A MULTIMODAL BIOMETRIC SYSTEM USING IRIS AND PALMPRINT

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by

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BABU BANARASI DAS UNIVERSITY
LUCKNOW

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CERTIFICATE

It is certified that the work contained in this thesis entitled **"A Multimodal Biometric System Using Iris And Palmprint",** by **Mohit Kumar Verma** (Roll No.1180449003), for the award of **Master of Technology** from Babu Banarasi Das University has been carried out under my/our supervision and that this work has not been submitted elsewhere for a degree.

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ABSTRACT

A biometric system is basically a system of image recognition that uses biometric characteristics to identify individuals. The thesis introduces a biometric multimodal system that is based on iris-based Palm Print verification and fusion. We suggest an approach to extracting features from each modality using four-level decomposition of the wavelet packet. It includes 256 packets capable of generating a simple binary code. Dictate standardized thresholds based on the first three highest energy peaks that would impact 0 or 1 for each wavelet packet. Specific fusion approaches were evaluated at different levels: character level, score level and error level. Its first fusion is an iris and palm print application, actually. For matching ratings the next one uses a weighted sum law. The next applies to the Hamacher t-norm's deficiencies. The standard database is used for testing the program proposed. The current approach and then each fusion method was checked for The consistency about the database of Casia iris merged with the database of Casia palm print. With each fusion process, the proposed solution to the multimodal biometric system achieves an increase in identification.

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Mohit Kumar Verma

Babu Banarasi Das Univerrsity, Lucknow

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LIST OF ABBREVATION

1. Card Verification Value …………………………………….…. CVV
2. Region Of Interest……………………………………………... ROI
3. Near Infra-Red………………………………………………. NIR
4. False Acceptance Rate………………………………………. FAR
5. False Rejection Rate…………………………………………FRR
6. Equal Error Rate……………………………………………...EER
7. Receiver Operating Characteristics……………………………..ROC
8. Discrete Wavelet Transforms…………………………………...DWT
9. k-nearest neighbors…………………………………………….. KNN
10. Vertical code…………………………………………………v code
11. Horizontal code………………………………………………....h code
12. Error Under Curve……………………………………………EUC
13. Local Binary Pattern…………………………………………LBP
14. Linear Discriminant Analysis…………………………………...LDA
15. Principal Component Analysis………………………………… PCA
16. Total Success Rate……………………………………………TSR
17. Content Based Image Retrieval……………………………… CBIR

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Chapter 1

Introduction

The personal verification system based on biometric is a method used for computing physical or social characteristics of the person. Biometrics system uses behavioral and physiological data for validation. In Biometrics technology, palm print, fingerprint, face, iris, ear etc. are classified as physiological characteristics, while signature, keystroke, gait, etc. are classified as behavioral characteristics. The biometric system can be a substitute digital solution to passwords, ID cards, driving licenses, passports, etc. The Biometric schemes have some limitations in terms of acceptability, accuracy, universality and distinctiveness. Individual validation assumes a significant job in the general public. It requires at any rate some degree of security to guarantee the character. Security can be acknowledged through one of the three levels.

Level 1 [Possession] : The client has something which is required to be created at the hour of validation. For instance, key of a vehicle or room.

Level 2 [Knowledge] : The client knows something which is utilized for validation. For instance, PIN (individual identification number), secret key, or then again Mastercard CVV (Card Verification Value).

Level 3 [Biometrics] : The client claims certain exceptional physiological and conduct qualities, known as biometric which are utilized for validation. For instance, face, iris, fingerprint, signature, walk.

There are a few situations where all the more then one degree of security are utilized to improve the exactness of any confirmation framework. Be that as it may, there are downsides in Level 1 and Level 2 security. For instance, key or keen cards might be lost or misused while passwords or PIN might be overlooked or speculated. Since both belonging and information are not inherent client properties, they are hard to be overseen by the client. Be that as it may, this isn't the situation with Level 3 security which depends on biometrics which can be considered as the study of individual verification utilizing the physiological (e.g. fingerprint, face, iris, etc.) and social qualities of people (e.g. signature, gait, voice, etc.). Instances of some notable biometric characteristics are appeared in Figs. 1.1.

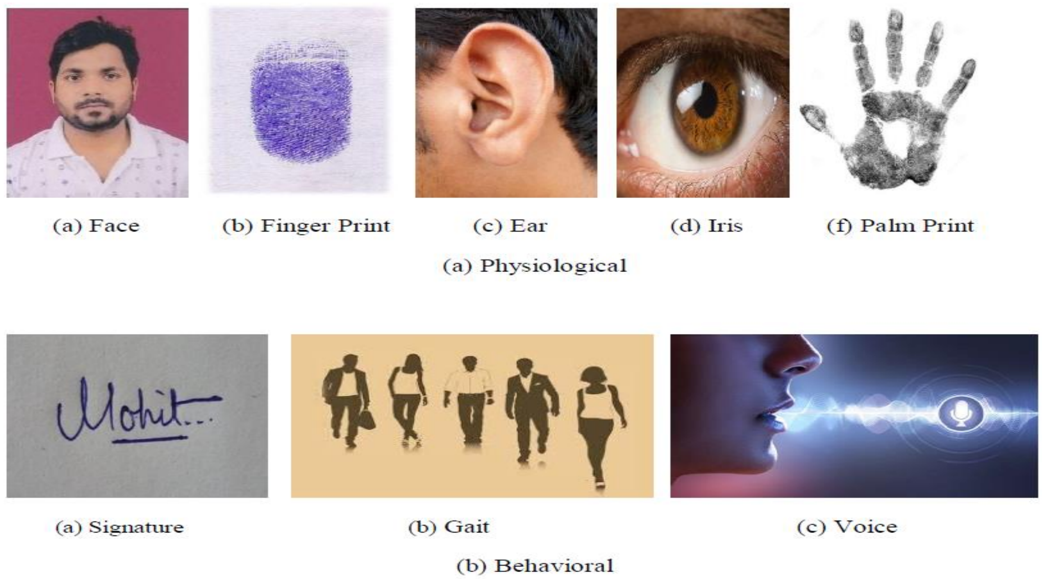


Figure 1.1 Some Biometric Traits

Any biometrics based validation framework is better than the conventional belonging or information based framework in light of the accompanying reasons.

- Biometric qualities are inherently identified with the client. They can't be lost, overlooked or off-track, consequently they are anything but difficult to manage.
- There is a need of physical nearness of the quality for confirmation.
- Features characteristics are unique.

A portion of the imperative properties that any biometric attribute ought to have are given below.

- Uniqueness: Characteristics related with the biometric quality ought to be different for everybody.
- Universality: The biometric quality ought to be claimed by everybody and ought to not be lost.
- Circumvention: The biometric attribute ought not be caricature or produced without any problem.
- Collectability: The biometric attribute ought to have the option to procure by some computerized sensor.
- Permanence: Characteristics related with the biometric quality ought to be time invariant (transiently steady).

- Acceptability: The biometric characteristic ought to be acknowledged by the general public without any complaint.

A biometric based individual verification is a multi-arranged procedure. In the starting stage, the crude picture is caught utilizing an obtaining sensor. This is very basic and significant stage since precision of any biometric framework is profoundly subject to the nature of pictures. In the subsequent stage, the ideal part from the picture, named as region of interest (ROI), is extricated from the procured picture. Third stage assesses the nature of the ROI. In the event that the nature of the ROI is poor, at that point one may go for re-procurement of the picture. In next stage, the ROI is preprocessed utilizing some improvement method. A few changes are likewise performed to get the strong ROI. Discriminative highlights from the improved ROI are separated in the following stage. At long last, highlights of a question picture have coordinated against those of image(s) in the database to verify the case.

1.1 Biometric Traits

There doesn't exist any biometric characteristic which satisfy every single wanted property carefully. For instance, facial highlights are not lasting for the duration of the life expectancy, fingerprints are not noticeable for dedicated individuals and so forth. Be that as it may, there exist a few notable biometric attributes which fulfill pretty much all biometric properties. Biometric qualities can be isolated dependent on physiological and conduct attributes.

1.1.1 Physiological based Traits

This subsection talks about a portion of the notable biometric attributes which depend on physiological qualities. These characteristics are face, fingerprint, ear, iris, and palm print.

Finger Print: Much time, fingerprints are being utilized for individual validation. Any run of the mill fingerprint is made up edges. There exist enormous measure of discriminative surfaces and examples, for example, circle, curve, whorl over a fingerprint. The edge finishing and the edge bifurcation are known as minutia highlights. These highlights are thought to be one of a kind and stable. A few minutia based fingerprint coordinating calculations are proposed. This sort of calculations utilizes the co-ordinates of details point alongside its direction. Unique mark sensors are effectively accessible yet the great quality fingerprint is a significant test. The low quality of fingerprints might be because of low quality of sensor or on the other hand outside variables, for example, dirt, oil, sweat and so on. It is additionally seen that workers have low quality fingerprints because of their tendency of work.

Advantages: Fingerprints are remarkable. Lesser measure of client collaboration is required for its securing and can be caught through modest sensors.

Challenges: The significant test is to get acceptable quality fingerprints.

Iris: Iris is considered as outstanding amongst other known biometric attributes. It is fundamentally a doughnut shape annular district that is limited by sclera and student. There exist discriminative surfaces inside iris as wrinkles, edges, sepulchers. It is difficult to catch iris in obvious light as it is touchy to light. Thus, iris procurement is caught in NIR (Near Infra-Red) light in high goals. Iris is fragmented and standardized into a fixed size rectangular strip. There exist a few surface based strategies to extricate parallel highlights which are coordinated utilizing hamming separation for validation. The iris based acknowledgment frameworks are generally seen as extremely exact and powerful. In any case iris can be caricature through contact lenses. The serious issue for iris is that it requires tough client collaboration during procurement. Likewise, iris is very delicate to any outside boost and it is difficult to control it.

Advantages: Iris have exceptionally discriminative one of a kind surface that is normally very much secured. They are difficult to adjust and quicker to process. Iris pictures can be obtained touchlessly.

Challenges: Precise iris division in differing light is exceptionally testing. The eyelid and eyelash alongside movement obscure and specular reflection is another issue. Off-edge iris acknowledgment is additionally a exceptionally testing issue.

Palm Print: The internal piece of a palm picture is considered as palm print. It incorporates edges, minutia, guideline line, delta focuses and rich palm print surface in wealth. These highlights are thought to be stable and unique. Binary features are removed utilizing a few surfaces just as factual and auxiliary properties. Soundness of palm print highlights is not yet basically considered.

Advantages: Palm print can be caught utilizing the minimal effort sensors in a touch-less way. The extricated palm ROI is huge and contains discriminative and remarkable highlights.

Challenges: Variety of light and rotation just as interpretation furthermore, taking care of the issue of interrupt are the significant difficulties.

Face: It is one of the most well-known and notable biometric characteristics. Pictures can be caught from separate and even can be removed from video outlines. In a regular face acknowledgment framework, at first face is identified from a test picture furthermore, highlights are separated. These highlights are coordinated against those put away in the database. A proper coordinating calculation is utilized to acquire the coordinating score. Most regularly geometric separations between facial key-focuses for example, eyes, nose, mouth. There are a few continuous applications, for example, reconnaissance, criminal identification, get to control the executives where it is being utilized. Face acknowledgment is non-meddling yet because of a few difficulties like present, light, impediment, maturing and articulation, its exhibition is found to be confined.

Advantages: Face is the most widely recognized and non-nosy attribute and thus, can be caught effectively utilizing modest sensors. It is generally adequate in the general public.

Challenges: The face present differs with the survey point alongside brightening. The outward appearances can misshape the face significantly while fractional impediment may shroud some facial areas. Maturing is a major challenge to manage in light of the fact that facial highlights don't change in a specific design.

Ear: Like other biometric attributes, it contains hearty, one of a kind and discriminative line based highlights. In an ear acknowledgment framework, ear is portioned from the crude profile face picture. Highlights acquired from ear are coordinated against those that are put away in database. The significant drawback of ear is the impediment which happens because of hair or some other remote body, for example, ear ring, top, ear telephones, etc.
Advantages: Like face, ear can likewise be gained non-rudely utilizing modest sensors. They are widespread and have vigorous shape that do not change excessively. The social acknowledgment of ear is high.

Challenges: Ear acknowledgment execution suffers in shifting enlightenment, posture and interpretation. The scale and outer body impediment like hair and ear rings are different difficulties to manage.

1.1.2 Behavioral based Traits

The absolute most well known social biometric attributes are given below.
Signature: The transcribed mark of an individual is an occurrence of individual verification. For the most part it is utilized for verification of the proprietor of bank checks or other off-line records. From any signature, the direction and co-ordinate based highlights in X and Y

headings are separated. They are coordinated with the highlights that are now accessible in the current database of the asserted character. General highlights, for example, composing edge, breakpoint and bends are named as static while pen-speed, composing time, pressure applied are named as unique highlights. There are two modes in which such framework works, one is on-line while other is off-line. Picture of the off-line mark is acquired by checking transcribed mark while advanced mark is gained through computerized signature cushion or tablet. It isn't all inclusive as uneducated people don't realize how to sign. It isn't perpetual as it can change with time and can be mock / manufactured without any problem.

Advantages: It has well acknowledgment socially.

Challenges: Mark can shift because of maturing, feeling or composing surface presenting huge test to computerized signature acknowledgment.

Gait: It is one of the conduct biometric attributes. It thinks about the attributes that are lying in transit that an individual strolls. Stride information can be gained utilizing moving light shows or video streams. Further, there are sensors that can record different vital boundaries, for example, weight and step designs that can be utilized for identification.

Advantages: It very well may be procured non-rudely and from separation; thus its client acknowledgment is acceptable.

Challenges: Significant difficulties are the method of taking care of varieties due to foundation, apparel or strolling surface.

Voice: It looks at how as an individual makes sounds while talking. It is accepted that each individual has its own regular surface and apparent quality that relies upon nasal tone, rhythm and enunciation. A few voice based trademark are extricated and utilized for voice based confirmation. Highlights are not changeless what's more, can be imitated/parodied without any problem. It isn't generally possessed as stupid people can't talk anything.

Advantages: It is well accepted by the society.

Challenges: Voice suffers from aging, emotion and other environmental variation severely.

1.2 Modes of Biometric System

There are three different potential modes in which any biometric framework can be worked and they are enlistment, verification and identification. Each client of the framework should be selected to the framework by giving pictures of the biometric attribute. Highlights are extricated from the pictures and are put away in the database. If there should arise an occurrence of verification or identification, highlights of the question picture are coordinated against those of the selected clients.

1.2.1 Enrollment

In this progression, a client enlists or registers to the current database. A biometric sensor is used to secure the picture from the client and its quality is assessed. On the off chance that the quality is above than an edge set from the earlier highlights are removed and an interesting identification number is doled out to it. Something else, picture is re-caught. This procedure of catching is rehashed until the ideal quality picture is caught. The procedure of enlistment subsystem is appeared in Fig. 1.2.

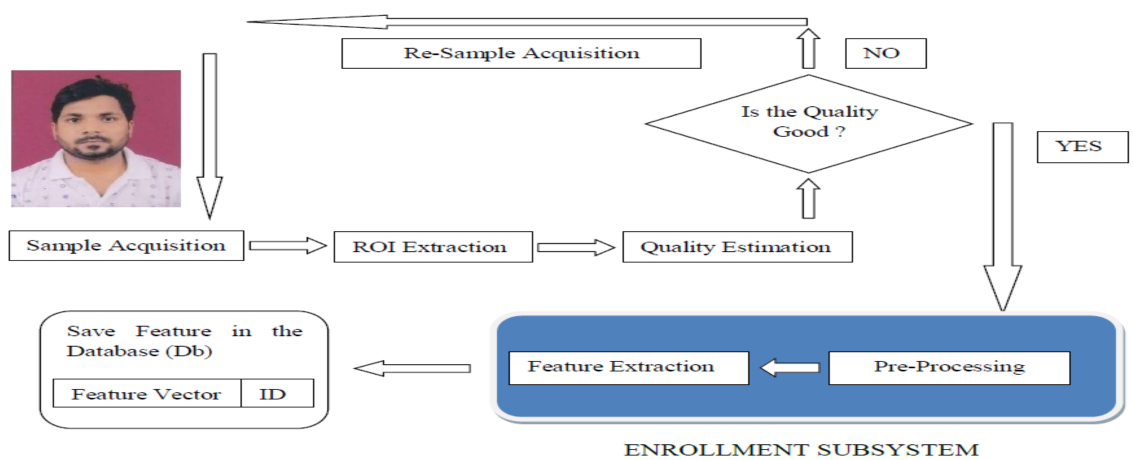


Figure 1.2 Flow Diagram of Enrollment Process

1.2.2 Authentication Process

It is otherwise called One-to-One (i.e. 1:1) coordinating. In this mode, client guarantees an personality and the framework verifies the accuracy of the case. Highlights from the biometric quality furnished by the client are coordinated with the highlights of the guaranteed personality put away in the current database.

