Improved Palm print recognition

A Dissertation submitted towards the partial fulfilment
of the requirement for the award of degree of

Master of Technology
in
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Submitted by

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2K14/SPD/02

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CERTIFICATE

This is to certify that the dissertation title "**Improved palm print recognition** " submitted by **Mr. Amit Gupta, Roll. No. 2K14/SPD/02**, in partial fulfilment for the award of degree of Master of Technology in "**Signal Processing and Digital Design (SPDD)",** run by Department of Electronics & Communication Engineering in Delhi Technological University during the year 2014-2016., is a bonafide record of student's own work carried out by him under my supervision and guidance in the academic session 2015-16. To the best of my belief and knowledge the matter embodied in dissertation has not been submitted for the award of any other degree or certificate in this or any other university or institute.

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DECLARATION

I hereby declare that all the information in this document has been obtained and presented in accordance with academic rules and ethical conduct. This report is my own work to the best of my belief and knowledge. I have fully cited all material by others which I have used in my work. It is being submitted for the degree of Master of Technology in Signal Processing & Digital Design at the Delhi Technological University. To the best of my belief and knowledge it has not been submitted before for any degree or examination in any other university.

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Amit Gupta

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CHAPTER 1

INTRODUCTION

In existing biometric framework finger prints are normally forged; voice, signature, and hand shapes are easily forged; and biometrics, for example, fingerprints, iris and face recognition, are susceptible to forge, i.e., the biometric identifiers can be duplicated and used to make artifacts that can betray numerous presently accessible biometric gadgets. The biggest challenge to bio-metrics is to improve recognition performance in terms of accuracy and efficiency both and become maximum resistant to spoofing attacks. To this end, numerous specialists have tried to enhance unwavering quality and baffle spoofs by creating biometrics that are exceedingly individuating.

Thus in this respect Palm print Pattern recognition has been introduced which is highly complex, hopefully insuperable challenge to those who wish to defeat them because blood vessels are hidden inside the body and furthermore in this there is no physical contact between the client and system.

In the present research work efforts are made to propose a system which can improve the performance in terms of accuracy of the palm print patterns and their features, which is recognized from the given images, a public database of palm prints “SDUMLA-HMT”. The proposed work includes the Image Processing using MATLAB R2014a and several other algorithms.

1.1 Objective and goal of the project

The ultimate goal of this research work is to reconstruct or improve the palm print image and recognize the ridge patterns along with their features. To achieve this goal the set of specific objectives of this thesis are:

- Image Processing
- Pre Processing of Image
    1. Binarization of Image,
    2. Edge Detection and
    3. Segmentation of ROI
- Image Enhancement using Local Histogram Algorithm.
- Feature extraction from the enhanced images using combination of Frangi filter, FAST (Features from Accelerated Segment Test) algorithm and FREAK (Fast Retina Keypoint) descriptors.
- Machine Learning's Discriminant analysis KNN (K-nearest Neighbor Algorithm) and NAÏVE BAYES is used to verify, calculate and compare these accuracies.

1.2 Detailed Literature Survey

Palm print Patten recognition and improvement of the image is a wide and prominent field of research. Large number of Image processing techniques, algorithms and filters or some other techniques has also been used in recent past by many researchers for this.

A. Gyaourova and A. Ross[1] have proposed an indexing technique that can either employ the biometric matcher that is already present in the biometric system or use another independent matcher. Index codes are generated for each modality using the corresponding matcher. During retrieval, the index code of the probe is compared against those in the gallery using a similarity measure to retrieve a list of candidate identities for biometric matching. the proposed indexing technique on a chimeric multimodal database resulted in a reduction of the search space by an average of 84% at a 100% hit rate. The main factor for the amount of speedup during identification was the penetration rate of

the indexing. Dai and Zhou [2] introduces high resolution approach for palmprint recognition with multiple features extraction. Features like minutiae, density, orientation, and principal lines are taken for feature extraction. For orientation estimation the DFT and Radon-Transform-Based Orientation Estimation are used. For minutiae extraction Gabor filter is used for ridges enhancement according to the local ridge direction and density. Density map is calculated by using the composite algorithm, Gabor filter, Hough transform. And to extract the principal line features Hough transform is applied. SVM is used as the fusion method for the verification system and the proposed heuristic rule for the identification system. A. Kong and D. Zhang [3] have presented a novel feature extraction method, the Competitive Coding Scheme for palmprint identification. This scheme extracts the orientation information from the palm lines and stores it in the Competitive Code. An angular match with an effective implementation is developed for comparing Competitive Codes. Total execution time for verification is about 1s, which is fast enough for real-timemapplications. The proposed coding scheme has been evaluated using a database with 7,752 palmprint images from 386 different palms. For verification, the proposed method can operate at a high genuine acceptance rate of 98.4% and a low false acceptance rate of 3*10-6 .Jiaa, Huanga and Zhang [4] have proposed palmprint verification based on robust line orientation code. Modified finite Radon transform has been used for feature extraction, which extracts orientation feature. For matching of test image with a training image the line matching technique has been used which is based on pixel-to-area algorithm. D. Huang, W. Jia, and D. Zhang[5] proposed a novel algorithm for the automatic classification of low-resolution palmprints. First the principal lines of the palm are defined using their position and thickness. Principal lines are defined and characterized by their position and thickness. A set of directional line detectors is devised for principal line extraction. By using these detectors, the potential line initials of the principal lines are extracted and then, based on the extracted potential line initials, the principal lines are extracted in their entirety using a recursive process. The local information about the extracted part of the principal line is used to decide a ROI and then a suitable line detector is chosen to extract the next part of the principal line in this ROI. After extracting the principal lines, some rules are presented for palmprint classification. The palmprints are classified into six categories considering the number of the principal lines and their intersections. From the statistical results in the database containing 13,800 palmprints, the distributions of categories 1–6 are 0.36%, 1.23%, 2.83%, 11.81%,

78.12% and 5.65%, respectively. The proposed algorithm classified these palmprints with 96.03% accuracy. Zhang, Kong, You and Wong [6] have proposed Online Palmprint Identification. The proposed system takes online palmprints, and uses low resolution images. Low pass filter and boundary tracking algorithm is used in preprocessing phase. Circular Gabor filter used for feature extraction and 2-D Gabor phase coding is used for feature representation. A normalized hamming distance is applied for matching. J. You, W. Kong, D. Zhang, and K. Cheung[7] proposed a dynamic selection scheme by introducing global texture feature measurement and the detection of local interesting points. Our comparative study of palmprint feature extraction shows that palmprint patterns can be well described by textures, and the texture energy measurement possesses a large variance between different classes while retaining high compactness within the class. The coarse-level classification by global texture features is e4ective and essential to reduce the number of samples for further processing at fine level. The guided searching for the best matching based on interesting points improves the system efficiency further. W. Li, J. You, and D. Zhang[8], have proposed an effective indexing and searching scheme for an image database to facilitate fast retrieval when the size of a palmprint database is large. There are three key issues to be considered: feature extraction, indexing, and matching . In general, in an image database, the extracted features are often associated to the original images as indices. A search for the best matching is conducted in a layered fashion, where one feature is first selected to lead the search by reducing the set of candidates. Then other features are used to reduce the candidate set further. Such a process will be repeated until the final output is determined based on the given matching criteria. The selection of features plays an important role for efficient search. An effective feature selection scheme should exclude the most impossible candidates, compare easily, require small size of space for storage. Prasad, Govindan and Sathidevi[9], have proposed Palmprint Authentication Using Fusion of Wavelet Based Representations. Features extracted are Texture feature and line features. In proposed system pre-processing includes low pass filtering, segmentation, location of invariant points, and alignment and extraction of ROI. OWE used for feature extraction. The match scores are generated for texture and line features individually and in combined modes. Weighted sum rule and product rule is used for score level matching.

Cappelli, Ferrara, and Maio [10] proposed high resolution palmprint recognition system which is based on minutiae extraction. Pre-processing is formed by segmentation of an

image from its background. To enhance the quality of image, local frequencies and local orientations are estimated. Local orientation is estimated using fingerprint orientation extraction approach and local frequencies are estimated by counting the number of pixels between two consecutive peaks of gray level along the direction normal to local ridge orientation. Minutiae feature is extracted in feature extraction phase. To extract the minutiae features contextual filtering with Gabor filters approach is applied. Minutiae cylinder code has been used for matching the minutiae features.

Yong et al. method for feature extraction divides the palm print image into a set of n small regions and then calculates the mean and S.D of sub regions. Euclidian square norm is employed for matching [11].

Zhi Liu and Shangling Song [13] this paper proposes a real time biometric recognitionsystem for the mobile device with the help of palm prints based on the blanket dimensions and lacunarity implementation which is on a DSP platform. In this ROI segmentation done after capturing the palm print images and then blanket dimension features and lacunarity features for the recognition is applied. The result shown: the EER of this method is 0.07%, which is quite less than the existing system. This system is quite suitable for the mobile devices as it consumes less power and relatively less computational complexity.

1.3 Motivation:

Numerous Biometric system had been discussed and developed in the recent past but it had been observed that they can be easily forged as we can watch in many movies and hear in tales.

In the propose work it had been selected palm print patterns for the biometric recognition because of following two reasons:

1. It is present inside the human body
2. It can be obtained from the live body only

So by having two features of the palm print pattern images it can be said that this biometric system is not so easy to forge and is very much reliable.

But the above two features also makes the system complex as the ridges are present inside the body so it not easy to capture the image of the patterns in good quality. So the image capturing and enhancement is the challenging task for the scholars.

The feature extraction is one of the important phase of any biometric system and it became more important when it comes for palm print images.

The above mentioned positive features for the security and reliability motivate to work on it and the challenge of the complexity makes much motivated.

1.4 Problem Formulation

The bigger challenge in palm print recognition and its Improvmentation is to extract its patterns from the low-contrast NIR (Near Infrared Image) images. Improvement of the ridge patterns and extraction of their features from low contrast images is still a tough task.

The basic idea of this research work is to process (enhance) the palm print images, extract its features and find out the accuracy by comparing different algorithms and techniques. The tools and algorithms of MATLAB R2014a is used. Image enhancement is done by the use of Local Histogram Algorithm on the pre-processed image of the database (NIR images).After this feature extraction process is done on the enhanced images with the help of, combination of Frangi filter, FAST algorithm and FREAK discriminator.

At the end the research comes to the important phase i.e. verification and accuracy calculation. This is being done with the help of Machine Learning's (Supervised Learning algorithm) Discriminant analysis. The accuracy is mentioned verified after comparing with various techniques of Supervised Learning Algorithm. After comparison with other techniques it has been observed that Discriminant Analysis gives more accurate result than others.

