Fingerprint Recognition Using a Hierarchical Approach

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This chapter introduces a topology-based approach to fingerprint recognition utilizing both global and local fingerprint features. It also describes a new hierarchical approach to fingerprint matching which can be used to accelerate the speed of fingerprint identification in large databases. The proposed matching scheme consists of two stages. In a coarse filtering stage, two fingerprint images are compared using the Singular Points method. Since the method does not resort to image enhancement and minutiae extraction, coarse matching is very efficient and can dramatically reduce the number of candidate fingerprints for minutia-level matching. During fine matching stage, Delaunay triangulation is used to speed up the minutia-level verification. This chapter also proposes to apply Radial Basis Functions to model fingerprint’s elastic deformation, which greatly increases the system’s tolerance to distorted images. Experimental results confirm that the proposed hierarchical matching algorithm achieves very good performance with respect to both speed and accuracy.

7.1 Introduction

Biometric technologies are automated methods of verifying or recognizing the identity of a person based on a psychological or behavioral characteristic. The recent developments in the areas of electronic banking, e-commerce, and security, has necessitated the development of reliable automatic personal authentication. Examples of physiological and behavioral characteristics commonly used for automatic identification include fingerprints, iris, retina, hand, face, handwriting, keystroke and voice. Fingerprint identification is one of the most reliable methods of personal authentication due to the number of properties, such as robustness, distinctiveness, availability and accessibility, that fingerprints posses. Compared to other biometrics, fingerprint recognition is a...
well-researched area, which experiences significant growth in the recent years. Existence of large fingerprint databases, for which it became very computationally expensive to repeat the matching procedures for each fingerprint image, drives the research further in this area. In this chapter, a scheme is presented which achieves much better matching performance for larger fingerprint databases in the presence of fingerprints with elastic distortions.

A fingerprint is formed from an impression of the pattern of ridges on a finger. A ridge is defined as a single curved segment, and a valley is the region between two adjacent ridges. In Fig. 7.1 some of the ridges enter from the bottom-left of the image, loop around a common center point, and exit on the left. There are a lot of features in fingerprints, some of which are introduced below. Local ridge discontinuities, known as minutiae, have little effect on the global ridge-valley pattern. However, it is the existence and location of these minutiae that embody much of a fingerprint’s individuality. There are two kinds of minutiae: ridge endings and bifurcations. Ridge endings are places where ridges terminate and bifurcations are locations where a single ridge separates into two ridges (see Fig. 7.2). Singular points have both global and local properties. There are two types of fingerprint singular points: cores and deltas. Locally, a core is the turning point of an inner-most ridge and a delta is a place where two ridges running side-by-side diverge. Core and delta points are illustrated by example (see Fig. 7.2).

Automatic fingerprint identification systems typically include feature extraction and matching components. Here, we provide a brief overview about general methods of feature extraction, that will be more formally introduced in the later sections. To match two fingerprint images, one typically matched the feature pattern extracted from the images. Although many new features were proposed overtime for fingerprint identification, minutiae is still the most important one due to its good performance and distinctiveness. However, in practice, a fingerprint image may not always be well defined due to the ele-