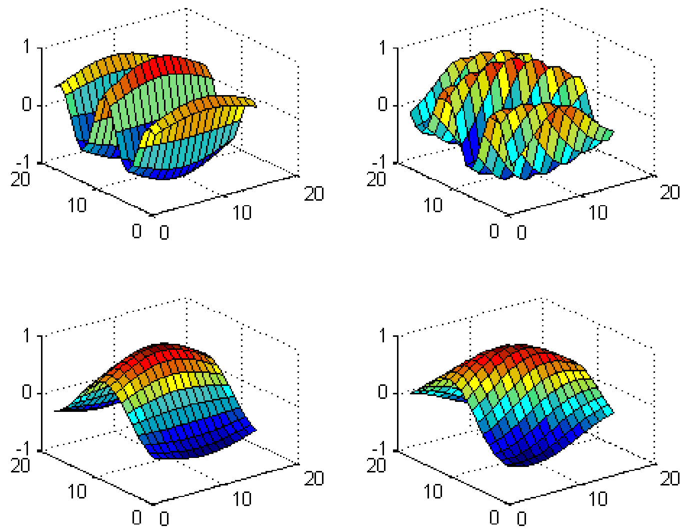

Figure 8: A bank of Gabor filter

After creating the filter bank, the convolution operation is performed with the enhanced image in figure 7 with all the Gabor filters. The some sample of the results are shown in figure 9.

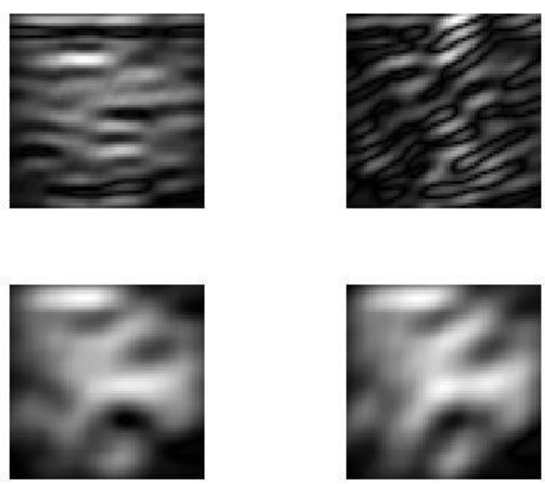

Figure 9: The output of convolution operation

Gabor filter algorithm

Input: enhanced image.

Output: 16 convoluted images.

- Step 1. Initialize variables,
- Step 2. Compute the central frequency
- Step 3. Generate the filter bank
- Step 4. Convolute the image with the filter bank.
- Step 5. Cut each image into 36 parts.
- Step 6. Store the output.

