Introduction
CHAPTER 1

INTRODUCTION

The major concern in today’s world is security. Security concerns are continuing to rise in volume and complexity. Security is an aspect that gives top priority by organizations, educational institutions and governments in identity and fraud issues [1]. In response to new menaces, organizations demand to implement or update a personnel security program to preclude unauthorized access to control systems and to protect vital data. According to the Personal Security Guidelines [2], efficient methods need to be developed for personnel security and control system integrity. Organizations should operate securely so that they do not form an unacceptable security risk that could impact the safety of other personnel or the public.

Fingerprints are indisputably one of the mainly studied biometric traits and most widely used in many applications like civil and forensic departments to support criminal investigations, and in biometric systems such as civilian and commercial identification devices. The fingerprint properties of a person are very accurate and are unique to an individual. Authentication systems based on fingerprint have proved to produce a low false acceptance rate and false rejection rate, along with other advantages like easy and low cost implementation procedure. Likewise, the fingerprint typically remains unchanged from birth to death [3]. Aside from being unique and unchanging, fingerprints can be collected in a non-invasive way with no side effects. Fingerprints have been used for over a century and are the most widely used forms of biometric identification [4]. Despite this widespread use of fingerprints, there has been little statistical work done on the uniqueness of fingerprint minutia. In particular, the issue of how many minutia points should be used for matching a fingerprint is unresolved.

1.1 Motivation

Currently available automatic fingerprint identification system generates a significantly high number of false alarms and this proposed work put forth the following most frequent and important weaknesses of Fingerprint Identification as follows
The first major challenge in the automatic fingerprint recognition system mainly depends on the quality of the input image of the fingerprint. The sensed data might be noisy or distorted. Noisy data could also be the result of defective or improperly maintained sensors or unfavorable ambient conditions. Noisy biometric data may be incorrectly matched with templates in the database resulting in a user being incorrectly rejected.

The second toughest dispute in fingerprint recognition systems is the alignment of the fingerprint image which has influence on fingerprint image enhancement phase, minutia detection phase and minutia matching phase of the system. Generally, image-processing techniques such as rotation, translation and registration will consume more time and hence impact the overall performance of the system.

The third challenge is robust, feature extraction to overcome false positives in fingerprint detection. The important step in the automatic fingerprint recognition system is to automatically and reliably extract minutia from the input fingerprint images [5]. In such recognition systems, the orientation of the fingerprint image has influence on fingerprint image enhancement phase, minutia detection phase and minutia matching phase of the system.

The fourth challenge is the matching of unequal numbers of minutia features in fingerprint based bio-metrics recognition systems.

The main motive of this thesis work is to enhance the fingerprint recognition system efficiency by overcoming the above said challenges.

1.2 Research Objectives

The objective is to improve fingerprint recognition system. The image is aligned using K-Means clustering and the image quality is enhanced using Gabor filter. The concept of Crossing Number is used to extract the minutia, followed by proposed localized Euclidean distance matching algorithm for minutia matching.

To enhance the fingerprint image quality using Gabor filter [6][7], which removes the noise; preserves true ridge/valley structures, increases the contrast and reduces the noise.
The Fingerprint image is aligned using K-Means clustering algorithm to improve the performance of the fingerprint recognition system.

The proposed Localized Euclidean Distance Minutia Matching algorithm gives better results while compare minutia sets of different sizes as well as in a slightly different orientation during the matching process.

1.3 Contributions of the Thesis

This research addresses the significance of fingerprint image enhancement algorithms for better minutia detection in biometric recognition systems.

Proposed and implemented a fast fingerprint image alignment algorithm using K-Means and Fuzzy C-Means clustering based image rotation technique.

Proposed and implemented a fingerprint alignment technique that reduced the false positives in minutia detection.

A novel image alignment and a fast and efficient Localized Euclidean Distance Matching algorithm are proposed and implemented for comparing and matching unequal minutia feature sets.

1.4. Proposed Approach

The successful installation of biometric systems in various civilian applications does not imply that biometrics are a fully solved problem. It is clear that there is plenty of scope for improvement in biometrics. Researchers are not only addressing issues related to reducing error rates, but they are also looking at ways to enhance the usability of biometric systems. Biometric systems that operate using any single biometric characteristic have some limitations which will lead to poor identification results. In such recognition systems, the matching of unequal numbers of minutia features is the most important and challenging step in fingerprint based bio-metrics recognition systems. This proposed research work used clustering based fingerprint image rotation algorithm, to improve the performance of the fingerprint recognition system and proposed a Localized Euclidean Distance Minutia Matching algorithm for matching, which will give better
results while comparing minutia sets of different sizes as well as in a slightly different orientation during the matching process.