1.5 Organization of Thesis Work

The rest of the thesis is organized in following way:

In chapter 2 the basic background theory of the project is discussed like the basic introduction of biometrics, different types of biometrics specially the palm print biometric system and their patterns, image processing. Preprocessing, image enhancement, noises present in the image, etc.

In chapter 3 is the descriptions about the methodologies used in the project, image enhancement techniques, feature extraction techniques are discussed along with their algorithms used. This chapter describes the project.

In chapter 4 is the chapter where the result analysis and discussion is done with the leveled figures along with the comparison of accuracy.

In chapter 5 Conclusion and further scope of the project is presented.

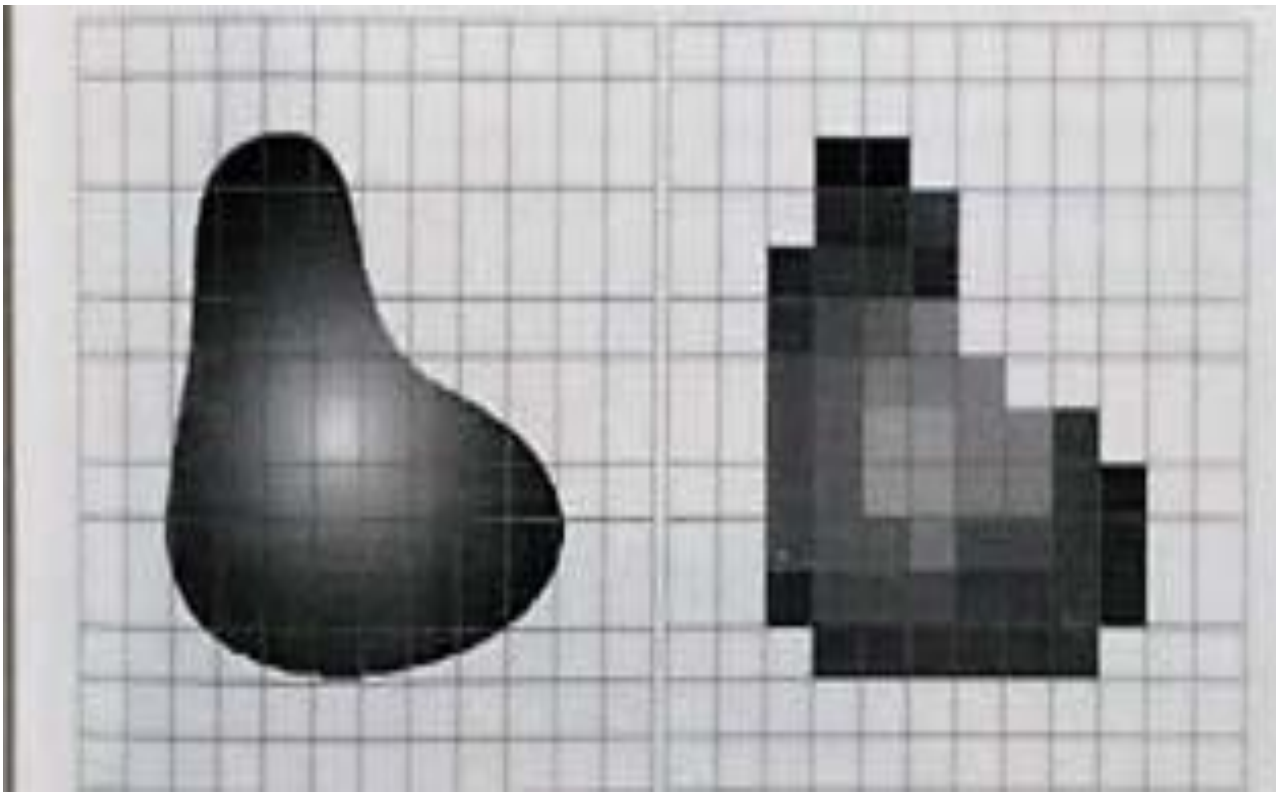
CHAPTER 2

BACKGROUND HISTORY OF PROPOSED WORK

2.1 Background

Digital Image

An image is worth of thousand words. These days image are the most convenient and the easiest way of conveying the information. Images are the visual information which help us to understand and perceive the surroundings in better way. Hence Image processing sector is very successful in attracting many researchers towards it over last few decades. The process of analysing images by digital computer is called as digital image processing.



(a) **(b)**

Figure 2.1(a) Continuous image projected on sensor array, (b) Result of image sampling and quantization [14]

Mathematically, an image is a two dimensional function, f(x, y), where x and y are spatial (plane) and the amplitude of 'f' at any coordinate (x, y) is called gray level of the image at that point. Whenever the values of x, y and amplitude values are of finite discrete quantities then images are known as a digital image [14]. A digital image is consists of some certain number of elements, each of elements has their particular value and location. These elements are called as pixels/ image elements/ picture elements. Pixels is a term used which is generally used to denote the digital element image [15]. A bit map is a rectangular array of pixels.

- **Binary Images:** It is the image representation of each pixels into single bit. Theyare just simple type of images and take only two discrete values i.e. black and white, where black is represented with '0' and white with '1'.This find applications in computer vision areas where general shapes of the image is needed.

- **Gray-Scale images:** These images are known as monochrome or single colourimages. A black and white image consist of pixels, each pixels hold a single number corresponding to the gray level of the picture at a particular location. For an 8 bit picture there will be 256 gray levels where '0' represents black and '255' denotes white.

- **Color Images:** A colour image is also consists of pixels and in this each pixelsconsists of three numbers corresponding to each Red, green and blue (RGB) levels of the picture at a particular location. RGB are the primary colours and every image can be formed by using and mixing RGB.

  For images of the same size a gray level image acquire 3 times less memory than color image. During this work many standard gray level images are used.

2.2 Biometric System

2.2.1 Introduction

Biometrics is the initial top features of a person. Biometric identification identifies an automated identification of individual predicated on feature vectors produced from their physiological and/or behavioral feature. Biometric systems for human being identification at a distance have ever been a growing demand in a variety of significant applications [16].

Smart recognition of human identity for security and control is an issue of concern worldwide today. Financial losses due to identity theft can be severe, and the integrity of security systems compromised. Hence, computerized authentication systems for control have found software in Criminal id, autonomous vending and robotic banking amongst others. Among the many authentication systems that contain been implemented and proposed, palm print biometrics is growing as the foolproof approach to automated personal id [17].

A biometric system is actually a pattern reputation system that operates by acquiring biometric data from a person, extracting an attribute arranged from the attained data, and looking at this feature arranged from the template occur the database. With regards to the application context, a biometric system may operate either in verification or identification mode.

In *verification mode,* the system compares the individuals identity from the template stored in the database. In this a database is maintain by the biometric system and the system verifies the data with the individual identity who claims that. Usually a PIN (Personal identification number), user name/password, smart card, and system compare that and determine that is true or not. Basically this identity verification is typically used for positive recognitions.

In *Identification mode,* the system identifies the person from the saved templates in the database and then match them from the input image. This system conducts one to many comparison to identify individual. This mode is critical component in negative recognition, where the person which is not recognized is denied to access [8].

2.2.2 Classification of Biometric Techniques

Generally Biometric Techniques are classified into two main categories:

1. Physiological Characteristic:

   This technique includes *PALMprint recognition, retina and iris recognition, handand PALM geometry, palm print pattern recognition, face recognition and DNA analysis*.

2. Behavioral Characteristic:

   This technique includes *handwriting recognition, signature recognition, voiceauthentication, gait, and keystroke dynamics* [18].

2.2.3 History of Biometrics System

Humans have used body characteristics such as face, words, and gait for a large number of years to identify one another. Alphonse Bertillon, head of the criminal identification section of the police team in Paris, developed and then practiced the idea of by using a numerous body measurements to identify criminals in the mid-19th century. His idea was gaining popularity and now more significant and practical biometric system i.e. human PALMprint biometric system came into existence in late 19^{th} century. Not long after this discovery, numerous significant law requirement offices grasped the possibility of first "booking" the Palmprints of lawbreakers and putting away it in a database (actually, a card record). Despite the fact that biometrics rose up out of its broad use in law implementation to distinguish criminals (e.g., illicit aliens, security freedom for representatives for touchy occupations, parenthood determination, crime scene investigation, and constructive recognizable proof of convicts and detainees), it is in effect progressively utilized today to set up individual acknowledgment in countless applications.

Gradually the biometrics become more secure, reliable and less complex identity and security asset in our daily life. Its use has gained the popularity in every sector now a days. But still we can't say it is the full proof and ultimate security and identification system so many scholars and researchers are working on this to make it more reliable and decrease its complexity.

2.3 Palm print Patterns

2.3.1 Introduction

After the discovery of PALM print biometric system later in year 1985 the palm print pattern recognition biometric system came into existence, it was developed by Joseph Rice [19]. In 1984 he had his character stolen, which prompted fake utilization of his bank account. He chose to make a move, which prompted his first ridge recognition model around 1985.

Palm print is a special physiological biometric for distinguishing people, taking into account the physical characteristic and attributes of the ridge designs in the human PALM. It is a genuinely recent development in the field of biometrics that is being connected to various fields, for example, medical, monetary, law requirement offices and different applications where abnormal amounts of security or protection is critical. Palm printrecognition is a method of biometric authentication that uses pattern-recognition techniques based on images of human palm print patterns beneath the skin's surface. Palm print recognition is one of many forms of biometrics used to identify individuals and verify their identity.