On the off chance that the comparability coordinating score is more than a pre-processed edge, at that point the case is verified and the client is thought of as an authentic client. Something else, the case is dismissed and the client is a fraud. The flow chart of the verification subsystem is appeared in Fig. 1.3. Assume, F_1 and F_2 are the feature vectors of a biometric characteristic of two subjects, S_1 and S_2. By the term \Matching somewhere in the range of S_1 and S_2", we mean the likeness or divergence between their element vectors F_1 and F_2. One can utilize any separation measure to acquire the comparability or the uniqueness score between the two include vectors. With no loss of simplification, let us accept that the separation measure gives the closeness score. In the event that the score is more prominent than a predefined limit at that point we can reason that the two pictures are coordinated (certified) else they are not coordinated (fraud).

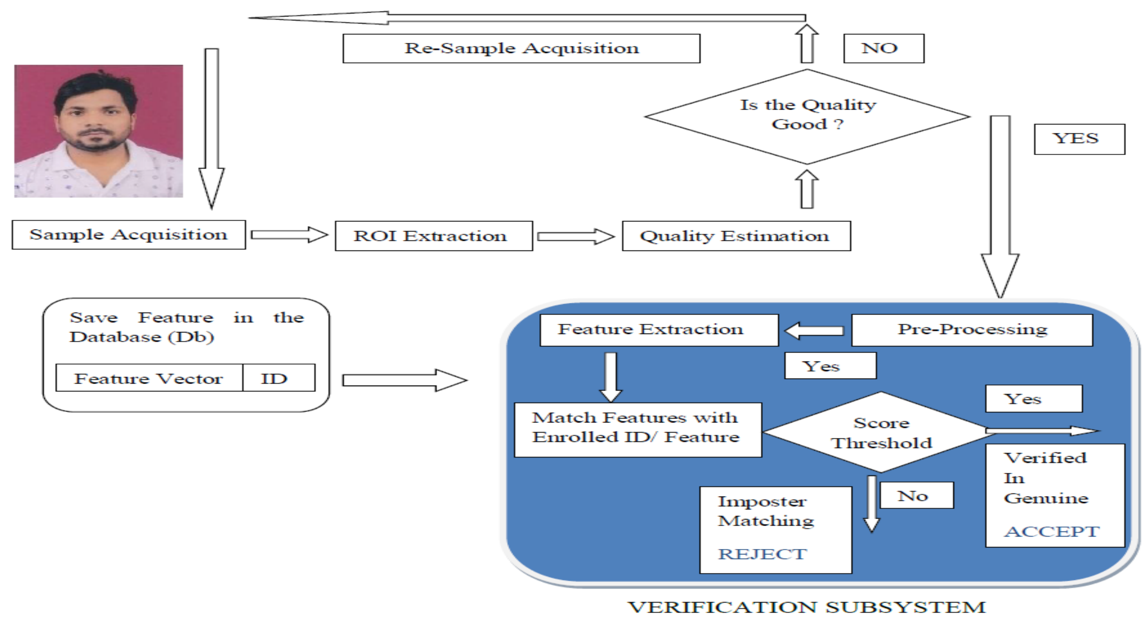


Figure 1.3 Flow Diagram of Authentication Process

1.2.3 Identification

It is otherwise called One-to-Many (i.e. 1: N) coordinating. In this mode, the framework might not have any data other than the introduced biometric quality. It endeavors to decide the right character of that client; subsequently it is named as Identification. The ROI of biometric picture is preprocessed and highlights are separated. The component vector is coordinated with highlight vectors of all clients in the database and the top best matches are gotten.

All the more plainly, let F_1 be test highlights of a biometric quality. The coordinating score might be processed utilizing an assortment of separation measurements to acquire the comparability or the disparity scores among F_1 and all component vectors that are put away in the database. Out of every one of these scores, the best N coordinating pictures are accounted for as N plausible matches. The identification subsystem is appeared in Fig. 1.4.

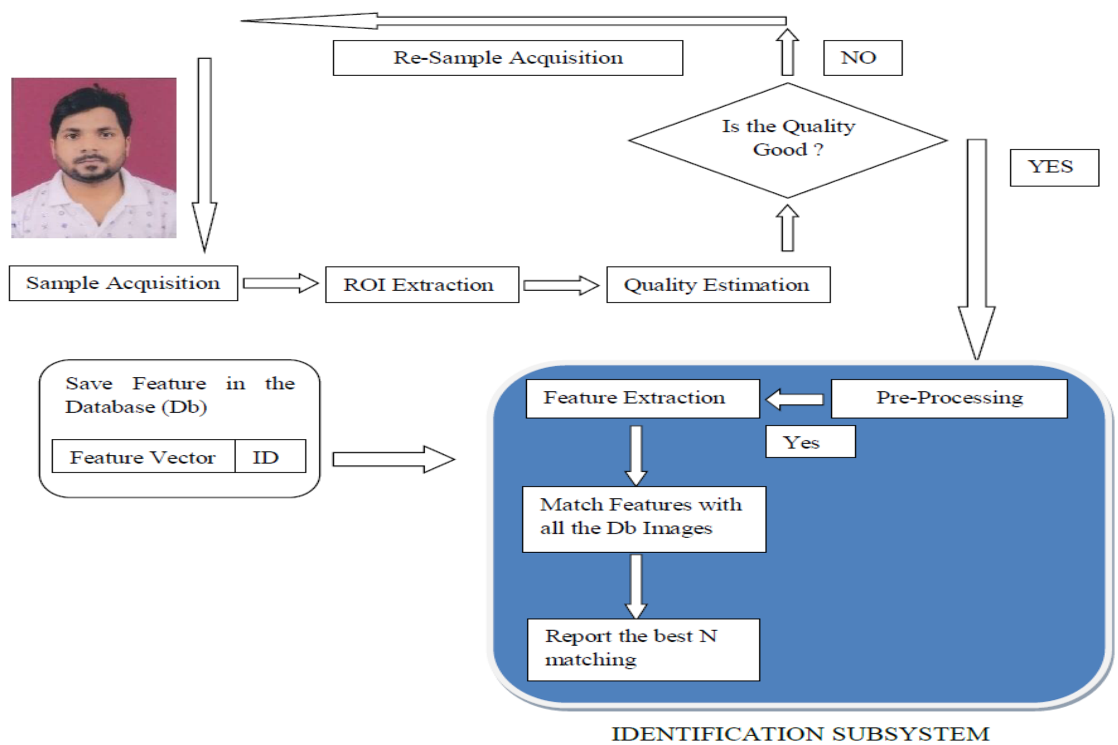


Figure 1.4 Flow Diagram of Identification Process

1.3 Multi-biometric System

The presentation of any uni-modal biometric framework is frequently got confined due to variety and uncontrolled natural condition, sensor exactness and unwavering quality just as a few quality specific difficulties, for example, present, demeanor, maturing and so forth for face. Additionally, it thinks about highlights to take choice on coordinating and thus, it is difficult to improve its exactness. Thus one can investigate the chance of intertwining more than one biometric tests, qualities or calculations. This is named as multi-biometrics [1]. There exist different sorts of multi-biometric framework. Some of them are talked about underneath.

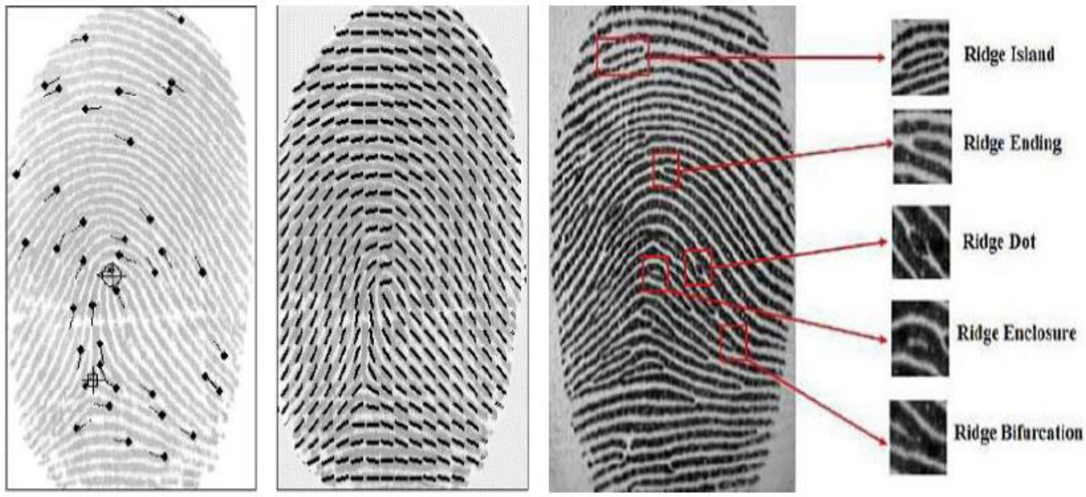
1.3.1 Types of Multi-biometric System

Any biometric based verification framework comprises of a few phases and has numerous difficulties and confinements. The point of any multi-biometric framework is to improve the exhibition of the framework.

Multi-sensor System: It considers pictures of same biometric characteristic where pictures are caught with the assistance of different sensors. Fig. 1.5 shows three kinds of fingerprint scanners which can be utilized to manufacture a multi-sensor biometric framework. These three sensors use utilizing different advancements to procure information and subsequently the quality just as discriminative highlights of their examples are significantly different.

Figure 1.5: Fingerprint Sensors

Multi-algorithm System: It thinks about numerous coordinating calculations to improve the exhibition of the framework. Pictures of the chose characteristic are caught utilizing single sensor. In Fig. 1.6, it is demonstrated that one can utilize different calculations applied over a similar picture. One calculation might be utilizing a few worldwide surface like direction field highlights while other one may utilize minutia based neighborhood highlights. Combination of these matchers is relied upon to perform better than any of these two calculations.



(a) Orientation Field Based (b) Minutia Based

Figure 1.6: Two Fingerprint Matchers

Multi-instance System: It thinks about more than one picture of the equivalent characteristic per client. Different examples are gathered. In Fig. 1.7, three examples of the equivalent finger gathered under controlled condition are appeared. This excess data is valuable to deliver the issues identified with neighborhood too as natural condition varieties.

Figure 1.7: Samples of Different Fingerprint

Multi-modal System: It considers various biometric characteristics for validation. Uncorrelated characteristics are considered to accomplish better execution [2]. Likewise it makes framework progressively vigorous against spoofing assaults as it turns out to be more what's more, more difficult to mimic every chosen attribute without a moment's delay. Yet at the same time print-assault also, parody assault may go around these frameworks [3].

Henceforth characteristic determination with better spoofing calculations is alluring. In Fig. 1.8, a multi-modular framework is appeared in which face, fingerprint, ear, iris and palm print tests are utilized.

(a) Face (b) Finger Print (c) Ear (d) Iris (f) Palm Print

Figure 1.8: Five different Biometric Traits (Multi-Modal)

1.3.2 Fusion Levels

There are a few different ways that can be utilized to meld different attributes in multi biometric framework. Combination should be possible at different levels which are discussed below.

Score Level: Tests of different qualities are coordinated with their comparing quality separately and scores are acquired. Scores are standardized to same scale and changed over into either divergence or likeness. These scores are joined to get the combined score. There exist a few score level combination procedures, for example, max, min, normal or weighted normal. For instance, let a face similitude score be 91 out of a size of [0 to 100] and an iris difference score be 0.27 in a size of 0 to 1.0. Either face score ought to be scaled to [0 to 1.0] and changed over into divergence (i.e.1 - 91/100 = 0.09), or iris score ought to be scaled to [0 to 100] and changed over into closeness (i.e. 100-0.27*100 = 73), before combination thus for combination of face and iris, one can utilized weighted normal of either 91 and 73 or 0.09 and 0.27 scores.

Feature Level: All highlights from every quality are first extricated exclusively for each subject. These highlights ought to be of a similar kind and are connected into one single multi-biometric layout which is utilized for confirmation. For instance, LBP based histogram highlights extricated from face what's more, iris pictures can be combined by linking both histogram in a steady progression to acquire a solitary histogram. The x^2 uniqueness measure can be utilized to get the combined multi-modular coordinating score.

Decision Level: All examples of different attributes are coordinated with their comparing characteristic to acquire singular scores. These scores are thresholded to acquire singular choice for every characteristic. The final choice is taken by melding them utilizing OR, AND or different guidelines. For instance, for face, iris and palm print attributes let the individual choices be Face = Accept, Iris = Reject furthermore, Palm print = Accept. Basic guidelines like in any event 2 Accept for coordinating can be utilized to settle on the choice.

1.4 Motivation of Thesis

There exist a few possibly suitable physiological and social biometric attributes. Each biometric characteristic has its own interesting and complex anatomical structure. The elements of this structure records to the discriminative force just as its security.

1.4.1 Iris

It is a ring comprised of tissues. The detailed iris related anatomical highlights are depicted in [4] and are appeared in Fig. 1.9. Dainty roundabout stomach between cornea and focal point is called as iris which has plenitude of miniaturized scale surfaces as sepulchers, wrinkles, edges, crown, spots and color spots. These surfaces are arbitrarily circulated; subsequently they are accepted to be one of a kind [5]. Iris surface is very ne and the majority of its subtleties are created during the early stage advancement. Surfaces of two subjects are accepted to be novel and even the correct eye of a similar subject is different from the left eye [6]. Iris is a normally very much ensured biometric as contrasted with different qualities and is likewise thought to be invariant to age.

Issues, for example, iris impediment because of eyelid and eyelashes and specular reflection stay to be tended to. Likewise exact iris restriction is a test. Tremendous sum of efforts are required to improve the exactness and unwavering quality of any iris based framework. Evaluating the iris quality is additionally a significant issue that must be settled. In this postulation, we have tended to a portion of these issues.

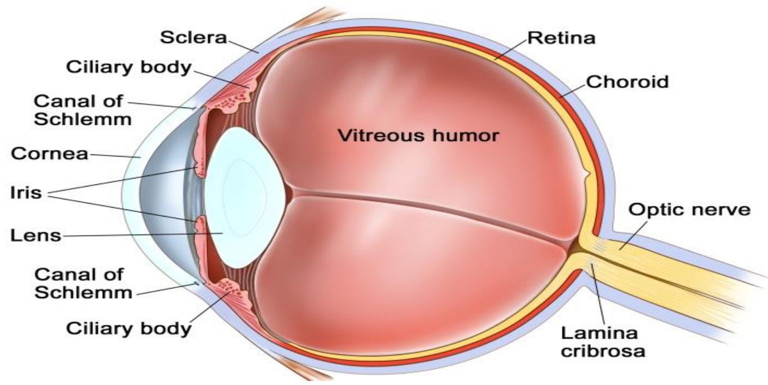


Figure 1.9: Iris Anatomy

1.4.2 Palm print

The internal piece of the hand is called as palm and the separated area of intrigue in the middle of fingers and wrist is named as palm print which is appeared in Fig. 1.10. Indeed, even monozygotic twins are found to have different palm print designs [7]. Example development inside this area should be steady just as one of a kind [8]. Enormous measure of surfaces as palm-lines, edges, wrinkles and so forth is accessible over palm print as appeared in Fig. 1.10. Prime favorable position of palm print over finger print incorporates its higher social acknowledgment since it is never being related with lawbreakers. It has bigger ROI territory when contrasted with fingerprint pictures that guarantees bounty of auxiliary highlights including standard lines, wrinkles, wrinkles and surface design. Because of bigger ROI, even low goals palm print pictures can be utilized to upgrade framework's speed however to lessen the expense.

