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ISTANBUL AYDIN UNIVERSITY

INSTITUTE OF SCIENCE AND TECHNOLOGY

AUTOMATIC PALMPRINT RECOGNITION

M.Sc. THESIS

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Department of Electrical and Electronics Engineering

Electrical and Electronics Engineering Program

October, 2019

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DECLARATION

I hereby declare that all information in this thesis document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results, which are not original to this thesis.

Eng. Fathiya EGREİRA

my husband and children,,

FOREWORD

To my supervisor, Assist. Prof. Dr. Necip Gökhan KASAPOĞLU. Without his persistence, target settings, and belief in me this would never have been finished. Thank you!

I would also like to take the opportunity to thank the IIT Delhi University for their gracious help providing their database for my use.

Lastly I would like to thank my husband, Abubaker Emheisen. Without his support and encouragement I would never have managed to combine family life and University at the same time.

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LIST OF ABBREVIATIONS

BR   : Biometric recognition
FR   : Face Recognition
DFT   : Discreet Fourier Transform
SR   : Speech Recognition
FE   : Features Extractions
WT   : Wavelet Transform
GF   : Gober Filter
FP   : Finger print
PR   : Palm recognition
LM   : Local maxima
PL   : Principle lines
PP   : Palm print
WR   : Wrinkles removing
CLPR   : Contactless palm recognition
PI   : Personal identification
MSE   : Mean square error
MAE   : Mean absolute error

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OTOMATİK AVUÇ İÇİ TANIMA

ÖZET

Güvenlik sistemlerinde, özellikle kötü amaçlı erişimlere karşı hassas veri koruma konusunda biyometrik tanımaya olan ilgi artmıştır. Gizlilik içeren kişisel veriler üzerinde yüksek düzeyde kimlik doğrulamayı zorunlu kılmak için büyük ölçüde kullanıldığı görülmektedir. Biyometrik tanıma sistemleri üzerinde yapılan araştırmaların başında; parmak izi, yüz tanıma ve diğer benzeri biyometrik ses tanıma işlemleri gelmektedir. Yukarıda belirtilen sistemlerin çoğunda, biyometrik izler yaş etkilerine daha yatkındır, büyüyen ve yaşlanan bir insanın yüzünde oluşan kırışıklıklar yüz hatlarının değişimine sebep olurlar. Benzer şekilde parmak izi, yaş etkileri nedeniyle kademeli olarak daha az belirgin hale gelebilir veya yaralanmalar veya incinmeler nedeniyle bozulabilir. Avuç içi tanıma, biyometrik tanımanın başka bir alternatifidir. Yaşın avuç içi yapısını gerçekten etkilemediği, zamanla değişmeyen biyometrik iz olarak bilinmektedir. Aynı zamanda sabit kalan ve avuç içi kimliği olarak kullanılabilecek ana hatlar gibi özellikler içermektedir. Bu projede avuç içi tanıma sistemi, kişisel kimlik tanımlama aracı olarak önerilmiştir. Çalışma, avuç içi üzerinde ilgi bölgesini etkin bir şekilde elde etmek için gelişmiş özellikleri ayrıştırma yöntemini içermektedir.Çalışma IIT Delhi el-avuç içi veritabanı kullanılarak gerçekleştirilmiştir. Çalışma sağ avuç içi tanımaya dayanmaktadır. İlgili bölge, avuç içi konturu üzerinde birden fazla geometrik noktaya değinilerek mümkün olan daha yüksek hassasiyette kırpılmıştır. İlgili kırpılan bölgenin her pikselindeki renk derinliğini analiz etmek için piksel piksel analizi ile ilgilenilen her kırpılmış bölgeden özellikler incelenmiştir. Ayrıca edinilen özellikler derin öğrenme sınıflandırıcıları kullanılarak sınıflandırılmıştır. En Yakın K Komşu, Rassal Orman, Temel Bileşenler Analiz ve İleri Beslemeli Sinir Ağı, yukarıda belirtilen özellikleri kullanarak eğitimden geçtikten sonra kişisel kimliği tahmin etmek için kullanılmıştır.Tanıma doğruluğu, her bir sınıflandırıcı ile değerlendirilmiştir ve bununla birlikte, İleri Beslemeli Sinir Ağı Sınıflandırıcısı, diğer sınıflandırıcılara kıyasla daha iyi performans göstermiş olup %81,25'lik bir tanıma doğruluğu sağlamıştır.

Anahtar Kelimeler: *avuç izi tanıma, En Yakın Komşu, Rastgele Orman, İleri Beslemeli Sinir Ağı ve Temel Bileşen Analizi.*

AUTOMATIC PALMPRINT RECOGNITION

ABSTRACT

Biometric recognition has gained extended attention in security systems especially in sensitive data protection against malicious accesses. It was seen greatly deployed to enforce high level of authentication on personal data where privacy is demanded. Research on biometric recognition systems begins with finger prints, face recognition and other biometrical alike voice recognition. In most of the aforementioned systems, biometrical taints are highly susceptible of age effects more likely, wrinkles are developing where person grow in age and that causes to change the face taints. Similarly, fingers print can fade out gradually due to age effects or it can be corrupted due to injuries or wounds. Palm recognition is another alternative of biometric recognition; it's known as time invariant biometrical taint where age is not really impacting the palm structure. It also contains features such as principle lines which remain constant and can be used as palm identity. In this project, palm recognition system is proposed as personal identification means. Study involves enhanced features extraction method for efficiently obtaining Region of interest on the hand palm. Study is performed using IIT Delhi hand palm database; study relied on the right-hand palm recognition. Region of interest is cropped in higher possible accuracy by refereeing multiple geometrical point on the palm contour. Features from each cropped region of interest by pixel to pixel analysis which attempts to analyze the colour depth in each pixel of the cropped region of interest. Furthermore, the acquired features are classified using deep learning classifiers. K Nearest Neighbour, Random Forest, Principle Component Analysis and Feed Forward Neural Network were used to predict the personal identity after they trained using the extracted features as aforementioned. The recognition accuracy is evaluated with each classifier and however, Feed Forward Neural Network Classifier is outperformed as compared to other classifiers, it yielded a recognition accuracy of 81.25 percent.

Keywords: *palmprint recognition, K Nearest Neighbour, Random Forest, Feed Forward Neural Network, and Principal Component Analysis(PCA).*

1   INTRODUCTION

1.1   Preface

Personal authentication is termed to the tasks which keen on recognizing persons, such technology is propagated from ancient centuries more likely Greek where a unique hair style and dress code were used to recognize novel people [1]. The authentication process is begun in new centuries using the so-called key to access particular places where personal authentication is needed [2]. Technologies of authentication are developed with time so that many alternatives to mechanical keys are introduced. A digital security system was used to provide more reliable authentication for accessing the sensitive places.

Digital locks were implemented by using a keypad for in source the security code to the system. Password based security systems are ensured some advantages over the mechanical systems; it dose prevent the problems of key misplacing or even key roping. However, with development of data science, personal identification was not behind the development [3]. Authentication process involves using the double check points (multiple check points) to verify the identity of the person.

That can be seen in applications that contains sensitive data or high level of privacy. Multiple check points involve using the mobile number and email address as supplementary means of verifications. A random generated code might be sent to the registered mobile number (or email address) of the person upon any attempt of accessing his data. With more development of authorization systems, biometrical features of the person are used to ensure the physical presence of the authorized character at the time of accessing high private data [4].

Biometric is essential to recognize the personal identity as a method ensures only actual person and concern person in the place of interest. This technology tackled the problem of password snooping and in turn tackled the issue of missing the keys (in case of mechanical lock system). Biometrical features are categorized into eye recognition, voice recognition, finger print and lately, palm recognition. The more

reliable personal identification systems are keen on identifying the time invariant biometrical features.

Hand palm is including features which acts as permanent and not impacted by age of human. Usually, some other parameters such as face biometric recognition, voice recognition and finger prints are highly affected by age, so system using that technologies may need to be upgraded every frequent. The upgrading part may include reimplementation of entire system as the dataset will be updated with new features corresponding to the current age of the candidate, the who features extraction process might get changes [5].

Palm recognition is considered as reliable alternative of the face recognition which highly affected by age as human face is differing on each ten years of his age as per some researches recently conducted [6].

1.2   Problem Statement

The availability of various method of personal identification such as finger print and eye recognition as well as voice recognition is not dispending the need any of it. each means of biometrical recognition may be perfect in its application, knowing the fact saying that each application has different requirements of authentication systems. Literature survey has shown that privacy enforcing methods can be implemented using multi-model of personal identification more likely, eye imprint and voice imprint at the same time.

The only considerable point is the cost of implementation, multi-model recognition system is experiencing a large computation cost and hence bigger processors and powerful computers might be needed. The researches to identify a method of personal recognition that remains reliable and implantable in reasonable cost is endless. So, many alternatives are found in this interest. Palm recognition system is made to derive a consistence and cost-efficient recognition system.

Some of previous studies where recognition system is implemented using a fingers imprint, it was realized that fingers print is highly time varying and the taints of that print might be fade out with time so it can't be depended as robust features. As per the previous studies, palm features are less susceptible to external performance degradation factors such as palm colour changing due to sun and wounds or

scratches as it happening in fingers. The critical problem of performing palm recognition is the region of interest detection.

The experiments and previous studies have shown that region of interest location error may cause large degradation in the performance of palm recognition paradigm. It is also realized that gap between the scanner (acquisition device) and hand is also one of the degradation factors of recognition performance.

Some researchers suggested using a time independent features that targeting the structure of palm veins. It was realized that special setup is required to acquire that photos (near infrared sensors and special camera), so it is not always possible to perform recognition by veins structure recognition.

1.3   Objectives

In this project, palm recognition system is proposed to recognize the different palms collected in IIT palm database. Since hand palms are varying from each other by color, size and structure; the recognition task is posing great challenge. It was also realized that few attempts are made in the literature for deploying the machine learning technologies in palm recognition. Accordingly, the following objectives are pledged by this study as achievements.

1. Implementation of smart image preprocessing machoism to remove the associated image noise and other interferences such as background objects.

2. Image preprocessing to include the so-called image normalization in order to reset the orientation of all candidate's data (images) into a known reference pinch mark.

3. Region of interest has remained a dispute for different types of image data, so-to-say, region of interest to be cropped efficiently and uniformly for all the database candidates.

4. In order to evaluate the worthiness of features extraction particularly the region of interest extraction, accuracy calculation to be evaluated. High accuracy of region of interest is expected.

5. As region of interest is cropped within the permitted level of accuracy (to be uniformly cropped in all the images), pixel to pixel analysis is to be performed as an attempt to analyze the region of interest colour depth as a way of recognize them.

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This method is generalizing the features of palm by combining the principle lines with color depth to formulate the final features vector.

6. Machine learning algorithms to be employed for mapping the features into their particular identity. Three deep learning algorithms to be used more likely Random Forest algorithm, K Nearest Neighbour (KNN) algorithm and Feed Forward Neural Network (FFNN). A method based on principle component analysis (PCA) is also applied palmprint database as a baseline method to make performance comparison..

7. In each mentioned algorithm, performance is monitored using the following metrics: Mean Square Error (MSE), Root Mean Square Error (RMSE), Accuracy, Time and Mean Absolute Error (MAE).

8. Highlighting the optimum machine learning algorithm and PCA in mapping the features into their accurate destination among the other proposed algorithms. In this, the following metrics are to be depended and recoded: high accuracy, lower Mean Square Error, Lower Mean Absolute Error and shorter time.

1.4   Thesis Organization

This decertation report is made to detail the implementations of the palm recognition system and to reveal the achievements and discuss the results. However, this report is containing five technical chapters which begins with chapter one that entitled as "Introduction" and contains the preface of the project and general idea of biometrical recognition systems. Problem statement is made available in this chapter along with the objectives of this research.

The report is propagated to chapter two that is entitled as "Literature Survey" which contains most recent research activities conducted in the interest of palm recognition.

Furthermore, chapter three made to reveal the methodology used in this implementation and all the steps of designed prototype. This chapter is entitled as "Methodology" and discusses the prototype structure and the way of its implementation, it details the machine learning role and PCA in delivery of higher recognition accuracy.