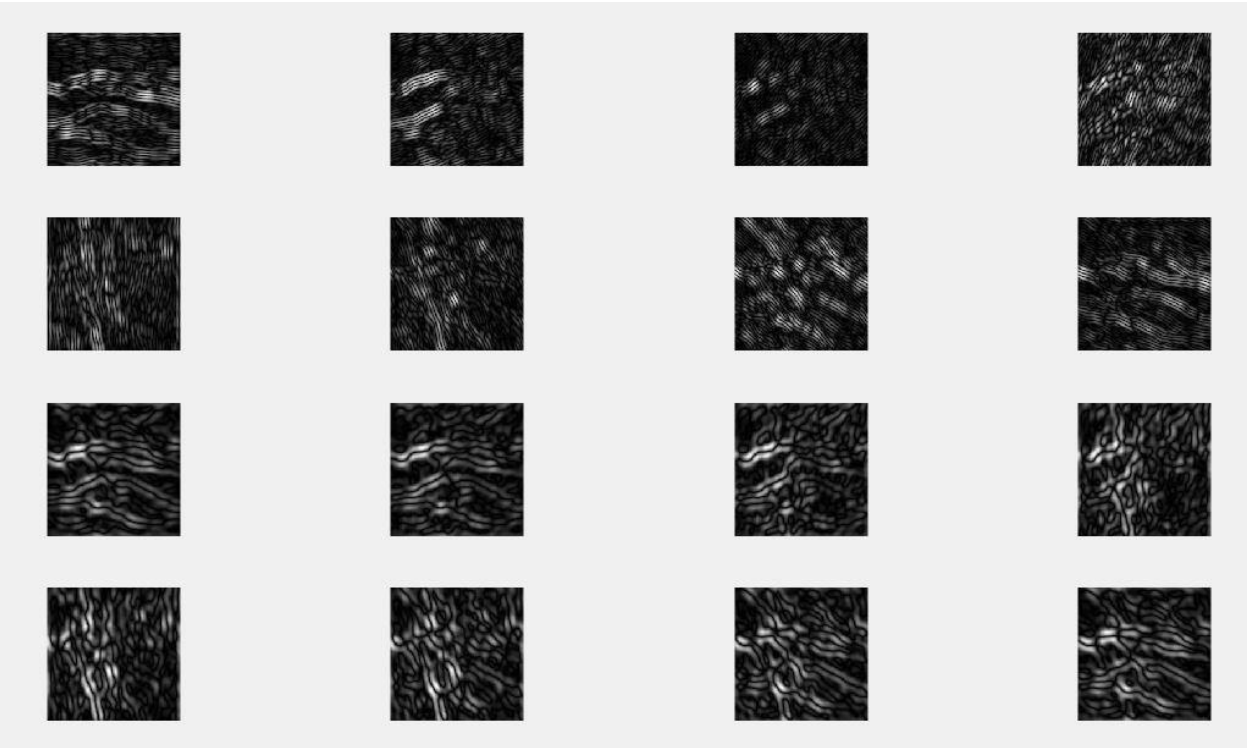

Figure 10: Gabor convoluted images.

3.5 Features Extraction

In the proposed method, before feature extraction, after convoluting the images with Gabor filters we cropped each convoluted image into **n** by **n** pieces and computing the standard deviation, the SKEW, the moment, and the energy as features for each cropped piece

1. standard deviation: (σ) is standard deviation ,(g) is Color levels for image ,($\bar{g}$) mean and p(g) is Probability Color levels for image.

$$\sigma_g = \sqrt{\sum_{g=0}^{L-1} (g - \bar{g})^2 P(g)} \qquad (12)$$

SKEW: (σ) is standard deviation ,(g) is Color levels for image ,

($\bar{g}$) mean and p(g) is Probability Color levels for image.

$$SKEW = \frac{1}{\sigma_g^3} \sum_{g=0}^{L-1} (g - \bar{g})^3 P(g) \qquad (13)$$

2. Energy: p(g) is Probability Color levels for image.

$$ENERGY = \sum_{g=0}^{L-1} [P(g)]^2 \qquad (14)$$

3. moment:
   m_{pq} *is moment* , r^p *is number row of image ana p is Positive value* $p = \{1,2,3,4,\ldots\}$, c^q *is number colom of image ana p is Positive value* $q = \{1,2,3,4,\ldots\}$, $I(r,c)$ *is value of each pPixels*

$$m_{pq} = \sum_r \sum_c r^p c^q I(r,c) \qquad (15)$$

Features algorithm

Input: image.

Output: feature template.

- Step 1. compute the standard deviation.
- Step 2. compute the SKEW.
- Step 3. Compute the moment.
- Step 4. Compute the energy.
- Step 5. Store the resulting vectors a template.

3.6 Matching

It is a classification method used to classify an object into which class it belongs based-on some distance metric specified for each method used. However, there are several distance metrics can be used such as "cityblock, chebychev, correlation, cosine, Euclidean, hamming", etc…

It is often useful to take more than one neighbor into account so the technique is more commonly referred to as k-Nearest Neighbor (k-NN) Classification where k nearest neighbors are used in determining the class. Since the training examples are needed at run-time, i.e. they need to be in memory at run-time, it is sometimes also called Memory-Based Classification **[17]**

This approach to classification is of particular importance today because issues of poor run-time performance is not such a problem these days with the computational power that is available.

In the proposed method we used the cosine metric to determine the distance between the object and all the neighbors in the classification space based-on the set of features generated for all the input to the classifier.

So k−NN classification has two stages:

• First is the determination of the nearest neighbors.

• Second the determination of the class using those neighbors.