2.3.2 Palm print Pattern Capturing Technique

To capture its high quality image a special device was developed which is not affected by ambient temperature. Generally, palm print pattern images are captured, based on the principles of light transmission or light reflection [20]. This is captured by the NIR (Near Infra-Red) camera, because NIR light can easily penetrate the bones of the PALM irrespective of the thickness of bone. The image capturing camera's basic diagram is shown below [13]:

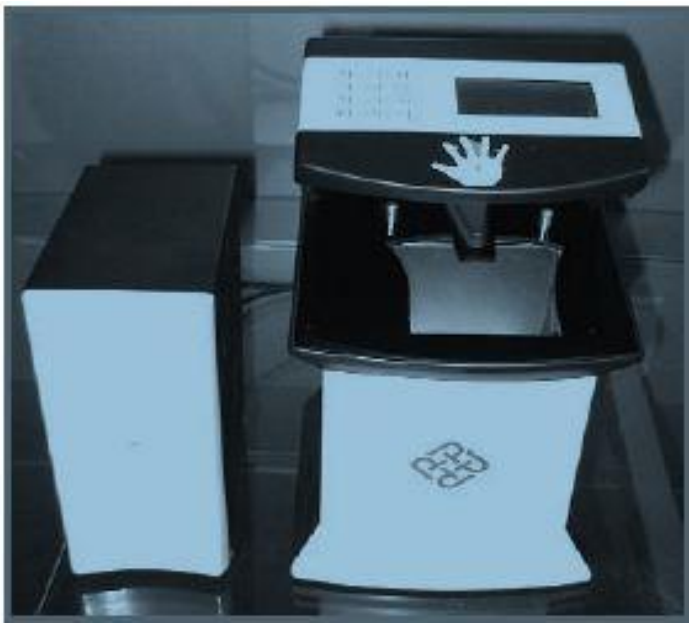


Figure 2.2 Basic diagram of the imaging device [13]

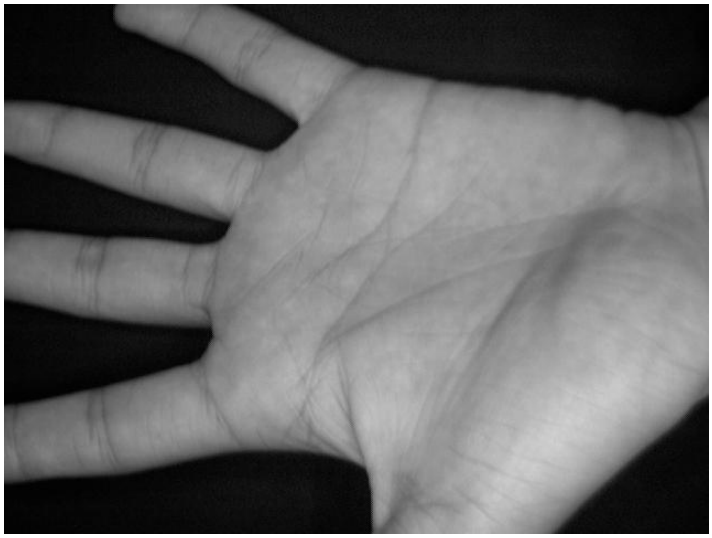


Figure 2.3 Image of a palm print Captured by the above device [13]

2.3.3 Limitations of Hand based biometric system

Hand based biometric system generally includes PALM print recognition, palm print recognition, palm knuckle recognition. Among these PALM print recognition is the one of the oldest way of recognition and is most mature. However it is the most vulnerable or easy to forge it is because it is easily exposed to all. There are some more challenges to this biometric due to the condition of PALM surfaces like sweat and dryness and these conditions significantly degrade the capturing performance of the PALMprint. PALM knuckle print and palm print based biometric frameworks are easy to copy because features are outside the human bodies. To defeat the restrictions of the present hand-based biometric frameworks, palm print recognition was proposed.

2.3.4 Advantages of Palm print Pattern over Other Hand Based Biometric System

1. ***Non-contact***: as palm print patterns are inside body so it not touchable so can't beinfringed;
2. ***Live body identification***: palm print patterns can only be extracted from a livebody;
3. ***High security***: palm print patterns are internal features i.e. inside body so not aneasy task to forge;
4. ***Small device size***: when compared to palm ridge based verification devices, mostpalm print recognition devices are smaller in size.

2.4 Image Processing

For image processing it is needed to convert a natural image into a digital image with the help of method called digitization. A digitized image can be stored in a digital memory or in some form of media like hard drive or CD-ROM. The digital image is already discussed in the section 2.1.

The digitization can be done with the help of scanner, or by video camera which is connected to grab the image to the computer. Once the image is digitized, it can be operated by various image processing operations. The main aim of image preprocessing is to enhance the image features relevant for further processing and results. As a result, the relevant details of the image are highlighted and noise is removed from the image.

Digital image processing operations and their area of expertise are shown below in a tree form.

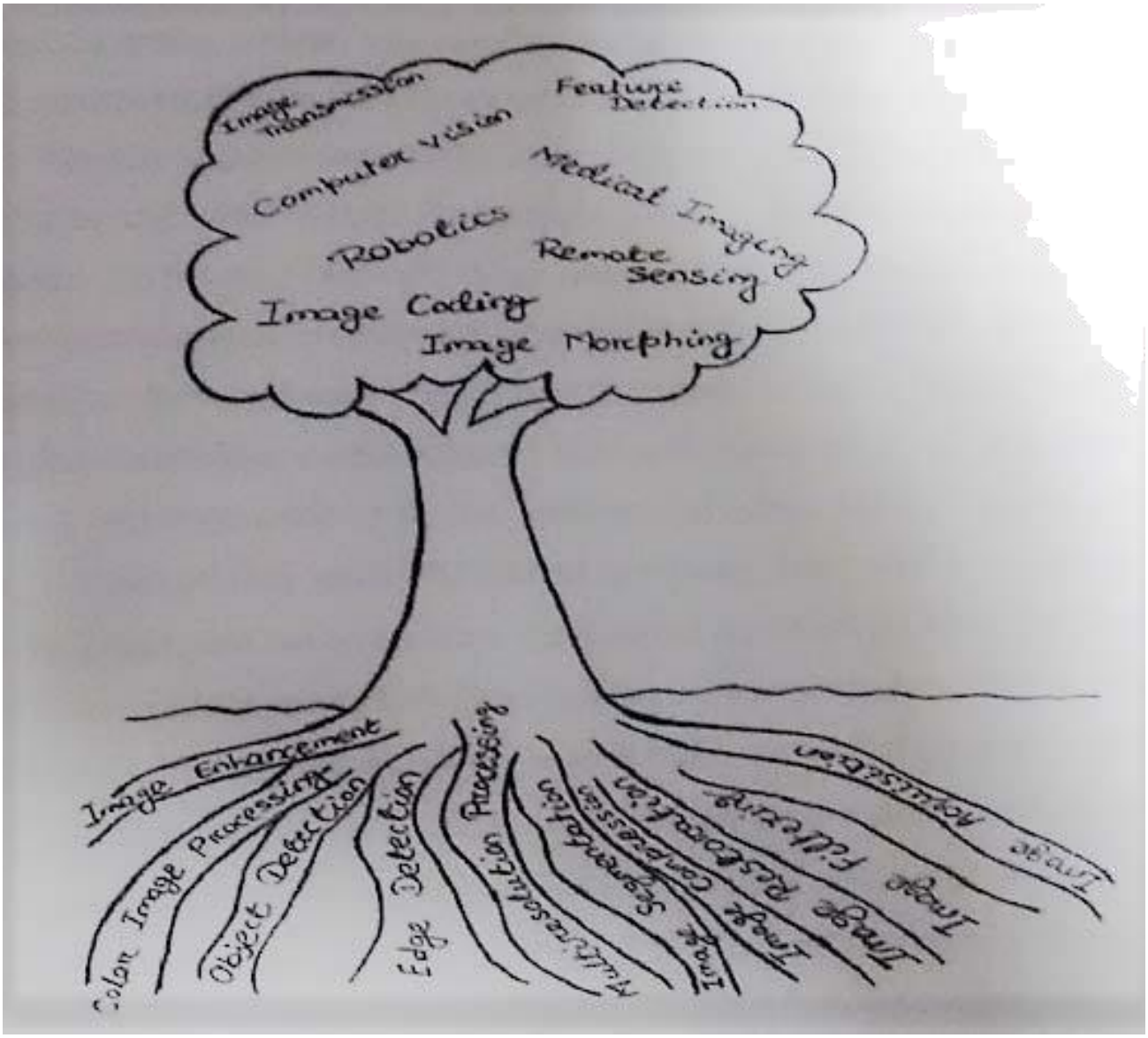


Figure 2.4 Image Processing Tree

2.4.1 Image enhancement

Images are captured at low contras in number of different scenarios. There may be some reasons like poor lighting conditions (e.g. picture taken at night or against the ray of light) for this. Due to this the image become too dark or too bright to interpret or visual observation. There are numerous image enhancement algorithms used for the image processing applications so that the distorted images can be visually understandable for the work to accurate certain features [21].

Image enhancement improves the quality, clarity of the images for the viewing clarity. Increasing contrast, and revealing details are the examples of enhancement operations on other hands removing blurring and noise comes under category Image restoration.

Applications of image enhancement

There are numerous of sectors where image enhancement and image processing techniques are used. Planetary scientists were the first users of this technique to improve the images obtained from the Mars, Venus or other planets. Radiologists, Doctors also use this method to manipulate MRI images, X-ray images, CAT scans. Image sharpening techniques for criminal detection are used by the Forensic science department. Many image enhancement algorithms are being used by airport authorities, banking sectors, government organisation (Adhar Card) for security purpose extensively to enhance biometric like PALM print, palm print, iris etc. Palm print manuscripts are used by many sectors like astronomy, astrology, architecture, law, music and medicine. This techniques are also used to enhance the documents which are degraded and as not to be able to retrieve the data written on it.

Image enhancement is one of the important image processing functions to enhance the observance of image in visual interpretation analysis.

2.4.2 Pre Processing of Image

The images usually captured or acquired by the cameras are generally noisy with translational and rotational variations. So to overcome this the images need to be processed (pre-processed). Generally it is the stage after image acquisition in which it is tried to remove the unwanted or undesirable content from the images. In this stage the images has to undergo different image shaping, sharpening and morphological improvement stages. Pre-processing is a characteristic under Images processing scheme which contains numbers of steps of enhancement, some of the general schemes are discussed below:

- **Binarization of Image**

This is the process of converting images into binary form i.e. in the form of ‘0’ and ‘1’,and that conversion images into binary form is called binary image which is already discussed in the section 2.1. The conversion of image into binary form make it easier to enhance the quality of the image. From binarization the images are converted into digital images.

Morphological opening and morphological closing are the operations which is performed under this section to improve the images.

