CHAPTER 1
INTRODUCTION

The fundamental issues in image processing and machine vision is the textural feature extraction, segmentation, classification and recognition. In ‘computer vision and image processing’ research, the main aim is to derive better tools that gives different perspectives on the same image, allowing us to understand not only its content, but its meaning and significance. Image processing cannot compete with the human eye in terms of accuracy but it can outperform easily on observational consistency and ability to carry-out detailed mathematical operations. Most of the image processing algorithms originate from fundamental principles of signal processing, pattern recognition or machine intelligence.

Biometrics is one of the pattern recognition troubles. The term “biometrics” is derived from the Greek words “bio” (life) and “metrics” (to measure). “Biometrics” is a general term used alternatively to explain a feature or a process. As a feature ‘A quantifiable biological (anatomical and physiological) and behavioral feature which is useable for automated recognition’ and as a process ‘Automated techniques of recognizing an individual based on computable biological (anatomical and physiological) and behavioral characteristics’.

In today’s automation era, information about everything is being processed by the machine with artificial intelligence and used in many sophisticated applications. Though many agencies have developed the state-of-the-art security systems, recent terrorist attacks exposed serious weaknesses of sophisticated security systems. Hence various agencies are more serious and motivated to improve security data systems based on physical or behavioral characteristics of human body usually called as biometrics [1]. Since previous three decades Biometric systems have been researched and tested, but able to enter recently into the public awareness due to high profile applications, use in entertainment media and increased use by the public in daily activities. Many companies are also implementing biometric technologies to secure areas, enhance user convenience and maintain time records. Use of biometrics makes it possible to identify a person which is based on who you are, rather than by what you have (e.g. an ID card) or what you keep in mind (e.g. a password). Most of the verification systems based on passwords (knowledge-based security) and ID cards (token-based security) can be breached easily when a password is disclosed to an unauthorized user or if the card is stolen by impostor. There are different
biometric modalities such as fingerprint, palmprint, hand shape, iris, face, voice, keystroke and signature. Each biometric technique has its own merits and demerits. Hence, none of the existing biometric systems can be considered as the best for all the applications [2]. Biometric systems that uses single information source (individuals identity) are called unimodal systems. Practically a unimodal biometric system suffers from applications with involvement of a large number of users (viz. in the order of millions) like:

- The fake finger can be made using materials like alginate, casting plaster. Then the peg board real hand can be put to fix the pose then mixture of any alginate and water is poured into the container then after removing hand from the board, mold is filled with mixture of plaster and water. This fake hand is recognized by the HandKey II system.
- By putting subject’s finger in impression material, molds can be created from latent fingerprints by photographic etching techniques like those used in making of PCB (gummy fingers) or play-doh and gelatin can be used to cast a fake finger.
- In worst case scenario dead fingers can be presented to the biometric recognition system [3].

This report stated to the US congress that approximately that more or less two percent of populace did not have a readable finger impression and thusly can't be selected into a biometrics scheme. The report prescribes a scheme utilizing at least double biometrics in a layered methodology for substantial scale applications, for example, outskirt crossing. This can be overcome by use of multiple biometric authentication system that combines information from multiple modalities to land at a decision.

The multiple biometric system combines at least two different biometric sources of a person (for ex. fingerprint and palmprint, face and fingerprint, iris and fingerprint, etc.) sensed by using various sensors. Two separate properties (like reflected and light infrared, 3D shape sensed with same sensor) of the same biometric can be pooled together. In orthogonal multiple biometric system, different biometrics involves little or no interaction among the individual biometric. The individual biometric is processed by independent multiple biometric. In joint multiple biometric schemes the processing of person biometric has influence on the result of another biometric. The information fusion in multiple biometric systems can be done at the data of the match score level or feature level data produced by multiple classifiers relevant to different modalities and at the decision level. In this work we have used two biometrics namely fingerprint and palmprint for person identification or system authentication as unimodal and multimodal biometric systems. Here we propose a robust system using two multi-resolution and multi-scale transforms for feature extraction of
fingerprint and palmprint as unimodal and multimodal biometrics used for person identification / system authentication.

1.1 Fingerprint as biometric

Every human being possesses fingerprints. Fingerprints are extremely unique; their particulars are permanent, even if they may temporally change somewhat due to cuts and damages on the skin or climates situations. The use of fingerprint in criminal investigation worldwide has a long history. Fingerprint is one of the most admired biometric techniques used to verify and identify a person. A fingerprint is the pattern of ridges and valleys (also called furrows in the fingerprint literature) on the exterior of a fingertip. In fingerprint literature, the terms ridges and valleys are used to describe the higher and lower parts of the papillary lines. In a gray-level fingerprint image, the ridge and valley structure in a local neighborhood form a sinusoidal shaped plane wave which has a clear frequency and orientation. Ridges are the lines and furrow is shallow trench of skin on an individual’s finger. The combination of ridges and furrows makes an individual’s fingerprint. The combination of ridges and furrows make the fingerprint of each person unique. The individuality of a fingerprint is solely determined by the local ridge characteristics and their relations.