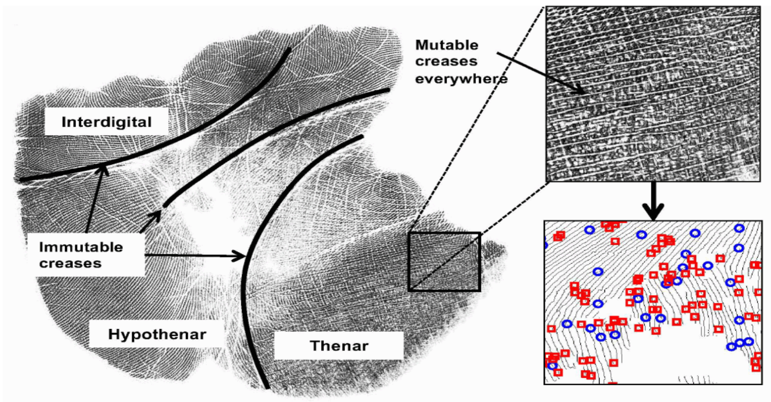


Figure 1.10 Palm print Anatomy

1.4.3 Multi-biometrics

A relative report among iris and palm print is introduced in Table 1.1. It has been watched tentatively that such a combination of at least two biometric modalities encourages the framework to dismiss the frauds significantly more confidently and hence more boosting the general framework execution significantly. The greater part of the state-of the- workmanship uni-modular biometric based confirmation frameworks perform obstruct by square what's more, pair-wise coordinating [9], [10], [11], [12], [13], [14], consequently they require pre-enrolled pictures. Be that as it may, they can't create exceptionally exact frameworks.

Any multi-modular framework utilizes some biometric characteristics to improve frame work's execution. Multimodal frameworks are increasingly important when the quantity of enlisted clients is extremely huge. The bogus acknowledgment rate develops quickly with the expansion in the size of the database [15], hence so various qualities are utilized to accomplish better execution. Additionally multi-modular frameworks can empower us to manage missing characteristic. The satire weakness is a lot lesser than any uni-modal framework; subsequently it is perfect for open air what's more, non-controlled situations. To best of the knowledge very little work has been done around there for the most part due to the non-accessibility of multi-modular datasets. Iris and palm print characteristics have uncorrelated highlights; hence so this proposal has thought about these characteristics for combination to improve the framework execution. Further, these characteristics are never used to structure a multimodal framework previously.

Property	**Meaning**	**Iris**	**Palm print**
Universality	Every individual must possess	M	M
Permanence	Features should be constant over a long period of time	H	H
Uniqueness	Features should be distinct across individuals	H	M
Performance	Possess high performance	H	M
Collectability	Trait can be easily acquired	L	M
Acceptability	Acceptable to a large percentage of the population	L	M

Circumvention	Difficult to mask or manipulate	M	M

Table 1.1: Biometric Properties (L = Low, M = Medium, H = High)

1.5 Performance Analysis Metrics

It is important to dissect the presentation of any biometric framework. The deductions drawn over execution investigation is utilized in making a decision about the reasonableness for its application. There exist a few presentation measures to break down a verification or identification framework.

1.5.1 Verification Performance Metrics

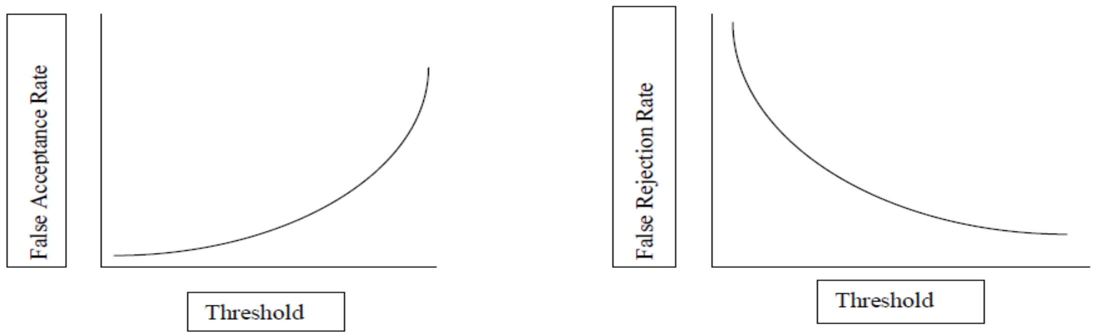
Like any model affirmation system, there are two sorts of mix-ups viz. False Acceptance Rate (FAR) and False Rejection Rate (FRR).At the point when two element vectors are coordinated, it produces a coordinating score. This score is either divergence or closeness score. For a divergence (closeness) score, on the off chance that it is less (more noteworthy) than a predefined edge, we expect, these two component vectors are coordinated. FAR is the likelihood of tolerating a sham as a veritable client wrongly. All the more obviously, on the off chance that we perform N unmistakable sham matching and M of them have acknowledged wrongly as veritable coordinating then FAR is given by :

$$FAR = (M/N)*100\% \qquad (1.1)$$

Correspondingly, FRR is defined as the likelihood of dismissing a certified client wrongly. That implies, on the off chance that we perform N unmistakable real matching and M of them have been got dismissed wrongly then FRR is given by:

$$FRR = (M/N)*100\% \qquad (1.2)$$

For various thresholds, if we plot FAR or FRR, we get a curve which is known as FAR or FRR bend. Test FAR and FRR bends are appeared in Fig. 1.11.



(a) Hypothetical FAR curve (b) Hypothetical FRR curve

Figure 1.11: Graphical Representation of FAR and FRR

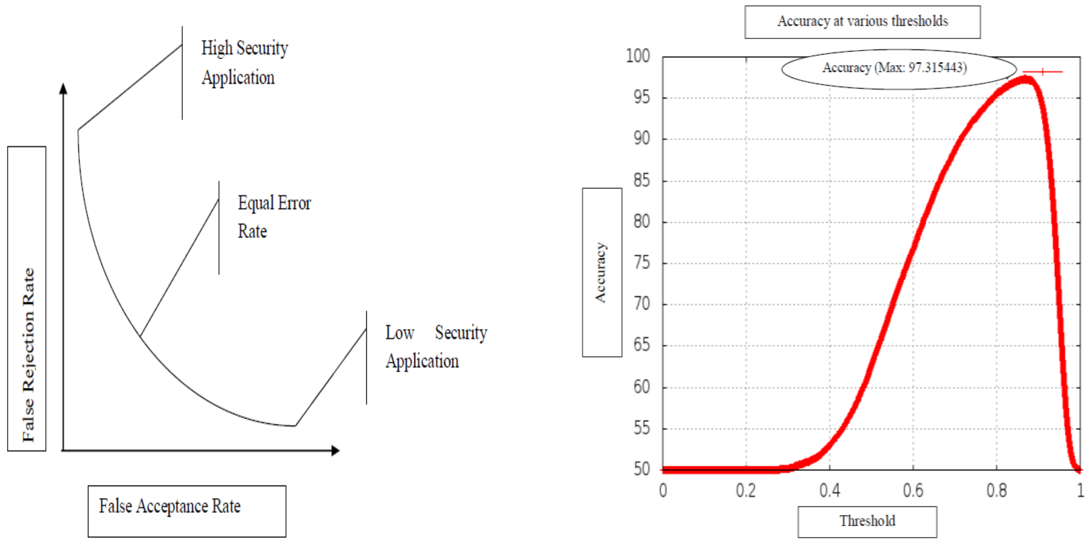
EER: Equal Error Rate (EER) is the estimation of FAR for which FAR and FRR are equal. That implies, EER is the purpose of convergence of FAR and FRR bends. Likewise, on the off chance that we draw a bend of FAR versus FRR for all edges and draw a line at 45_ from inception then EER is the purpose of crossing point of that line with the FAR versus FRR bend. It is appeared in Fig. 1.12(a).

Accuracy: If T is the limit for which (FAR+FRR) /2 is least for all FAR and FRR at different limit, at that point we define the precision at T as

$$\text{Accuracy} = (100 - (FAR_T + FRR_T)/\ 2)\ \% \qquad (1.3)$$

Where FAR_T, FRR_T are FAR and FRR at limit T. The edge (T) at which the mix of FAR and FRR gives the most elevated precision, is thought of as the ideal limit. It very well may be seen that precision may not be greatest at the limit of EER.

Receiver Operating Characteristics (ROC) Curve: It is a graph plotting FAR against different FRRs. It assists with breaking down the conduct of FAR against FRR as appeared in Fig. 1.12(a). It quantifies the discriminative intensity of the framework among real and sham's score. A perfect ROC bend would incorporate a point at FRR = 0, FAR = 0 which signifies EER = 0. The bend gives a decent approach to look at the exhibition of two biometric frameworks. Lower the ROC bend (towards both co-ordinate hub) better is the framework since zone under the bend (i.e. blunder) is lesser.



(a) Hypothetical EER curve (b) Hypothetical Accuracy curve

Figure 1.12: Graphical Representation of EER and Accuracy

Error under ROC Curve (EUC): It is a scalar amount defined as the zone under the ROC bend. It assesses the measure of blunder brought about while one settles on choice on certified and sham matching.

Decidability Index: It estimates distinctness among sham and certified coordinating scores and is characterized by:

$$d' = \left| \mu_G - \mu_I \right| / \sqrt{(\sigma^2_G + \sigma^2_I)/2} \qquad 1.4$$

where μ_G and μ_I are the mean and σ_G and σ_I are the standard deviation of the veritable and faker scores separately.

1.6 Thesis Contribution

This theory manages the issue of planning some efficient biometric frameworks. It has considered two biometrics qualities viz: iris and palm print. At long last, it has proposed an efficient multimodal biometric framework which utilizes two qualities. Score level combination is performed to get the coordinating score of the multimodal framework. The commitment of this proposition ranges over all stages engaged with the improvement of any biometric framework.

1.6.1 ROI Extraction

The data acquisition system captures the biometric samples. It is required to extract the region of interest (ROI) from the acquired samples. We have proposed efficient algorithms to extract the ROI from iris and palm samples.

Iris Extraction: It requires the specific confinement of internal just as external iris limit. Improved Hough and Integro-differential changes are utilized in the manner that they can supplement to one another to extricate the internal further more, external limits separately. The iris ROI is removed efficiently by utilizing the modified hough and area confined integro-differential change.

Palm print Extraction: The palm print has an impossible to miss and well defined structure. Some milestone key-focuses, for example, valley and slope focuses are utilized to fragment the palm print ROI.

1.6.2 Quality Estimation

The nature of the removed biometric ROI assumes a significant job in the generally execution of any framework. Consequently, a few general just as attribute specific quality boundaries are proposed to assess the nature of any iris and palm print test.

Iris Quality Estimation: The nature of an iris test is demonstrated as a capacity of six characteristics to be specific center, movement obscure, impediment, difference and brightening, widening and specular reflection.

Palm print Quality Estimation: The palm print picture quality is gotten by evaluating the measure of three essential highlights, in particular palm standard lines, edges and wrinkles.

1.6.3 Biometric Feature Enhancement and Transformation

An enhancement algorithm that can be used to get sturdy iris and ROI for palm printing was proposed. ROIs are transformed using the locale proposed Gradient-based binary pattern to get both extremely biased and stable A reflection of the texture.

1.6.4 Biometric Feature Extraction and Matching

A biometric extraction and matching feature algorithm is proposed Test Identification / recognition identifier. The components of the discriminative corner are used for Fitting in. The matching algorithm uses the sparse-point tracking concept but Its three limitations viz. Nearness, similarity and limits of patch-wise mistake. The matching algorithm proposed is parameterized and is fine balanced to allow matching.

1.6.5 Multimodal Biometric System

We proposed an effective biometric multimodal framework that uses two traits, that is. Iris and palm print. Because the same corresponding algorithm is used to suit Iris and palm, fusion is achieved with clear score level. To break down the presentation of the framework, we have made a few illusory multi-modular biometric databases. The framework is advanced to perform efficiently with the goal that it very well may be considered as a constant application. In this postulation we have indicated that uncorrelated highlights of different modalities can be intertwined to accomplish better execution.

1.7 Thesis Organization

This proposition contains eight sections. A general biometric framework with its properties has been talked about in first section. Additionally inspiration of the proposition introduced. The writing survey on every one of the two characteristics viz. iris and palm print is introduced in Chapter 2. Additionally, it has introduced the some notable work on different multi-modular based biometric framework. Some picture handling and PC vision based strategies which are utilized to plan our frameworks have been introduced in the following part.

In Chapter 3, an effective iris based acknowledgment framework has been proposed. Each iris is effectively fragmented utilizing an improved round hough change for inward iris limit (i.e. student) discovery. The vigorous integro-differential administrator is utilized to distinguish external iris limit that utilizes the understudy area.

On the off chance that the nature of the gained iris test is not exactly a predefined edge then the picture is recovered. This early quality appraisal is exceptionally urgent to deal with the issue of low quality what's more, non-perfect symbolism. The sectioned iris is standardized to polar directions (for example rectangular strips) and LBP (Local Binary Pattern) calculation is proposed to get strong highlights.

The corner highlights are extricated and coordinated utilizing the proposed divergence measure Corners having Inconsistent Optical Stream).
The framework has been tried over openly accessible CASIA 4.0 Interval what's more, Casia iris and palm databases which comprise of 2,639 and 16,212 pictures individually.

A viable palm print based acknowledgment framework has been proposed in Chapter 3&4. The palm print division is finished by getting the two valley focuses and afterward a square molded ROI is removed. The nature of the obtained palm print test is evaluated utilizing the proposed quality appraisal boundaries and if the quality is not exactly a predefined edge, it is recovered. The portioned palm print is preprocessed utilizing the proposed LBP (Local Binary Pattern) to get strong highlights. The proposed framework has been tried over freely accessible CASIA and PolyU palm print databases which comprise of 4528 and 7720 pictures individually.

In Chapter 5, an efficient multi-modular based solution and framework. Palm print and iris have been proposed and these frameworks are examined on the fanciful databases made by us. Ends alongside the future extent of work have been introduced in the last part.

Chapter 2

Literature Survey

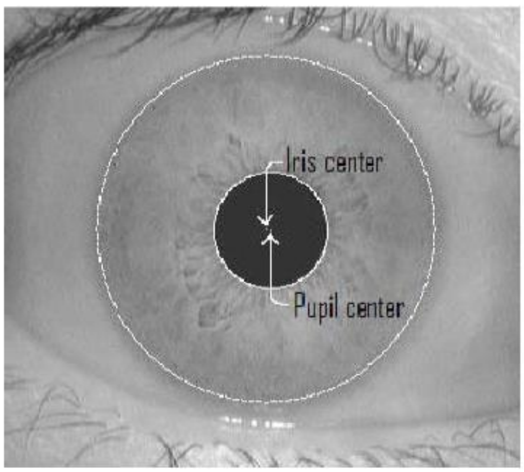
Jingyan Wang et al. (2009) proposed a framework for combinig iris and palmprint for PIA based on Gaussian mixture model (GMM) and score normalization. They have used investigates the fusion of palmprint and iris biometric features. A new fusion scheme at score level that combines is proposed. Multimodal Biometric Recognition Using Iris Feature Extraction and Palmprint Features by Hariprasath. S et al. (2012). They have used multi modal biometric system of iris and palm print based on Wavelet Packet Analysis is described. Fingerprint-Iris Fusion Based Multimodal Biometric System Using Single Hamming Distance Matcher" by Ujwalla Gawande et al. (2013). They have used to proposed the development of a fingerprint and iris fusion system which utilizes a single Hamming Distance based matcher to provide higher accuracy than the individual unimodal system. Fusion of Iris and Palmprint for Multimodal Biometric Authentication" by Nassima Kihal et al.(2014). They have used propose an approach for feature extraction of each modality by using wavelet packet decomposition at four levels. Novel Multimodal Identification Technique using Iris & Palmprint traits with Various Matching Score Level Proportions using BTC of Bit Plane Slices" by Sudeep D.Thepade et al. (2015). They have used Iris and Palmprint traits considered with score level fusion to get proposed multimodal identification technique using Block Truncation Coding (BTC) applied on the individual biplanes of iris and palmprint images. Palmprint & Iris for a Multibiometric Authentication Scheme Using Log-Gabor Filter Response" by Farid Kadri et al. (2016). They have used features of Iris and palmprint are extracted using Log Gabor filter. The Hamming Distance is used for matching of Iris or palmprint feature vector. Fusion of Palm Print and Iris for Multimodal Biometric Recognition by Ms.Priya.J et al. (2016). They have used feature extraction from iris and palm print of single person. Application of BSIF, Log-Gabor and mRMR Transforms for Iris and Palmprint based Bi-modal Identification System" by Bilal Attallah et al. (2017). They have used Log-Gabor filter and BSIF (Binarised Statistical Image Feature) coefficients are employed to obtain the iris and palmprint traits, and subsequently selection of the features vector is conducted with mRMR (Minimum Redundancy Maximum Relevance) transforms in higher coefficients. To match the iris or palm-print feature vector, the Hamming Distance is applied.