The results achieved after implementation the model are made available in chapter four which is entitled as "Results and Discussion". The last chapter would be the Conclusion which describe the model strength and summarize the results and achievements. The last part of this dissertation would be the references and publications which enlist whole the references that helped to construct this thesis.

2   LITERATURE SURVEY

Identification systems are essential to enforce privacy and security criteria on any organization. Traditionally, various identification methods (means) are being used to allot authentication of particular people for doing specific tasks. It was beginning with using keys to access particular places and hence it has developed to used PIN (passwords). The aforementioned traditional means of authentications are suffered from several drawbacks such as losing the key (in case of key locks) or even likely to forget the PIN (passwords). Further, password protected organizations are likely susceptible to hacking or crackers where this password can stand for full safety or protection[1].

This study proposed the use of biometrics as alternative and effective technology of privacy enforcement. Authors defined the so-called biometric identifications as a means or method that deploy the permanent and very personal parts of the human body in recognition process while authentication tasks. Such organs can be eye imprint, voice imprint, face recognition and palm recognition.

This approach , is proposed a palm recognition system as personal recognition system which is basically determines a features of palm image that recognizes the humans. It is said that; each palm has unique features useable in distinguishing the people. The system introduced in this study is merely relying on image processing techniques to determine palm features. By using a sixteen reference points taken in the palm image, palm geometry can be evaluated; said by the authors. A good recognition rate is derived in this approach but the main drawback is likely the reference points cannot actually determine the hand geometry if at all any of hands was in different angle. Palm rotation degree is vital to the success of such project[1].

Another study is made for deployment of palm in personal recognitions in places such as airports, machines such as ATMs and crime investigations. Author mentioned that palm consists of essential features make it fit enough for users' identifications. Features a like main lines of palm, delta points, minutiae, wrinkles and ridges are considered as rich sources of features over the palm[2].

This study involves capturing of palm images using a scanner (traditional paper scanner), where each candidate is being asked to place their right palm on opened laid scanner. The laid is left opened in order to ensure black background in all captured images. The images are treated using a line curved method and directional algorithm in such way image is scanned in all directions in order to set a corner point. As soon as these points are detected from the said palm; the region of interest is defined and hence features extraction is began.

The region of interest is divided in forty-one sub-blocks and each block is studied for pixel intensity measurement by determining the standard deviation of each block's pixels. Further, features vector is formed by those standard deviation value (forty-one for each image). Study involves comparing the features from each image to evaluate the similarly rate. No recognition rate is mentioned in this approach.

This study involves palm recognition of occluded hand more likely hand with gloves. For first instant, hand edges are detected and then figures widths are calculated. For hand with gloves, width of figure is always not similar to the normal palm image, for this reason, the obtained width is scaled down by a factor in order to get as accurate as possible geometry[3].

Hand features are calculated using the colour depth or each pixel and hence different classification algorithms are used for evaluate the matchings between the test object and database contains. Algorithms such as Random Forest and K-Nearest Neighbour are used in this study and author is mentioned that good accuracy rate was obtained. The data used in this study is considered as surgical data as Kinect sensor is used for capturing a deep penetration information from the palm. As those data are obtained using the Kinect sensor, the biometrical features are extracted from that using the geomatical calculations as aforementioned.

Authors mentioned that biometric recognition is outperformed over the conventional methods of identification due to the raises in information security in current days. In this study, authors proposed a none invasive approach of data acquisition using the information of veins structure in palm area. The vessels of blood under the palm skin is forming unique structure in every person which make it a rich source of features for identification purpose, at[4].

As any other similar paradigm, image processing is beginning with image segmentation to cut the region of interest only and to remove the wrist visible part and fingers parts from the image. Hereinafter, images tops and valleys are identified and ultimately image is normalized. The study relies on fusion techniques features to enhance the vessels image recognition. Authors mentioned that error rate of their proposed paradigm was equal to thirty six percent only.

This study emphasis to evaluate a simulation of hand movement to help the sign language speakers. This study involves features extractions from the moving hands and then apply those features as movement commands to a three-dimensions shape (avatar). This study aimed to modulate the palm actions (movement) in order to simplify the life of people using the sign language. The main goal of this study is to predict the Hamburge sign language symbols and notations, at [5].

Images of hand is captured using device called Kinect (a product of Microsoft. Another software is used to connect the Kinect device with Matlab (for compatibility support) called as OpenNI library. The data from this device are generated as Red, Green and Blue bands image and directed to the Matlab where palm recognition process is made. During the image processing phase, hand edges are detected and process to evaluate the plane of the palm is initiated. The resulted data are used to move special avatar (animated body) which may express the hand palm movement produced from palm analysis in the real-time image.

Author mentioned that personal identifications (authentication) advancement involved relying of biometrical uniqueness such as voice signature, palm features and many similar parts of body. The current advancement of palm recognition that been focused in this study was about development of unique biometrical recognition system relying on blood vessels characteristics recognition on the palm at [6].

Hand palm recognition impression, if any was used for identification purpose are considered as time variant features which might be partially fade out within time. Some biometrical characteristics of human such as face or fingers are highly susceptible to age effects such as wrinkles which make it not suitable for permanent personal recognition system. Such biometrical characteristics might be upgraded in the recognition system at every age of person. In this study, vessel characteristic is said as permanent features that not changed by time and remain same for the entire life of human.

Study is proposed to wrist wearable device to monitor fingers motion. The study is made to fulfill the hand motion recognition which considered as vital field in human computer interface. This motion is detected using a wearable hand glove and placing a five IR light emitting diodes surrounds a camera. The camera is sensing the reflection of the IR rays from the glove and hence fingers motion is simulated. TTRPP algorithm is used for processing the captured images from the hand's fingers motions. The images are firstly preprocessed by removing the background information and then image object (upper) contour is evaluated in order to evaluate hands motion. The results of this study revealed by the author has shown four different thumbs to fingers hand motions are detected. A computer program developed using java platform is made to virtualize the outcomes of this paradigm. All real-time hand gesture (thumb-to-finger) motion are made at [7].

The approach proposed to depend palm as fundamental means of biometrical recognition is based on the fact that another biometrical recognition means such as fingers print are more susceptible to cuts or wounds. This makes the fingers unfit for long term biometrical recognition. Palm is relied in biometric recognition due to their robustness and rich time invariant features such as principle lines. This study involves a method for principle line detection which detects the plan lines according to their directions at [8].

This approach keeps track of hand lines according to direction calculations. One other technique is used for implementing the strategy palm feature extraction. It uses four filters (masks) to generate four different images from the original image. Features are extracted from each image by calculation of variance and standard deviation which become as unique feature of every image.

Region of interest in palm image recognition is vital step for successful recognition, it is however accurately required in each palm recognition project. Region of interest must be located and cropped identically (same area) in all the images within the database. Region of interest is vital for successful features extractions and hence it is vital for accurate palm recognition. In this study, several approaches were proposed for region of interest detection; more likely, centroid and radius method. The terminology of centroid involves detection of palm central point. The maximum radius from the center is obtained and hence this is considered as region of interest at [9].

This study is obtained a unified region of interest for all the images of the dataset. The region of interest is made with one-hundred and twenty-eight pixels width and same as a height. Further, the subtracted images are analyzed to detect the blood veins under the hand skin.

Another approach is made to recognize the hand palm by conduction a set of statistical calculations. The said palm is firstly acquired using a charged couple device (CCD) and then all the acquired images are preprocessed to remove the extra information such as background objects. The key points of performing the so-called statistics is detecting the palm object contour at [10].

Eight parameters are obtained after performing the statistical calculations and considered as palm identity; as per the author, such parameters are not same (differs) from hand to hand and unlikely can be a common amongst hands. The set of statistical parameters mentioned by the author are: thumb finger width, middle finger width, ring finger width, palm width, fore finger width, length of thumb finger, length of ring finger and length of middle finger.

The results of this study are said to be reliable as these parameters are not unique for every hand and even if one of more than one parameter of this set is identical for some hands, all cannot be identical (similar). In other word, if at least one of those eight parameters differ while comparing two palms then it means that two palms are not similar (not related to the same person).

 The large-scale development in data science posed a challenge of information security. It required an approach to act against steeling of data by autonomous. Author replayed the fact that human have some uniqueness in terms of biometrical features that can be used as paramount identity of them. Such parameters (features) can be detected from human unique biometrical structured organs such as eye recognition, face recognition, voice imprint and by palm recognition at [11].

The infrastructures of this study are about recognition of hand palm by analyzing its under skin blood veins. Author believes that features extracted from blood veins at hand palm is hundred times more than features of finger print. More specifically, veins recognition is dealing with time invariant features which enhances the recognition system reliability for long term.

This study employed the hardware-based learning approach that can be trained with several palm images captured by small camera. The hardware paradigm is using neural network to perform palm recognition base on veins structure. It was realized that author used several performance metrics such as epochs number, training time, number of correct decisions and number of wrong decisions.

The study keens on interpretation the ancient manuscript found in caves of Indonesia and Thailand. Hand palms are found printed on tree leaf which is considered as source of data (database). This kind of project may consider the degradation of the image quality (palm image quality degradation where the baselines of the palm are not clearly visible) as it was made long time ago (deployed to hundreds in years back) at [12].

The process initiated in this study is targeting recognition of glyph transliterated on the leaf manuscripts; the process is beginning with image segmentation and then glyph recognition. The glyphs are being recognized by spatial prediction of them on original manuscript. Five different patterns are being recognized from the glyphs according to their position (spatial) pattern in the manuscript. The study proposed for tackling the difficulties that might be faced by the researchers in interpretation of the ancient manuscripts. A translator which acts according to the information from transliteration engineer may convert the glyphs into roman text.

Author have mentioned that matching the test sample with particular database contains is challenging in palm recognition projects. The paramount concern of such projects is to identify the features that capable to discriminate the samples efficiently. Author mentioned that features of same samples may show some level of mismatching and features from different samples may show higher level of mismatch. Known of the aforementioned fact, once can understand that features of particular sample are susceptible to some changes alike dusting of images, wounds, some kind of diseases and etc, at [13].

Furthermore, human age is directly impacting the palm in terms of skin structure. Features according to this study is composed into two categories more likely, palm print related features which are mostly a geometrical calculation of palm and Alpha point; furthermore, those features which is related to palm nature such as datum and principle line features. This study employed a hierarchical combination of palm natural features and geometrical features to recognize the palm print for different test

samples. The designed paradigm is falling into two stages, more likely detection of palm print and verification of palm print.

A new study is made to use spectrum analysis for identifying the palm spatial information. The system was made for segmenting the image (palm prints) into smaller bands (segments) and them spectrum analysis is made on those segments. Fourier transform is used to convert each segment pixels into frequency domain. The method of spectrum analysis within the segments of palm image is provided a large knowledge about palm features, at [14].

In this study, principle Component Analysis is proposed to obtain image classification after producing spectrum information(data) from the image's segments. Author mentioned that proposed method provides high resolution result in quicker time as compared to other presented algorithms. Commenting of the palm features, author mentioned that palm principle lines are remained stabled for entire life of human; he added; that principle features might be scattered due to wrinkles and ridges development.

hand palm is enriched with prominent features that less susceptible to colour variation due to external effects (i.e. sun light). It is also not experiencing a growth of hair which may act against features extraction. This study promoted using the structure of palm's veins (growing user the palm skin) as personal identity ,at [15].

The method of acquiring the palm veins image is quite uneasy, unlikely the way of acquiring a normal palm image (i.e. using a cameras). They method of veins image acquisition is depending of the idea of infrared waves observation by hemoglobin of blood. Known the fact which is saying that two different kinds of hemoglobin are presented in the blood, more likely the oxidized hemoglobin and deoxidized hemoglobin. As blood is carry oxygen to different body tissues using hemoglobin travelling by veins and in the same time the deoxidized hemoglobin is transported from the tissues to the hart by means of arteries.

The method used in this study involved detection of reflected near-infrared waved from the blood veins (around 760 mm near infrared wave length can be observed by blood veins and the rest is reflected to special screen where it can be used for recognition. Unlikely, the blood arteries (which hold the deoxidized hemoglobin) are

not observing any amount of those waves, so it can not be detected and used in recognition).