Let us assume that we have a training dataset D made up of $(x_i)_{i \in [1,|D|]}$ training samples. The examples are described by a set of features. Each training example is labeled with a class label $y_j \in Y$. Our objective is to classify an unknown example q. For each $x_i \in D$ we can calculate the distance between q and x_i as follows:

The distance metric used is the cosine metric

$$Cosdis \quad (A,B) = \frac{\sum_{i=1}^{n} |Ai| * |Bi|}{\sum_{i=1}^{n} \sqrt{Ai^2} * \sum_{i=1}^{n} \sqrt{Bi^2}} \qquad (16)$$

$$\text{Angular distance} = \frac{\cos^{-1}(\, Cosdis(\text{A,B})\,)}{\pi} \qquad (17)$$

$$\text{Angular similarity} = 1 - \text{Angular distance} \qquad (18)$$

Matching algorithm:

Inputs : training template, testing feature vectors.

Output : matching ratio.

- Step 1. Create labels – training label, testing label.
- Step 2. Create the K-nearest neighbor model
    - Input : training template, training label, cosine metric
    - Output : classification model
    - M1 <- classification model
- Step 3. Classify the objects using the predict method
    - Input: M1, testing feature vectors
    - Output : classification label
    - N1 <- classification label
- Step 4. Compare the N1 and testing label
- Step 5. Compute the matching ratio
- Step 6. Display the result.

Chapter 4

4.1 Introduction

In biometrics research, [15] [16] combing multiple imaging modalities has been proven to be a promising way to enhance performances of recognition. According to electromagnetic theory, hertzian waves ranging from visible light spectrum to near infrared provide increasing stronger penetrability into objects. For hand biometrics, multi-spectrum illuminator can penetrate subcutaneous tissues at different depths in palm regions and form images of both surface skin textures and hypodemia (including palm veins). Based on this property, we design a multi-spectrum imaging device to capture correlative and complementary information of human hands.

CASIA Multi-Spectral Palm-print Image Database V1.0 (or CASIA-MS-PalmprintV1 for short) is released in order to promote research and progress on multiple spectral imaging of biometric modalities.

Brief Descriptions of the Database

CASIA Multi-Spectral Palm-print Image Database contains 7,200 palm images captured from 100 different people using a self-designed multiple spectral imaging device, as shown in Figure 11(a). All palm images are 8-bit gray-level JPEG files. For each hand, we 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 contain six palm images which are captured at the same time with six different electromagnetic spectrums. Wave-lengths of the illuminator corresponding to the six spectrum are 460nm,630nm,700nm,850nm,940nm and white light respectively. Between two samples, we allow a certain degree of variations of hand postures. Through that, we aim to increase diversity of intra-class samples and simulate practical use. In our 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. We design a control circuit to adjust spectrums automatically. Six typical palm-print images in the database are shown in Figure 11(b).