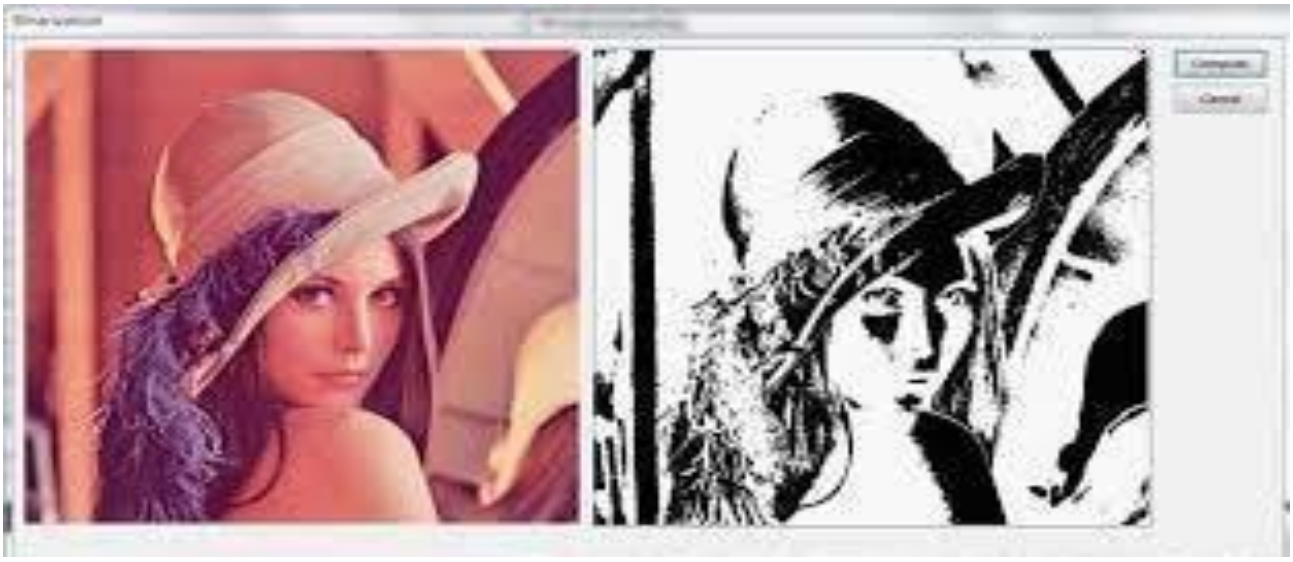


Figure 2.5 BinarizedImage

- **Edge Detection**

Edge detection is a set of mathematical methods whose aim is at identifying points of a digital image at which the image brightness changes sharply or, more formally, hasdiscontinuities. The points on which the image brightness changes sharply are organized into a set of curved line segments termed as edges. Edge detection is a fundamental tool in image processing, machine and computer vision, particularly in the areas of featuredetection and extraction. The edges extracted from a 2-D image of a 3-D scene can beclassified as either viewpoint dependent or viewpoint independent. A viewpoint independent edge is inherent properties of the 3 -D objects, like surface markings and surface shape. A viewpoint dependent edge may change as the viewpoint changes, and is a geometry of the scene, like objects occluding one another [22].

Figure 2.6 Edge detection of the image [22].

- **Segmentation of ROI (Region of Interest)**

It is the step in the image processing in which the images which is acquired from the camera or it can be applied to the preprocessed images to define the ROI. ROI is the region which is required or needed by the client for the further processing, it is always the smaller part of the acquired image. On ROI, segmentation process is applied so that the images are well managed and easily enhanced.

In order to determine a morphometric parameter within an image, the computer program needs to differentiate from wanted and unwanted areas. This ROI generally find out on the criteria of pixels intensity values. The process of separating interested objects from uninterested objects are called **segmentation**. When images are segmented on the criteria of intensity the client defines a range of pixel intensity values that encompasses interested objects. When the client defines a gray-scale intensity value, above which the objects lie and below which encompasses the background, the image is called **thresholded**, and the process is said to be as thresholding.

Once segmented, the pixels of the image can be reassigned the intensity values of either 0 (uninterested) or 1 (interested). If intensity values are required, then the binary image can be used as a **mask** to cover the original image exposing only the ROI pixels. Once masked, the image intensity values underneath can be obtained [23].

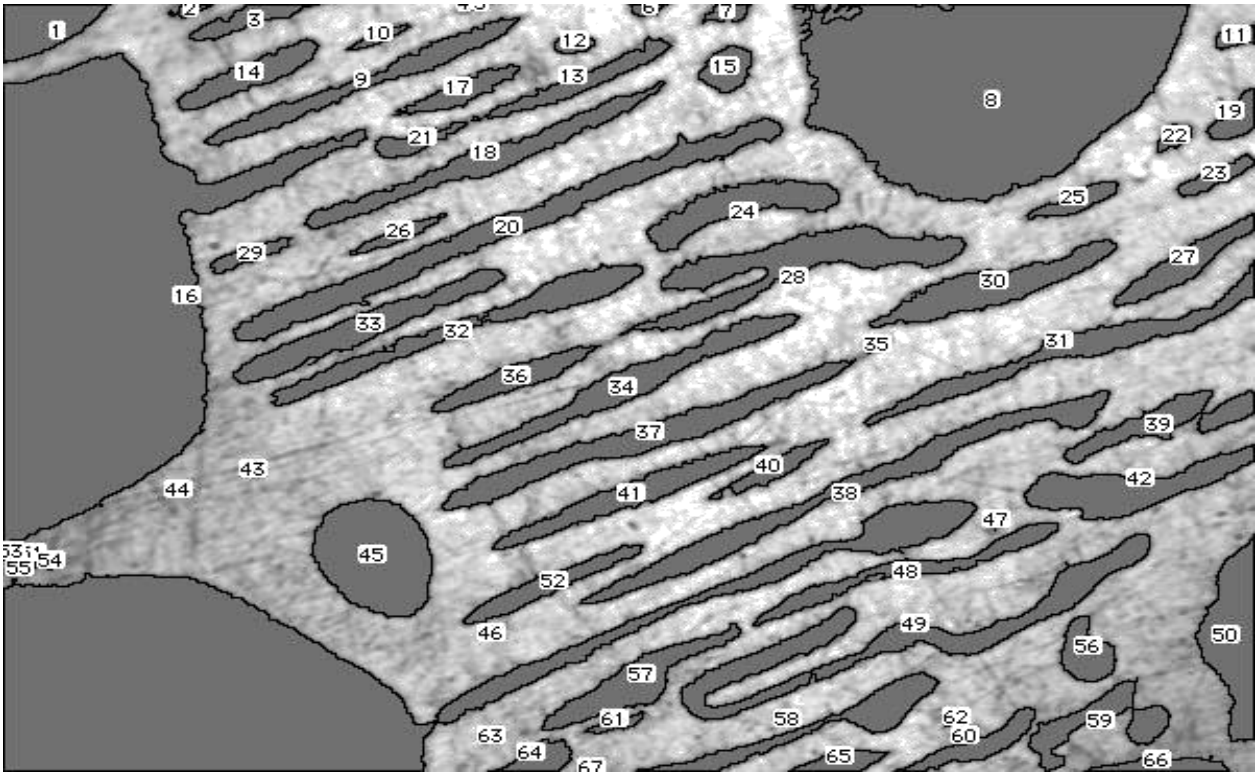


Figure 2.7 Area of ROIs using segmentation

2.4.3 Contrast Enhancement

Image enhancement techniques generally employs various contrast enhancement techniques to increase the amount of observance perception.

Contrast enhancement techniques can be broadly classified into two categories. In first category gray pixels modification based on the statistical information of the images. Where as in the second category the contrast will be enhanced by first the components of the images based on frequency i.e. high and/ or low frequency, and then manipulating them separately and at the end recombining them together with different weights

Some of the contrast enhancement techniques are described below:

- **Image Negative**

The negative of an image with gray levels which is in the range [0, L-1] is obtained by using negative transformation, given in equation (2.1),

$$s = L - 1 - r \tag{2.1}$$

Where L is maximum Gray level intensity of the input image whereas r and s denotes the value of pixels before and after processing. This type of processing is usually used for enhancing gray and white details associated in dark regions of an image.

- **Logarithmic Law**

This technique is one of the simplest techniques of contrast enhancement. It uses to expand dark valued pixels of an image while compressing higher level values with the help of log transformation which convert the input gray level to output gray level. The general formula for log transformation is given below:

$$s = c. \log (1+r) \tag{2.2}$$

Where c denotes contrast and, where r & s are input and output gray levels respectively, r is greater or equals to 0.

- **Power Law**

Power law is given as:

$$s = c. r^{y} \tag{2.3}$$

The devices used for image capturing, printing, and display respond according to the power law equation. The exponent used in the equation (2.3) is referred as gamma. The process of correcting this power law is called gamma correction. The image which is not be corrected properly can look bleached out or dark. To produce accurate gray levels and appropriate brightness the gamma should be adjusted properly.

- **Histogram Equalization**

The techniques of enhancing the images which has pixels less than average, where details in the darker region is not often perceptible is called as histogram modification, in which original images are rescaled so that the histogram of modified picture follows some desired form [24].This technique assumes images carried information is related to the probability of existence of each gray level. To maximize the information, the transformation should be redistributed to the probabilities of occurrences of gray levels.

- **UnsharpMasking (UM)**

It is an image enhancement technique which was first used in year 1930 at Germany for the first time to increase the acutance, or apparent sharpness of photographic pictures. In this UM technologies, an image of high pass filter version scale is added to this image itself. This technique can be represented with the help of following equation.

$$I'_{x,y} = I_{x,y} + \lambda I''_{x,y} \quad (2.4)$$

$I'_{x,y}$, $I_{x,y}$ original and enhanced images respectively. $I''_{x,y}$ is high pass component of the original image. The original image is scaled with an amplification factor λ as per the requirement to obtain the enhanced image I'

2.4.4 Image Analysis

To produce a description of an image, image analysis is associated with the formation of quantitative measurement from any image. Image analysis techniques need certain feature extraction that results in the identification of the subjects. Segmentation techniques i.e. discussed in section 2.3.1 are used to isolate the desired subject from the image so that measurements can be done on it subsequently [25].

2.4.5 Image Compression

Data Compression [26], is the process in which to represent given quantity of information the amount of data required to represent. Hear the data refers to means by which the information is transferred. Same amount of information is represented by the various amounts of data. Sometimes it also happens that the given data which contain some data do not have the required information in the data, it is just said to contain data redundancy. Data redundancy is the main concept in image compression which can also be defined mathematically.

Given n_1 and n_2 represents the information-carrying units in 2 data sets that represents the same image.

The relative data redundancy R_D of the data set n_1, is:

$$R_D = 1 - 1/C_R \tag{2.5}$$

C_R refers to the compression ratio:

$$C_R = n_1/n_2 \tag{2.6}$$

If $n_1 = n_2$, then $C_R = 1$ and $R_D = 0$, indicating that the 1st representation of the information contains no redundant data.

A typical compression ratio around 10 or (10:1) indicates that 90% ($R_D = 0.9$) of the data in the 1st data set is redundant.

2.5 Noise in Digital Image Processing

So first of all it will be discussed about the noise. A noise is any distortion or undesired information that makes an image contaminated.

Sources of noise in the image

There are various sources of noises to make any image distorted or contaminated, some of them are discussed below:

During image acquisition e.g. from CCD (Charged Coupled Device) camera, caused from thermal energy and light levels, fluctuations of electronic signals in detector.

During image transferring e.g. wireless network, may be corrupted by lighting or other atmospheric disturbance.

2.5.1 Some general image noises Gaussian noise

It is the noise which can be modelled by random values which is added to an image, so it is said to be additive noise. It is an idealized form of white noise, which created by random signal fluctuations. [26]

Rayleigh noise

It is described by,

$$P(z) = 2/b\,(z-a)\exp(-(z-a)^2/b) \text{ for } z \geq a \quad (2.7)$$

$$P(z) = 0 \text{ for } z \geq a \quad (2.8)$$

Periodic noise

An image is called to be corrupted by periodic noise if that image signal is subject to periodic, rather than a random disturbances [26]. This noise can be filtered with the help of frequency domain techniques.