This study is basically deployed multi-dimensional features vector to identify the palm print recognition. For constructing such vector, features of palm figure joint widths and palm print width are detected from each hand. First of all, images are captured more likely one-thousand and fourteen images captured from one-hundred and thirty-two subjects, at [16],.

Image normalization was done using the discreet wavelet transform and hence features are extracted using the support vector machine. Author mentioned that his experiment was outperformed in terms of palm detection accuracy. He said that 89 percent of detection accuracy was obtained from this paradigm.

In this approach, solution was produced to decorrelation of high order data that corrupting the quality of features extractions schemes. author deployed independent principle component analysis for tackling the third, fourth and above order features. Naturally, pixel to pixel processing in image recognition is quite difficult due to high processing power requirement, at [17] .

In order to solve the problem of long processing time and high processing power, data dimensional reduction is commonly used in context of image processing. The reduction of data is involving selection of particular pixels (in image processing) that dominate the maximum features and dispense the other data that may not reveal a lot about the image. Some data may reveal same information (duplicate information) about the image, in such circumstances, unique data should be shortlisted to prevent unnecessary processing cost and this is the definition of dimensional reduction of image data. Assuming the image is consisting of matrix of pixels [x y], where x is the number of rows and y is the number of columns, reduction in image's dimensions is about vomiting the columns and rows that not reveal essential information in particular interest (purpose of project).

Since world tends to use biometrical taints as personality identification means, palm recognition was one of those taints that attracted many of researchers to analysis it, said by the author. Particularly, palm recognition accuracy is directly related to the region of interest selection as explained in aforementioned researches. In this study, author mentioned an essentials fact critical to palm recognition accuracy, at [18].

The hand placement of the palm scanner must of within the boundaries, as hand displacement on the scanner can directly affect the accuracy of region of interest detection and hence, it will produce different region of interest that not identical to those regions of interest in the database. That generates different feature's vector which case serious performance malfunctioning.

This study proposed to produce a region of interest from the captured hand palm and hence to remove the scratches and other obstacles from the palm image and then image is segmented into smaller segments which will be used for recognition work.

Author mentioned that many previous research activities were conducted in fever of features extraction and region of interest accuracy. However, palm recognition is found in two different platforms, more likely, contact acquisition system and contact less acquisition system. The first platform involved capturing the palm image by placing the hand directly on the scanner. While the second platform is named as contactless, it involves placing the hand on distance from the scanner and scanner is usually being a camera in this platform, at [19].

This study is keen on discovering the impact of hand distance from the scanner in contact less palm recognition system. It uses a low resolution, wide angle camera to detect palm image and hence it aims to derive the impact of distance variation between the hand palm and the camera. A constant stable light source is used to provide a constantly distributed illuminated image. Results revealed at the end of this study shown that small separation between the camera and hand palm is resulting a better resolution in palm recognition comparable to recognition of large separation between camera and hand.

This study interests are enhancement of current biometrical recognition systems by designing multimodal barometrical attributes that participate the accuracy level of the recognition system. However, multimodal recognition system is functioning by gathering the features from different sources (such as finger prints and width of the fingers at the same time) and using it to derive the features in recognition systems, at [20].

In this study, two biometrical features that related to palm recognition process are used to provide more reliable palm recognition system. It employed the hand palm

veins image features correlated with fingers print of the hand. Results shown that correlating the both sources (veins image and fingers print) is yielding noticeable performance.

3 METHODOLOGY

3.1   Overview

Palm image processing goes through several stages of modifications where image is reprocessed and filtered against the undesired associates. It is also involving image features extraction which is particularly focused on cropping the Region of Interest from the said palm and then applying the technologies of image processing to extract the features from that area. This chapter is demonstrating the details of preprocessing and how dose image is got smoothing and normalizing. Also, it describes the details of the Region of interest cropping technique.

The ultimate stage of implementation is about extracting the uniqueness of each cropped image by analyzing each pixel individually and then to obtain the generalized the overall pixels information to formulate the final features vector. That vector contains of the pixel colour variable that term to the accurate colour changing in each pixel of palm's image.

Since image is nothing but matrix or organized colour based pixels, pixel is a point that formulate the image objects. In world of palm recognition, the identification of palm is termed to monitoring the principle lines structure (shape) and wrinkles over the palm. However, this going to be monetarized by tracking the colour variation of the image in different pixels. So-to-say, final stage of implementation is classification stage which is committed to be achieved using the machine learning algorithms and PCA. However, this chapter is made to enlist the implementation steps of palm recognition paradigm.

3.2   Database Preparation

Since palm image processing is interested domain by large number of researchers, several sources of information were made available to support the research progress. However, this project is depended on open source database called as polyU database of palm print. It was prepared by IIT Delhi and contains of palm prints of left and right images of different peoples. Different size and colour palm images are included

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within this database, it was collected during the summer of 2006 in the venue of IIT Delhi as palm print of students and made available to support the researches in public sector.

The images were collected using contactless approach which made using a normal camera to capture the palm print from short distance (around ten centimeters). The images are captured in empty cubical container where object is been asked to place his hand inside that cubical container and then image is taken. The background of that container is made as evenly distributed black colour to prevent the background objects association (interference).

Figure 3.1 depicts a sample of database contains, Figure demonstrates eight samples of database contains. Images capturing is noteworthy achieved using a circular florescent as lamination source.
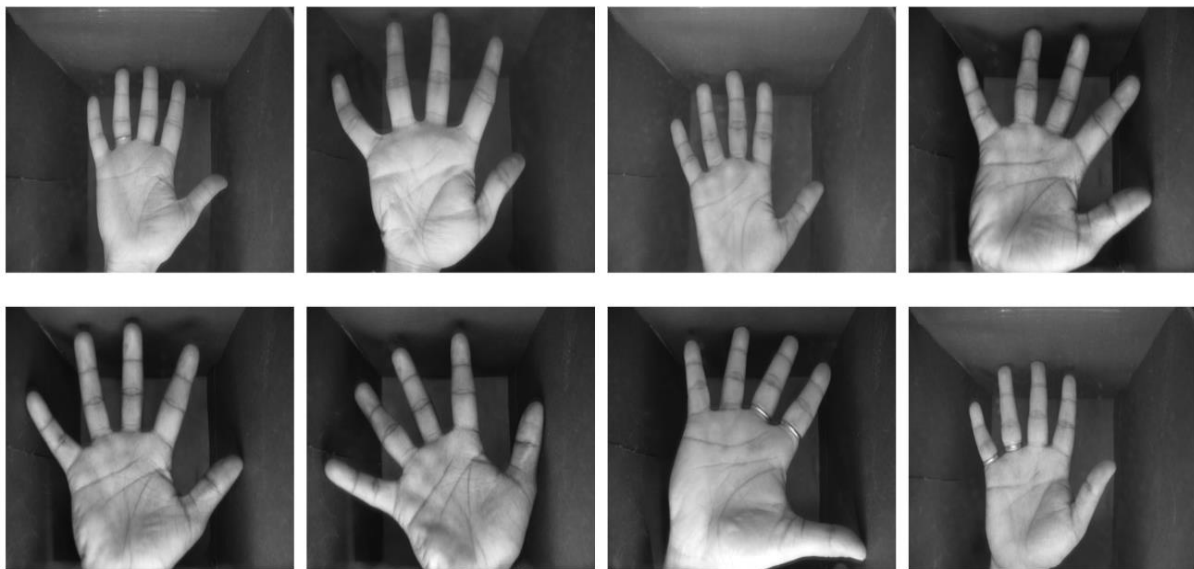
Figure 3.1: Database sample contains showing the palm print of the right and left hand with different   orientation.

3.3   Image Preprocessing

The images found over the database are termed with several attributed which are listed below. Preprocessing is conduction of several strategies to improve the image quality which enhances the accuracy of recognition system. It is worthy to say that less online open source data is available and hence this data was one of few best

available as open sources. The attributes that considered as challenges posers are be listed herein:

1. Mainly, images are captured for different (various) of individuals with help of black backgrounded empty cubic container. Each individual (subject) was instructed to place his hand on that container. Well, some of those subjects were found it inconvenient to place their hand properly in that container due to bulky hand size as in Figure 3.2.   Due to that, palm orientation is found fluctuating from image to image, resulting noteworthy angular change in palm angle.

2. The orientation of palm inside the black container might take the right side or left side in different angular values.

3. The angle between the fingers of palm are essential to produce the value of palm orientation (rotation of palm); so, it was realized that not all object's fingers are in same angle and however as demonstrated in Figure 3.3. Object may need to narrow the fingers separation in some cases where the hand is bigger that available space of black container.

4. Images may include an external object such as finger rings or bracelet which may degrade the feature extraction performance, the sample of such coexistence is depicted in Figure 3.4.

5. The combination of background and lamination source made the image looks like some part are endarked and other are less endarked, on top of that and due to less lamination, hand shadow was visible in some images. That pose a challenge of more none actual interference (objects) that might be visible while image processing due to ununiformly distributed light.

6. The quality of all images is somehow suffering of less resolution and also complete band information were not available because of basic camera usage while capturing the said images. Furthermore, the contactless method of image capturing used in this database are not included a user-pegs which made some images are near to the focus of the camera and other are far. The aforementioned Figures above are listed hereinafter and depicted the cases as described above.

