Preface

Authentication of a person to ascertain his/her identity is an important problem in society. There are three common ways to perform authentication. The first relies on what a person possesses such as keys, identity cards, etc., while the second is based on what a person knows such as passwords, personal identification numbers (PINs), etc. The third way of authentication relies on what a person carries, i.e., the unique characteristics of a human being (Biometrics). Even though the first two methods are well established and accepted in society, they may fail to make true authentication on many occasions. For example, there is a possibility that items under possession may be lost, misplaced, or stolen. Similarly, one can forget passwords, etc. As a result, authentication may not be correct. However, this is not true in case of biometrics. Thus, most of the limitations of the traditional ways of authentication, which are based on possession and knowledge, can be overcome by the use of biometrics. Since it uses the characteristics of a person's own body or behavior which he/she always carries, there is no chance of forgetting or losing it. Moreover, body characteristics used for authentication are much more complicated and difficult to forge compared to remembering a string (such as password), even of a very long size. The main motivation behind the use of biometrics is to provide a convenient mechanism for person authentication with the help of his/her biological or behavioral characteristics and to eliminate the use of much inconvenient ways of authentication such as that based on ID card, password, physical keys, PINs etc.

There are two types of characteristics used in biometrics for person authentication. The first type of characteristics are physiological in nature, while the other is based on the behavior of human beings. Physiological characteristics depend on "what we have" and derives from the structural information of the human body, whereas behavioral characteristics are based on "what we do" and depend on the behavior of a person. The unique biometric characteristic (be it physiological or behavioral) which is used for authentication is commonly referred as a biometric trait. Common examples of physiological biometric traits are face, ear, iris, fingerprint, hand geometry, hand vein pattern, palm print, etc., whereas signature, gait (walking pattern), speech, key strokes dynamics, etc., are examples of behavioral biometrics.

Among various physiological biometric traits, the ear has gained much popularity in recent years as it has been found to be a reliable biometrics for human recognition. The use of ear for human recognition has been studied by Iannarelli in 1989. This study suggested the use of features based on 12 manually measured distances of the ear. It has used 10,000 ear images to demonstrate the uniqueness of ears and has concluded that ears are distinguishable based on a limited number of characteristics. This has motivated researchers in the field of biometrics to look at the use of ear for human recognition. Analysis of the decidability index (which measures the separation between genuine and imposter scores for a biometric system) also suggests the uniqueness of an individual ear. It has been found that the decidability index of the ear is in an order of magnitude greater than that of face, but not as large as that of iris. Below is a list of characteristics which make ear biometrics a popular choice for human recognition.

1. Ear is found to be very stable. Medical studies have shown that major changes in the ear shape happen only before the age of 8 years and after that of 70 years. The shape of the ear is found to be stable for the rest of life.
2. Ear is remarkably consistent and does not change its shape under expressions like face.
3. Color distribution of the ear is almost uniform.
4. Handling background in case of ear is easy as it is very much predictable. An ear always remains fixed at the middle of the profile face.
5. Ear is unaffected by cosmetics and eye glasses.
6. Ear is a good example of passive biometrics and does not need much cooperation from the subject. Ear data can be captured even without the knowledge of the subject from a distance.
7. Ear can be used in a standalone fashion for recognition or it can be integrated with the face for enhanced recognition.

Ear recognition consists of two important steps and they are (i) Ear detection and (ii) Recognition. Ear detection carries out the segmentation of the ear from profile face before using it for recognition task. Most of the ear recognition techniques directly work on manually segmented ear images, however, there also exist a few approaches which can take complete side face image as input and segment the ear automatically. This book will present some efficient but automatic ear detection techniques for 2D as well as for 3D.

Recognition step deals with the task of human recognition based on the segmented ear. Major challenges in 2D ear recognition are due to poor contrast and illumination, presence of noise in the ear image, poor registration of gallery (database), and probe images. Challenges in 3D ear recognition arise mainly from poor registration of gallery and probe images and presence of noise in the 3D data. This book presents efficient recognition techniques both in 2D and 3D, which have attempted to overcome these challenges.

This book consists of five chapters. A brief description of the content of each chapter is as follows. Chapter 1 is an introductory chapter and presents the basics of a biometric system, different biometric traits, various performance measures, information about various publicly available ear databases, etc.

Chapter 2 talks about ear detection in 2D. It first reviews existing ear localization techniques available in the literature and subsequently presents an efficient recently proposed ear localization technique in detail. This ear localization technique is found to be invariant to scale, rotation, and shape. It makes use of connected components of a graph constructed with the help of edge map of the profile face image to generate a set of probable ear candidates. True ear in this technique is detected by performing ear identification using a rotation, scale, and shape invariant ear template.

Chapter 3 talks about ear recognition in 2D. It starts with presenting a review on ear recognition techniques available in the literature. Further, in detail it describes a recently proposed efficient ear recognition technique in 2D which makes use of multiple image enhancement techniques and local features based on Speeded Up Robust Features (SURF). The use of multiple image enhancement techniques in it has made it possible to counteract the effect of illumination, poor contrast, and noise while SURF-based local feature helps in matching the images that are not properly registered and suffer from pose variations. For a given ear image, this technique obtains three enhanced images which are used by SURF feature extractor to generate three sets of SURF features for an ear image. Three nearest neighbor classifiers are, respectively, trained on these three sets of features and finally results in all the classifiers fused to get the final result.

Chapter 4 starts with presenting a review on 3D ear detection technique and subsequently discusses in detail a recently proposed technique for ear detection in 3D. As we know, detection of ears from an arbitrary 3D profile face range image is a challenging problem due to the fact that ear images can vary in scale and pose under different viewing conditions. The technique discussed in this chapter is capable of handling these issues due to variations in scale and rotation. Moreover, this technique does not require any registered 2D image for ear detection in 3D. Also, it can detect left and right ear at the same time without imposing any additional computational cost.

Chapter 5 focuses on ear recognition in 3D. It first presents a detailed review of human recognition techniques in 3D. Further, it discusses a recent human recognition technique which makes use of 3D ear data along with registered 2D ear images. The technique first coarsely aligns the 3D ear data using local features computed from registered 2D ear images and then uses Generalized Procrustes Analysis and Iterative Closest Point (GPA-ICP)-based matching technique for final alignment. It integrates GPA with ICP to achieve robust 3D ear matching. Coarse alignment of the data before applying GPA-ICP helps to provide a good initial point for GPA-ICP-based matching algorithm.

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