Figure 1.1  Architecture of the Proposed Fingerprint Recognition System
Phase 1: Fingerprint Image Alignment Stage

In this stage three methods are considered for image rotation. The time taken for rotation is very minimal when we use K-Means clustering based image rotation algorithm. Hence, K-Means clustering based fingerprint image rotation method is considered. Based on the obtained $\phi$ value, the fingerprint image will be rotated.

Phase 2: Fingerprint Image Enhancement Stage

The first challenge faced in this proposed fingerprint recognition system is in the selection of enhancement algorithm to be used for preprocessing. The fingerprint image enhancement is evaluated using Histogram Equalization, Fast Fourier Transformation and Gabor Filter. The Gabor Filter performed 5 to 6 times better than the other two algorithms. The algorithm enhanced the ridges and valleys in corrupted areas of the fingerprint and this makes the ridge ends and ridge bifurcation more visible and distinguishable from the image. It also helps in removing the spurious minutia too, which may also prove to be harmful in matching fingerprints correctly.

Phase 3: Fingerprint Minutia Extraction Stage

In this phase, two methods are adapted in which the minutia is detected. In the first method, the minutia’s are detected without aligning the image. In the second method, the input image is aligned using the proposed k-means clustering based fingerprint image rotation algorithm and then the minutia’s are detected. This proposed rotation algorithm could be applied as a pre-processing step before minutia detection. In both the methods the images are enhanced using the proposed Gabor filter. Finally the results clearly show that the aligned images give more accurate true minutia’s then the unaligned images. Hence, the result will be better detection of minutia as well as better matching with improved performance.

Phase 4: Fingerprint Minutia Matching Stage

A Final stage in fingerprint recognition system is matching of unequal number of minutia features. The proposed clustering based fingerprint image rotation algorithm and Localized Euclidean Distance Minutia Matching algorithm (LEDMM) is used, to improve the performance of the fingerprint recognition system, which gives better results
while comparing minutia sets of different sizes as well as in slightly different orientation during the matching process. A fingerprint database from the FVC2000 (Fingerprint Verification Competition 2000) [8] and FVC2002 [9] are used to test the experiment performance. The experimental results on the fingerprint image database demonstrate that the proposed methods can achieve much better minutia detection as well as better matching with improved performance in terms of accuracy.

1.5 Thesis Outline

The thesis is organized in seven chapters and the chapter one is introductory in nature. The rest of the chapters discuss the backgrounds, literature review and contributions of the thesis. The overview of each chapter is given below:

In Chapter 2, the fundamental concepts and terminologies of digital image processing and other aspects related to biometric technology, its prerequisites and the needs are explained. In addition, modes, phases and types of biometric system are also discussed.

In Chapter 3, an elaborate study on fingerprint recognition system includes the discussion of related work done in the concept of fingerprint recognition, fingerprint image alignment, fingerprint image enhancement, minutia extraction and minutia matching.

In Chapter 4, the preliminaries and backgrounds on fingerprint image pre-processing stages that are borne out throughout this research study, namely binarization, fingerprint image segmentation (Find Direction and ROI), thinning and minutia extraction is reported in detail.

In Chapter 5, presents the approach on comparison of fingerprint image enhancement algorithms for better minutia detection. This chapter deals with three fingerprint enhancement methods which are very much different in the way of enhancing the input image for minutia detection.

In Chapter 6, the work proposed on a K-Means clustering based fingerprint image rotation algorithm to improve the functioning of the fingerprint recognition system was studied. This rotation algorithm can be used as a pre-processing step before minutia detection and minutia matching phase of the scheme. The minutia’s are detected by two
ways. In the first method, the minutia’s are detected without aligning the image. In the second method, the input image is aligned using the proposed K-Means clustering based fingerprint image rotation algorithm and then the minutia’s are detected. A quick, efficient Localized Euclidean Distance Minutia Matching algorithm is used for the matching purpose.

Chapter 7 concludes this work and offers a critical discussion as well as an outlook to future work that envisages for pursuing.