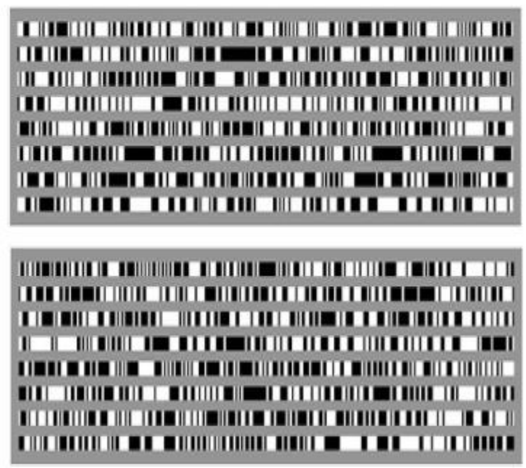
This section presents the writing study on the work completed on these two characteristics.

2.1 Iris based Biometric System

The iris ROI ought to be precisely restricted which is trying because of parcel of variety in light and other extraneous components. The iris test experiences dimensional in consistency among eye pictures which is caused because of understudy expansion, head development, eye development and so forth.

Thus, the ROI is standardized to a rectangular segment of fixed size. The work in iris acknowledgment framework is finished by Daugman [16]. The integro-differential administrator is utilized to find roundabout limits by identifying substantial bounce or drop in summation of pixel forces over the circle. The multi-scale quadrature 2D gabor wavelet coefficients are utilized. A parallel component vector (for example iris code) of 256 bytes is created which is appeared in Fig. 2.1(a).





(a) Localized Iris (b) Iris Code

Figure 2.1: Images are taken from [21]

Highlight vectors acquired from two iris pictures are coordinated by the hamming separation. Xudong Kang et al are doing this [17].

This reduces the complexity of computations and improves the precision of classification of hyper spectral objects. Sheng Zheng et al. propose 2-D gabor filter, multi-source image fusion process with help value transform [18]. The classification of SVMs (Support Vector Machine) is used to measure object help values. 2-D DWT (Discrete Wavelet Transforms) is used for Parmeshwar Manegopale multi-determination highlight extraction [19]. K.Grabowski et al. have developed a different approach for the extraction of iris features. The hair wavelet-based DWT transform is used in their paper [20]. J.Daughman had already established Gabor wavelet analysis [21] to synthesize iris image characteristics, iris signature, phasors and their position on a complex plane are analyzed and coded.

Havlicek et al. sampled binary evolving frequency distributions using the corresponding Hamming distance [22] to form a vector function. Boles and Boashash used a zero-crossing technique that describes the transformation of the one-dimensional wavelet at various levels of resolution to explain the iris texture [23].

Camus and Wildes [24] have introduced a calculation which depends on Daugman's integro-differential administrator that look in cubic space of (x, y, r). of applying the administrator legitimately accepting all focuses as applicant focus focuses, they have utilized neighborhood minimas of power as seed focuses, making the procedure quicker by 3.5 occasions when contrasted with Daugman's calculation [25]. Genuine iris community is analyzed by estimating the picture fix angle data. Additionally consistency is estimated over the eight beams going from the accepted likely focus at a $(\pi/4)^0$ point contrast, as appeared in Fig. 2.2. It gives an exactness of 99.5% in the event of having no glasses and that of 66.6% with glasses.

(a) Incorrect Center (b) Correct Center

Figure 2.2: Mapping of radial rays into a polar representation pupil and iris boundaries become vertical edges

Bonney et al. [26] have separated student by utilizing least significant bit-plane along with disintegration and enlargement activities. Utilizing student region, the standard deviation in even and vertical bearing is registered to look for limbic limit; both limits are displayed as ovals and is appeared in Fig. 2.3. This strategy doesn't depend on round edges identification; henceforth it isn't limited to roundabout iris.

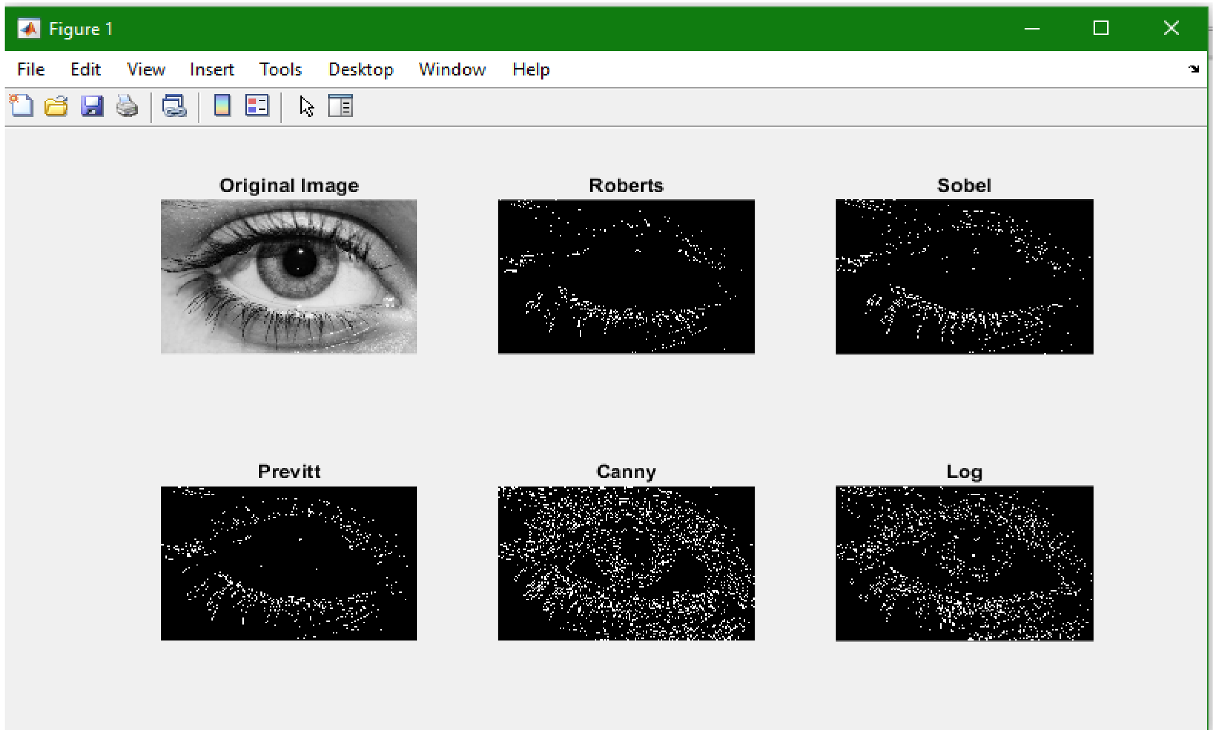


Figure 2.3: (a) Original Image (b)Roberts Image (c)Sobel Image (d)Previtt Image(e) Canny Image (f)Log Image

1. Canny technique out plays out the various strategies despite the fact that its computational multifaceted nature is higher. Canny can be utilized for the extraction of even articles with weak edges.

2. The Sobel likewise identifies the different highlights and is computationally progressively proficient as Canny however with all the more bogus edges. Sobel is ideal for objects with Strong edges as lakes, Stadium and so on.

3. Different calculations as Robert and Prewitt likewise recognize the different highlights and arena yet flops if there should arise an occurrence of littler highlights and the scope of usable edge is exceptionally low.

4. For any strategy for edge recognition, the computational intricacy increments with the expansion in the spatial goals.

5. Likewise, it was discovered that for the extraction of specific highlights certain groups ought to be utilized as the reaction of these highlights to these groups are high. The IR band was seen as reasonable for extraction of direct highlights as streets, structures, limits and so forth. The ground truth check affirmed that the edge identification is influenced by shadows, salt and pepper clamor among which the last can be dispensed with by utilizing fitting low pass channel.

Canny Method

BW = edge (I,'canny') specifies the Canny method.

BW = edge (I,'canny',thresh) indicates affectability limits for the Canny technique. sift is a two-component vector where the primary component is the low limit, and the subsequent component is the high edge. In the event that you indicate a scalar for sift, this worth is utilized for the high edge and 0.4*thresh is utilized for the low limit. In the event that you don't determine sift, or if sift is vacant ([ ]), edge picks low and high qualities consequently.

BW = edge(I,'canny',thresh,sigma) determines the Canny strategy, utilizing sigma as the standard deviation of the Gaussian channel. The default sigma is 1; the size of the channel is picked naturally, in view of sigma.

[BW,thresh] = edge(I,'canny',...) restores the edge esteems as a two-component vector.

Sobel Method

BW = edge (I,'sobel') specifies the Sobel method.

BW = edge (I,'sobel',thresh) determines the affectability limit for the Sobel strategy. edge disregards all edges that are not more grounded than sift. On the off chance that you don't indicate sift, or if sift is vacant ([ ]), edge picks the worth consequently.

BW = edge (I,'sobel',thresh,direction) determines the course of identification for the Sobel strategy. course is a string determining whether to search for 'even' or 'vertical' edges or 'both' (the default).

BW = edge (I,'sobel',...,options) gives a discretionary string input. String 'nothinning' accelerates the activity of the calculation by avoiding the extra edge diminishing stage. As a matter of course, or when 'diminishing' string is determined, the calculation applies edge diminishing.

[BW,thresh] = edge (I,'sobel',...) returns the threshold value.

[BW,thresh,gv,gh] = edge (I,'sobel',...) returns vertical and flat edge reactions to Sobel angle administrators. You can likewise utilize the accompanying articulations to acquire slope reactions:

- if ~(isa(I,'double') || isa(I,'single')); I = im2single(I); end
- gh = imfilter(I,fspecial('sobel') /8,'replicate');
- gv = imfilter(I,fspecial('sobel')'/8,'replicate');

Roberts Method

BW = edge (I,'roberts') specifies the Roberts method.

BW = edge (I,'roberts',thresh) determines the affectability limit for the Roberts technique. edge overlooks all edges that are not more grounded than sift. In the event that you don't determine sift, or if sift is vacant ([ ]), edge picks the worth naturally. BW = edge (I,'roberts',...,options) where alternatives can be the content string 'diminishing' or 'nothinning'. At the point when you determine 'diminishing', or don't indicate a worth, the calculation applies edge diminishing. Determining the 'nothinning' choice can accelerate the activity of the calculation by avoiding the extra edge diminishing stage.

[BW,thresh] = edge(I,'roberts',...) returns the threshold value. [BW,thresh,g45,g135] = edge(I,'roberts',...) returns 45 degree and 135 degree edge reactions to Roberts slope administrators. You can likewise utilize these articulations to get slope reactions:

- if ~(isa(I,'double') || isa(I,'single'));
- I = im2single(I);
- End
- g45 = imfilter(I,[1 0; 0 -1]/2,'replicate');
- g135 = imfilter(I,[0 1;-1 0]/2,'replicate');

Prewitt Method

BW = edge (I,'prewitt') specifies the Prewitt method.

BW = edge (I,'prewitt',thresh) indicates the affectability limit for the Prewitt strategy. edge disregards all edges that are not more grounded than sift. In the event that you don't indicate sift, or if sift is unfilled ([ ]), edge picks the worth consequently.

BW = edge (I,'prewitt',thresh,direction) determines the heading of identification for the Prewitt technique. course is a string determining whether to search for 'flat' or 'vertical' edges or 'both' (the default).

[BW,thresh] = edge(I,'prewitt',...) returns the threshold value.

Laplacian of Gaussian Method

BW = edge (I,'log') specifies the Laplacian of Gaussian method.

BW = edge (I,'log',thresh) indicates the affectability edge for the Laplacian of Gaussian technique. edge overlooks all edges that are not more grounded than sift. In the event that you don't determine sift, or if sift is unfilled ([ ]), edge picks the worth consequently. On the off chance that you determine a limit of 0, the yield picture has shut shapes, since it remembers all the zero intersections for the information picture.

BW = edge (I,'log',thresh,sigma) indicates the Laplacian of Gaussian strategy, utilizing sigma as the standard deviation of the LoG channel. The default sigma is 2; the size of the channel is n-by-n, where n = ceil(sigma*3)*2+1.

[BW,thresh] = edge (I,'log',...) returns the threshold value.

Zero-Cross Method

BW = edge (I,'zerocross',thresh,h) indicates the zero-cross strategy, utilizing the channel h. sift is the affectability limit; if the contention is unfilled ([ ]), edge picks the affectability edge consequently. On the off chance that you determine an edge of 0, the yield picture has shut forms, since it remembers all the zero intersections for the info picture.

[BW,thresh] = edge (I,'zerocross',...) returns the threshold value.

The eye iris seems to be the vibrant region surrounding the pupil. Remove the extra portion after the iris photo has been taken, and then calculate the histogram. Used the 2D distribution function, the Gaussian filters removes the object noise. The canny edge detector will give best result compare to all edge detection.

The haar wavelet will be used for extracting of the iris feature. It turns huge data sets into representations. Using wavelet transform, it de-composes images at different levels. The measure of energy is given as,

$$E= \sum^{y} j, k\ si\ (j,k)^2 \qquad (2.1)$$

Here the wavelet energy of each iris sub-image is used to measure the threshold for encoding the sub-images. The [T] threshold is set as,

$$K= \mu(E1,E2\ldots\ldots\ldots En) / Max(E1,E2\ldots\ldots..En\ ) \qquad (2.2)$$

Where K is consistent, the sub-picture wavelet energies 1 .... N sub-pictures and μ (E1,E2 ....) are mean vitality top qualities for wavelets. Endless supply of highlights from every one of the three properties, these appraisals are combined and ordered utilizing the KNN classifier. The KNN classifier is the least complex grouping framework wherein its tends asymptotic to the perfect Bayes classifier under mellow suppositions on k and N. Since a legitimate preparing stage isn't required. It figures an euclidean separation between two of the closest vectors. The dependability of the framework is controlled by the estimation of an inappropriate acknowledgment rate and the bogus dismissal pace of the most extreme framework. Scores are utilized to mirror the higher closeness of the formats. At that point, for the candidate to fluctuate from the imposer, a solitary farthest point is set.

2.2 Palm print based Biometric System

Palm print acknowledgment frameworks are extensively founded on basic and measurable highlights. In line-like auxiliary highlights are extricated by applying morphological tasks over edge-maps. In auxiliary highlights, for example, focuses on guideline line and some disconnected focuses are used for palm print validation.

Using the Gabor filter, palm print elements are extracted [27]. 2-D The Gabor filter is used to measure palm print image texture quality. Texture characteristics are measured at various Palm printing speeds and orientations [28].

$$G(x\ , y)= (\exp\ (x' + y2\ .y2)/ -2_{\sigma}^{2}\ ) \cos(2\pi(x'/y)) \qquad (2.3)$$

Where
$x' = x \cos\theta + y \sin\theta$, $y, = -x \sin\theta + y \cos\theta$

σ denotes variance

θ denotes orientation

Iris characteristics are taken with haar wavelet transform, that is one of the simplest wavelet transformations efficient of expressing more knowledge sets to relatively smaller representations. The differential equation is transformed into a series of algebraic equations. The hair wavelet decomposes the picture to K = 1, 2, 3,4 etc. This determines at each point the horizontal, vertical, and diagonal orientation.