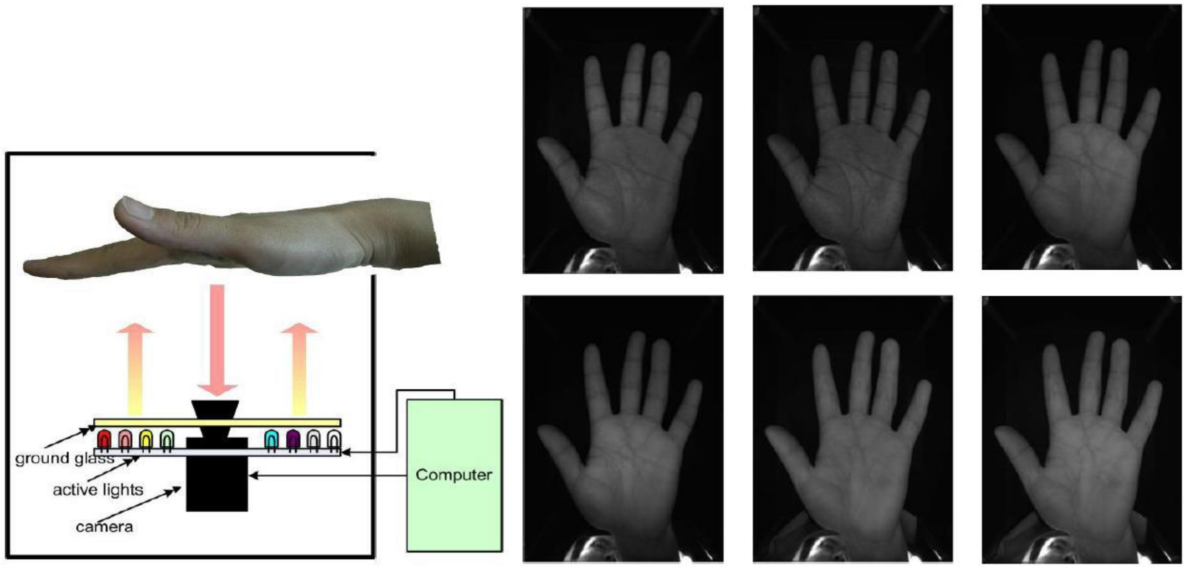

Figure 11(a) Our self-developed multi-spectral imaging device,

Figure 11(b) Six typical palm_print images in the database.

4.2 Test & Result

After extracting the ROI, and enhancing the ROI extracting result with Gaussian matching filters, and after applying the Gabor filter bank, cropped each image (resulted from the Gabor convolution) into several pieces, therefore more pieces more extracted features.

At first we cropped the image into 4 pieces and the experimental results as follows:

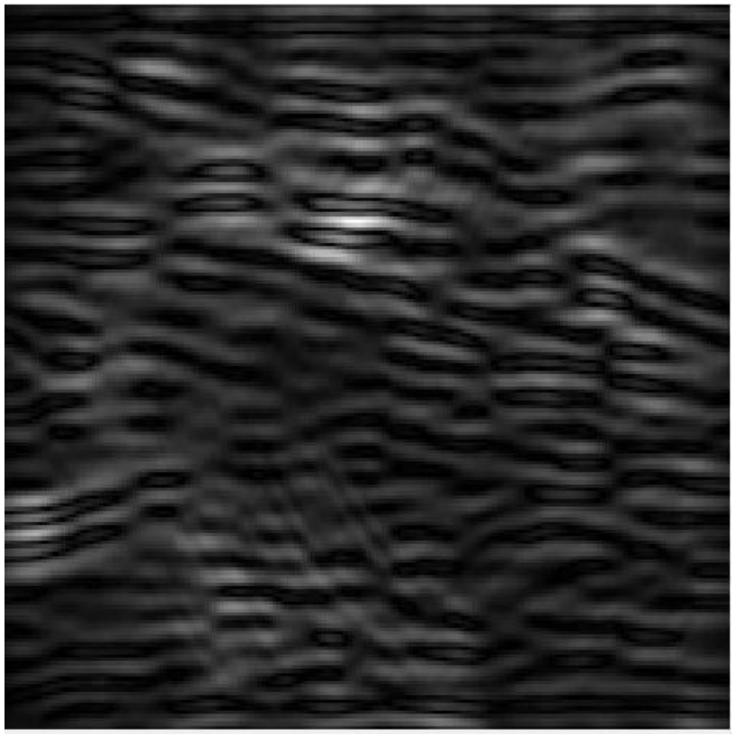

Figure 12 a. original image

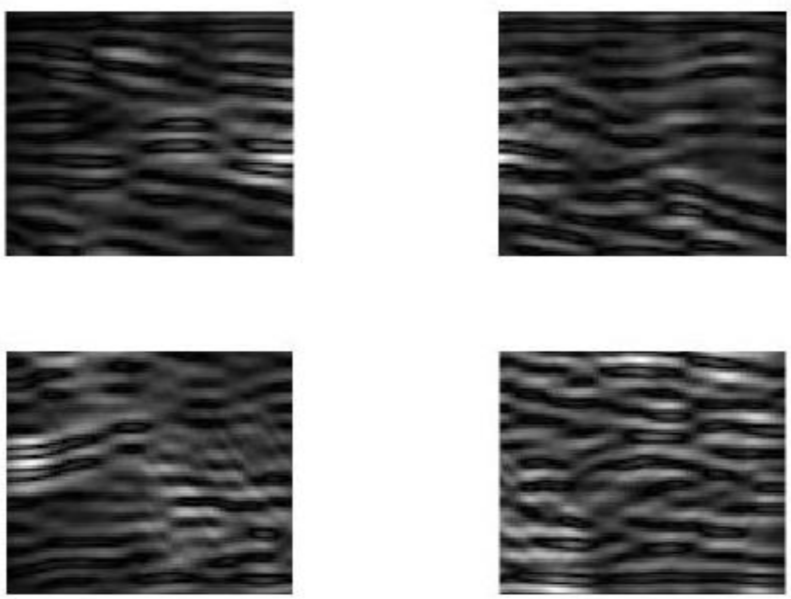

Figure 12 b. 4 parts.