Figure 3.2: A demonstration of bigger than usual palm on far distance of sensor focus.
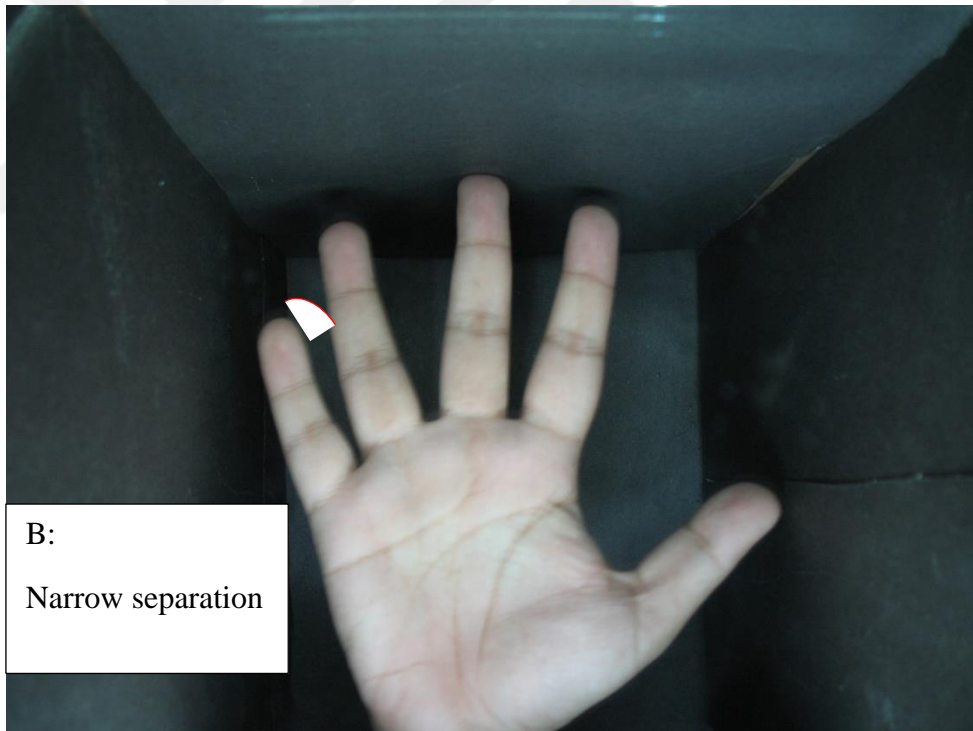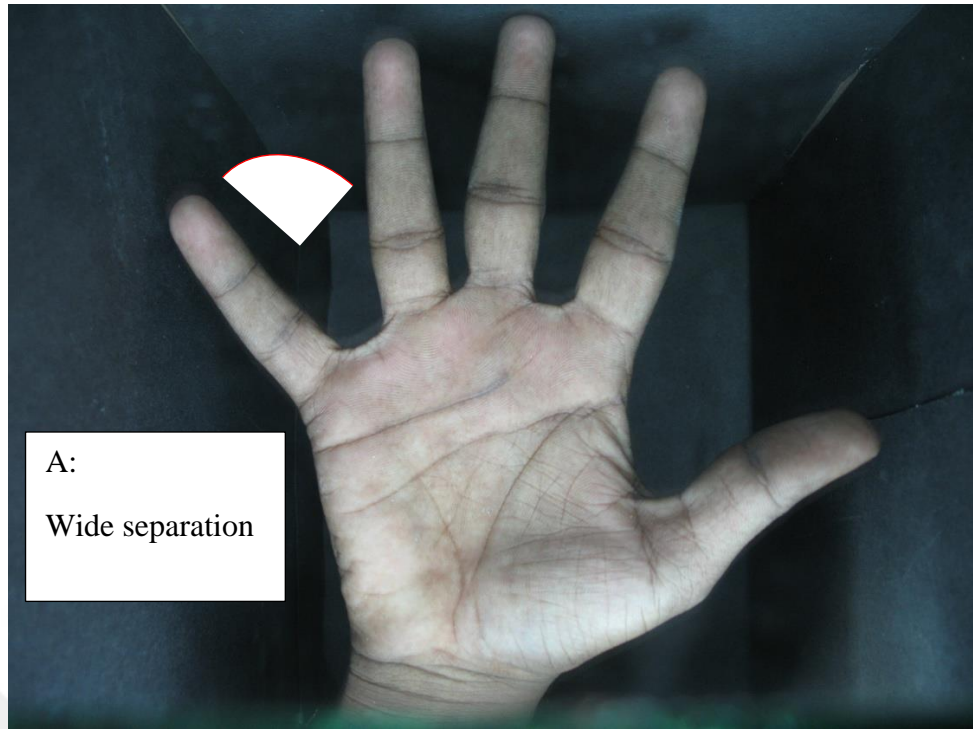
Figure 3.3: Palm's fingers separation angles, Figures demonstrates samples of separations mismatch.
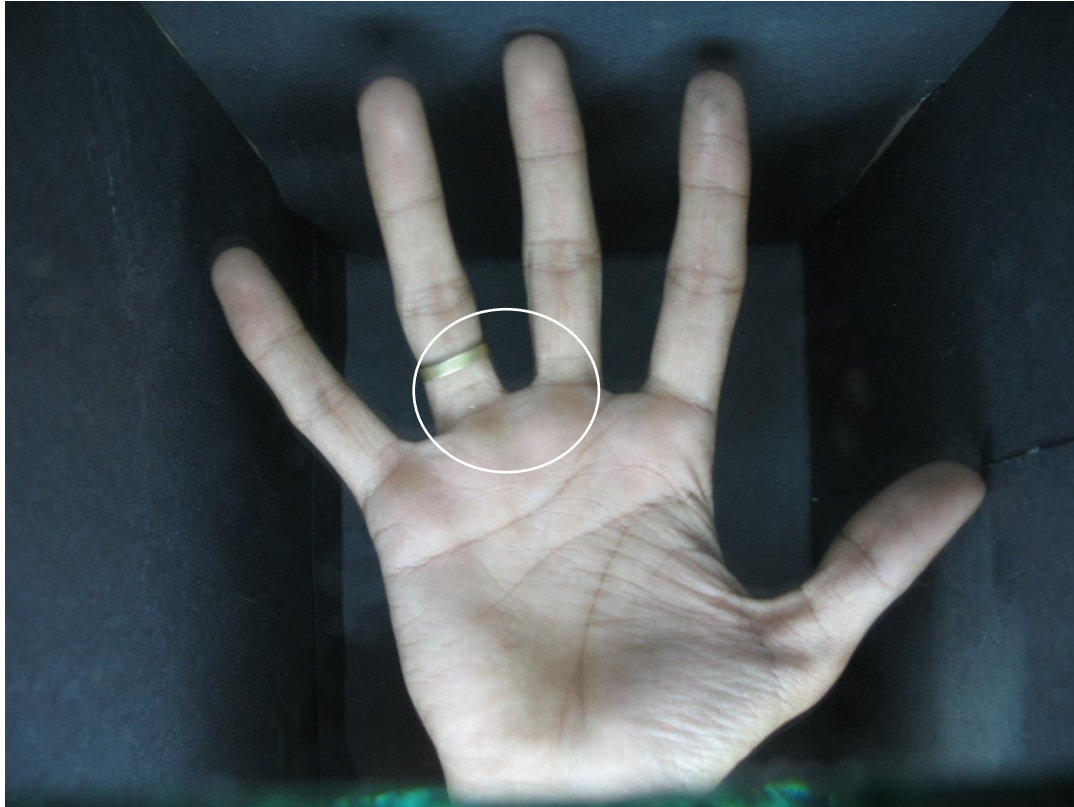
Figure 3.4: Hand palm image showing ring association with finger.

3.3.1 Normalization

The aforementioned challenges listed above are supposed to be tackled in ordered to establish robust recognition system. However, the main point of this processing is angle detection (identification of image orientation) more likely to monitor whither image is rotated towards right or towards left. The first essential step of this work is to calculate the rotation angle. This angle can be calculated at first and then by using reference known angle calculated for properly set (oriented) image, the direction of rotation can be obtained; more likely, in clockwise direction or anti clockwise direction.

In order to normalize the image (palm print), the challenges mentioned in previous section are to be solved one by one. As all challenges are set cleared, image of palm print will result in same rotational angle at all database contents. Furthermore, all the said interferences such as rings or lighting problem and other issues will be removed and merely palm print will be resulted without presenting any other element at the image.

The procedure of normalization is illustrated in Figure 3.6., it begins with elimination of the multi-elements appeared in the background due to bad lamination. The algorithm described in Figure 3.7 is implemented in Matlab and applied to all images in the database. The steps included in this algorithm can be detailed as following:

a. All images from the database are sourced to the algorithm workstation using guided loops where an array of all the images names are used as index to guide that loop for calling each and every image to the process.

b. The images are encountered for multiple elements apart from the hand palm, it is obvious that such elements are not desired to be present while processing. In other word, only palm region of the image should be isolated and forwarded for the next processing step. In order to perform this step, image objects are determined by using BOUNDARY function in Matlab which returns all elements boundaries along with their labels. For example, for a particular image, BOUNDARY function yielded four objects, now one of those objects must be the palm region and identifying which of the region is representing a palm is not yet made as no clue of finding that as in this step of algorithm.

c. Another function is called as REGIONGROUPS is employed in the next step of processing which is in turn determining the area of each object detected from the step (b) along with the area, centroid is determined as well for each area.

The palm region can be identified after completion of this step using the fact that the bigger area is the hand palm area, palm dominate the bigger area in all the captured images.

d. Image samples are studied very deeply and geometrically analyzed to find the points (pixel points) that is corresponding to the wrist coordination, centroid and first finger coordination. Figure 3.5 depicts the three-reference points detection on the hand palm print.
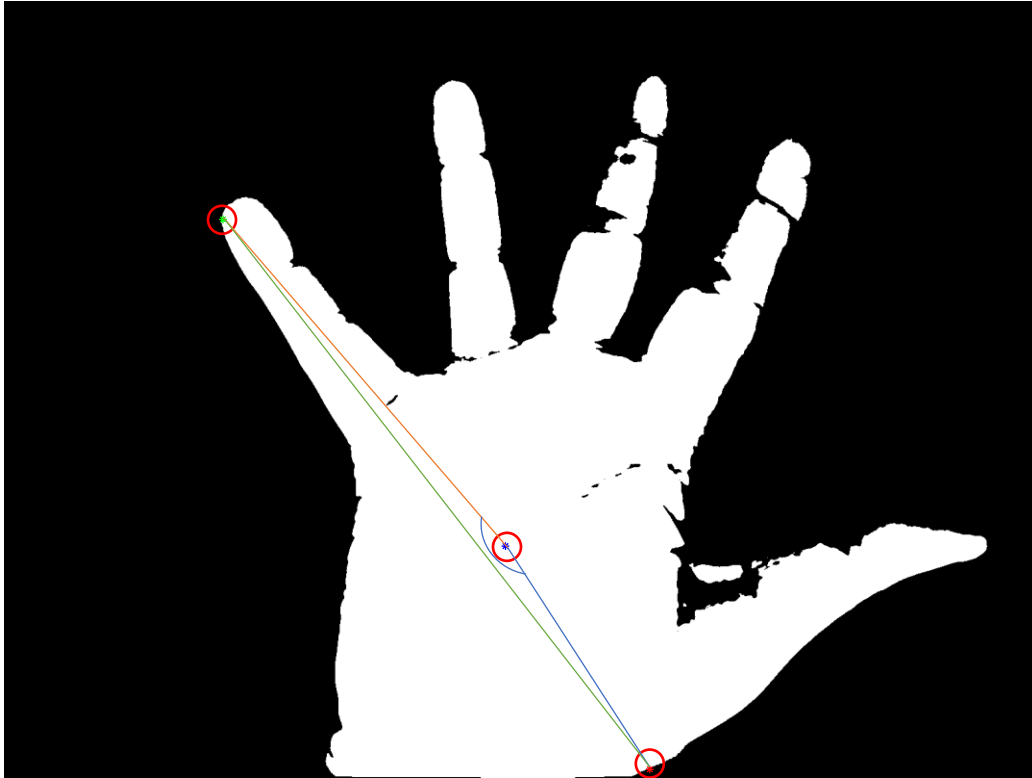
Figure 3.5: Selection of three reference points on the palm plane.

Figure 3.5 depicts three points selected on palm plane and located on the top of first finer, on the centroid of palm and on the lower part of palm (on the section/joint of pam and wrist, below the thumb finger. The analysis work performed on large number of images and hence the lower point (third reference point) is realized on vertical plane at 1020 pixel. Well, the location of third point may differs due to hand let or right orientation. However, the value 1020 pixel is realized locating at the lower thumb parallel to the forefinger.

From the other hand and as illustrated in the Figure above, the angle ø is being determined and termed as angle of orientation of the palm. Known that first-finger peak point can vary with the hand direction so, this angle may efficiently uncover the palm orientation.

e. As soon as the angle of orientation is yielded from the step d, one of database contents (single image) that can be seen properly captured and illustrating the palm print in proposer visibility.

The angle calculated for such image can be used as reference angle which can be used to reset all other images in the database. Let proper angle (reference angle is termed as Ø) and the image n angle calculated with light of point d is represented by ø. The rotational angle can be obtained from the following expression:

$$\Delta = Ø - ø \qquad\qquad (3.1)$$

The result of this equation can be positive (+) or negative (-), the positive results refer to clockwise rotation (right rotation or orientation). Otherwise, negative results refer to anti-clockwise rotation (left rotation or orientation).

At the end of this step, all database images will set in unique orientation angle and it can be ready now for Region of Interest Cropping. The algorithms details in step (e) can be illustrated in Figure 3.6.
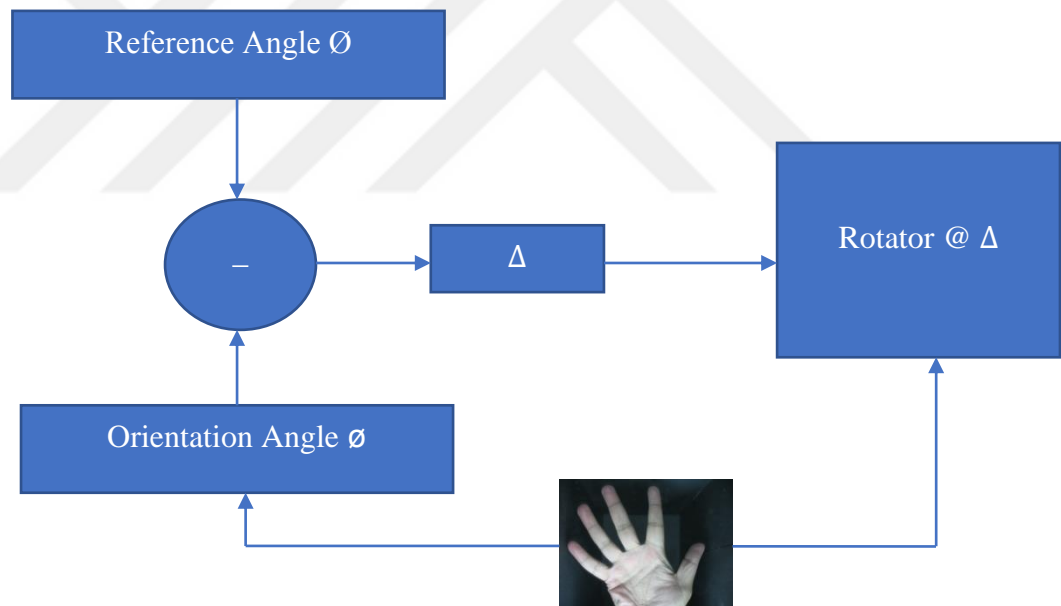
**Figure 3.6:** Angle normalization (reorientation process) paradigm.