The ridges and furrows present in the finger show good similarity in each small local windows, like parallelism and average width. The prominent local ridge is referred to as minutiae. This characteristic of the fingerprint image is used to compare an individual’s finger image with the others stored finger images. Minutiae consist of ridge ending, ridge bifurcation, short ridge or independent ridge, ridge enclosure, island, spur, crossover or bridge, delta and core. Ridge ending is the sudden end of a ridge; a single ridge which divides into two ridges is ridge bifurcation, ridge that commences, travels a short distance and then ends is termed as short ridge, or independent ridge. Island is a single small ridge inside a short ridge, a single ridge that bifurcates and reunites shortly afterward to continue as a single ridge is called ridge enclosure. A bifurcation with a short ridge branching off a longer ridge is called as spur whereas; crossover or bridge is a short ridge that runs between two parallel ridges. Y-shaped ridge meeting is known as a delta and core is a U-turn in the ridge pattern. Depending on the sensor resolution and placement of finger on the sensor a good quality fingerprint holds 25 to 80 minutiae. In some cases, it is difficult to extract prominent minutia, as the fingerprint impression is distorted due to various reasons like scars, injury, dry skin etc. Therefore such poor quality fingerprint image leads to false
minutia. A fingerprint image grabbed with optical sensor showing the main elements is shown in Figure 1.1.

![Fingerprint Image](image)

Figure 1.1 Example of fingerprint image.

Due to development in automation the security problems related to it have been noticed and addressed to a great extent. Thus the fingerprint based biometric systems have been developed for large number of recognition applications using local and global features of fingerprint. Various transforms have been used for extracting the textural features of the fingerprint image. Combination of minutia and textural features leads to a considerable improvement in whole performance of the scheme even at low resolutions. To accelerate the methodology of fingerprint recognition the fingerprints have been classified in various classes like right loop, left loop, arch,whorl, twin loop and tented arch.

1.2 Palmprint as biometric

The palmprint patterns are not same even in monozygotic twins, hence a unique feature can be obtained from the palm for identification of person, and therefore security is considered as the main area of application for palmprints. Since these are permanent patterns and the rich structure of palmprint, provide a lot of information useful in person identification. Low resolution imaging, low intrusiveness, high user acceptance and stable line features are the physical characteristics which make palmprint advantageous as compared to the other. The textural features, points and lines on the palm distinguish the palms in palmprint recognition. Hence over last decade the palmprint became an active area of
Palmprint based recognition can be categories as off-line and on-line. Figure 1.2 shows on-line and off-line palmprint image.

Research on off-line palmprint verification has been the fundamental concentrate in the previous few years where all palmprint tests are inked on paper and afterward these specimens are transmitted into a PC through a computerized scanner. For the highresolution off-line palmprint images (up to 500 dpi) the same techniques as applied to fingerprint images could be useful for extracting singular points, datum points, and lines for personnel identification.

![Image of palmprint](image)

Figure 1.2 Examples of palmprint image (a) on-line, (b) off-line.

Palmprint contains many unique features which are utilized for matching purpose. These features are consists of principle lines, ridges, wrinkles, singular point, minutiae point and textures patterns. Out of these principle lines and wrinkles can be easily extracted even in low resolution images with less than 100 dpi whereas to extract the rest of features require high resolution images. To extract the principle lines, ridges, wrinkles, singular point, minutiae point and textures patterns various transforms and models have been proposed in the literature which includes Gabor, Radon, wavelet, contourlet, curvelet etc. and the dimensionality of the feature vector has been reduced using subspace analysis techniques. The identification of palmprint is obtained by matching the query palmprint to the stored database consisting of large number of palmprints. This process takes more execution time. Therefore, palmprints are classified into several categories and matching of query palmprint is done in the corresponding category only. This minimizes the searching time and computational complexity of identification process in recognition system. This can be categorized as coarse-level classification.

### 1.3 Scope of work

Because of availability of advanced scanners and computerized system, now a day's use of hand geometry for Person identification is preferred in automated systems. Identimat-
first commercially available system was developed in 1970. It measured the length of fingers and the hand shape. Similarly that time the automated systems using fingerprint checking were extensively utilized in law enforcement. Many researchers have proposed and developed the machine based recognition algorithms that uses biometrics like fingerprint and palmprint. From last two decades fingerprint identification is substantially noticed; however the physical work or skin problems cause un-cleared fingerprints in some peoples. Similarly the high costs of input devices and the disturbances face by users at time of taking the images caused negligence in using of retina and iris recognition, eventhough it gives very high accuracy. It made the researchers to focus on voice verification and face recognition system although these systems performances are not satisfactory.