ID	Num of part	GB x	GB y	Enhance L1	Enhance sigma 1	Percentage Match
1	4	9	7	20	1.8	38.5 %
2	**4**	**8**	**6**	**19**	**1.9**	**52 %**
3	4	8	6	16	2.2	51 %
4	4	9	7	20	1.8	38.5 %
5	4	11	9	20	1.8	37.5 %
6	4	8	6	20	1.8	43 %

Table (1) Results of 4 parts

16 pieces and the experimental results as follows:

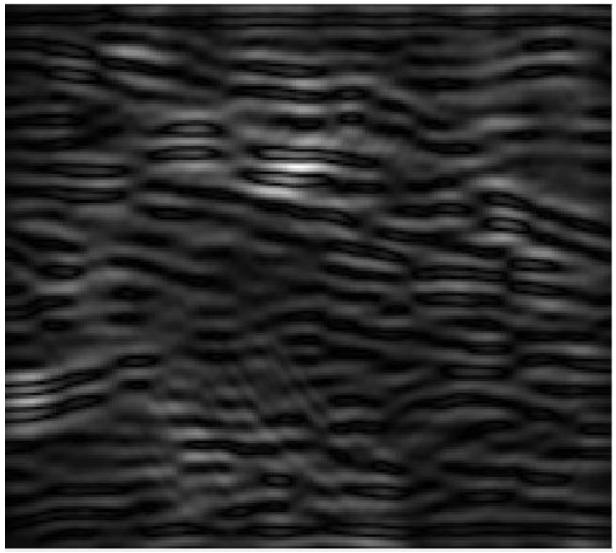

Figure 13 a. original image

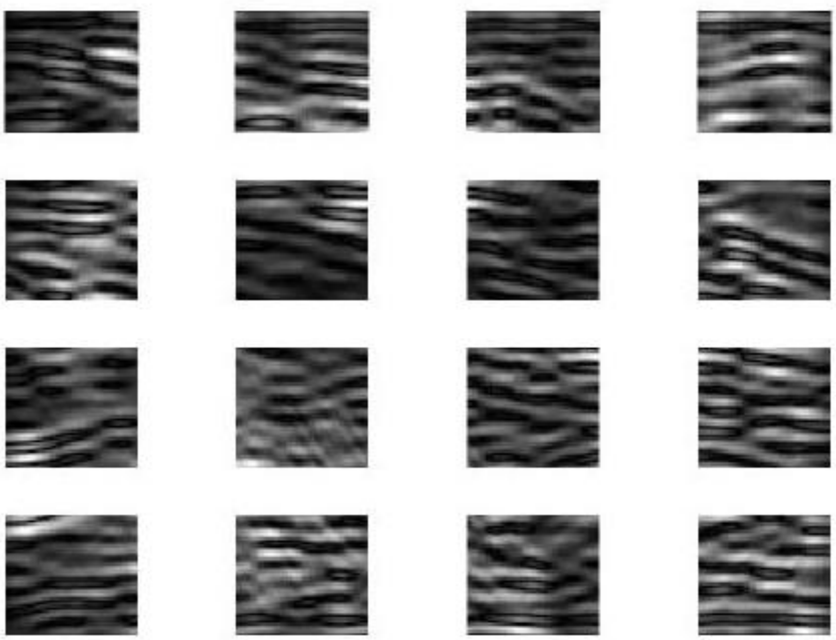

Figure 13 b. 16 parts.