Speckle noise

Speckle noise (or simply just speckle) can be modelled by random values multiplied by pixel values, so it is also said to be multiplicative noise [26].

Impulse noise

A digital image capturing process changes an optical image to a continuous electrical signal that is, then, sampled [27]. Impulse noise generally introduced in the images while transferring or obtaining them over a channel which is unsecured. Sharp and sudden disturbances into an image signal give rise to the introducing of impulse noise.

Uniform Noise

The Pdf of a uniform noise is given by [26].

The following graph is between mean (P (z)) and variance (Z),

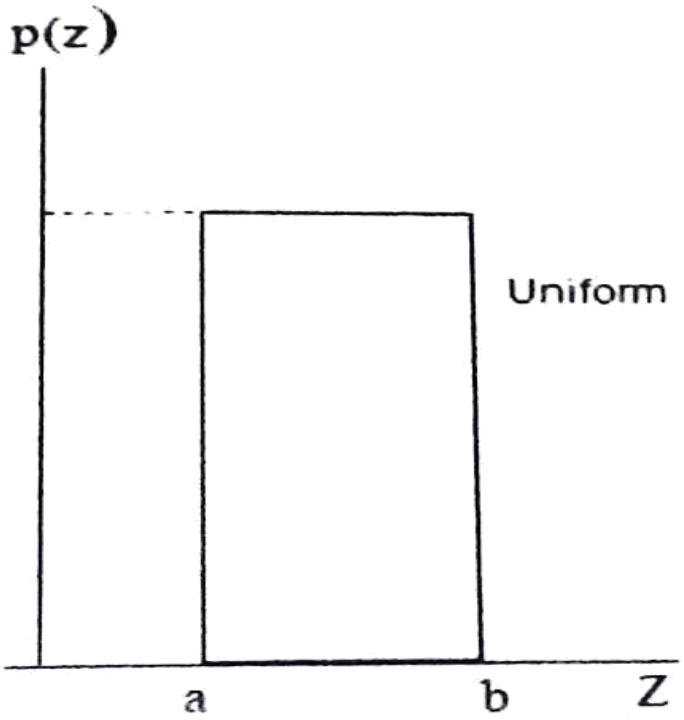


Figure 2.8 Uniform Distribution

2.6 Application areas of Image Processing

In this era of technology, there is very less area where digital image processing is not impacted in any ways. The field which uses Digital image processing very frequently are mentioned below:

- Criminology/ Forensics
- Medical Imaging
- Remote sensing
- Military
- Transportation

CHAPTER 3

PROPOSED WORK AND TECHNIQUES USED

3.1 Proposed Work Methodology

In the present research work, the steps of image processing of palm print patterns and feature extraction of these images are same as proposed by ReshmaRajan and Indu M.G. [6]. However in this work, new thing being added or the work of ReshmaRajan and Indu M.G. has been further extended by finding (calculating) the accuracy by two algorithms of Machine Learning's (Supervised Learning) Discriminant Analysis algorithm and KNN(K-Nearest Neighbor Algorithm). At the end of the work the best techniques among above those have been shown by comparing the accuracy calculated by these.

In the proposed work there are certain technical steps being followed, that steps are given below:

- Image Processing
- Pre Processing of Image
- Binarization of the acquired image
- Edge Detection using Sobel filter
- Segmentation of ROI (Region Of Interest)
- Image Enhancement
- Final Image Improvement using Local Histogram Algorithm.
- Feature Extraction with the combination of Frangi filter, FAST (Features from Accelerated Segment Test) algorithm and FREAK (Fast Retina Keypoint) descriptors.
- Accuracy calculation of the features extracted from the enhanced image of palm print patterns. This accuracy calculation is proposed with the Machine Learning's (Supervised Learning technique) Discriminant Analysis algorithm and KNN (K-Nearest Neighbor Algorithm).

- Comparison between above two proposed methods of Machine learning for accuracy calculation i.e. which one gives more accuracy of the feature extracted from palm print patterns.

3.2 Flow of Proposed Work for Image Processing

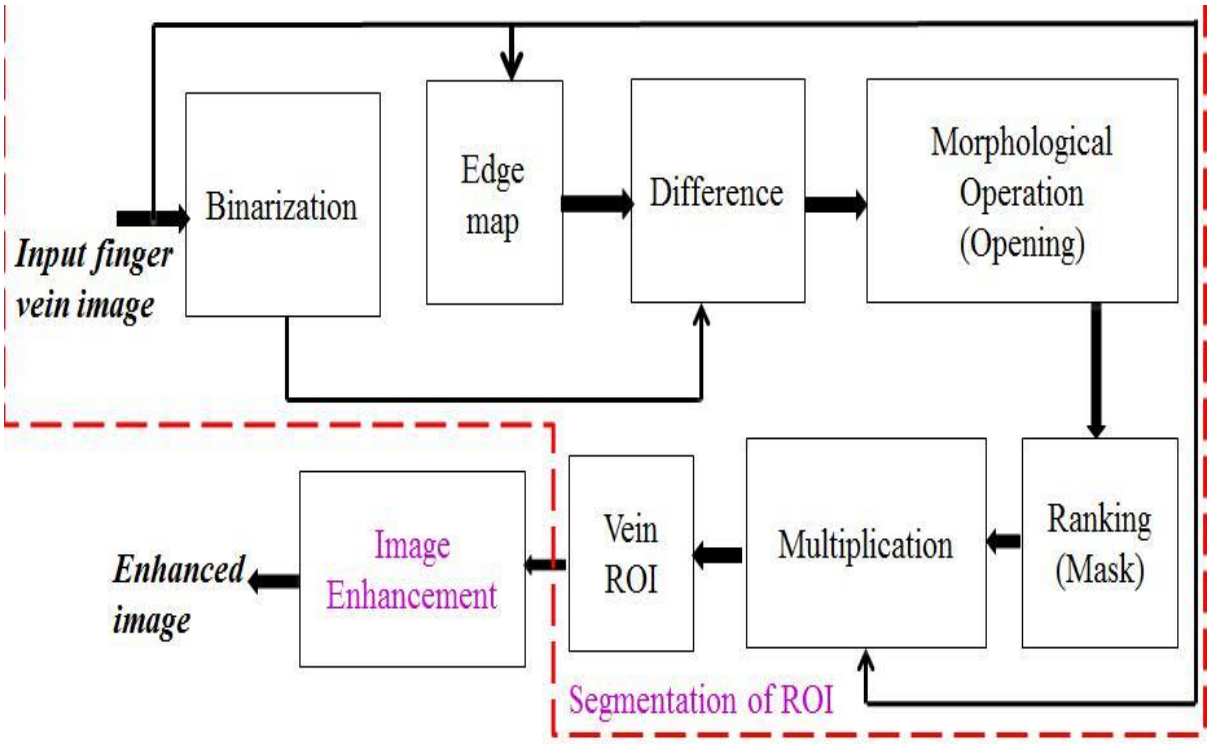


Figure 3.1 Flow Chart of proposed Method (Image Processing) [6]

In the above Figure 3.1, it is shown about the flow of the proposed work and steps followed for the Image Processing section that includes preprocessing. Binarization of acquired image, Edge detection, segmentation of ROI, and image enhancement.

The results obtained after these steps will be shown in the next chapter. This chapter will conclude only about the processing steps and used techniques. Techniques used for the above steps and all the steps for the proposed work and results is a software named MATLAB R2014a in which Image Processing tool box is used.

3.3 Programming steps for the Image Processing

Following Steps are performed on the software for Image Enhancement

As already discussed in the above section 3.2 that the programming software used for the proposed work is MATLAB R2014a and the tools of Image Processing is used for the work. The coding is done in the software to enhance the acquired images of the palm print pattern and all the steps mentioned in the section 3.2.

The coding is done on the tool box of image processing to enhance the image that have been acquired by the NIR camera.

In this process we first perform conversion of original image which is a colored image i.e. RGB image to gray image. It is converted to gray image because this image acquire 3 times less memory to store than RGB image and also very much easy to analyze a gray image.

Then after the conversion of the gray image to double data type then steps performed finding of standard deviation, then after the images are converted into complimentary image of gray image. Now after this step the black portion of the image will convert to white and white to black. Then morphological operation is applied to fill the holes of the distorted images that is found later the edge detection using Sobel filter is done.

After the Edge Detection step now the subtraction step of edged image and image found after morphological operation is done. This step is also shown the flow chart i.e. figure 3.1. This step is performed and help to find out the ROI of the image. Now multiplication of

the ROI image from the original image is done as mentioned in the flow chart i.e. figure 3.1.Then in the final step image enhancement and image resizing codes are applied.

Image Enhancement is done with an inbuilt algorithm of image processing tool box i.e. Local Histogram Algorithm.

3.3.1 Local Histogram Algorithm

It is a technique used to increase the local contrast of any image, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast [22].

It is the mathematical inbuilt algorithm of the MATLAB, which the user can call directly and use this algorithm directly for their desired work. This is generally used in X-Ray, DNA, MRI, etc. very frequently.

3.4 Feature Extraction Techniques

The proposed block diagram of palm print feature extraction is shown in Figure 3.4. The feature map of palm print image is extracted with the help of Frangi filter, then Features from Accelerated Segment Test (FAST) algorithm is used to find the point of interest from the palm print feature map. For each point of interest, a Fast Retina Keypoint (FREAK) descriptor is extracted and is centered around on it [6].

In case of palm print pattern extraction the ridges oriented mainly along the x-axis and their diameter does not changes much. Thus, it can be considered to fix the diameter, something that simplifies the problem and multiscale analysis is not needed [28].

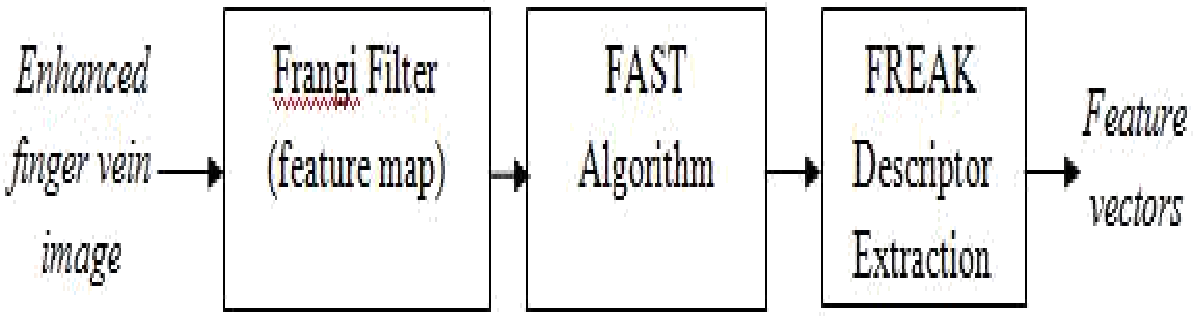


Figure 3.2 Block diagram of Feature Extraction [6]

3.4.1 Frangi Filter

The image processing method is based on the analysis of Eigen values in Hessian matrix and is originally developed for PALM blood vessel detection in medical sector images. Whenever it is required to find out the line like structure in an image, it can also be used in other areas. To determine the locally the likelihood of a blood vessels present in the region the Eigen values of the Hessian matrix are used.