3.4   Region of Interest

In this stage of processing, particular area from the hand is isolated and used in feature extraction as vital platform to personal recognition system. Region of interest in palm recognition system is representing the region below the hand's four fingers

except the thumb and sided by the thumb from the right side (right hand palm recognition system).

The method to identify the region of interest is highly associated with the success of hand reorientation. All images from database are to be rotated in the same angle (rotation angle to be reset) so that features collections from all images will be even. In other word, features collection from the region of interest are focused essentially on the colour variation in such way principle lines and wrinkles and skin colour should be all available at the palm region of interest.

The combination of aforementioned three attributes i.e. hand palm colour, principle lines and palm wrinkles can produce strong features that can highly relied on recognition the palms. It is however not possible to that two hands will yield the same vector of those features. Hence, this features combination is essential way for palm uniqueness productivity.
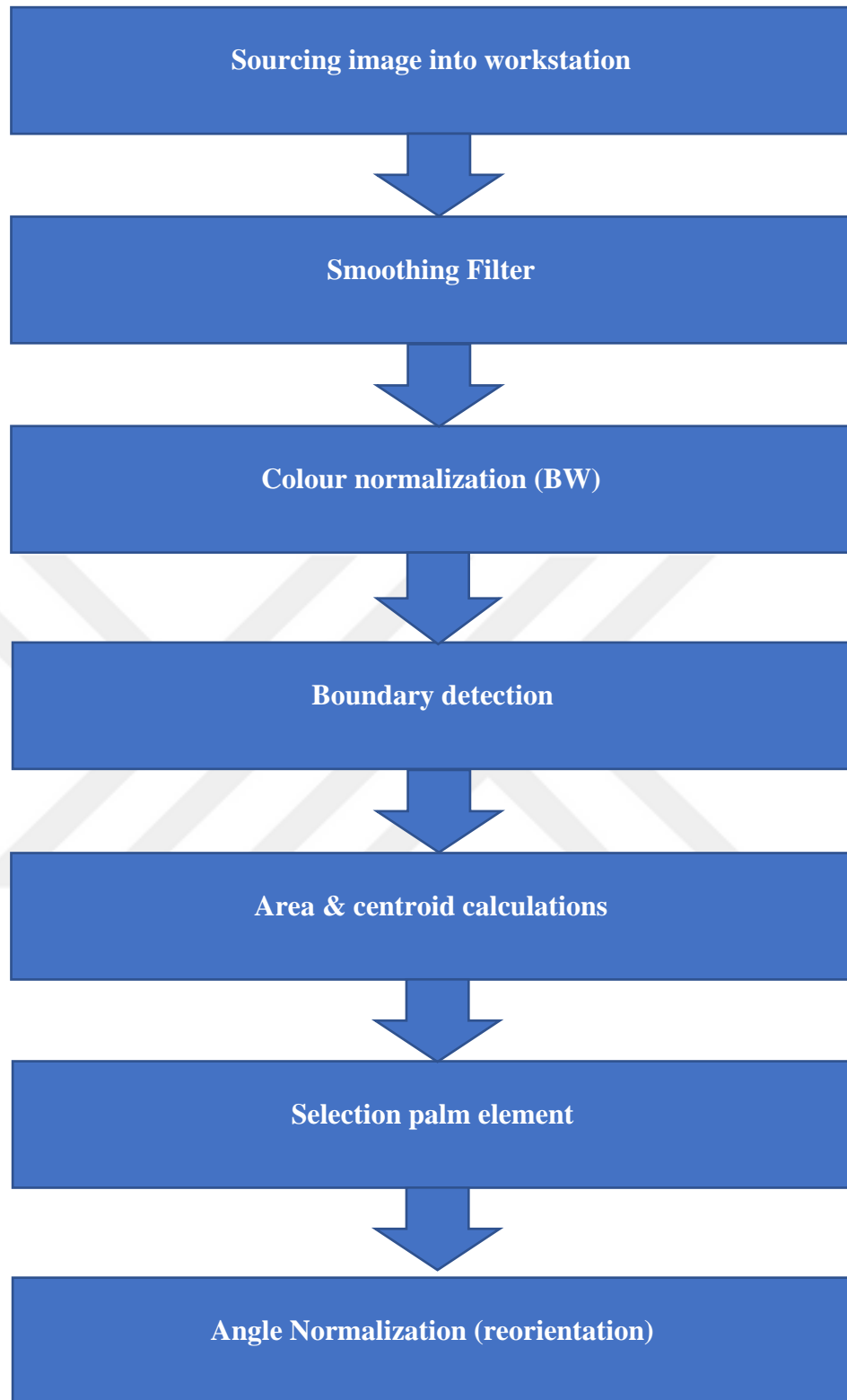
Figure 3.7: Image normalization algorithm steps.

Region of interest is cropped in each image according to the following parameters:

a. The cropped image must be in rectangular shape with having width of (250) and height of (300);

b. The content of this cropped image must include the main three desired features mentioned in the previous section namely: principle lines, wrinkles and skin colour. It is noteworthy that skin colour will remain same in all images and the wrinkles may relatively remain same. The point of dispute is principle lines which might be accurately appear on the cropped image.

c. Area of cropped image must be identical in all images.

d. Rotation of palm must be identical (as accurate as possible) in all of cropped images.

Figure 3.8 depicts the samples of cropped images (region of interest). The practical model that implemented to perform the cropping according to the above limitations has shown some rejection rate as some (fewer) samples were found involving some background information or not accurately displaying the principle lines (partially principle lines displaying).

However, in order to draw the actual performance (practical) performance of image cropping, following formula can be applied:

$$ROI_{accr} = \frac{Number\ of\ correctly\ cropped\ images}{Total\ number\ of\ images} \times 100\ \% \qquad \textbf{(3.2)}$$

$$ROI_{accr} = \frac{48}{50} \times 100\ \% \qquad \textbf{(3.3)}$$

$$ROI_{accr} = 96\ \%$$

The results of region of interest cropping is ninety-six percent which means that system is out performed for gathering the features from different biometrical properties. This system is taking into consideration the features of fifty palm prints based on contactless image acquisition system.

Figure 3.8: Region of interest samples that cropped from the palm images.

3.5   Classification

Images cropped for obtaining the region of interest as shown in Figure 3.8, features are extracted from all region of interests and kept together in an array called as features array. In this stage of system, all features from all samples are set in matrix called features matrix. The target array is also established as numerical values starting from one through fifty which corresponds to each row in the features matrix.

Accordingly, machine learning setups are used to predict the identity according to the features. In this, three algorithms are used namely: Random Forest, K-Nearest Number and Feed Forward Neural Network. The data of features matrix are used to train each algorithm individually and hence each algorithm is made to predict the identity as algorithm is tested with any feature vector.

The classification steps is: each algorithm is trained and tested and hence, the performance of training and testing are evaluated using the Mean Square Error, Mean Absolute Error, Time and Accuracy.

First of all, let the target that equivalent to the correct prediction is called as T and the results obtained from the classifiers (PCA, K Nearest Neighbour, Random Forest and Feed Forward Neural Network) to be R. The error vector can be as E.

$$E[n] = T[n] - R[n] \tag{3.4}$$

Now the error vector $E[n]$ will contain n number of elements, each element will have three possibilities of values zero, below than zero and above zero. Zero elements are representing the corrected answers and rest is representing the error. Now, the first important metric which is representing the accuracy of recognition after feeding the classifier with large number of inputs and classifier must produce the correct prediction (zero error element). The accuracy is given is equation **(3. 5).**

$$Accuracy \tag{3.5}$$
$$= {Number\ of\ zero\ elements\ in\ error\ vector} \big/ {Number\ of\ total\ inputs}$$

The second metric is the Mean Square Error which can be calculated by number of error (none zero value in the error vector) as per the equation **(3.6)**.

$$MSE = \frac{\sum E[n]^2}{N} \tag{3.6}$$

Where N is the total number of error (none zero values in error vector). The other metric is Root Mean Square Error which is given in equation in **(3.7)**.

$$RMSE = \sqrt{MSE} \tag{3.7}$$

Another metric is Mean Absolute Error which is given in equation **(3.8)**.

$$MAE = \frac{\sum |E[n]|}{N} \tag{3.8}$$

The last metric is terms to the time taken by classifier to achieve this accuracy. The classifiers used in this paradigm can be listed as below:

3.5.1 Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a popular method for data compression and has been successfully used as an initial step in many computer vision applications, including palmprint and object recognition.

PCA algorithm is essentially purposed to simplify the spotted variables by reducing its dimension and this can be achieved by removing the correlation between independent variables. The PCA method is transforming the original independent variables into new variables that are not correlated, without losing important information. In this new transform space, these new variables then are called principal components PCs.

As it reduces the dimension computation time can be decreased and the unnecessary complexity of palmprint images can be removed.

Basic steps for PCA based feature extraction from 2D images are given as follows:

a. Reading Dataset Images

In the first step, palmprint images are taken from a database of M images, and size of each image is NxN. The images which are 2D matrices are converted into column vectors where each palmprint image into a column vector with length of NxN. Each column vector Img_i represents a palmprint image and the whole dataset is shown by X as in Figure 3.9.
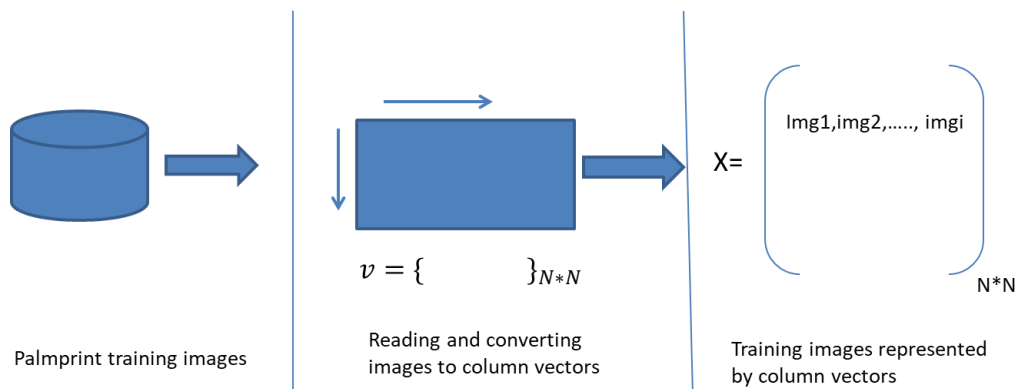
Figure 3.9: Tips of Reading and Converting Images in the training Dataset.

b. Calculating Covariance Matrix of the Dataset

In this stage, mean of the input dataset can be calculated by using the equation (**3.9**).

$$m = \frac{1}{M}\sum_{i=1}^{M} x_i \qquad \text{(3.9)}$$

where M is the total number of palmprint image in the database and x_i is the column vector form of the palmprint images. If d_i is the difference between each palmprint. image in column vector form x_i , and mean of the palmprint images in column vector form $d_i = x_i - m$ then A can be written as follows: $A = [d_1 \quad d_2 \quad \dots \quad d_m]$. Size of matrix A is N^2xM. Covariance matrix can be calculated as:

$$C = \frac{1}{M-1}\sum_{i=1}^{M}(x_i - m)(x_i - m)^T = \frac{1}{M}AA^T \qquad \text{(3.10)}$$

The size of the covariance matrix is N^2xN^2.

c. Calculation Eigenvalues and Eigenvectors of the Covariance Matrix

In this step, determining the eigenvectors and eigenvalues of the matrix C, is a difficult task for a typical image size. Therefore, we need to find an efficient method to calculate the eigenvectors and eigenvalues. the satisfy formula of matrix C is:

$$Cu_i = \lambda_i u_i \qquad \text{(3.11)}$$

where u_i is the eigenvector of the matrix C, and λ_i is the eigenvalue of matrix C.