ID	Num of part	GB x	GB y	Enhance L1	Enhance sigma 1	Percentage match
1	16	8	6	16	2.2	80 %
2	16	8	6	17	2.1	78.5 %
3	**16**	**8**	**6**	**18**	**2.0**	**82 %**
4	16	9	7	20	1.8	74.5 %
5	16	7	5	20	1.8	75.5 %
6	16	8	6	20	1.8	76.5 %

Table (2) Results of 16 parts

36 pieces and the experimental results as follows:

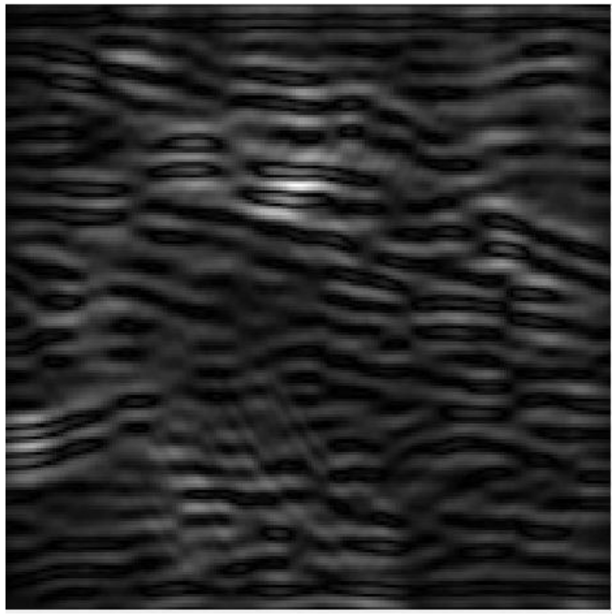

Figure 14 a. original image

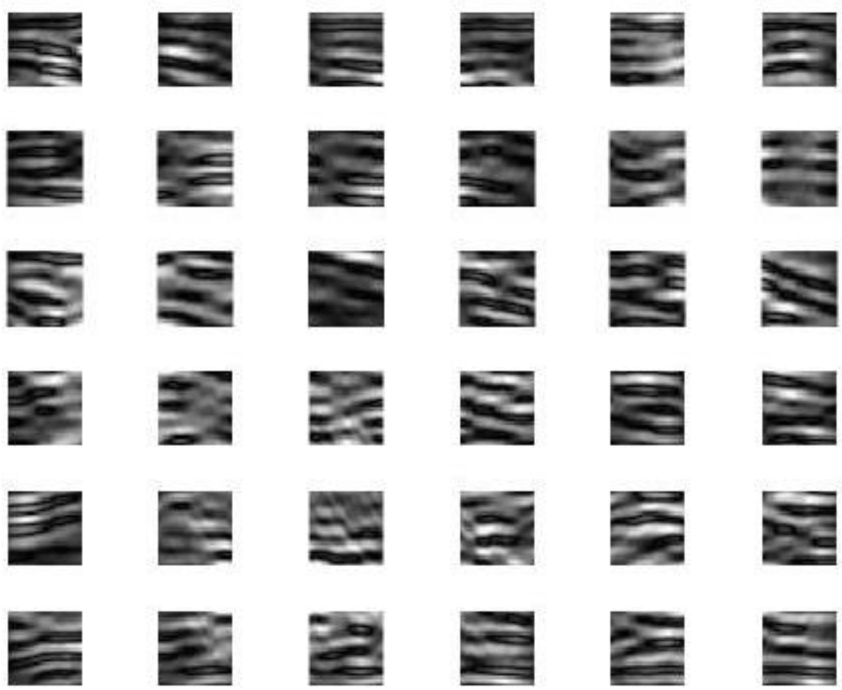

Figure 14 b. 36 parts.

ID	Num of part	GB x	GB y	Enhance L1	Enhance sigma 1	Percentage match
1	36	9	7	20	1.8	85.5 %
2	36	8	6	17	1.7	89.5 %
3	36	8	6	19	1.8	87 %
4	36	8	6	18	1.6	88.5 %
5	36	9	6	20	1.7	90 %
6	**36**	**9**	**8**	**19**	**1.9**	**94 %**

Table (3) Results of 36 parts

64 pieces and the experimental results as follows:

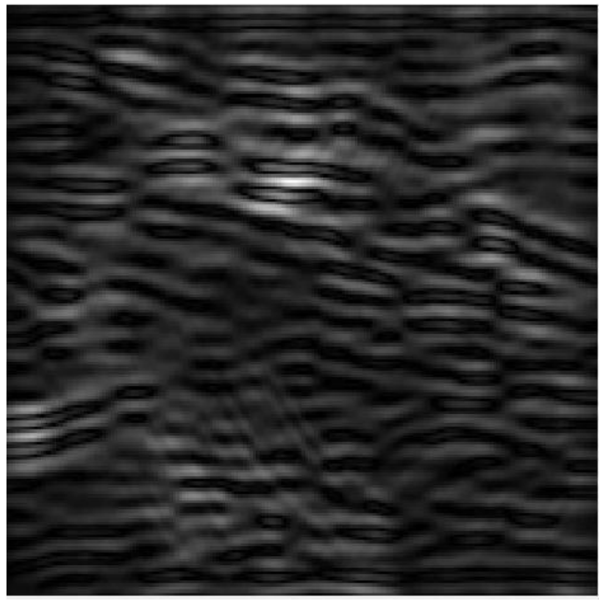

Figure 15 a. original image.

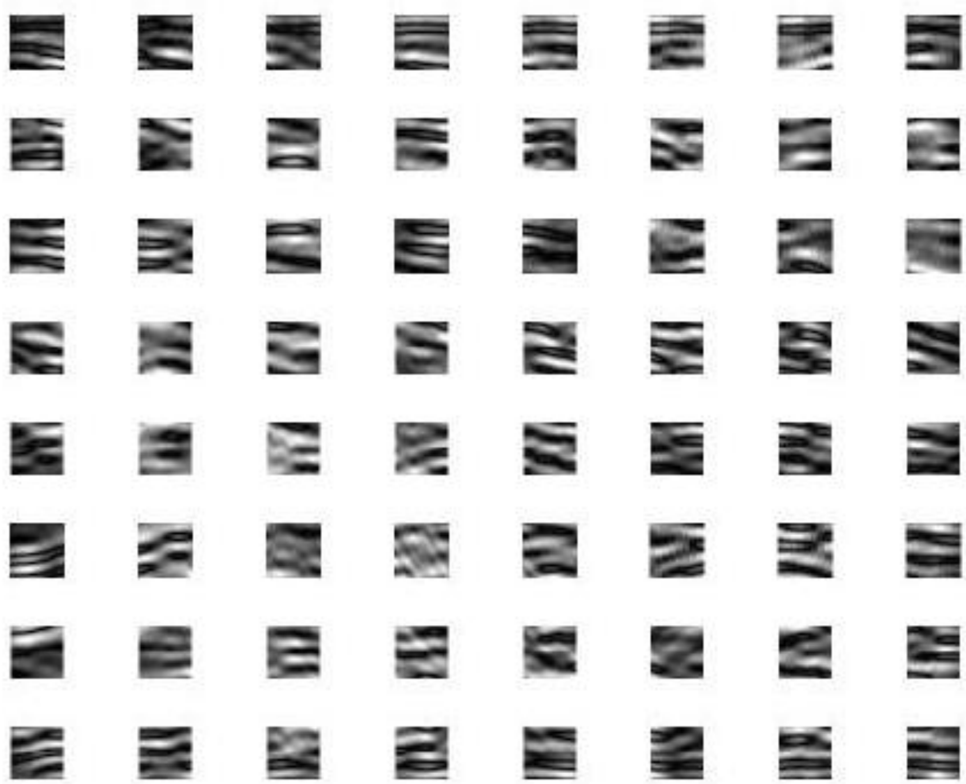

Figure 15 b. 64 parts

ID	Num of part	GB x	GB y	Enhance L1	Enhance sigma 1	Percentage match
1	**64**	**9**	**8**	**19**	**1.9**	**90.5 %**
2	64	9	7	20	1.8	89.5 %
3	64	9	7	18	1.4	88 %
4	64	9	7	22	2.2	89 %
5	64	8	6	20	1.8	88.5 %
6	64	8	6	16	1.2	83.5 %

Table (4) Results of 64 parts

Chapter 5

Conclusion and future work:

Palm Vein authentication uses features of the veins, which are inside the palm. The palm vein patterns like other biometric patterns are unique. In addition, palm vein patterns are virtually impossible to replicate because they are inside the body. Using the palm vein is extremely robust, demonstrating a unique ability to easily cope with sweaty, dry palm.

After acquiring the hand image and extracting the ROI, the ROI is enhanced using a Gaussian matching filter. Then a bank of Gabor filter is created and convolution on the enhanced images, then we extract features for the result of Gabor algorithm.