Generally, the method based on the Hessian Eigen value analysis is capable of detecting bob-like, plate-like, and also tubular structure within an image. The Frangi filter is used to extract the palm print structure (feature map) from the image.

For the given pixel of an input image, a Hessian matrix is formed from the image second order partial derivatives and is given by:

$$H = \begin{bmatrix} \frac{\partial^2 I}{\partial x^2} & \frac{\partial^2 I}{\partial x \partial y} \\ \frac{\partial^2 I}{\partial y \partial x} & \frac{\partial^2 I}{\partial y^2} \end{bmatrix}$$

Where, I denotes the grayscale input image, H denotes the Hessian matrix and x & y are the coordinates of the pixels within I. The partial derivatives are calculated as pixel intensity differences in the neighborhood of the pixel [6].

In the proposed work of feature extraction using Frangi filter is done with the programming code and the steps performed. Steps of the programming are described the end of the section 3.4.3.

3.4.2 FAST (Features from Accelerated Segment Test) Algorithm

The FAST (Features from Accelerated Segment Test) algorithm is used for the detection of corners (point of interest) of an image patch. Fig. 3.3 shows the twelve point segment test corner detection in an image patch.

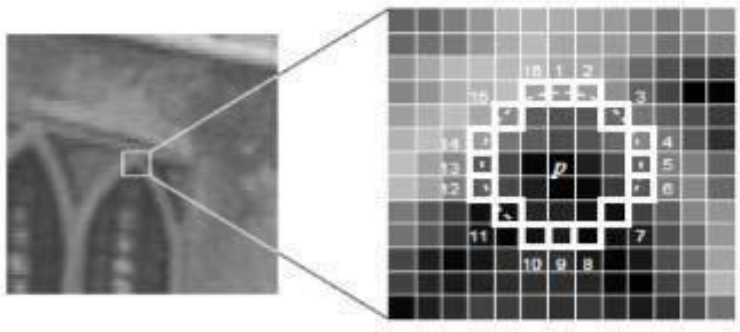


Figure 3.3 Twelve point segment test corner detection of an image patch [6].

Consider a parent pixel p as given in Fig 3.3. Then select a circle of sixteen pixels around the pixel p. Let Sp be the image intensity and t be the selected threshold value. In the circle of sixteen pixels, if there exists a set of l continuous pixels which are all brighter than Sp+ t (Sp is the intensity of the parent pixel), or all darker than Sp−t, the detector classifies p as a corner point, otherwise p cannot be a corner point.

This segment test will then be applied to the remaining parent pixels by examining all pixels in the circle. The pixels used in the corner detection are highlighted as white-colored squares [6].

3.4.3 FREAK (Fast Retina Keypoint) Descriptors

The FREAK (Fast Retina Keypoint) descriptor is motivated by the human visual system or specifically, the human retina. A binary string is calculated by comparing the image intensities. The advantage of a binary descriptors is that the Hamming distance is used instead of Euclidean distance, it is because the computation of hamming distance is simpler than Euclidean distance. The topology of the retina is mimicked for the design of the FREAK descriptor [6].

Programming Steps for Feature extraction

In this section of programming steps of the feature extraction first the steps done isFrangi filter and the images saved after applying Frangi filter step is in the folder named 'Ivessel'.

Then next steps of corner detection, which is done with the help of FAST Algorithm.

The coding steps used in the software is described in this section are for the proposed work of feature extraction of palm print pattern image from the enhanced image.

3.5 Accuracy Calculation and Verification

It is one of the important step and the new work of the proposed work. It is also the further work of the literature discussed in [6]. In this proposed work the accuracy of the feature extraction is calculated with the help of Discriminant analysis and KNN (K-Nearest Neighbor Algorithm). Both are one of a techniques of Supervised Learning of Machine Learning.

In this section we will come to know about the Machine Learning technique and their types of algorithms.

3.5.1 Machine Learning Algorithm

Machine learning algorithm is a type of artificial intelligence learning algorithm which provides computers with the ability to learn without being clear cut programmed. Machine learning emphasizes more on the progress of computer programs that can teach themselves

To develop and change whenever exposed to new data. The technique of machine learning is very similar to data mining. Both systems search through data to look for patterns [29].

Types of Machine Learning Algorithm:

- Supervised learning
- Unsupervised learning
- Semi supervised learning
- Reinforcement Learning

But the most widely used Machine Learning Algorithms use are **Supervised Learning** and **Unsupervised Learning.** Most of the machine learning's about 70% are supervised and10% are unsupervised learning. The remaining two are very less used.

- **Supervised learning**

This algorithm is trained as such using labelled examples where for an input desired output is known. Let's take an example, a piece of equipment could have data points named either 'F' or 'R', where 'F' is for failed and 'R' is for runs. This algorithm receives a set of inputs along with corresponding correct output. This algorithm learns by comparing its correct output and actual output to find errors. It then modifies the model correctly. Supervised learning is commonly used in applications where historical data predicts likely future events.

- **Unsupervised learning**

This algorithm is used against the data that has no historical labels. The system is not told the "right answer." The algorithm must figure out what is being shown. The aim of this algorithm is to explore the data to find some structure within it. Unsupervised learning algorithm works well on transactional data, e.g., it can identify segments of clients with similar attributes who can then be treated similarly in marketing campaigns, or it can find the main attributes that separate client segments from each other.

The Machine learning algorithms along with the types of algorithm and categories of algorithm are shown very precisely in the form of table shown below [22].

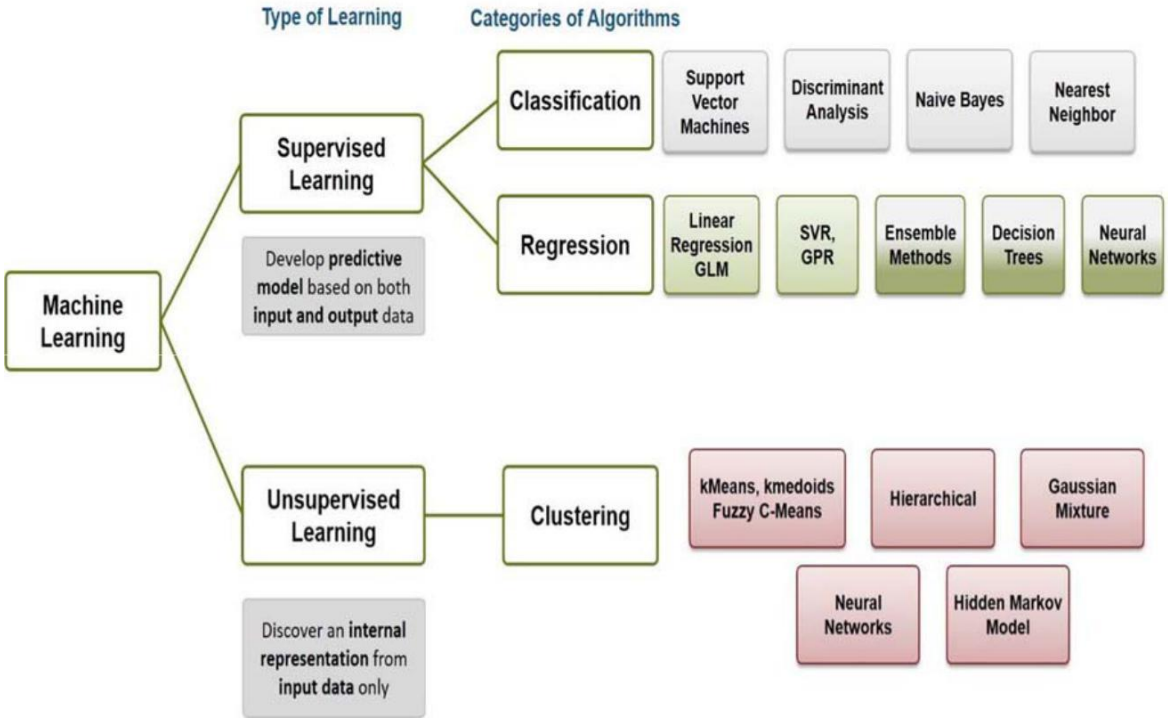


Figure 3.4 Machine learning and their classification [22]

The proposed work used the Discriminant Analysis and KNN algorithm which fall under supervised learning. So let's see about them.

3.5.2 Discriminant Analysis

This analysis technique is a Statistical analysis to predict a categorical dependent variable (called a grouping variable) by one or more continuous or binary independent variables (called predictor variables). Discriminant analysis is used when groups are known a priori (unlike in cluster analysis), each case must have a score on one or more quantitative predictor measures, and a score on a group measure [22].

3.5.3 KNN (K-Nearest Neighbor Algorithm)

In pattern recognition, is a non-parametric method used for classification and regression. It is a type of instance-based learning, or it may be called as lazy learning, where the function is only approximated locally and all calculation is deferred until classification. The KNN algorithm is one of the simplest of all machine learning algorithms.

3.5.4 Naive bayes

The Bayesian Classification represents a supervised learning method as well as a statistical method for classification. Assumes an underlying probabilistic model and it allows us to capture uncertainty about the model in a principled way by determining probabilities of the outcomes. It can solve diagnostic and predictive problems. It calculates explicit probabilities for hypothesis and it is robust to noise in input data.

- Proposed work is done by the use of above described techniques i.e. KNN,naive bayes and Discriminant Analysis. These are the inbuilt functions of the Image Processing tool in MATLAB.

The proposed work in this section call that function for the calculation of accuracy and verification. That coding using the algorithm for the comparison of results of the three proposed algorithm i.e. discriminant analysis, naive bayes and KNN.

- The next and the final step of the proposed work is the comparison between the techniques i.e. Discriminate Analysis, Naive bayes and KNN.
- At the end it has been concluded about the best performing step i.e. is Discriminant analysis, the code of this is shown in figure 3.8.
- The above all the steps have been properly performed and described in this image, now the results will be shown in the next chapter 4.