In practice, the number of the images in database, M, is relatively small. The eigenvectors (v_i) and eigenvalues (a_i) of matrix $L = A^T A$ are much easier to calculate. The size of L is MxM. Therefore, we have:

$$A^T A v_i = a_i v_i \qquad \text{(3.12)}$$

and we if each side of the Eq.**(3.9)** is multiplied by A,

$$AA^T(Av_i) = a_i(Av_i) \qquad \text{(3.13)}$$

Then, we can derived the eigenvectors of matrix C as follows

$$u_i = Av_i \qquad \text{(3.14)}$$

d. Representing Palmprint Images Using Eigenpalms

After calculate the eigenvectors of matrix C, retain only the eigenvectors with the largest eigenvalues (i.e. the principal components). Then, project the mean-shifted images into the eigenspace using the retained eigenvectors, by the operation:

$$P_i = u_i' * A[1:K] \qquad\qquad (3.15)$$

where P_i is the weight of the projection can be used as a feature vector for each palmprint image, and K is the number of features.

3.5.2   K-nearest Neighbour KNN

Depending on the Euclidean distance between the elements in the dataset, K-nearest Neighbour algorithm can produce the relationship between many elements and hence to cluster the similar attributed elements into one cluster. This classifier can efficiently produce the classes in lesser time and acceptable accuracy. The steps of this classifiers can be illustrated in the Figure below.

In pattern recognition, the KNN algorithm is a method for classifying objects based on closest training examples in the feature space. KNN is a type of instance-based learning, or lazy learning where the function is only approximated locally and all computation is deferred until classification [9-12]. The KNN is the fundamental and simplest classification technique when there is little or no prior knowledge about the distribution of the data. This rule simply retains the entire training set during learning and assigns to each query a class represented by the majority label of its k-nearest neighbors in the training set. The Nearest Neighbor rule (NN) is the simplest form of KNN when K = 1. In this method each sample should be classified similarly to its surrounding samples. Therefore, if the classification of a sample is unknown, then it could be predicted by considering the classification of its nearest neighbor samples. Given an unknown sample and a training set, all the distances between the unknown sample and all the samples in the training set can be computed. The distance with the smallest value corresponds to the sample in the training set closest to the unknown sample. Therefore, the unknown sample may be classified based on the classification of this nearest neighbor. Figure 3.10 shows the KNN decision rule for K= 1 and K= 4 for a set of samples divided into 2 classes. In Figure, an unknown sample is classified by using only one known sample; in Figure more than one known sample

is used. In the last case, the parameter K is set to 4, so that the closest four samples are considered for classifying the unknown one. Three of them belong to the same class, whereas only one belongs to the other class. In both cases, the unknown sample is classified as belonging to the class on the left.
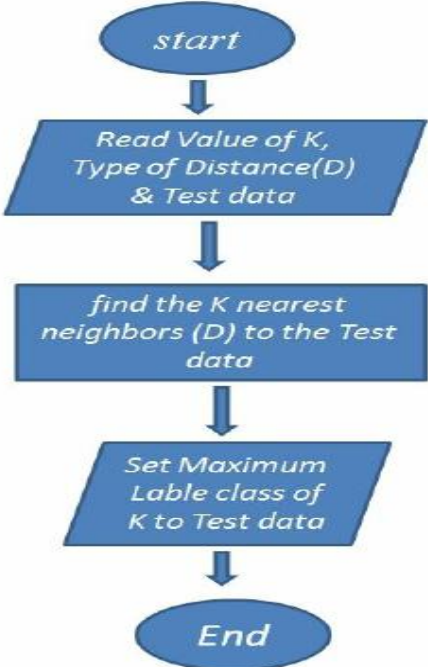

Figure 3.10: KNN algorithm flowchart.

The performance of a KNN classifier is primarily determined by the choice of K as well as the distance metric applied. The estimate is affected by the sensitivity of the selection of the neighbourhood size K, because the radius of the local region is determined by the distance of the Kth nearest neighbour to the query and different K yields different conditional class probabilities. If K is very small, the local estimate tends to be very poor owing to the data sparseness and the noisy, ambiguous or mislabelled points. In order to further smooth the estimate, we can increase K and take into account a large region around the query. Unfortunately, a large value of K easily makes the estimate over smoothing and the classification performance degrades with the introduction of the outliers from other classes. To deal with the problem, the related research works have been done to improve the classification performance of KNN.

3.5.3 Random Forest

This algorithm is evaluated recently to ensure some levels of reliability on complex problems classification. It uses the concept of tree branches where each branch can contain particular fruits (in similar size or some nature). In random forest, data with mixed attributes can be rearranged and reformed several times, at every time data is being arranged, class or branch is form. The next step is to rearrange the particular classes (branches) itself so that new sub-branch can be obtained.

The goal of this rearrangement (division of data in to sub-branches) is to produce a ranch with completely similar attribute, in other word. However, Gini index to be calculated at each time sub-branch is made and hence a result of Gini index may reveal the level of correlation between data elements gathering in one branch, Figure 3.11 depicts the sub-branches establishment process.
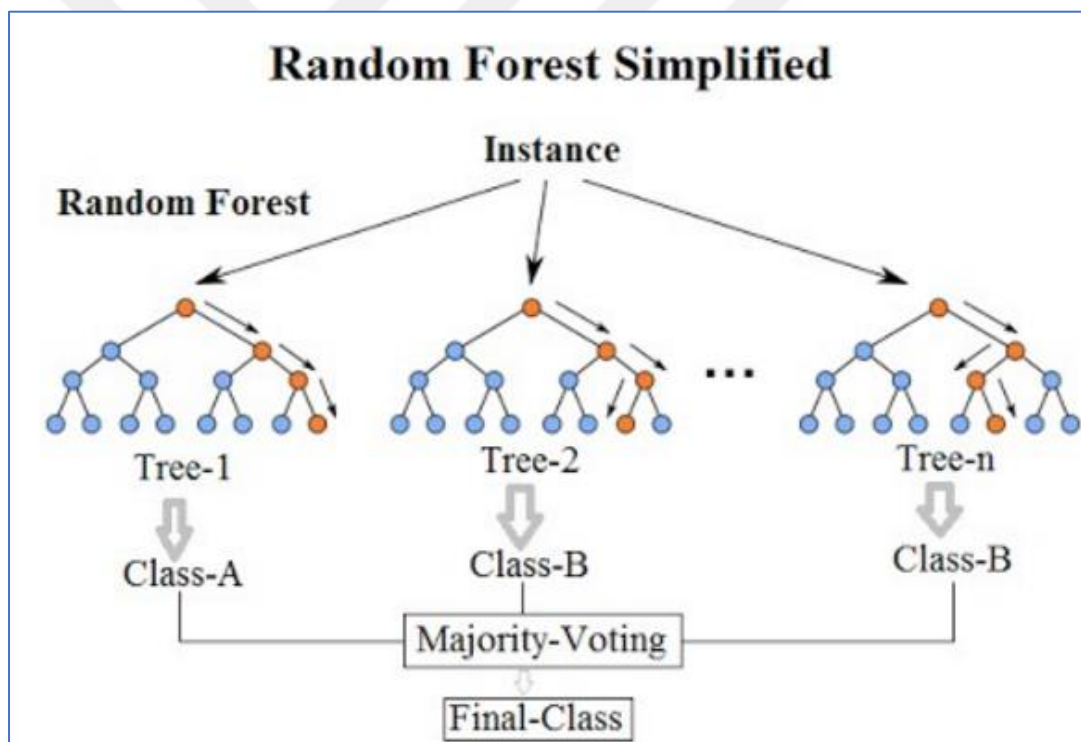
Figure 3.11: Random Forest Branches establishment process.

Each node of the tree corresponds to a rectangular subset of R D, and at each step of the construction the cells associated with leafs of the tree form a partition of R D. The root of the tree corresponds to all of R D. At each step of the construction a leaf of the tree is selected for expansion. In each tree we partition the data set randomly into two parts, each of which plays a different role in the tree construction. We refer

to points assigned to the different parts as structure and estimation points respectively. Structure points are allowed to influence the shape of the tree. They are used to determine split dimensions and split points in each internal node of the tree. However, structure points are not permitted to effect the predictions made in the tree leafs. Estimation points play the dual role. These points are used to fit the estimators in each leaf of the tree, but have no effect on the shape of the tree partition. The data are randomly partitioned in each tree by assigning each point to the structure or estimation part with equal probability. This partition is required to ensure consistency; however, there is no reason we cannot have additional parts. For instance, we could assign some points to a third, ignored part of the partition in order to fit each tree on a subset of the data. However, we found that subsampling generally hurts performance, so we do not pursue this idea further. The tree construction is parameterized by k_n, which gives a minimum number of estimation points that must appear in each leaf. The subscript n, which corresponds to the size of the training set, indicates that the minimum leaf size depends on the number of training data.

When a leaf is selected for expansion we select, at random, $\min(1+\text{Poisson}(\lambda), D)$ distinct candidate dimensions. We choose a split point for the leaf by searching over the candidate split points in each of the candidate dimensions. A key difference between our algorithm and standard random forests is how the set of candidate split points is generated. In a standard random forest, points are projected into each candidate dimension and every possible split point is Figure 3.11. The search range in each candidate dimension is defined by choosing m random structure points (indicated by arrows) and searching only over the range defined by those points. Candidate split points can only be selected in the region denoted by the solid line; the dashed areas are not eligible for splitting. evaluated as a candidate split point. In our algorithm we restrict the range of the search by first selecting m of the structure points in the leaf and evaluating candidate split points only over the range defined by these points. Restricting the range in this way forces the trees to be (approximately) balanced, and is depicted in Figure 1. For each candidate split point S we compute the reduction in squared error, where A is the leaf to be split, and A0 , A00 are the two children which would be created by splitting A at S. The notation $\bar{Y}_A$ denotes the empirical mean of the structure points falling in the cell A and Ns (A) counts the

number of structure points in A. The variables $I_j \in \{e, s\}$ are indicators which denote whether the point (X_j, Y_j) is a structure or estimation point. The split point is chosen as the candidate which maximizes $I(S)$ without creating any children with fewer than k_n estimation points. If no such candidate is found then expansion is stopped.

Tree purity can be measured using gini index, The Gini index or Gini coefficient is a statistical measure of distribution developed by the Italian statistician Corrado Gini in 1912. It is often used as a gauge of economic inequality, measuring income distribution or, less commonly, wealth distribution among a population. The coefficient ranges from 0 (or 0%) to 1 (or 100%), with 0 representing perfect equality and 1 representing perfect inequality. Values over 1 are theoretically possible due to negative income or wealth.

3.5.4 Feed forward neural network FFNN

Feed Forward Neural Network is type of deep learning technology that uses part of dataset for training. The training session of FFNN may involve tuning the model weighs to obtain as perfect as possible accuracy at the output. Feed Forward Neural Network is being deployed in large number of engineering and science application to resolve their complex problems. Hence, they were shown a noticeable performance and proved their efficiency.