The function of haar wavelet is defined as: $h_o(x) = 1/\sqrt{m}$

$$hi(x) = \begin{cases} 2^{j/2}, & (k-1)/2^j \le x \le k - ½ / 2^j \\ -2^{j/2}, & (k - ½)/2^j \le x \le k / 2^j \\ 0, & \text{otherwise} \end{cases} \quad (2.4)$$

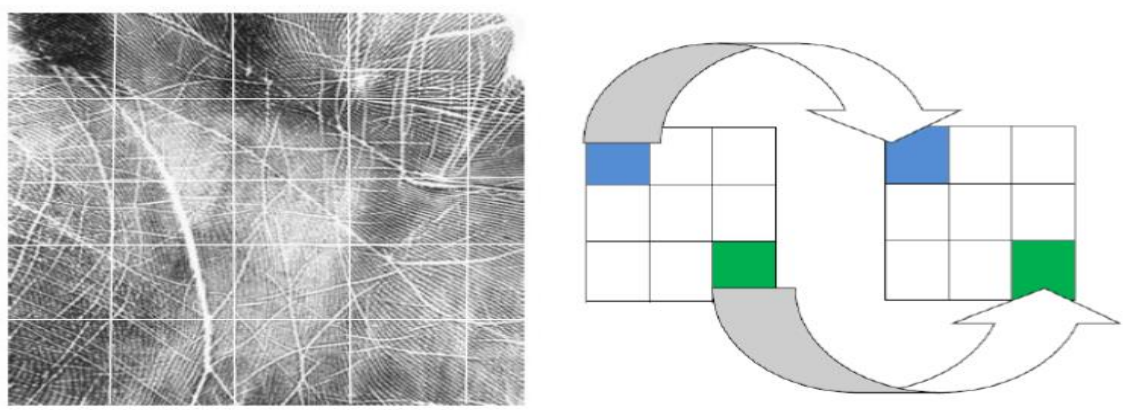
Where
M=2j (j = 0, 1, 2, 3, 4, ...) shows the level of the wavelet i= 0, 1, 2, 3, 4, ... m-1 as the parameter for translation.

Gaussian filter used to measure middle and radius of the pupil. The frame gives a corresponding score which shows the vector's similarity to the model vector. Using weighted fusion method, these values are combined. And equate these fused score to the threshold value. A case-based learning approach is the KNN (k-nearest neighbors) The classifier used to know the identity of the person.
The database of all 50 images is included in the training dataset. This tests the distance to the Euclidean from each point, and finds the closest point.

$$d_{2st} = (x_s - y_t)(x_s - y_t), \quad (2.5)$$

Where measures are equal distances between x_s and y_t.

In [29], each palm print is apportioned into non-covering hinders as appeared in Fig. 2.15. From each square, Zernike second based highlights are registered. The request existing apart from everything else signifies the level of the degree of the detailed information. Higher the request, more is the data. Lower request minutes are utilized to register highlights as they can coarsely speak to the picture data. Squares are likewise weighed dependent on the entropy of the square and the binarised highlight vector is coordinated utilizing the hamming separation.



(a) Palm print Image (b) Corresponding sub-image matching

Figure 2.4: Partitioning for 2D square based Palm print System

In palm print tests are partitioned into covering square squares as appeared in Fig. 2.4(b). The 2D square is changed over into two 1D signal by performing averaging activity in horizontal and vertical ways. The stage difference between level and vertical signs is binarised utilizing zero-intersection to acquire the twofold vector. The hamming separation is utilized for coordinating.

In [30], the palm print is separated into circular strips. The range of the strip is a variable and is improved for execution.

Like Fourier transform, Stockwell transform can likewise be utilized for otherworldly deterioration. But that as it may, the immediate stage utilized by Stockwell change produces include vector that encodes both stage and time which is more valuable than just stage or extent as we can get from Fourier transform. Thus, utilizing Stockwell change are from this annular ring. The 2D annular ring is changed over into 1D normal vector over which Stockwell change is applied. These highlights are binarised and hamming separation is utilized for coordinating. [31]

2.3 Multi-modal Biometric System

Multimodal biometric systems provide additional information that improves accuracy recognition quality by compensating for the limitations of single biometrics. Two biological features are of interest to us: iris and identity authentication palm print. The iris biometric identification ability is now well established and accepted. This is because of its unique features, such as defense (by a cornea), individuality (Any two irises could not be the same), fake-proof (because the true iris responds to the light) [31]. Typically the word iris is used to denote the eye's colored part. This is a complex process involving musculature, organs and blood vessels [32].

The picture quality could be determined by measuring the pixels in the picture [33]. Therefore, The human iris image is a legitimate biometric signature for authentication or verification of your personal identity. Certain iris properties for automated recognition systems that make it superior to fingerprints include, but are not limited to, the complexity of medically adjusting its risk-free shape, Its inherent protection and isolation from the physical environment, and its simple physiological response to light[34]. Specific technological advantages over fingerprints for automated representation processes included the convenience in optically capturing the iris without contact. The method of extracting variations is easier in relation to the above fact, due to its intrinsic polar geometry. The pairing of the left and right palm print pictures has become one of the popular verification techniques [35]. Palm print and a range of improvements over other features. In particular there are many features in the palm region such as main lines, symmetry, wrinkle, delta point, minutiae, date point, and texture [36]. Due to its reliability and simplicity, Palm print has been used for criminal recognition as a powerful tool in law enforcement. The rationale for selecting hand features as a basis for identity verification stems from its user friendliness, flexibility of the environment and discriminatory ability. We present a single algorithm for each biometric modality that allows primitives to be extracted and these traits to be fused at different levels: feature, score and decision.

Chapter 3

Identification of Problem and Formulas

Their exist a few procedures for extracting features from iris and palm print. These procedures can comprehensively be separated into two classifications: global and local. Any global element extraction method thinks about entire picture to get highlights from the picture while then again, nearby methods think about just a couple neighboring pixels or a fixed size in every one of local fixes. Some of the well known global extraction techniques are designed with the help of Gabor filters, local binary patterns, Radon based transforms, Gaussian based ordinal, Wavelets, Stockwell change, Zernike second and discrete cosine change (DCT). Similarly, there are several local feature extraction techniques to extract features. Some of them are PCA, LDA, Gabor - PCA, LBP - PCA, DFT etc. Advantages of the use of global features is that they can be computed at once for the whole image, hence they should be easy to compute and fast. But full image approximation may create the problem of under-estimation. Local features are extracted for each pixel, block or key point; hence, they are computationally intensive. But performance-wise, they are found to be better because of the effective use of smaller neighborhood and similar patch approximation.

Generally, features of iris and palm print are converted into binary vector and hamming distance based measures are used to compute matching scores between two feature vectors. One of the disadvantages of such a matching strategy is that if the images are not well registered, the performance of the system gets severely affected. This is because it never attempts to compute the pixel or patch level correspondence.

3.1 Local Binary Pattern (LBP)

It is a well known texture operator which is simple and computationally efficient and effective. It assumes that any image texture has some pattern and a strength is associated to it. It is invariant to enlightenment and its force has the range from 0 to 255; consequently, it very well may be acknowledged as a gray scale picture. It depends on the suspicion that pixel's relative dark incentive regarding its 8 neighborhood pixels can be more steady than its own force esteem. A 8-bit nearby parallel example is processed by thresholding its 8 neighbors as for itself and by speaking to the ordinal connection as appeared in Fig. 3.1

The LBP features of each image can be computed in the form of LBP histograms. These histograms are saved in the form of 1-D vectors and are used to compute distance. Let S and M be the histograms of the probe image and the gallery image respectively. To discriminate histogram features, there exist several possible dissimilarity measures as discussed below.

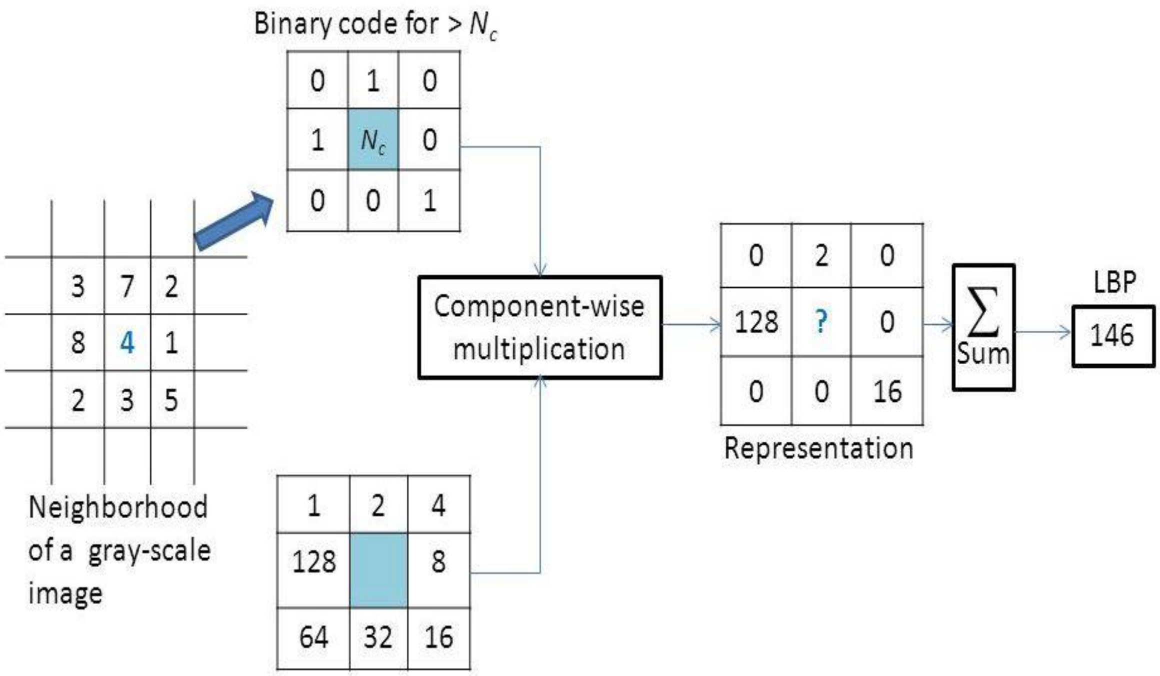


Figure 3.1: LBP Computation

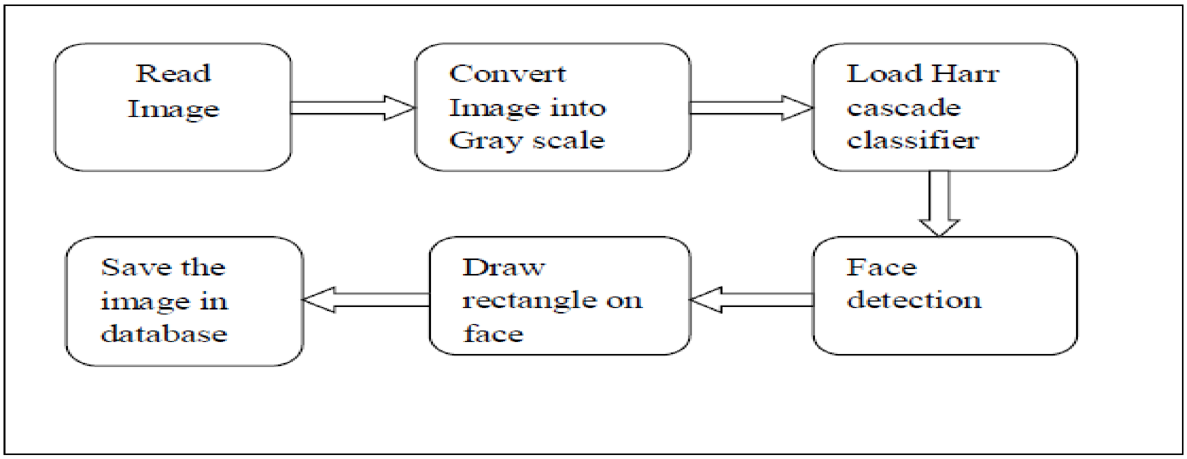
$$\text{Histogram intersection: } D(S, M) = \sum_i \min(S_i, M_i) \qquad (3.1)$$

$$\text{Chi square statistic } (\chi^2): \ \chi^2 (S, M) = \sum_i (S_i - M_i)^2 / S_i - M_i \qquad (3.2)$$

$$\text{Log-likelihood statistic: } L(S, M) = \sum_i S_i \log M_i \qquad (3.3)$$

where Si and Mi are i^{th} bin of histograms S and M respectively.

The LBP based histogram features can be used for face recognition. Let us assume that we have two facial images probe and gallery between which we have to find out the dissimilarity score. Locales like left eye, right eye, nose and lips of every facial picture are isolated into 8*8 = 64 squares. For each square, a histogram is calculated using decimal values of the binary patterns as labels.



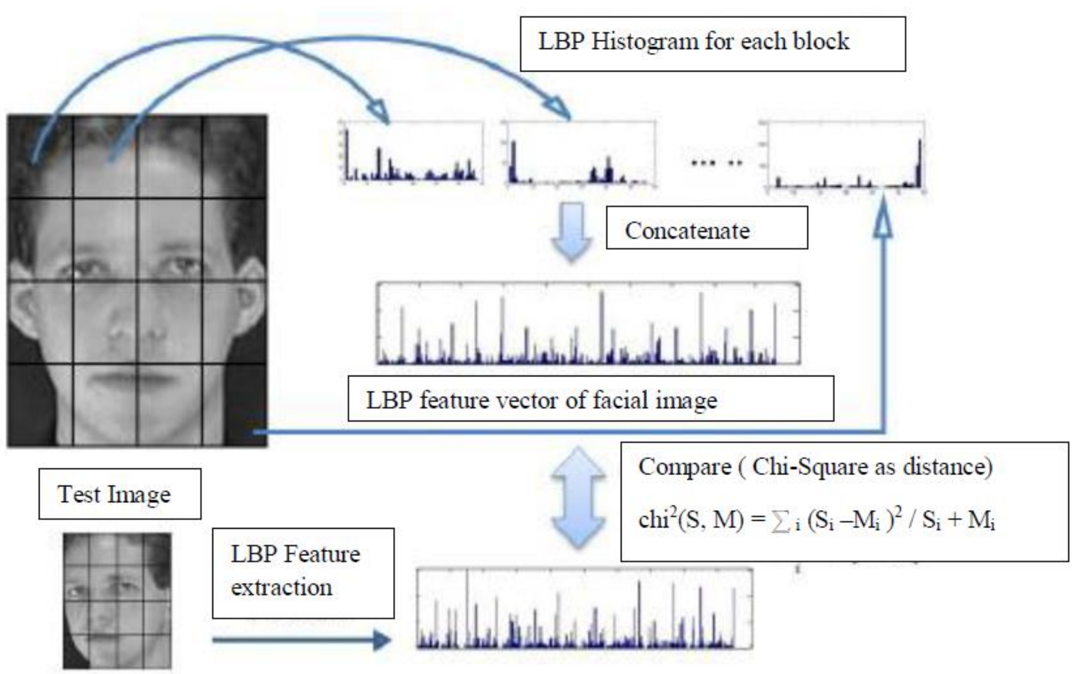


Figure 3.2: Application of LBP in Face Recognition
[35]

The concatenation of the histograms for each block in each region acts as the feature vector of that image (say H probe and H gallery for probe and gallery respectively). This feature vector is used for calculation of dissimilarity between the probe and the gallery images. The Chi square (χ^2) measure can be used to obtain the dissimilarity between probe and gallery image as

$$\chi^2 (H_{probe}, H_{gallry}) = \sum_{i=0}^{255} (H^i_{probe} - H^i_{gallery})^2 / H^i_{probe} + H^i_{gallery} \quad (3.4)$$

where H^i_{probe} and $H^i_{gallery}$ are the values for i^{th} label of probe and gallery histograms respectively. Overall dissimilarity score for probe and gallery images can be expressed as

$$D(probe, gallery) = \sum_{\forall Region} \sum_{\forall Blocks} \chi^2 (H_{probe}, H_{gallery}) \quad (3.5)$$

It can be noted that since D provides the dissimilarity information between two samples, lower the value of D, better is the match.

3.2 Corner Point Detection

Some key points that are visually significant, lie on the edges or sharp discontinuities. But all points on the edges in an image cannot be considered as key feature points because they all look similar along that edge. Corners have strong derivative in two orthogonal directions and can provide enough robust information for tracking. We have considered corner points as features because of their repeatability and discrimination.