CHAPTER 4

EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Introduction of MATLAB

The proposed algorithms and the technique have been implemented on Intel CORE at 2.90 GHz using MATLAB version R2014a. MATLAB has the characteristics of all languages features and next generation development platform.Matlab is very suitable for many trades and powerful large scale software.

Matlab has the tools like linear algebra, digital signal processing, control theory, statistics, dynamic system simulation, time series analysis, and many more advance tools. Matlab is very widely and frequently used in designing the study units, industrial development department, and in research & solving specific issues.

Matlab name was MATrix and LABoratory for the starting years. After 7 years, this technology was not enough modern. Moler, SteaveBangert Corporation establish Math Work Inc. in year 1984 and their official market. From now onward Matlab kernel was written in C language.

4.2 Language features of Matlab

Matlab language has the following features

- Programming Efficiency
- Easy to use
- Expansion Capacity
- Statement is simple and rich in content.
- Efficient and convenient and array operations
- Convenient graphics

4.3 Result Gallery

This section consists of results that has been obtained after the proper performance of the research work with the help of previously described tools and algorithm. This section shows the leveled result.

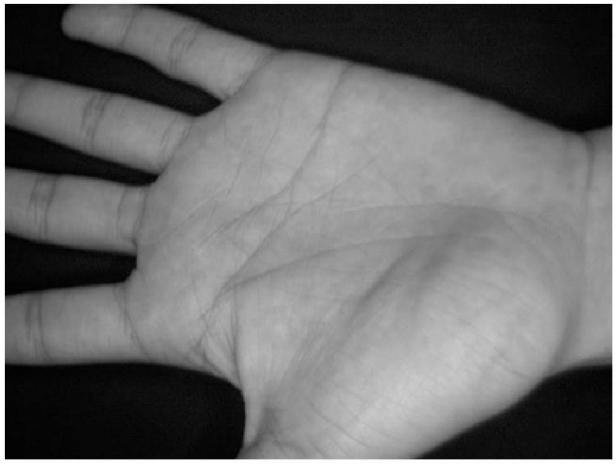


Figure 4.1 Image of palm print acquired using IR sensor

The thesis work is dedicated towards identifying a good level of segmentation and thereafter categorizing the results according to classification technique. In this regard the complete work will be evaluated using different subjects and their respective set of images. Figure 4.1 shows a finely acquired image using a novel sensor. The sensor image indicates that image quality around right side is little distorted or commonly pronounced as image artefacts.

Figure 4.2 Image after binarization using Otsu method

In this figure 4.2, the image will be analyzed using Otsu method. Otsu method uses a simple histogram based cumulative probability approach, the bins calculated in histogram shows a probability value. Using this probability value and identifying a valley in that probability in bins the user will have had to use Otsu method to calculate a unique threshold, using that threshold it is necessary to Binarize the image, if the figure 4.1 and 4.2 are compared the results will tell the reader that image quality in Binarized figure 4.2 is black in the region of interests. Thus image quality will be assessed and improvements will be made.

Figure 4.3 Image in black and white after morphological opening

If figure 4.2 and figure 4.3 are compared then the images are used and Binarized, but the most obvious thing is the quality of image, in this regard the image assessed in figure 4.3 shows a no artefacts in the region of interests drawn by black and white. Thus the purpose of image opening is to remove opening, so that region of interests becomes artefacts free.

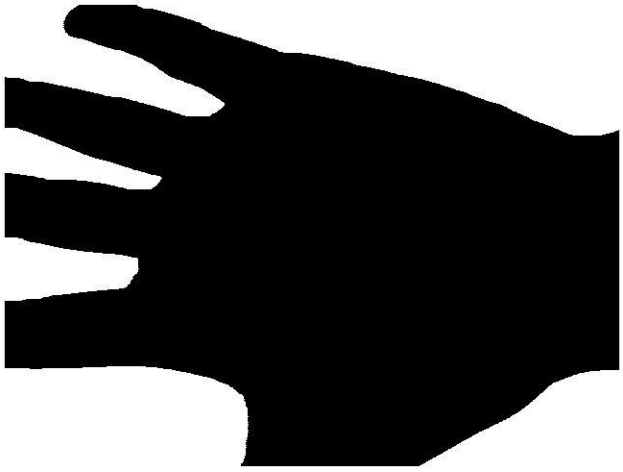


Figure 4.4 Image after complete noise removal.

The existing method of image preprocessing is considered complete when Image noise removal is done. To present such facts figure 4.4 describes this well enough using a image filtering operation. It is commonly seen in this image and when compared with figure 4.3, noise can be seen as small dots of white region, small holes in the white region or the unwanted artefacts in the white region. To better understand the image is correctly and showing them in the figure here indicates that image quality is good enough using a simple morphing operation.

Figure 4.5 Image after complete complementary operation.

In this image the quality of image is done but the figure 4.5 indicates that image will be complemented as the region of interests in only the PALM region which is well perceived. In this image the proper PALM image portion can be seen.

Figure 4.6 Image after edge detection using Sobel filtering

In this figure 4.6 image is further reduced to edges and pixels marked in this image highlights the boundary region of an image. The image will be converted to boundaries using pixel based operation available as a Sobel edge detection method in MATLAB as a function.

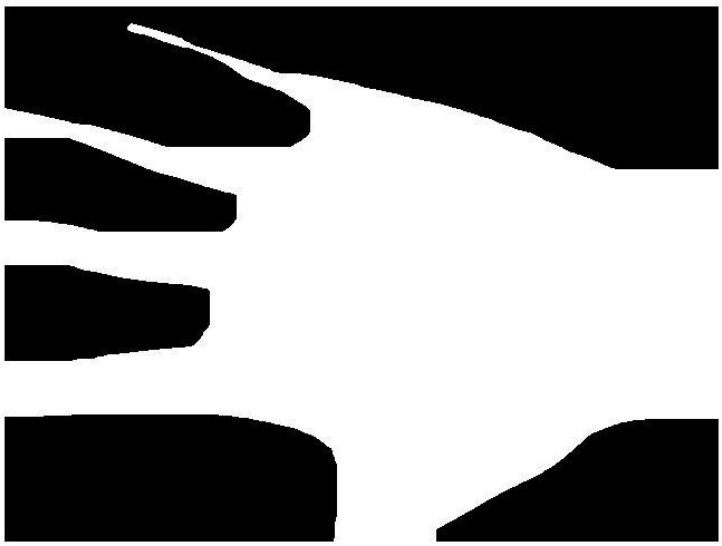


Figure 4.7 Image will be assessed using small subtraction of edge image and morphing

Image will be assessed using a unique subtraction operation using the quality of image using morphological operation and edge image in figure 4.5 and figure 4.6 respectively. The quality of image will be seen here as an outer region will be coming out in this image and the region will be marked and the border must be eliminated.

Figure 4.8 Image after a complete filtering, noise removal and subtraction

Image in figure 4.8 is a good level of pictorization of region of interests. Subjects are using different technique to filter and to remove the images artefacts, but the ultimate aim will be recognize that region which is full noise free and that PALM region is only shown here. Now if this image is considered technically it is also known as mask image, where black region is masks and white region is open region.

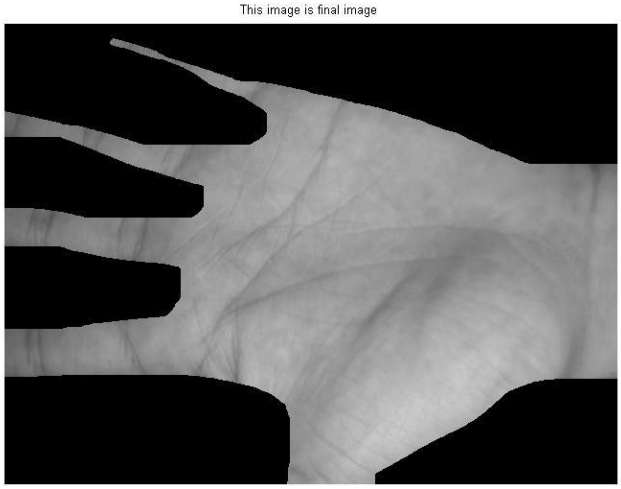


Figure 4.9 Image after final ROI implementation.

In this section of result, the image so obtained is a complete segmented image representation of PALM classed with two regions. The prime region is a region of interests that is labeled here as PALM and the rest of the region is black. This image is a consequence of overlapping of two images, original image in figure 4.1 and figure 4.8.

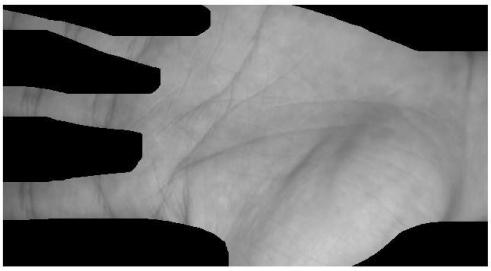


Figure 4.10 Reduced dimension of region of interests.

The aim of this image is to reduce the task of computation complexity and thus by reducing the exact region of image by deleting the nearby background which is not important for the calculation of imperative features.

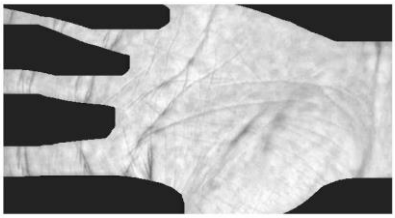


Figure 4.11 Enhanced image of reduced dimension of PALM image.

As a user is primarily concerned with the image which is high in quality and thus the calculation so done will be highly separable if the image obtained in figure 4.10 could be made more brightened. In this regard the research work has suggested that if the image quality is not good after all preprocessing steps, then increasing the contrast by applying a local histogram concept commonly available as function of MATLAB image processing as adaptisteq.

This is the final stage of Image Enhancement section, hear the image is enhanced.

