Chapter-2

Formulation of the Problem and Methodology
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2.1 Introduction:

Biometrics refers to the automatic recognition of individuals based on their physiological and/or behavioral characteristics. Although the problem of automatic fingerprint matching has been extensively studied, it is nevertheless, not a fully solved problem. In this thesis, an information fusion approach is adopted to address some of the limitations of existing fingerprint matching systems. A hybrid fingerprint system that utilizes both minutiae points and ridge feature maps to represent and match fingerprint images has been developed. The hybrid matcher is shown to perform significantly better than a traditional minutiae-based matcher. The ridge feature maps extracted by this technique have also been used to align and register fingerprint image pairs via a correlation process, thereby obviating the need to rely on minutiae points for image registration. To address the problem of partial prints obtained from small-sized sensors, a fingerprint mosaicking scheme has been developed. The proposed technique constructs a composite fingerprint template from two partial fingerprint impressions by using the iterative control point (ICP)
algorithm that determines the transformation parameters relating the two impressions. To mitigate the effect of non-linear distortions in fingerprint images on the matching process, an average deformation model has been proposed. The model is developed by comparing a fingerprint impression with several other impressions of the same finger and observing the common ridge points that occur in them. An index of deformation has been suggested in this context to aid in the selection of an ‘optimal’ fingerprint impression from a set of impressions. Unimodal biometric systems perform person recognition based on a single source of biometric information and are affected by problems like noisy sensor data, non-universality and lack of individuality of the chosen biometric trait, absence of an invariant representation for the biometric trait and susceptibility to circumvention. Some of these problems can be alleviated by using multimodal biometric systems that consolidate evidence from multiple biometric sources. Finally, techniques to combine fingerprint information with the other biometric traits of a subject (viz., face Iris and signature) are presented. To enhance user convenience, a learning methodology has been used to compute user-specific parameters in a multibiometric system. Information fusion systems, as presented in this thesis, are expected to be more reliable and robust than systems that rely on a single source of information.
2.2 OBJECTIVES

a) To study the fingerprint representation system that uses minutiae matching technique and ridge feature maps.

b) To develop a hybrid fingerprint matching technique that combines minutiae information with ridge feature map to generate a single matching score for better performance.

c) To integrate information available in two different impressions of the same finger to prepare a composite information from the individual impressions. Mosaicking the images and then extracting (template) minutiae for better matching performance.

d) To extract Scale Invariant Key Points for the effective verification of fingerprints.

e) To develop a deformation model for estimating distortion effects in fingerprint impressions based on ridge curve correspondence.

f) To develop a multi biometric system using fingerprint, face, iris and signature traits for the better performance of biometric system.
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2.3 Materials and Methods

In chapter 3 & 4 Fingerprint images of 640 different fingers, corresponding to 160 different subjects, were acquired using the Veridicom sensor. 4 different impressions of each of these fingers were obtained over two different sessions separated by a period of six weeks (2 impressions in each session). The two impressions acquired at the same session were used to construct the template minutiae set of a finger, while the other two impressions were used as query images during the test phase of the experiment. Thus, 640 pairs of images were used to construct the minutiae templates \( M_{R1} \) and \( M_{R2} \), and the rest (1280) were used as query images. We refer to this database as the VERIDICOM database.

The performance of the proposed Scale invariant key points based fingerprint verification has been evaluated on FVC2002 DB1 and DB2 public domain fingerprint databases. Both the databases contain images of 100 different fingers with 8 impressions for each finger.

In chapter 5 in order to apply the TPS model to reliably estimate fingerprint deformation, we need to have several impressions of the same finger. Large number of impressions of a finger are not available in standard fingerprint databases (e.g., FVC 2002). Therefore, fingerprint images of 50 fingers were acquired using the Identix sensor (256 x 255, 380 dpi) over a period of two weeks in our lab. There were 32 impressions corresponding to every finger, resulting in a total of 1600
impressions. One half of the impressions ($L = 16$ for each finger, resulting in 800 impressions) were used as templates to compute the average deformation model for each finger, while the remaining 800 impressions were used as query images for testing.

In chapter 6 the multi-biometric system has been tested on a database of 250 individuals. The training database contains a face, iris, two fingerprint images and one or two signature image(s) for each individual. The face image has been taken under controlled environment using a digital camera. The face images of frontal view are obtained under different orientations and lighting conditions. The fingerprint images are acquired using optical sensor at a resolution of 500 dpi. The iris image is acquired using 3-CCD Camera and the signature is acquired on a custom made template. The multimodal system has been designed at multi-classifier and multi-modal level. At multi-classifier level, multiple algorithms/classifiers are combined to generate better results.
2.4 Research Scope and Methodology

In this thesis, multiple sources of information are consolidated to enhance the performance of automatic fingerprint authentication systems. A few of the challenges presented in the earlier section are, consequently, addressed. The five major contributions of this thesis are listed below.

1. A hybrid fingerprint matcher that avails of both the minutiae and texture information present in fingerprint images has been developed. The texture information is extracted by applying a set of 8 Gabor filters to an enhanced fingerprint image, and texture features are represented using ridge feature maps.

2. To address the problem of partial prints, a fingerprint mosaicking scheme has been developed. The proposed scheme examines two partial impressions of a finger and constructs a composite template image that includes information from the individual prints.

3. To extract Scale Invariant Key Points for the effective verification of fingerprints.

4. An average deformation model for fingerprint images has been proposed. This model accounts for the non-linear distortions present in fingerprint images. The model is developed by comparing a
fingerprint impression with several other impressions of the same finger and observing the common ridge points that occur in them.

5. To enhance the performance of a biometric system using fingerprint, face, Iris and signature traits of a subject are also used. By fusing information gleaned from multiple biometric indicators, the performance of a biometric system can be improved. The proposed multibiometric system also employs a learning technique to compute user-specific parameters in order to improve verification performance.

In the subsequent chapters, a detailed description of each of these contributions is provided.