We faced several constrains, such as, the long-time of execution, this problem is the result of slow hardware (better hardware requirements will result in a faster execution), another constrain was the used database, we propose to use database with less noise images.

As a future work we intend to: use a better hardware, a new database, more features, and try to implement dimension reduction for the feature vectors of each acquired image.

REFERENCES

[1] L. Wang, G. Leedham and S.-Y. Cho, “Infrared imaging of hand vein patterns for biometric purposes”, IET Comput. Vis., Vol 1, pp. 113-122, 2007.

[2] Jinfeng Yang, Yihua Shi, Jinli Yang, “Person identification based on finger-vein features”, Computers in Human Behavior, Vol. 27, pp. 1565–1570, 2011.

[3] Hao Luo, Fa-Xin Yu, Jeng-Shyang Pan, Shu-Chuan Chu, Pei-Wei Tsai,”A survey of Vein Recognition Techniques”, Information Technology Journal, Vol. 9, pp.1124-1149, 2010.

[4].Anil K. Jain, Arun Ross, and Sharath Pankanti, “Biometrics: A Tool for Information Security”, IEEE Transactions on Information Forensics and Security, vol. 1, no. 2, pp 21-38, June 2005.

[5].Anil. K.Jain, Arun Ross, Salil Prabhakar, “An introduction to biometric recognition”, IEEE Transactions on circuits andsystems for video technology, vol. 14, no. 1,pp 67-80, Jan 2004.

[6]. Essam-Eldean F. Elfakhrany, Ben Bella S. Tawfik, “IRIS Recognition using Conventional Approach” IEEE 9th International Colloquium on Signal Processing and its Applications, 8 - 10 Mac,2013.

[7]. Geetika, Manavjeet Kaur “ Fuzzy Vault with Iris and Retina: A Review” International Journal of Advanced Research in Computer Science and Software Engineering , Volume 3, Issue 4,
April 2013.

[8]. Asima Akber Abbasi, M.N.A. Khan and Sajid Ali Khan “A Critical Survey of Iris Based Recognition Systems” Middle-East Journal of Scientific Research 15 (5): 663-668, 2013.

[9].D R Prithvi, R Madhu “Recognition Using Secret Key in Iris Feature Extraction and Palm Print Features” Proceedings of AECE-IRAJ International Conference, Tirupati, India, ISBN: 978-81-927147-9-0, 14th July 2013.

[10]. Savita Borole, Prof. S. D. Sapkal “Extraction of Dual Tree Complex Wavelet Feature for IRIS Recognition” International Journal of Advanced Research in Computer and Communication
Engineering Volume 2, Issue 7, July 2013.

[11] Sergious Theodoridis, Konstantinos Koutroumbas “Pattern Recognition second edition” Elsevier (USA). 2003.

[12] SCOTT E UMBAUGH “DIGITAL IMAGE PROCESSING AND ANALYSIS second edition” Taylor & Francis Group, LLC, 2010

[13] 77.Ali Mohsin Al-juboori, Wei Bu Xiangqian Wu, and Qiushi Zhao, “Palm Vein Verification Using Multiple Features and Isometric Projection”, International Journal of Signal Processing, Image Processing and Pattern Recognition Vol.7, No.1 (2014), pp.33-44

[14] Ali Mohsin Al-juboori, Wei Bu, Xiangqian Wu, and Qiushi Zhao, “Palm Vein Verification Using Gabor Filter” IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 1, No 1, January 2013

[15] Ying Hao Zhenan Sun,Tieniu Tan and Chao Ren, "Multi-spectral palm image fusion for accurate contact-free palmprint recognition", Proceedings of IEEE International Conference on Image Processing, 2008, pp.281-284, USA.

[16] Ying Hao,Zhenan Sun,Tieniu Tan, "Comparative Studies on Multispectral Palm Image Fusion for Biometrics", Proceedings of Asian Conferernce on Computer Vision 2007, vol.2, pp.12-21,Tokyo,Japan.
[17] K-Nearest Neighbor Classifiers " P´adraig Cunningham and Sarah Jane Delany" University College Dublin Padraig.Cunningham@ucd.ie Dublin Institute of Technology Sarahjane.Delany@comp.dit.ie Technical Report UCD-CSI-2007-4 March 27, 2007