Chapter 5
Additional Biometric Traits

Every biometric system relies on one or more biometric modalities. The choice of modality is a key driver of how the system is architected, how it is presented to the user, and how match vs. nonmatch decisions are made. Understanding particular modalities and how best to use the modalities is critical to overall system effectiveness.

Whither Biometrics Committee, National Research Council, 2010

Earlier chapters in this book focused exclusively on three specific biometric modalities - fingerprint, face, and iris. These traits have been extensively studied in the literature and have been incorporated in several government, military, and civilian biometric systems around the world. However, apart from these traits, several other biometric attributes have also been studied in the context of applications ranging from border control systems to surveillance to forensic analysis. Examples of such attributes include hand geometry, ear, speech, signature, gait, DNA, and teeth. Further, soft biometric attributes (i.e., attributes that provide some information about the individual, but lack the distinctiveness and permanence to sufficiently differentiate any two individuals) such as scars, marks, and tattoos (SMT), periocular region, and human metrology have also been studied in the biometric literature. This chapter will introduce a few of these traits in order to convey the breadth of work being conducted in the field of biometrics.

5.1 Introduction

As stated in Chapter 1, a wide variety of biometric traits have been proposed and studied in the literature. In some cases, academic curiosity about the uniqueness and permanence of certain biological traits has spurred exploratory research (e.g., iris); in other cases, new application domains have resulted in the exploration of novel biometric traits (e.g., periocular biometrics). Furthermore, certain biometric traits are uniquely suited for some applications and scenarios. For example, voice may be more practical in tele-commerce applications; the ear may be useful in surveillance applications where only the side-profile of the human face is available; gait patterns may be relevant in identification-at-a-distance scenarios; hand geometry may be appropriate for use in systems requiring the verification (as opposed to identification)
of a few enrolled identities thereby mitigating some of the concerns associated with using a strong biometric cue such as fingerprint; and the iris or fingerprint may be chosen in applications where the subject is cooperative and in close proximity to the sensor.

Apart from the aforementioned traits, ancillary information such as gender, ethnicity, age, height, and eye color can also be used to improve the matching accuracy of a biometric system. For example, if a female subject (probe) is matched incorrectly against a male subject (in the gallery), then the gender information can be used by the biometric system to reject the match. Ancillary attributes provide additional information about the individual, but lack the distinctiveness and permanence to sufficiently differentiate two individuals. However, they can be used to narrow the search space of potential matches in an identification system (e.g., if the input probe is deemed to be an “Asian Male”, then an identification system can constrain its search only to “Asian Male” identities in the database) or when other biometrics traits are not readily available (e.g., using the periocular information when the iris is deemed to be of poor quality). Such traits are commonly referred to as soft biometrics in the literature. Unlike some other attributes such as fingerprint and iris, soft biometric traits are not necessarily “unique” to an individual. They can be shared across a significant fraction of the population (e.g., gender) and may lack permanence (e.g., scars, marks, and tattoos, abbreviated as SMT).

Given the diversity of biometric traits discussed in the literature, in the interest of being concise, we restrict our discussion to the following four biometric traits in this chapter: ear, gait, hand geometry, and soft biometrics.

5.2 Ear

The appearance, structure, and morphology of the human ear has been studied as a biometric cue for a number of years. While most face recognition systems extract the attributes of the human face from frontal images, the visibility of the ear in non-frontal poses of the face (e.g., side view) makes it a viable biometric in many scenarios. The human ear is observed to exhibit variations across individuals as assessed by the curves, surfaces, and geometric measurements pertaining to the visible portion of the ear, commonly referred to as the pinna. The structure of the pinna depicting various anatomical features can be seen in Figure 5.1.

As a biometric trait, the ear offers several advantages: (a) the structure of the ear has been observed to be stable despite aging, and ear growth is almost linear after the age of four; (b) the ear, unlike other facial features, is minimally impacted by changes in facial expression; and (c) image acquisition does not involve explicit contact with the sensor.

A typical ear recognition system consists of the following components: (a) an ear detection module (also known as segmentation) that localizes the position and spatial extent of the ear in an image; (b) a feature extraction module that extracts discriminative features from the ear; (c) a matching module that compares the fea-