The autocorrelation grid M can be utilized to compute corner focuses that are having solid symmetrical subordinates. The framework M can be defined for any pixel at the i^{th} line of the j^{th} segment of a picture as:

$$M (i, j) = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \quad (3.6)$$

Where

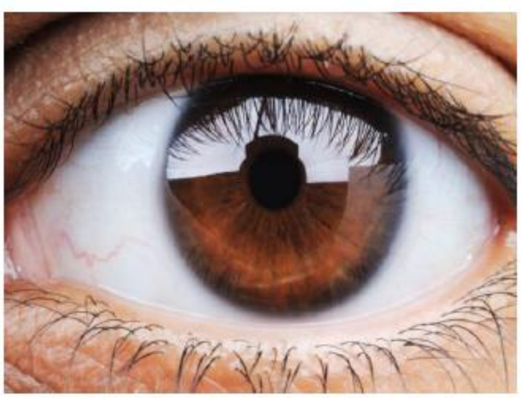
$$A = \sum_{-k<=a,\ b<=k} w(a,b).\ I^2_x\ (i+a,\ j+b)$$

$$B = \sum_{-k<=a,\ b<=k} w(a,b).I_x\ (i+a,\ j+b).I_y\ (i+a,\ j+b)$$

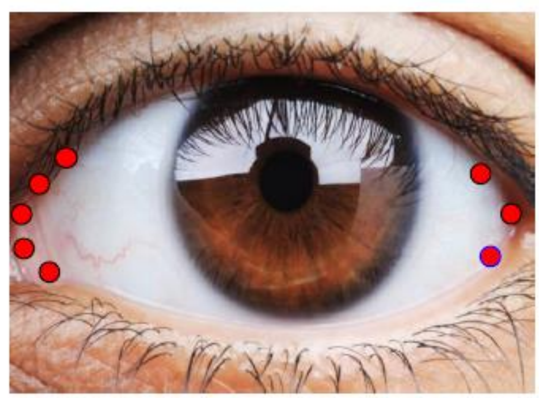
$$C = \sum_{-k<=a,\ b<=k} w(a,b).I_y\ (i+a,\ j+b).I_x\ (i+a,\ j+b)$$

$$D = \sum_{-k<=a,\ b<=k} w(a,b)\ .\ I^2_y\ (i+a,\ j+b)$$

and w(a; b) is the weight given to the neighborhood, I_x (i + a, j + b) and I_y (i + a, j + b) are the partial derivatives sampled within a patch of size (2K+1)*(2K+1) centered at the pixel (i, j). However, all neighbors may not have same weight. The matrix M can have two eigenvalues λ_1 and λ_2 such that $\lambda_1 >= \lambda_2$ with e_1 and e_2 as the corresponding eigenvectors. All pixels with $\lambda_2 >=$ T (smaller value of own). Over a threshold) shall be known as the corner points. An example is given in the Example. 3.3.



(a) Original



(b) Extracted Corners

Figure 3.3: Corner Features shown in Red

3.3 Gabor Filter: Gabor channel, Gabor channel bank, Gabor change and Gabor wavelet are generally applied to picture preparing, PC vision and example acknowledgment. This capacity can give exact time-recurrence area represented by the "Vulnerability Principle". A roundabout 2- D Gabor channel in the spatial area has the accompanying general structure [20-21],

$$G(x,y,\theta,u,\sigma) = 1/2\pi\sigma^2 \ \exp\{-(x^2+y^2)/2\sigma^2\} * \exp\{2\pi i(ux\cos\theta + uy\sin\theta)\},$$

where $i=\sqrt{-1}$; u is the recurrence of the sinusoidal wave; θ controls the direction of the capacity and σ is the norm deviation of the Gaussian envelope. Such Gabor filters have been generally utilized in different applications. Also to exact time-recurrence area, they additionally give power against differing splendor and differentiation of pictures. Besides, the filters can demonstrate the responsive fields of a basic cell in the essential visual cortex. In light of these properties, in this paper, we attempt to apply a Gabor filter to palmprint verification.

Convolution in the spatial space of every essential ghastly return for capital invested with the chose Gabor channel ~G is performed. For each essential shading ROI picture the convolution gives the genuine part of the surface picture and the fanciful piece of the surface picture. The genuine and fanciful pieces of the surface picture are binarized utilizing a zero limit. The double pixel estimation of the genuine part b_r or of the fanciful part b_i of the separated picture is gotten as follows:

$$b_r = 1, \ Re[\sim G[x, y, \theta, u, \sigma] * I] \geq 0$$
$$b_r = 0, \ Re[\sim G[x, y, \theta, u, \sigma] * I] < 0$$

for the genuine piece of the separated surface picture P_R, and

$$b_i = 1, \ Im[\sim G[x, y, \theta, u, \sigma] * I] \geq 0$$
$$b_i = 0, \ Im[\sim G[x, y, \theta, u, \sigma] * I] < 0$$

for the fanciful piece of the separated surface picture P_I , where ' * ' signifies the 2D convolution in the spatial area and $I \in \{I^R, I^G, I^B\}$ is the essential unearthly ROI picture.

A fingerprint is a pattern of ridges and valleys. The dark area of the fingerprint is known as ridges and white areas that exist between the ridges called valleys [1]. In fingerprint minutiae denotes to specific plot points. UPEK Fingerprint Database used for verification. Fingerprint recognition process based on minutiae consists of the following steps:

Preprocessing and Thinning: The captured fingerprint image may be in gray scale of in color. In the binarization step fingerprint image is converted into binary image [8]. In this step the fingerprint image is converted into grayscale, and then to binary data. The image enhancement also include in the preprocessing stage. During the preprocessing the image is normalized and applied filters (Gabor filter) for recover the ridge structures and remove the noise. Binarized image is thinned to reduce the thickness of all ridges lines to one pixel width. This step will help to extract minutiae points, as thinning does not change the location of the minutiae points compared to the original fingerprint Minutiae Extraction and Minutiae Matching: This step develops the minutiae locations and angles in the fingerprint. Crossing number (Cn) is used to identify the minutiae points, which is defined as half of the sum of differences between intensity values of two adjacent pixels. If crossing number is 1, 2, 3 or greater, then the minutiae points are considered as ending, normal ridge, bifurcation respectively.

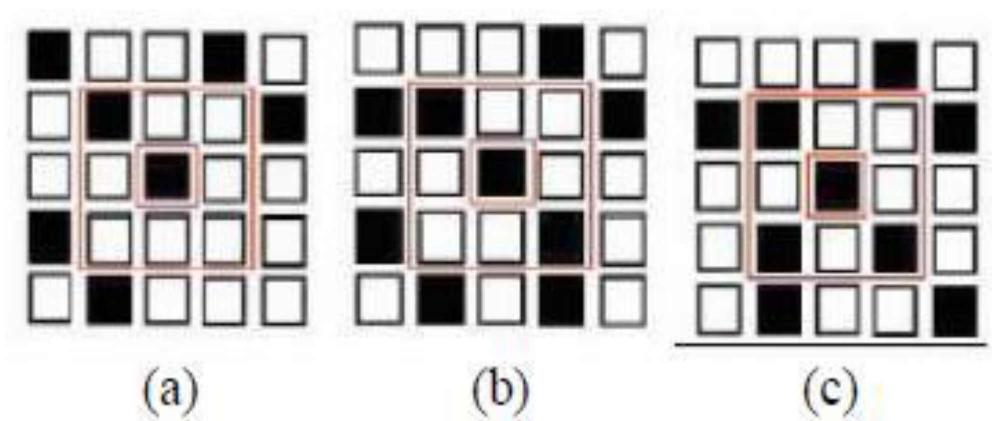


Figure 3.4: Minutiae Extraction, (a) Ending minutiae, Cn=1 (b) Normal ridge pixel, Cn=2 (c) Bifurcation minutiae, Cn=3.

FAR (False Acceptance Rate), FRR (False Rejection Rate), TSR (Total Success Rate) and EER (Equal Error Rate) has been used for evaluating the proposed method for verification. In any biometric scheme, the FAR determines the rate of invalid persons who are incorrectly accepted, while FRR determine the total rejection rate for the right persons.

The TSR (Total Success Rate) determine the correctness of any biometric system while determine total error in any biometric system.

FRR = (NFR / NEA) X100 %
FAR = (NFA/NIA) X100 %
TSR = (1 – (FAR+FRR)/TNA) X100 %
Where,
NFR= Number of false rejection,
NEA=Number of Enrollee Attempts,
NFA=Number of False Acceptance,
NIA=Number of Impostor Attempts,
TNA=Total Number of Attempts.

Chapter 4

Solution Approach

4.1 Proposed Methodology

Two biometric characteristics which are palm print and iris have been fused together in the proposed system. Specific features erase the palm print and the iris. By Gabor texture feature extraction the score of extracted features is determined and Such scores are combined using wavelet fusion method. It is therefore possible to change the current algorithm and analysis to other applications of multimodal biometric fusion.

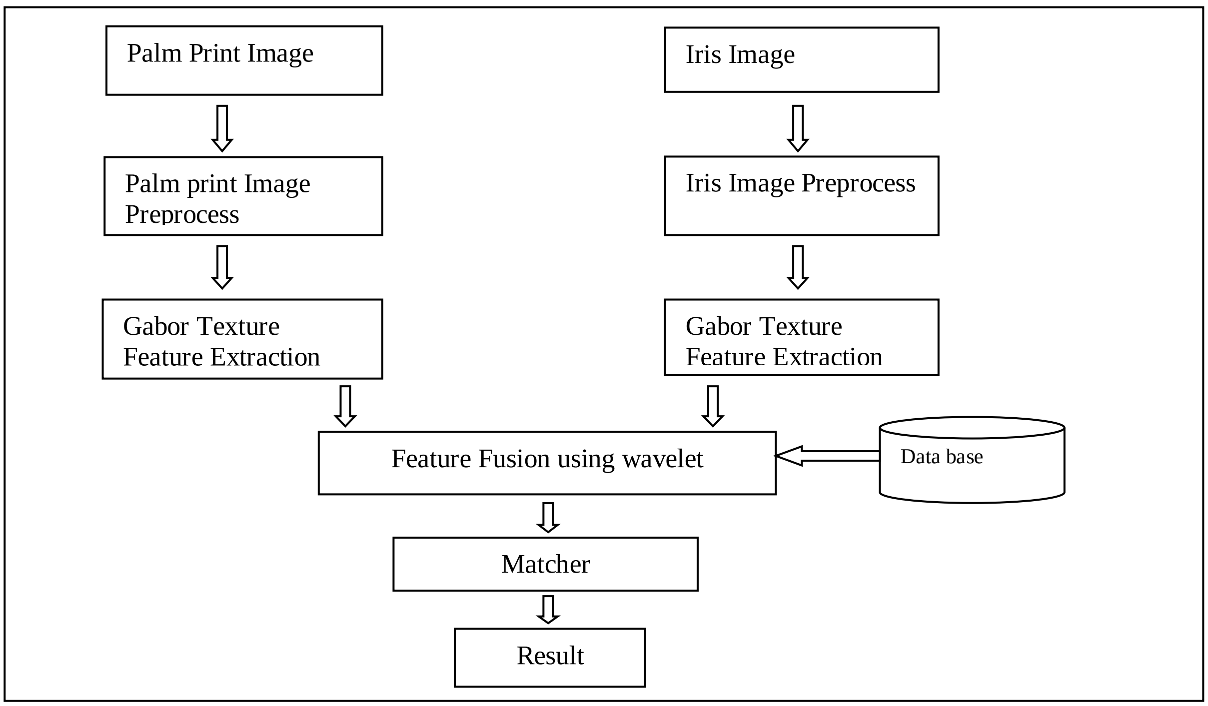


Figure 4.1 Proposed Methodology

- Join the image of the palm print and iris as input.
- Pick the extraction function using texture of the gabor.
- The function is merged by using the wavelet fusion function.
- The nearest distance-calculated neighborhood algorithm is used for object classification.
- Classify the text image and calculate the matching score and take the matching image as output. [41]

4.1.1 Palm Print: This chapter deals with the problem of designing effective recognition based on palm print recognition system. The Palm print ROI is extracted using a segmentation algorithm for key points Suggested at[9]. Features such as the palm prints, lines and ridges are used to match two palm prints. As with any biometric system, Recognition program based on palm print consists of five key activities, Viz: Extraction by ROI, Estimated quality, preprocessed ROI, extraction and matching features. The complete design of the device proposed is shown in Fig. 6.1 Two in public The available CASIA[15] and PolyU[57] palm print databases are used to analyze the Quality of program proposed.

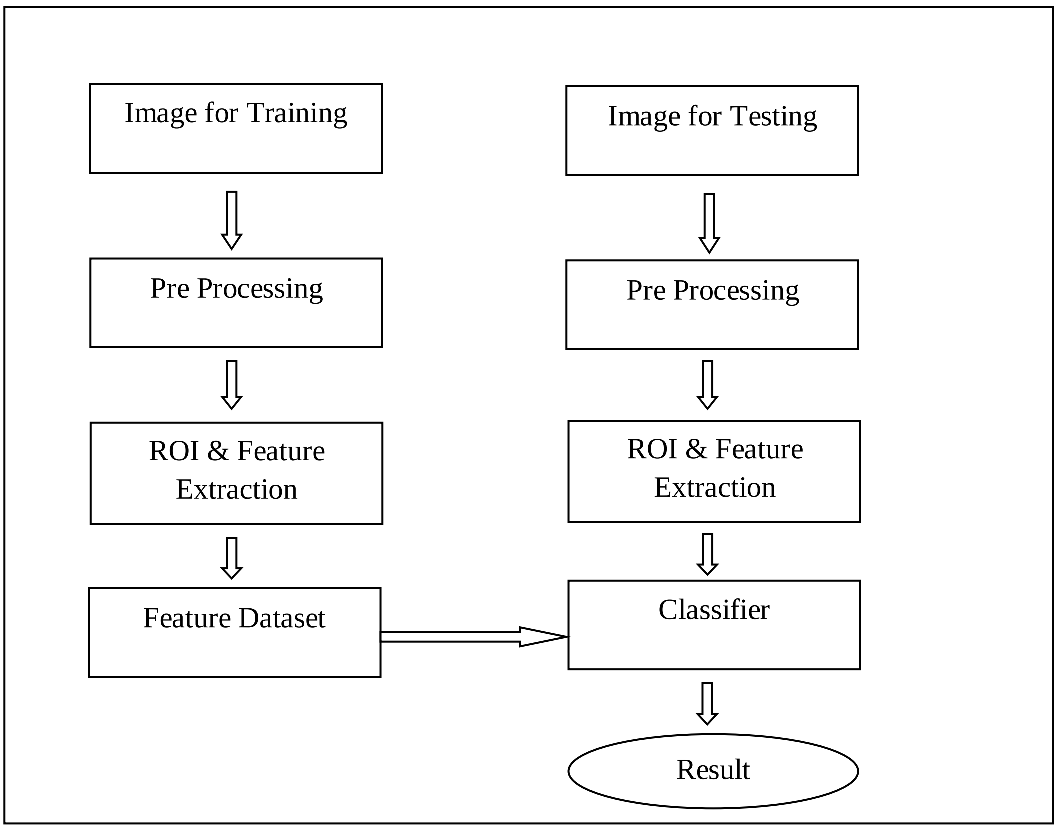
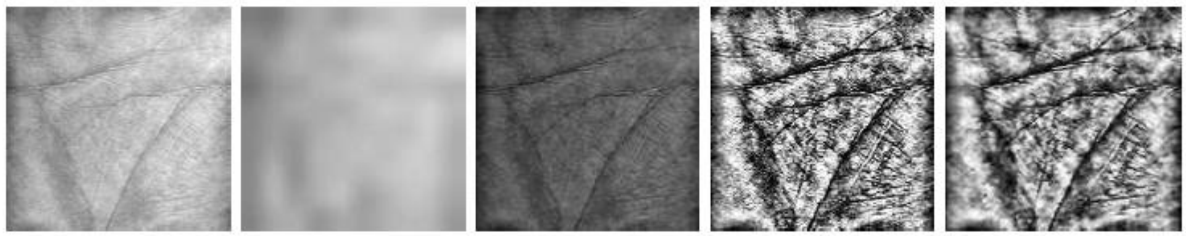


Figure 4.2 Architecture of Palm Print

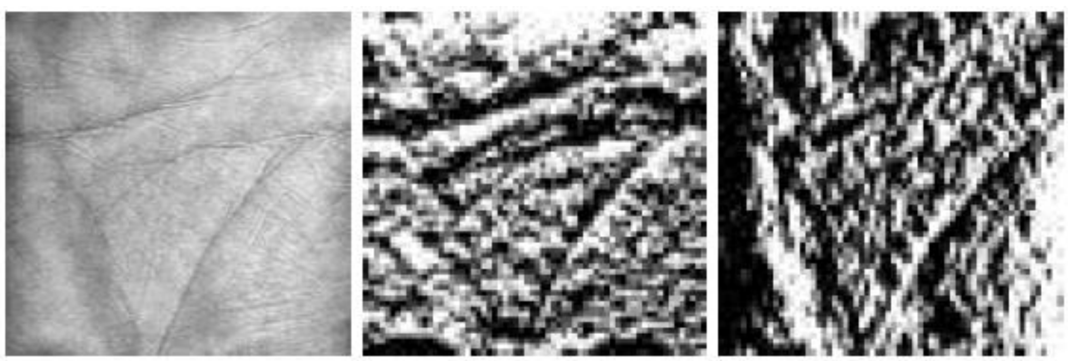
4.1.2 Palm print Image Preprocess: The extracted region of interest (ROI) of palm print is generally of poor contrast. The image enhancement algorithm discussed in Section 4.3.1 is applied over the ROI. The enhanced palm print has better quality texture as shown in Fig. 6.3. It uses local block average as the background illumination which is subtracted from the original ROI to obtain uniformly illuminated ROI which is shown in Fig. 6.3(c). Finally image is enhanced using CLAHE [55] and noise is removed using weiner filtering. The enhanced palm print ROI is shown in Fig. 6.3(e).