In this paradigm, a larger portion of data was used for training and rest was used for testing, however, Accuracy of this classifier were found optimum with respect to the other classifiers in aforementioned, FFNN structure is given in the below Figure 3.11, noting that it consists of n number of layers i.e. input layer, hidden layer and output layer, layers are containing a nodes which are interconnected with weights and biases.
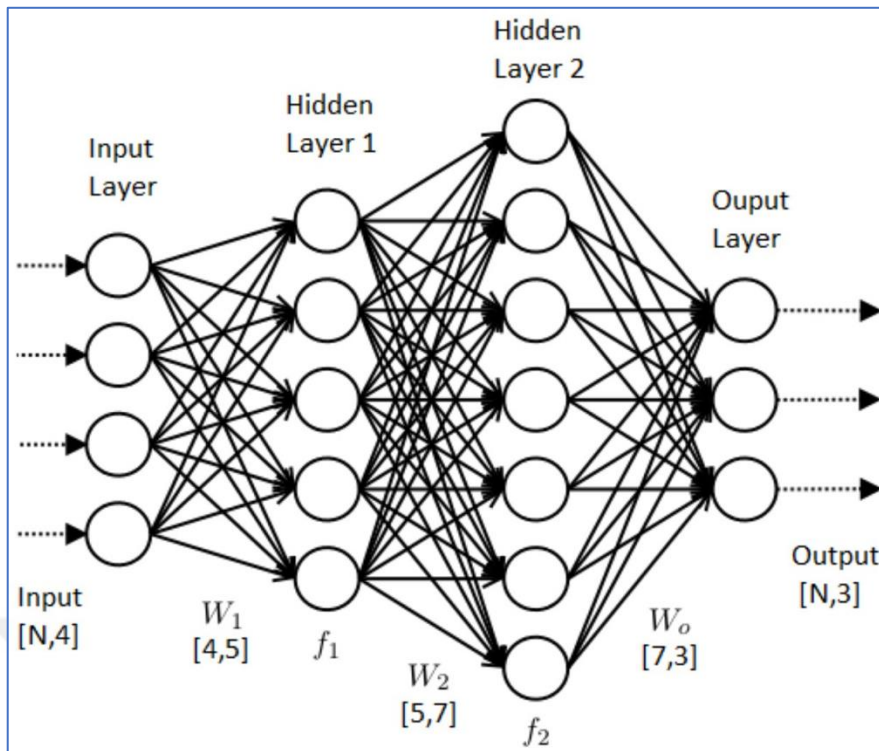
Figure 3.12: Neural Network layers structure.

The MLF neural network operates in two modes: training and prediction mode. For the training of the MLF neural network and for the prediction using the MLF neural network we need two data sets, the training set and the set that we want to predict (test set). The training mode begins with arbitrary values of the weights - they might be random numbers - and proceeds iteratively. Each iteration of the complete training set is called an epoch. In each epoch the network adjusts the weights in the direction that reduces the error (see back-propagation algorithm). As the iterative process of incremental adjustment continues, the weights gradually converge to the locally optimal set of values. Many epochs are usually required before training is completed. For a given training set, back-propagation leaming may proceed in one of two basic ways: pattern mode and batch mode. In the pattern mode of backpropagation learning, weight updating is performed after the presentation of each training pattern. In the batch mode of back-propagation learning, weight updating is performed after the presentation of all the training examples (i.e. after the whole epoch). From an 'on-line' point of view, the pattern mode is preferred over the batch mode, because it requires less local storage for each synaptic connection. Moreover, given that the patterns are presented to the network in a random manner, the use of pattem-by-pattern updating of weights makes the search in weight space

stochastic, which makes it less likely for the back-propagation algorithm to be trapped in a local minimum. On the other hand, the use of batch mode of training provides a more accurate estimate of the gradient vector. Pattern mode is necessary to use for example in on-line process control, because there are not all of training patterns available in the given time. In the final analysis the relative effectiveness of the two training modes depends on the solved problem. In prediction mode, information flows forward through the network, from inputs to outputs. The network processes one example at a time, producing an estimate of the output value(s) based on the input values. The resulting error is used as an estimate of the quality of prediction of the trained network. In back-propagation learning, we usually start with a training set and use the back-propagation algorithm to compute the synaptic weights of the network. The hope is that the neural network so designed will generalise. A network is said to generalise well when the input-output relationship computed by network is correct (or nearly correct) for input/output patterns never used in training the network. Generalisation is not a mystical property of neural networks, but it can be compared to the effect of a good non-linear interpolation of the input data [S]. Principle of generalisation is shown in Figure 3.12. When the learning process is repeated too many iterations (i.e. the neural network is overtrained or overfitted, between overtrainig and overfitting is no difference), the network may memorise the training data and therefore be less able to generalise between similar input-output patterns. The network gives nearly perfect results for examples from the training set, but fails for examples from the test set. Overfitting can be compared to improper choose of the degree of polynom in the polynomial regression. Severe overfitting can occur with noisy data, even when there are many more training cases than weights. The basic condition for good generalisation is sufficiently large set of the training cases. This training set must be in the same time representative subset of the set of all cases that you want to generalise to. The importance of this condition is related to the fact that there are two different types of generalisation: interpolation and extrapolation. Interpolation applies to cases that are more or less surrounded by nearby training cases; everything else is extrapolation. In particular, cases that are outside the range of the training data require extrapolation. Interpolation can often be done reliably, but extrapolation is notoriously unreliable. Hence it is important to have sufficient training data to avoid the need for extrapolation. The design of our selected FFNN is given as below:

Table 3.1: The design of our selected FFNN.

Particle	Details
Max epocs	100
Goal MES	1 e-200
Number of layers	3
Nodes in each layer	30 (inputs), 10 (hidden), 1 (output)
Training method	LM

4 RESULTS and DISCUSSION

The performance metrics of the palm recognition system is judge using the aforementioned four performance metric namely: Accuracy, Mean Square Error, Mean Absolute Error and Time. However, while using three different classifiers, performance is examined every time with reference of above metrics and the results can be listed in below Table.

Table 4.1: Results of performance evaluation from the MSE point of view.

Algorithm	MSE
PCA	396.798
KNN	739.28
Random Forest	438.57
FFNN	374.67993

Table 4.2: Results of performance evaluation from the MAE point of view.

Algorithm	MAE
PCA	5.5327
KNN	23.607
Random Forest	438.57
FFNN	374.6799341

Table 4.3: Results of performance evaluation from the RMSE point of view.

Algorithm	RMSE
PCA	19.9198
KNN	27.189705
Random Forest	20.942
FFNN	19.356650

Table 4.4: Results of performance evaluation from the Accuracy point of view.

Algorithm	ACCURACY
PCA	37.50
KNN	33.9673
Random Forest	44.44
FFNN	81.25

Table 4.5: Results of performance evaluation from the processing time point of view.

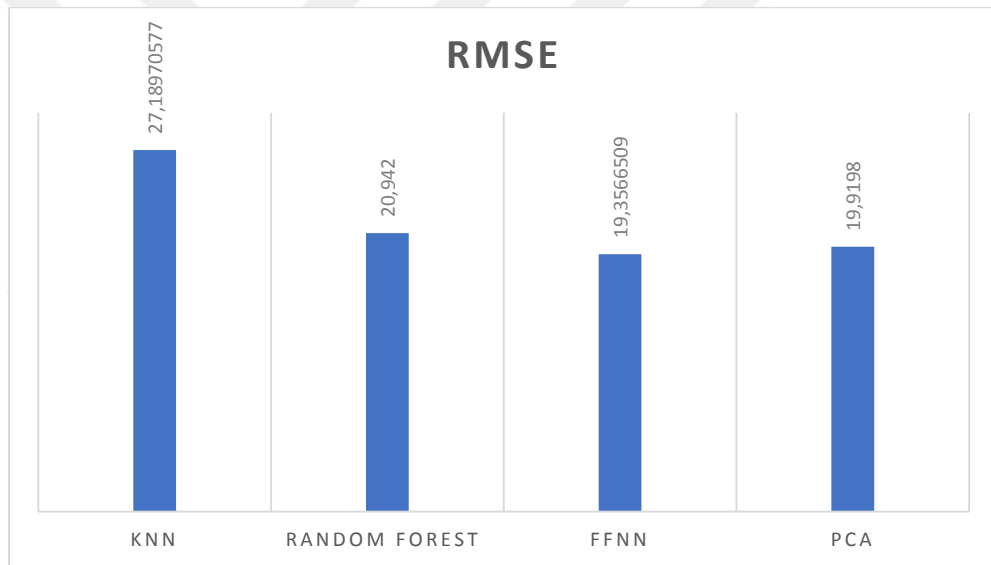| Algorithm	Time
PCA	0.040617
KNN	0.35345
Random Forest	3.87
FFNN	26.124724

Graphically, results can be represented in Figures 5.1 through 5.2:
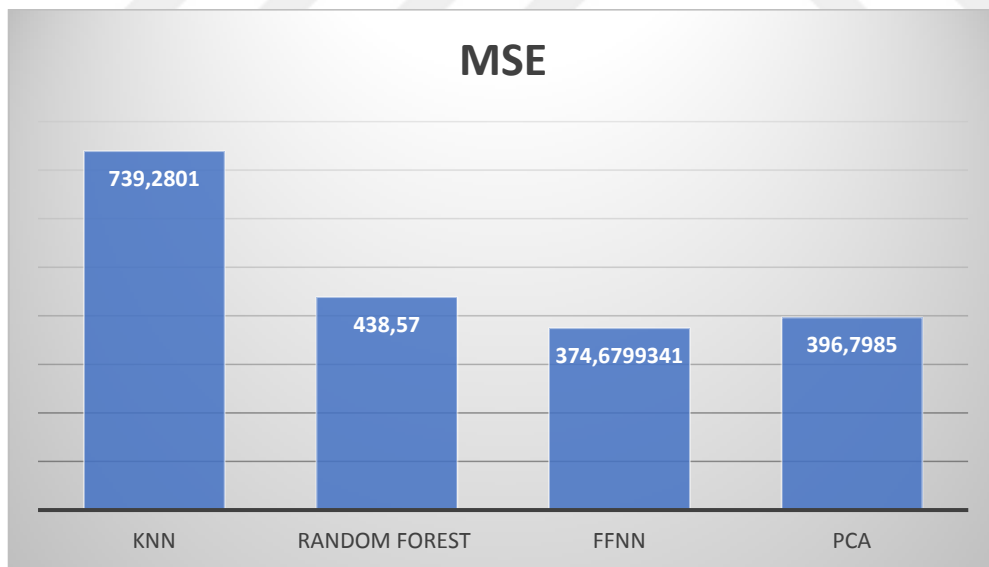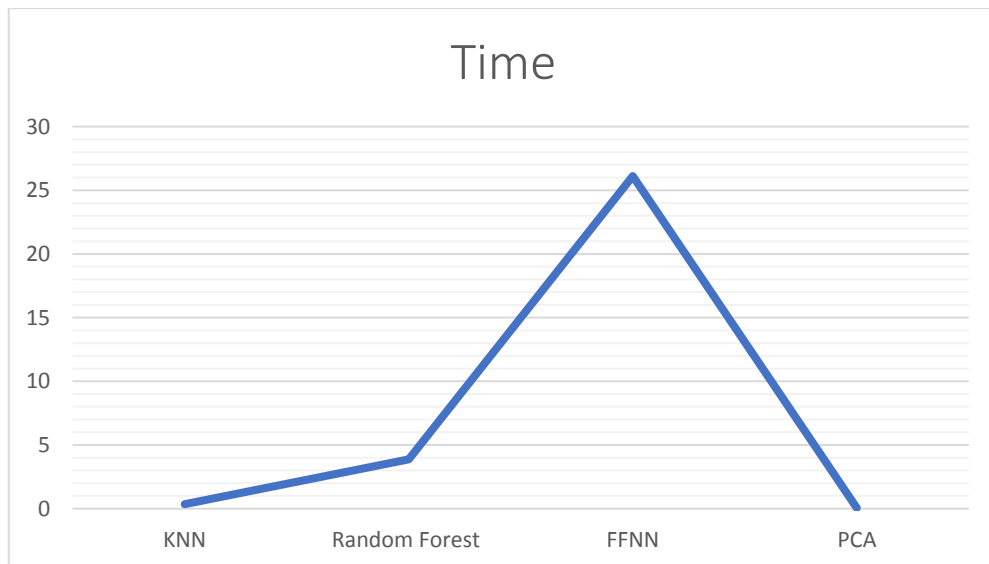

Figure 4.1: Performance based on MSE measure.
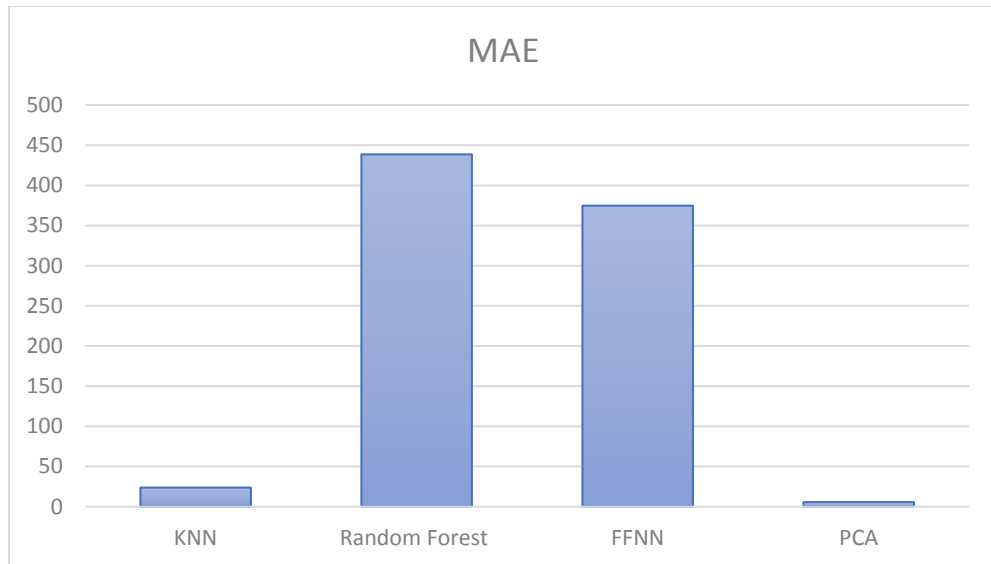
Figure 4.2: Performance based on MAE measure.