Comparatively new biometric-Palmprint is advantageous with the biometrics currently used. It concerned with the part of the hand that consists of palm lines and ridges. The palmprint capturing devices are available at low cost compared to that of required for iris; palmprints possess more information compared to fingerprints; wrinkles and principal lines are the additional distinguishable characteristics of palmprints which can be extracted from low resolution images also; all these features of palm like ridge and valley, palm geometry, wrinkles and principal lines can be combined to form a highly accurate biometric system. Hence now a day palmprints are extensively used for person identification using automated systems. The unique features of a palm there permanence and its rich structures gives a lot of useful information required for identification. Low resolution imaging, low intrusiveness, high user acceptance and stable line features are the physical characteristics which make palmprints advantageous as compared to the other. The textural features, points and lines on the palm distinguish the palms in palmprint recognition. Hence over last decade the palmprint became an on the go area of research.

Research has been conducted vigorously in the area of biometric for past four decades and huge progress has been made still there is scope for improvement. Existing recognition systems have reached a certain degree of maturity when operating under constrained conditions and encouraging results have been obtained. However, they are far from achieving the ideal of being able to perform adequately in all the various situations that are commonly encountered by applications, utilizing available techniques in practical life. Ultimate goal of researchers in this area is to develop the sophisticated hand based multiple biometric recognition system which increases the recognition rate. So, considering all the above cases listed in limitations, unimodal and multimodal biometric approaches to fingerprint and palmprints will make a great effect in real time applications. Liveness
detection reads claimant’s physiological signs of life and will be effective to overcome the spoofed biometrics presented to the system.

1.4 Statement of work

As suggested in the section 1.1, unimodal biometric system has serious weaknesses. Use of multiple modalities in the biometric recognition system can enhance the robustness of the system. Therefore purpose of this thesis is to improve the recognition and identification system using multimodal biometric recognition system. Main objective is to analyze present unimodal biometric systems and to propose new multimodal biometric recognition system using fingerprint and palmprint. To achieve desirable confidence, multi-scale and multi-resolution approach is proposed to extract the features from modalities

1.5 Methodology

The objective of the research work has been achieved by implementing existing techniques of feature extraction and proposes a framework for multi-resolution and multi-scale transforms for personnel identification or system authentication using fingerprint and palmprint. Objectives of the proposed work are listed below:

- To understand the fingerprint and palmprint recognition techniques.
- To extract features from fingerprint and palmprint as the unimodal biometrics using various transforms like discrete Dyadic wavelets, Radon transform and orientation field to concurrently derive the advantages of the building blocks with time resolution as well as frequency resolution.
- To extract singularity points like core and delta points from the fingerprint image.
- To authenticate the system using local and global features from the fingerprint image.
- To propose an automatic person identification / authentication system using multimodal biometrics by combining fingerprint and palmprint to alleviate the accuracy of hand based biometric systems for real time applications.
- To simulate the proposed approaches and carry out the experimentation for verification of results.
- To compare performance of the proposed technique with state-of-the-art work.
- Analyze performance of the algorithms using standard databases like FVC2000 and PolyU.
1.6 Analysis of work

In biometric system errors like failure to enroll (FTE) and failure to capture (FTC) are regularly used to sum up the accuracy. Genuine Acceptance Rate (GAR), False Rejection Rate (FRR), False Acceptance Rate (FAR), are the standard metrics of identification accuracy of biometric system. There is tradeoff between FAR and FRR. Performance evaluation is done by using the region of operating curve (ROC). It is a graph of FAR Vs FRR. Another important metric is equal error rate (EER), which is the average error observed when FAR and FRR are equal. The accuracy or error rate measure gives the performance of classification system. The error rate is calculated as the ratio of the misclassified palm numbers and the total number of palm samples in the test set. The percentage of correctly classified palms means the accuracy.

The error rate for a classification system usually given as- a function of percentage of database which the system requires to search. It is called as penetration rate. The confusion matrix gives more detailed analysis of the classifier behavior. This matrix has a row for each true class and a column for each hypothesized class; each cell at row $r$ and column $c$ reports how many fingerprints belonging to class $r$ are (in) correctly assigned to class $c$.

Theses parameters will be calculated and performance of the proposed and implemented algorithms will be judged on the standard databases like FVC2000 and PolyU.

1.7 Organization of the thesis

This thesis is concerned with unimodal and multimodal biometric based automated recognition system using fingerprint and palmprint. Chapter 2 consists of a comprehensive literature survey. Chapter 3 explains general block diagram of proposed automated recognition system using fingerprint and palmprint as unimodal and multimodal biometrics. For making the proposed system translation and rotation invariant, the procedure to extract ROI from the captured palmprint image and fingerprint image along with extraction of singularity points like core and delta points from the fingerprint image has also been explained.

Chapter 4 evaluates the performance of unimodal and multimodal fingerprint and palmprint recognition system using multi-resolution and multi-scale transforms like Radon transform, Discrete Dyadic wavelets and orientation field for feature extraction. The standard databases used to test the effectiveness of the algorithms contain FVC2000 for fingerprint images and PolyU database offered by Hong Kong Polytechnic University (PolyU) for palmprint images. At the end in Chapter 5 the work is concluded and provided directives for future work.