(a) Original (b) Bg Illum. (c) Uni. Illum. (d) Enhanced (e) Noise Removal

Figure 4.3: Palm print Image Enhancement

In order to obtain robust representation (v code and h code) that can tolerate Small amount of variation in illumination, images are transformed with LBP Transformation. In Fig an original palm is displayed along with its v code and h code. 6.4. It uses the local (vertical and horizontal) gradient sign around any pixel to Get 8 bit Lbp_code. This is resistant to slight variability in illumination.



(a) Orig. Palm print (b) Palm v code (c) Palm h code

Figure 4.4: Original and Transformed (v code, h code) for Palm print

4.1.3 Gabor Texture Feature Extraction

The Gabor change, named after Dennis Gabor, is an exceptional instance of the brief timeframe Fourier change. It is utilized to decide the sinusoidal recurrence and stage substance of neighborhood areas of a sign as it changes after some time. The capacity to be changed is first duplicated by a Gaussian capacity, which can be viewed as a window work, and the subsequent capacity is then changed with a Fourier change to infer the time-recurrence analysis. The window work implies that the sign close to the time being investigated will have higher weight. The Gabor change of a sign x(t) is characterized by this recipe:

$$G_x(\Gamma,\omega) = \int_{-\omega}^{\omega} x(t)e^{-\pi(t-\Gamma)} e^{-jwt}\, dt \qquad (4.1)$$

The Gaussian capacity has limitless range and it is unreasonable for usage. Be that as it may, a degree of essentialness can be picked (for example 0.00001) for the conveyance of the Gaussian capacity.

$$e^{-\pi a^2} >= 0.00001 \; ; |a| \leq 1.9143$$

$$e^{-\pi a^2} < 0.00001 \; ; |a| > 1.9143 \qquad (4.2)$$

Outside these constraints of combination (|a| >1.9143) the Gaussian capacity is sufficiently little to be overlooked. In this way the Gabor change can be sufficiently approximated as

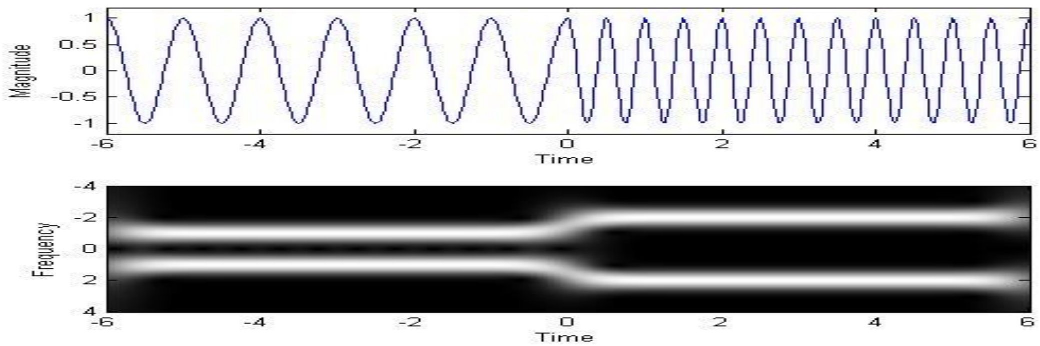
$$G_x(\Gamma,\omega) = \int_{-1.9143+\Gamma}^{1.9143+\Gamma} x(t)e^{-x(t-\Gamma)^2} e^{-jwt}\, dt \qquad (4.3)$$

This improvement causes the Gabor to change commonsense and feasible.

The window work width can likewise be differed to advance the time-recurrence goals tradeoff for a specific application by swapping the $-\pi(t-r)^2$ with $-\pi\alpha(t-\Gamma)$ for some picked alpha.

The principle use of the Gabor change is utilized in time–recurrence examination. Accept the accompanying condition for instance. The information signal has 1 Hz recurrence segment when t = 0 and has 2 Hz recurrence part when t > 0

$$X(t) = \begin{cases} \text{Cos}(2\pi t) & \text{for } t \leq 0 \\ \text{Cos}(4\pi t) & \text{for } t > 0 \end{cases} \qquad (4.4)$$



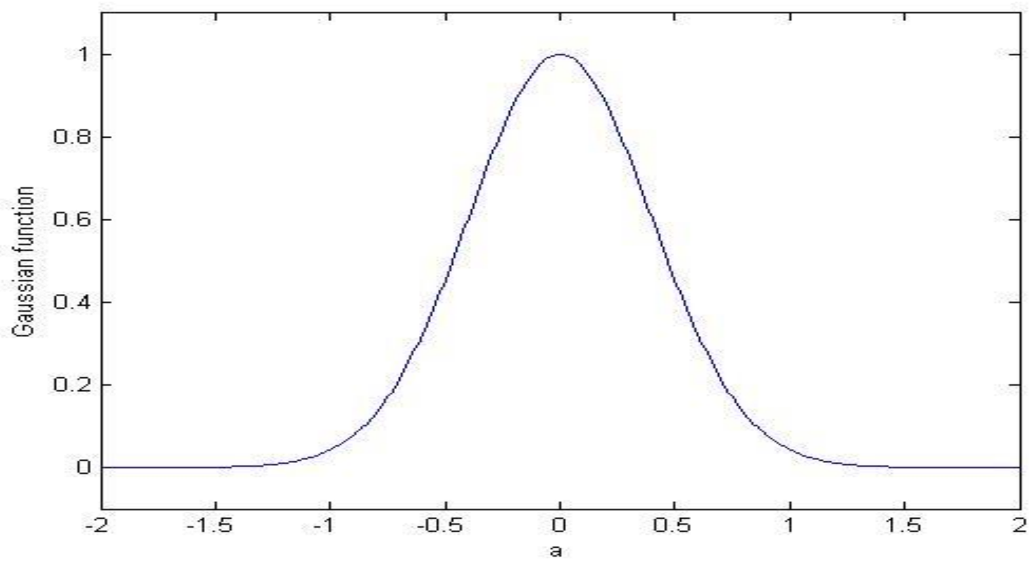


Figure 4.5: Gaussian Function graph

In any case, if the all out data transmission accessible is 5 Hz, other recurrence groups with the exception of x(t) are squandered. Through time–recurrence examination by applying the Gabor change, the accessible data transmission can be known and those recurrence groups can be utilized for different applications and transfer speed is spared. The correct side picture shows the information signal x(t) and the yield of the Gabor change. Just like our desire, the recurrence circulation can be isolated into two sections. One is $t = 0$ and the other is $t > 0$. The white part is the recurrence band involved by x(t) and the dark part isn't utilized. Note that for each point in time there is both a negative (upper white part) and a positive (lower white part) recurrence segment.

There are many features exhibited in a palm where, some feature can extract from online palm print (without using ink) and some features are extracted from offline (using ink and paper).

- Geometry features: geometry features like palm size, width, length, area can extract from the palm image.
- Principal line features: principal line location and its form on the palm image are most important physiological features.
- Minutia features: Minutia feature like wrinkles, datum points, ridges and valleys, delta points and singular points are highly unique for personal identification.

4.1.4 Iris Image: The pupil of an eye can be modeled as a dark circular region within the iris. Each eye image is scaled down for faster processing and thresholded based on image brightness to filter out pixels of the pupil and to get a binary image It. This reduces the calculation for pupil boundary (i.e. iris internal limit) on just dim pixels in the picture. Be that as it may, there might be a few eyelashes, eyebrows or shadow focuses which can go about as commotion in internal limit discovery. Additionally, specular reflection on the pupil boundary may cause the mistaken identification of the limit. Subsequently, morphological administrator of flood-filling with four neighbors is applied to the paired picture It. Pixels which can't be reached by flood-filling the foundation structure openings are expelled. In this way, specular reflection inside the understudy district and other dull spots brought about by eyelashes are expelled as appeared in Figure. 4.3(b) spoke to as I_{tf} .

(a) I^1(Original) (b) I^1_{tf} (Thresholded)

Figure 4.6: Iris Pupil Segmentation (Thresholding)

The Sobel filters in both horizontal and vertical bearings are applied on the iris picture to acquire the horizontal and vertical slope pictures. The Sobel subordinate is an estimation to picture force slope in a provided guidance. The angle greatness picture Ig is acquired by

$$Ig(x, y) = \sqrt{(I^2_{gh}(x, y) + I^2_{gv}(x, y))} \qquad (4.5)$$

where I_{gh} and I_{gv} are horizontal and vertical gradient images.

4.1.5 Iris Image Preprocessing: The extracted region of interest (ROI) of iris contains surface data yet for the most part is of helpless difference. Appropriate picture upgrade strategy is required to apply on the ROI. So as to acquire a strong portrayal that can endure little measure of light variety in iris pictures are changed. In this area, the procedure that we have used to upgrade and to change the standardized iris pictures is examined.

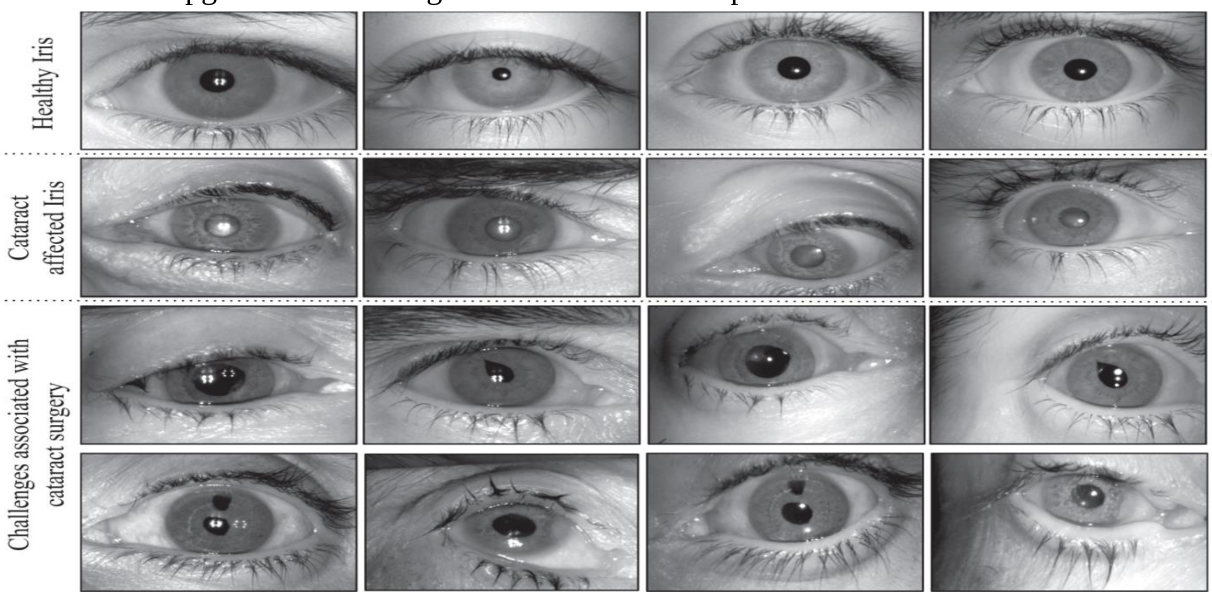
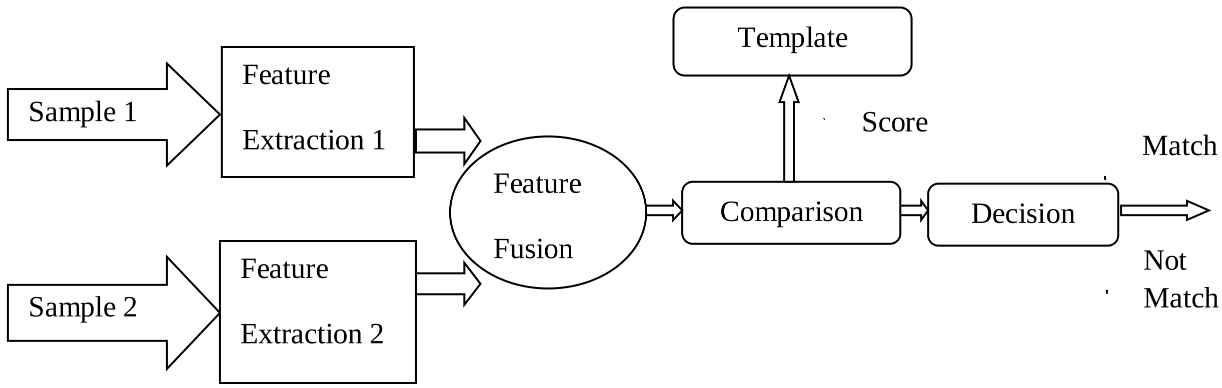


Figure 4.7: Iris texture analysis

4.1.6 Feature Fusion using wavelet: Feature level fusion alludes to consolidating feature from various sensors, numerous examples, different attributes, to get connected resultant element vector. Feature separated from one attribute must be perfect with the list of capabilities of the other. For a contrary include set component level combination is beyond the realm of imagination. Feature decrease procedures are utilized to speak to a bigger element of melded feature vector. Not many specialists utilized combination at include level due to multifaceted nature in mapping the similarity of calculation of various biometric character and bigger measurements in intertwined feature. Biometric characters has rich data and combination of feature characters is accepted to be increasingly compelling contrasted with different degrees of combination. By the data got at the element level, the framework discards the excess as well as holds separate data.



4.1.7 Match Score & Decision Level: Biometrics framework matcher gives coordinate score which shows the level of comparability between the element vector and the put away format highlight vector. The match scores determined for each kind of biometric character are consolidated to give a combined resultant coordinate score. Borda tally technique utilizes total of positions appointed by singular matchers to ascertain joins rank. Match score of diverse biometrics determined are changed in to a typical space to get the resultant score. Classifiers are utilized to solidify coordinate score to show up at official conclusion for example KNN classifier, SVM classifier, Bayesian classifier and so on. An official conclusion for acknowledgment is taken dependent on the match score determined. Strategies like greater part casting a ballot, AND-OR administers are utilized for an official conclusion.

Numerous biometrics coordinates data from different modalities to improve the exhibition of the biometric framework. Multimodal biometric framework tends to numerous impediments of uni-modal. Right now of data from various modalities utilizing the four degrees of combination is given as an outline. The combination levels specifically sensor level, highlight level, coordinate score level and choice level are given different situation utilized for combination. Feature level combination incorporates the rich data of various modalities at the underlying phases of handling.