Figure 4.3: Performance based on RMSE measure.

Figure 4.4: Performance based on time measure.
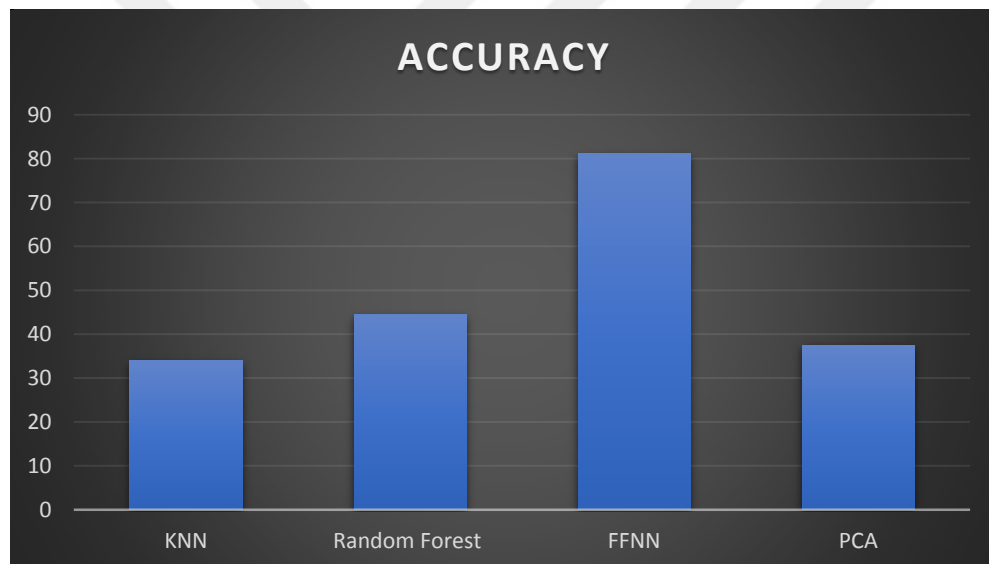
Figure 4.5: Performance based on accuracy measure.

The above demonstration of results revealed over the above fixed Tables and Figures revealed the following facts:

 a. Mean Square Error is reported minimum on the Feed Forward Neural Network and keep increasing on PCA, Random Forest and KNN respectively.

b. Mean Absolute Error is termed to best possible over the PCA, Random Forest and slightly less on Feed Forward; it reaches minimum on the K-nearest Neighbour algorithm.

c. Root Mean Square Error is actually inverse of the Mean Square Error curve, it shows best ever value of the Feed Forward Neural Network and keep worsen in both Random Forest and K-nearest Neighbour algorithm respectively.

d. Accuracy measure (accuracy of recognition) reaches maximum at Feed Forward Neural Network, it yields accuracy of 81.25 percent and accuracy of other classifiers reaches 44, 37 and 33 percent in Random Forest, PCA, and KNN respectively.

e. Time of processing is found peak in Feed Forward Neural Network and reduced in both Random Forest and KNN respectively; it reaches minimum on the PCA algorithm.

5 CONCLUSION

Personal identification included variety of techniques that in turn aim to verify the authenticity of people seeking access of particular data or systems. each means of biometrical recognition may be perfect in its application, knowing the fact saying that each application has different requirements of authentication systems. Literature survey has shown that privacy enforcing methods can be implemented using multi-model of personal identification more likely, eye imprint and voice imprint at the same time.

The only considerable point is the cost of implementation, multi-model recognition system is experiencing a large computation cost and hence bigger processors and powerful computers might be needed. The researches to identify a method of personal recognition that remains reliable and implantable in reasonable cost is endless. So, many alternatives are found in this interest. Palm recognition system is made to derive a consistence and cost-efficient recognition system.

In this project, Machine learning based palm recognition system is made, IITD database was used and system involved efficient preprocessing stages to generate features in less possible error. However, Region of interest is cropped from all the images perfectly and hence features are classified using KNN, Random Forest, PCA and FFNN algorithms. Accuracy of recognition is found optimum in FFNN based palm recognition system which produced image accuracy in 88.4 percent while the PCA produced an accuracy with 37.5 percent and KNN and Random Forest have produced 33 and 44 percent respectively .

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APPENDIX

Appendix 1: MATLAB code for data normalization
Appendix 2: MATLAB code for ROI
Appendix 3: MATLAB code for database vector

Appendix 1: MATLAB code for data normalization

MATLAB code for data normalization

```matlab
function [angle]=normal(A)
close all
% clear
% clc

A=imread(A);
G = fspecial('gaussian',[5 5], 2);
C = imfilter(A, G, 'same');
BW = im2bw(C, graythresh(C));
[B,L,N] = bwboundaries(BW);

%detect hand object only
d=[];
for i=1:length (B)
   d(i)=length (B{i});
end
ho=find (d==max(d));

% detect hand object boundary
boundary=B{ho};

%detect and plot peaks
[pks1,locs1] = findpeaks(boundary(:,1));

% image scale normalization


cr = regionprops(BW);
%%% detect bigger area
ar=[];
for i=1:length (cr)
   ar(i)=cr(i,1).Area;
end
ar;

biar=find(ar==max(ar));

centroid=cr(biar,:).Centroid;




%%% finding minium point inthe hand
%%%first point

dpp=find(boundary(locs1(:),1)>=1020);
dq=find (boundary(locs1(:),1)==boundary(locs1(dpp(1),1)));
```

```matlab
v1=[boundary(locs1(dq),2),boundary(locs1(dq),1)];


%second point

v2=[boundary(1,2),boundary(1,1)];

%%% third point
% siz=size(A);
% v3=[siz(1,2) siz(1,1)];
v3=[centroid(1,2),centroid(1,1)];


%%%find the slop of points
xvector=[v1(1,1) v2(1,1) v3(1,1)];
yvector=[v1(1,2) v2(1,2) v3(1,2)];

%angle between v3v2 and v3v1
m1=(v2(1,2)- v3(1,2))/(v2(1,1)-v3(1,1));
m2=(v3(1,2)- v1(1,2))/(v3(1,1)-v1(1,1));

angle=abs(atan( (m2-m1)/(1+(m1*m2) )) );
angle = radtodeg(angle);
angle=180-angle;
end
```

Appendix 2: MATLAB code for ROI

MATLAB code for ROI

```matlab
%this function is correcting the image with respect to image (1)
%it yeilds Three refrecence points of image v1 v2 v3
%yeilds Image after correction
%yeilds image BW after correction
%hand boundary detection
%peaks of the vertical axis of image
function [A boundary locsy v3 ff]=corimg(angle, image)

close all
% clear
% clc
% image=dataa{8};
% angle=phase(8);
AA=imread(image);
refangle=152.6055;
rotangle=angle-refangle;
A=imrotate(AA,rotangle);
G = fspecial('gaussian',[5 5], 2);
C = imfilter(A, G, 'same');
BW = im2bw(C, graythresh(C));
[B,L,N] = bwboundaries(BW);

%detect hand object only
d=[];
for i=1:length (B)
    d(i)=length (B{i});
end
ho=find (d==max(d));

% detect hand object boundary
boundary=B{ho};
% imshow(A)
% hold on
% plot (boundary(:,2),boundary(:,1),'r*')
% hold off

%detect and plot peaks
[pks1,locs1] = findpeaks(boundary(:,1));
[~,locsy] = findpeaks(boundary(:,2));

% image scale normalization


cr = regionprops(BW);
%%% detect bigger area
ar=[];
```

```matlab
for i=1:length (cr)
   ar(i)=cr(i,1).Area;
end

ar;

% imshow(A)
% hold on
% plot(wz(1,2),wz(1,1),'g*')
% hold off


biar=find(ar==max(ar));
ff=max(ar);
centroid=cr(biar,:).Centroid;



%%% finding minium point inthe hand
%%%first point

dpp=find(boundary(locs1(:),1)>=1020);
dq=find (boundary(locs1(:),1)==boundary(locs1(dpp(1),1)));

v1=[boundary(locs1(dq),2),boundary(locs1(dq),1)];


%second point

v2=[boundary(1,2),boundary(1,1)];

%%% third point
% siz=size(A);
% v3=[siz(1,2) siz(1,1)];
v3=[centroid(1,2),centroid(1,1)];


%%%find the slop of points
xvector=[v1(1,1) v2(1,1) v3(1,1)];
yvector=[v1(1,2) v2(1,2) v3(1,2)];



end
```

Appendix 3: MATLAB code for database vector
MATLAB code for database vector

```matlab
%database vector
load ('data');
phase=[];
for i=1:length (data)
    phase(i)=normal(data{i});
end
phase;
imagess=[];
imagess.w=[];
%area of hands and centroid
hand=[];
hand.area=[];
hand.centrx=[];
hand.centry=[];
hand.diff=[];


for i=1:length (data)
    Being_Proccessed_iteration=i

  [img bond pks v3 ff]= corimg(phase(i),data{i});
   hand(i).area=ff;
hand(i).centrx=v3(1,1);
hand(i).centry=v3(1,2);
hand(i).diff=v3(1,1)-v3(1,2);

%  imshow(img)
%  hold on
%  %for j=1:length (pks)
%  for j=8
%     plot (bond(pks(j),2),bond(pks(j),1),'r*')
%  end
%  hold off
%
% xt=bond(pks(j),:);
% xt=[xt(1,1) xt(1,1)];
v3;

%centreoid correctoion
ll=0;
m=v3(1,1)-v3(1,2);
 if m>50
   v3(1,1)=844.5543 -100;
   v3(1,2)= 883.0369+250;
 end
```

```matlab
width = 250;
height = 300;
xCenter = v3(1,1);
yCenter = v3(1,2);
xLeft = xCenter - width/2;
yBottom = yCenter - height/2;

CropROI=imcrop(img,[xLeft yBottom width height]);
begin=i*5;

imagess(i).w=CropROI;
end

%  imshow(CropROI);
% hold on
% plot (pointy,pointx,'r*')
% hold off
v3
% size(CropROI)

for i=1:length (data)
figure(i)

   imshow(imagess(i).w);
end

ds=zeros(length (data),251);
for i=1:length (data)
dd=imagess(i).w;
dd=dd(:,:,1);
ds(i,:)=sum(dd);
end
%data normalization
ds;
fks=[];
for i=1:length (ds(1,:))
fks(i)=max(ds(:,i));
end
dds=ds;
for i=1:length (ds(1,:))
dds(:,i)=dds(:,i)/fks(i);
end

target=1:48;
```

RESUME

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