Subject 1 Image 1 feature	Image 2 feature	Image 3 feature	Image 4 feature
198	199	95	77
132	103	193	3
83	11	193	7
29	18	155	229
53	196	70	108
3	67	128	1
192	93	64	68
3	66	19	1
46	197	0	1
133	222	72	3
89	227	5	196
21	243	135	3
211	251	36	195
200	65	129	215
7	19	195	197
94	71	200	196
135	1	149	249
211	65	34	163
4	18	162	27
163	108	131	195
250	1	197	165
4	236	67	86
204	22	69	131
123	81	79	67
251	33	133	88
195	143	1	42
172	1	194	6
254	67	193	169

18	164	77	7
199	3	195	216
139	242	87	203
3	131	108	5
201	71	108	5
208	1	69	145
35	229	201	93
42	216	206	113
0	69	134	219
6	227	71	133
67	137	167	213
164	66	7	75
142	29	4	193
64	82	195	2
78	1	74	5
69	56	0	220
92	171	27	5
193	9	135	252
67	60	139	203
64	197	88	37
3	206	167	157
135	248	71	65
199	67	200	203
210	227	5	7
64	197	196	197
123	254	16	129
57	19	226	13
135	7	1	11
129	7	141	1
1	174	3	197

5	34	58	69
3	98	1	3
225	202	195	82
97	139	0	3
253	225	133	229
235	67	124	195
65	197	44	194
251	156	110	100
209	233	141	216
193	71	211	55
101	225	87	222
136	249	20	195
1	152	2	199
195	132	68	1
250	252	35	3
6	65	122	208
65	7	11	169
221	254	197	2
151	135	227	2
225	5	65	161
99	69	193	35
71	5	86	214
71	173	69	6
163	76	128	196
67	78	65	193
3	145	66	131
69	135	67	224
65	198	251	31
7	68	92	28
169	39	131	180

7	69	71	132
71	68	169	197
3	204	252	202
203	207	1	179
195	137	193	197
69	203	194	3
3	234	193	195
131	85	85	195
69	1	102	248
71	199	140	195
1	68	32	5
94	71	0	193

Table 4.1 Features of Subject 2.

This table is drawn to show case the number of subjects selected shown by number of columns, here the number of images will be 4 and for each subject 100 prime features are used. If calculations are traced the features are evaluated using freak method and FAST detector for corner detection.

4.4 Accuracy Calculation and Comparison between techniques

In the present section it will be the presentation of result accuracy of the research work and at the end the comparison result will be shown with three different algorithms i.e. with Discriminant Analysis, naive bayes and other one is KNN.

4.4.1 Accuracy calculation

In this section the result accuracy will be calculated with the help of the algorithm used of Machine learning's supervised learning. The techniques of supervised learning used in the research work are Discriminant Analysis, Naïve bayes and KNN.

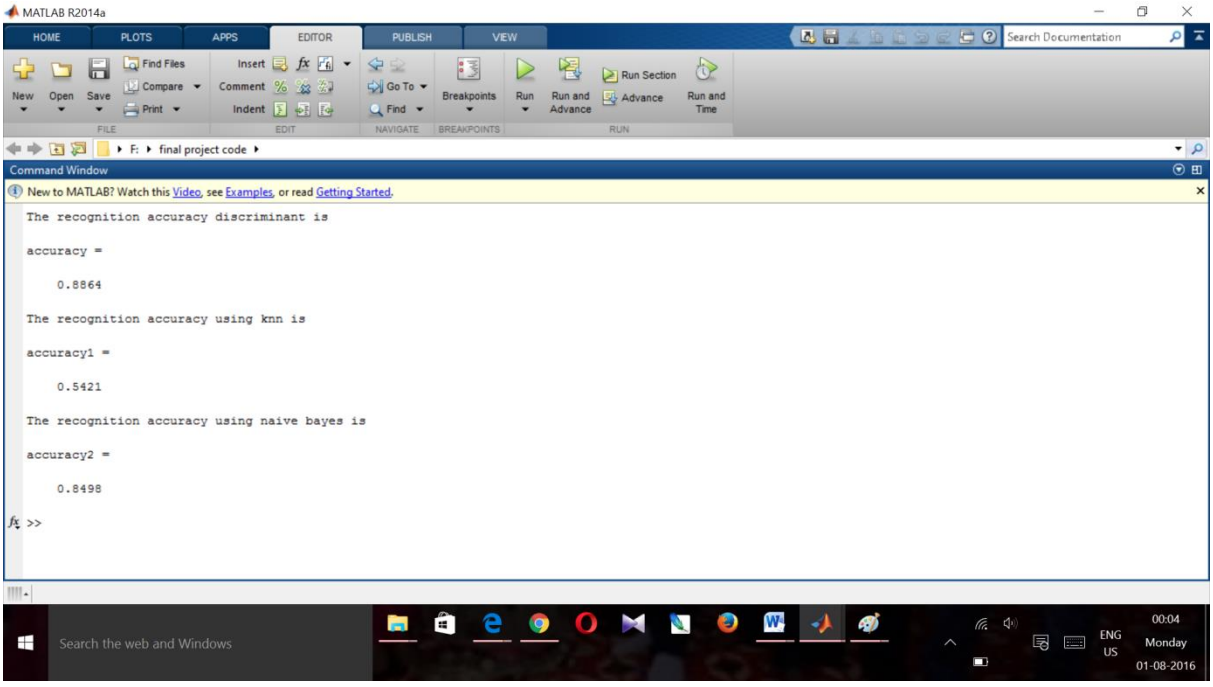


Figure 4.12 Screenshot of the accuracy calculation of the work

Figure 4.12 shows the accuracy of three methods which is used. The accuracy obtained from the KNN technique is 54.21%, whereas accuracy calculated from other technique, Discriminant analysis is 88.64% and naive bayes have 84.98%.

4.4.2 Comparison of Accuracy

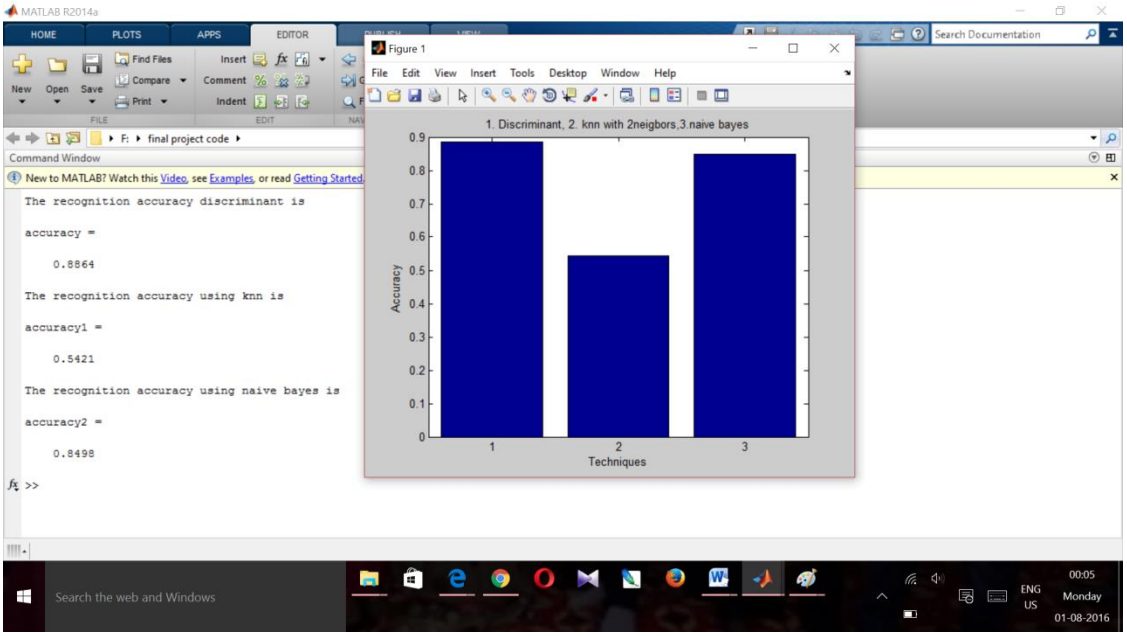


Figure 4.13 Recognition accuracy of three different methods.

The above figure 4.13 shows the comparisons between two techniques used in the work for the calculation of accuracy of the features abstracted from the images of palm print patterns of the given subjects. The techniques used is 1) Discriminant analysis of Machine Learning algorithm, and 2) KNN (K-nearest Neighbor Algorithm). (3) Naive Bayes.

The accuracy obtained from the KNN is 54.21% whereas from Discriminant analysis the accuracy obtained is far more than KNN i.e. 88.64%. And from naive bayes is 84.98%.

4.5 Result Discussion

The comparison of results obtained from the research work is well described in the section 4.4. This section well discuss about the accuracy calculation result and the comparison of three techniques. Accuracy of the features of human palm print patterns have been derived in this proposed research work after enhancing the acquired images of different subjects obtained from the open data source [1].

From the technique Discriminant analysis the accuracy obtained is 88.64% whereas when it has been tried to improve the accuracy with the help of some other technique it had been got that the accuracy obtained from the present technique is best. The comparison made from the other technique is KNN algorithm of same supervised learning technique. From this KNN technique the accuracy obtained is far less from the proposed technique i.e. 54.21% and accuracy obtained from naïve bayes is also less than proposed technique i.e. 84.98%.

The discussion of the result and accuracy is very well described by the above given two figures (figure 4.12 and figure 4.13). For better comparison following table is presented.

Comparison of all three algorithmic results

Methods	**Accuracy**	**No of Observations**
Discriminant Analysis	88.64%	17
K-NN	54.21%	17
NAÏVE BAYES	84.98%	17

Table 4.2 Comparison Table

The above table shows the comparison between the results/ accuracy obtained from the algorithms used in this research work. From hear we can easily compare and find the better result.

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

In this proposed work two algorithms Discriminant Analysis, Naïve bayes and KNN is used for the accuracy or result calculation.

This accuracy is calculated from the human palm print patterns features which has been already extracted from the enhanced images in this work. The accuracy calculated using Discriminant Analysis is 88.64%, by using Naïve bayes is 84.98% and by using KNN is 54.21%.

By seeing above accuracy we can compare all three techniques and find the best method and conclude that Discriminant analysis is the best technique to calculate the accuracy of palm print pattern's features.

5.2 Future Scope

In this era of smart systems it is very tough to make secure our assets or data from the smart devices like mobile phones, laptops or tablets. Every now and the then we can hear the news about the hacking of online bank accounts, debit cards and credit cards of some particular person.

By increasing forgery systems it has been needed to make our security system smarter and reliable. Although we do have many reliable and secure system developed but still it's not so secure.

So with the help of this research work we can develop a new biometric system which is more reliable. The palm print pattern biometric system can be developed as the GUI (Graphical User interface) for mobile devices, laptops and tablets so that it can be used for any operating system for security purpose. This system can also be used in the ATM machine for the security of personal account. This system can also help in removing debit

Or credit card system from our daily life instead palm print acquisition system can be developed and used for detection of personal account in ATM card and/or during shopping. A new hardware or implementation on FPGA (Field Programming Gate Array) can be done as the future work or scope. This palm print pattern recognition system can also be added in our UId card/ Adhar Card to make it more secure as Adhar card has started to spread its wings in almost every sector in India. Government of India has stretched its use in many sectors like banking system, providing subsidies to the people, and providing wages to MGNREGS (Mahatma Gandhi National Rural Employment Guarantee Scheme) employees and many more schemes. So due to these reasons our Adhar card should or can be more secure.

As this system is one of the prominent, secure and reliable biometric system so this has the broad area of future scope because every security system requires the security. There may be many more areas or sectors where this system can be used and it will be more useful and beneficial after its hardware implementation.

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