Chapter 5

Result and Discussion

We chose to utilize the three combination techniques to show combination of data from various biometric modalities [39] dependent on: feature, score and decision. The primary objective of a Content Based Image Retrieval (CBIR) method should be to obtain the graphical qualities of such a picture as either color, form, shape or other mixture [40].

5.1 Feature Fusion

Consolidate the element vectors of every methodology (iris and palm printing) to make a composite vector trademark that is additionally used to coordinate. Trademark vectors of the iris are linked with separately palm print vectors Casia[41]. The iris and Casia palm print include combination yielded preferred outcomes over each element taken independently in light of the fact that we had a FAR of simply 0.5 percent for a 100 percent GAR (typically required by such a framework). This shows intertwining the component level with that database was less viable.

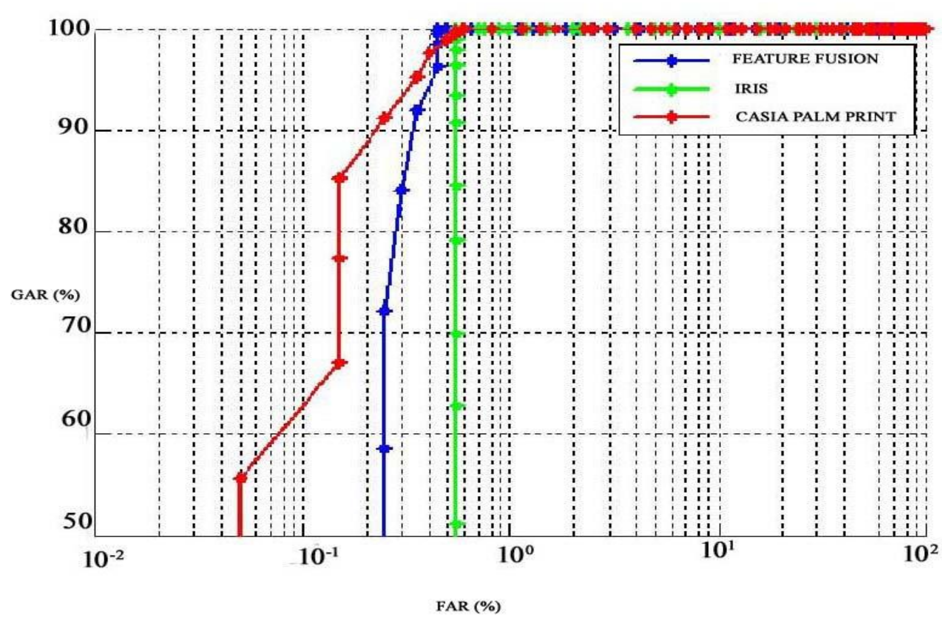


Figure 5.1: Iris, Casia palm print and Fusion feature

5.2 Score Fusion

Score fusion analyzed them separately instead of merging feature vectors, and individual matching scores are then combined to make decisions. By using a simple weighted sum-rule method described below [42], we achieved this fusion.

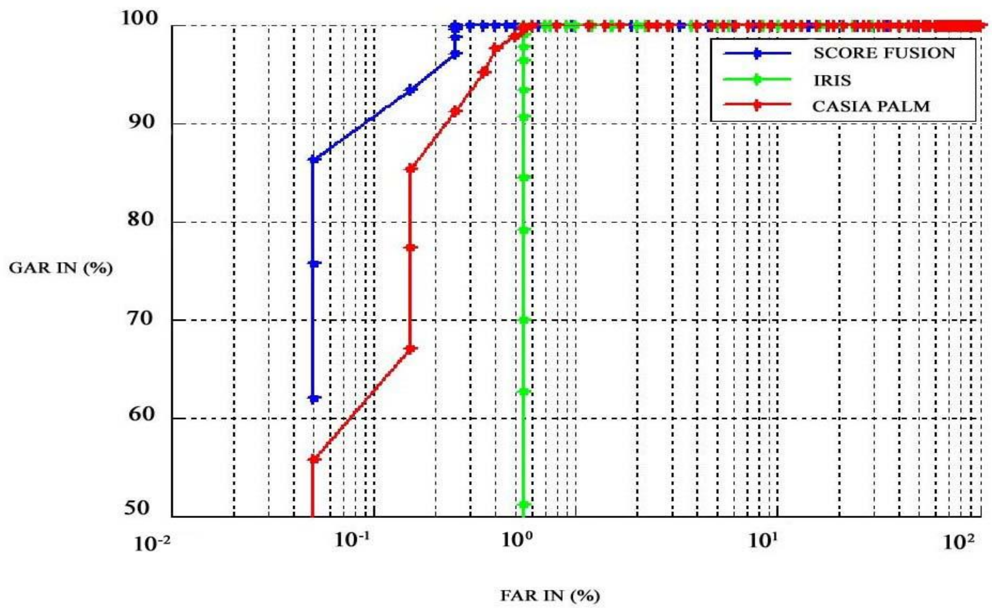


Figure 5.2: Iris, Casia palm print and Fusion score

$$S_f = \alpha 1 SIRIS + \alpha 2 SPALM \qquad (5.1)$$

$$\text{Including} \begin{cases} \alpha 1 = ERRIRIS / (ERRIRIS + ERRPALM) \\ \\ \alpha 2 = ERRPALM / (ERRIRIS + ERRPALM) \end{cases} \qquad (5.2)$$

$\alpha 1, \alpha 2 \in [0, 1]$

Condition 7 shows that the last score is produced utilizing even a straight blend of both the iris and the palm scoresFor iris and Casia database we have similar loads: a 1 = a 2 = (0.5). We accomplish a 100% GAR at FAR=0.35 percent. We got a GAR of 100 percent. From these obviously score combination beats work combination.

5.3 Decision Fusion

Decision level combination turns out to be less recorded and is commonly viewed as lower than score-level combination, since choices have less data content than "awful" scores consolidated. Numerous strategies are utilized, for example, Bayesian choice fusion, Dempster-Shafer verification theory[43], all of which change the choices into scores, with the transformation parameters gained from a preparation set. In our exploration, we use blunder combination which is additionally a sort of combination of choices in which mistake rates accept the job of choices. In the wake of normalizing the blunder rates FAR and FRR, we can join any two mistake rates x and y with t-standards, for example, the Hamacher t-standards. The utilization of these benchmarks for blunder level combination isn't yet attempted in the writing. T-standards applicable for combination are talked about in [44,45]. Triangular standards [46] (t-standards) and tconorms give off an impression of being the most widely recognized guardians of parallel capacities, meeting the criteria of the combination and disjunction administrators, separately. Such T(x, y) and S(x, y) t-conorms are two spot capacities which change the unit square into the unit interim; for example T(x, y): [0,1].[0,1].[0,1] and S[x,y] : [0,1].[0,1].[0,1] . Specifically, t-standards may not allow the suspicion that the strategies to be melded are provingly autonomous. These are repetitive, commutative, and acquainted capacities. In this paper we utilized a Hamacher t-standard (with parameter r = 2) additionally named by condition (5.3) and the Einstein result illustrated.

$$(x .y/2-x-y+xy) \quad (5.3)$$

We accomplished 100% GAR and 0.0210 FAR with the assistance of Einstein's t-standard. ROCs with different information base combinations. Clearly we have better outcomes for each degree of combination.

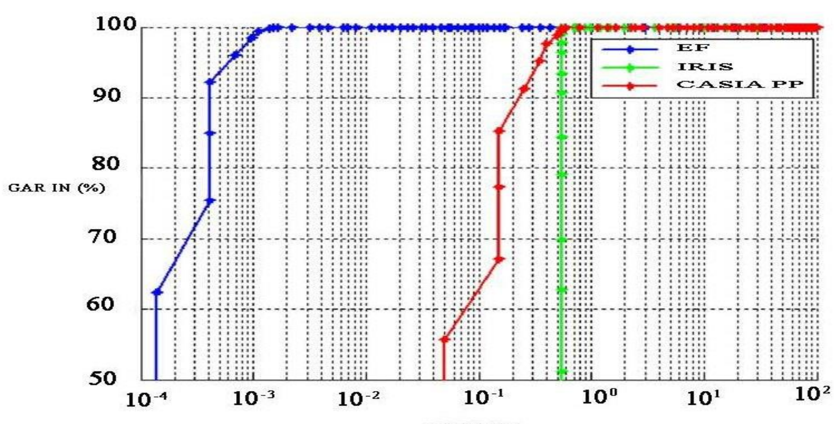


Figure 5.3: Iris, Casia palm print and Fusion error

Sr. No.	**Leval of Fusion**	**FAR In percentage**	**GAR In percentage**
1	Feature Fusion	0.50	100
2	Score Fusion	0.35	100
3	Decision Fusion	0.0210	100

Table 5.1: FAR and GAR at the various fusion level.

5.4 Performance Analysis

The proposed multimodal system is tested over three self created databases. The performance parameters for all three traits individually along with the fusion are given in Table 5.2. training and testing along with multiple training and testing strategy are considered and performance parameters viz: FA = Falsely Accepted imposters, FR = Falsely rejected genuine, EER = Equal error rate and CRR = Correct recognition rate are reported.

Biometric Traits			Iris		Palm print		Fusion	
Testing Strategy	Total Genuine	Total Imposter	FA	FR	FA	FR	FA	FR
			EER	CRR	EER	CRR	EER	CRR
1Tr-1Test	323	121452	240	0.66	235.33	0.66	0	0
			0.19	99.80	0.19	99.90	0	100
1Tr-4Test	1104	344212	476.33	1.33	948.66	2.66	0	0
			0.11	99.91	0.22	99.83	0	100
2Tr-1Test	698	242904	464	1.33	464	1.66	0	0
			0.19	100	0.19	100	0	100
2Tr-4Test	1438	848424	1033	3	1971.33	5.66	0	0
			0.12	100	0.23	99.91	0	100
3Tr-1Test	1047	364356	696	2	694	2	0	0
			0.19	100	0.24	99.91	0	100

3Tr-4Test	2657	776293	1392	4	3007	9	0	0
			0.10	100	0.24	99.91	0	100

Table 5.2: Database Specifications for Interval CASIA (Db1) containing images from 349 Subjects in (3+4) = 7 different poses. First 3 images are considered for training and Last 3 are taken as testing.

One can observe that after fusion, results obtained for all databases under all different testing strategies tend to become almost perfect (i.e. CRR = 100% with EER = 0%).

Moreover, one can also observe that with the increase in the number of training and testing images, the genuine and the imposter matching are increased significantly that affect the performance of any uni-modal system but the performance of each fused system remains almost invariant. Hence, one can also infer that the fusion of multiple traits introduces great amount of scalability with respect to system performance. More and more matching can be considered without much performance degradation. This is achieved because many different uncorrelated biometric traits are fused that enhances the uniqueness and the discriminative power of the combined sample and the fused score becomes more and more discriminative.

Chapter 6

Problem Definition

- Under less constrained lighting environments, it is expected that the captured iris images and Palm print image contain types of noise.
- Iris segmentation is the most important task in iris based biometric authentication system and if the iris part of an eye image is not detected precisely then an error is created in overall iris recognition method.
- Palm print also most important task for authentication system and if palm image not detected precisely then an error is created in overall palm recognition method.

Chapter 7

Conclusion and Future Scope

A point of the whole work was to investigate the blend of iris and palm printing attributes, and subsequently accomplish the best yield that couldn't be accomplished with a solitary biometric indicator alone. The proposed highlight extraction technique is basic and adaptable, since it depends on breaking down wavelet bundles with basic parallel coding. The outcomes got were significant for each biometric include which was taken separately. Our outcomes additionally demonstrated that the merger of iris and palm print at various levels ordinarily yielded better outcomes, aside from the component combination strategy. That could be because of the somewhat straightforward combination process (connection) utilized here. It shows the viability of our procedure for each biometric methodology, with explicit combination strategies. One bit of leeway of our multimodal approach is the single device used to remove characteristics from two diverse biometric modalities. Regardless of whether the size of the image is unique, we are getting a similar size for each code. The examination of these codes is performed for every database utilizing a particular separation, the "Hamming separation," which causes us to lessen the calculation time. In the end, our outcomes indicated that the choice level combination with the t-standard had given the best productivity.

The multimodal systems e.g. thumbprint-iris, Palate-Finger veins-fingerprints, head geometry-voice-body language and heartbeat-voice-body language give better matching results in comparison to single feature based systems in terms FRR, FAR, GAP, and GRP. A multimodal system based on thumbprint-iris will be very much useful for identifying a living person or a dead person. The researchers can further improve the performance existing thumbprint-iris based multimodal system in terms of accuracy, storage and comparison time.

References

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Paper Published

1. "Multimodal Biometric System: A Review", International Conference on Data Science, Machine Learning & Applications (**Indexed in SCOPUS, UGC, Springer link & Major AI**), Jan 2020. (Communicated (Accepted)).

2. "A Multimodal Biometric System using Iris and Palmprint", **'International Journal of Engineering and Advanced Technology (IJEAT)'** that will publish at **Volume-9 Issue-3, February 2020** in Regular Issue on **29 February 2020.** It will be available live at http://www.ijeat.org/download/volume-9-issue-3/

Curriculum Vitae

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Objective

To be associated with a dynamic and progressive organization that will allow me to utilize my abilities and qualifications in the field to add value to the organization while providing me with opportunities for growth.

Profile

At present pursuing **Master of Technology** in Department of **Computer Science, BBD University**, Lucknow, UP, India.

Education

● June 2018-20,BBD University Lucknow, **M.Tech 3rd Semester (CSE Software Engineering)** with **90.83%.**

● July2016, Kashi Institute Of Technology, Varanasi , **B.Tech (Computer Science)** with **64%.**

● March 2011, Radhika Bal Vidya Mandir, Jaunpur, UP, **12th** (**CBSE Board**) with **58%.**

● March 2008, Harihar Singh Public School,Jaunpur, UP, **10th** (**Uttar Pradesh Board**) with **63.33%.**

Publications

A. International Journals

● **"**A Multimodal Biometric System using Iris and Palmprint", **'International Journal of Engineering and Advanced Technology (IJEAT)'** that will publish at **Volume-9 Issue-3, February 2020** in Regular Issue on **29 February 2020.** It will be available live at http://www.ijeat.org/download/volume-9-issue-3/

B. International Conferences

● **"Multimodal Biometric System: A Review"**, International Conference on Data Science, Machine Learning & Applications (**Indexed in SCOPUS, UGC, Springer link & Major AI**), Jan 2020. (Communicated (Accepted)).

Subject Knowledge

- Software Engineering.
- Software Design &Testing.
- Advance Software Engineering .
- Automata.
- Requirement Engineering
- Software Agents
- Database Management System

Industrial Training

- COMET, Indian Institute of Technology (2 month)

Technical Proficiency

- C, C++, HTML
- Photoshop
- MS Word, MS Power Point, MS excel
- R-Language

Language Known

- English: Read, Write and Speak.
- Hindi: Read, Write and Speak

Extra-Curricular Activities

● **Five Days Faculty Development Program** on **R-Language for Analytics and Data Science,** organized by Spoken Tutorial Project, **IIT Bombay** from 26 April, 2020 to 30 April, 2020 remotely at Amity Institute of Information Technology, **Amity University**, Uttar Pradesh, Lucknow, India.

Hobbies

- Playing Cricket
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(Submit in Duplicate)

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3. Thesis title: "A Multimodal Biometric System Using Iris And Palmprint" .
4. Degree for which the thesis is submitted: M-Tech (Computer Science)
5. Faculty of the University to which the thesis is submitted: Mr. Mohd. Saif Wajid
6. Thesis Preparation Guide was referred to for preparing the thesis. ☐YES☐ NO
7. Specifications regarding thesis format have been closely followed. ☐YES☐ NO
8. The contents of the thesis have been organized based on the guidelines. ☐YES☐ NO
9. The thesis has been prepared without resorting to plagiarism. ☐YES ☐NO
10. All sources used have been cited appropriately. ☐YES☐NO
11. The thesis has not been submitted elsewhere for a degree. ☐YES ☐NO
12. Submitted 2 spiral bound copies plus one CD. ☐YES ☐NO

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10. All sources used have been cited appropriately. ☐YES ☐NO
11. The thesis has not been submitted elsewhere for a degree. ☐YES ☐NO
12. All the corrections have been incorporated. ☐YES ☐NO
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