Human Ear Recognition System

M

Durgesh Singh
Indian Institute of Technology (BHU), India

Sanjay Kumar Singh
Indian Institute of Technology (BHU), India

INTRODUCTION

Biometrics has been an active field of research as there is an ever-growing need to automatically authenticate individuals. In almost all the security aspects, biometric systems play a significant role. Traditional methods of automatic recognition, such as ID cards or passwords, can be stolen, forgotten or faked. On the other hand, biometric characteristics are unique, permanent, universal and measurable. Biometrics method of identification is preferred over traditional methods for various reasons such as: firstly the person to be identified is required to be physically present at the point of identification and secondly the identification based on biometric techniques avoids the need to remember a password or using ID.

In biometrics system universality, distinctiveness, permanence, performance, collectability, acceptability and circumvention mainly these seven parameters are used to decide whether a human trait can be used as biometric or not. Based on these seven parameters, a brief comparison among biometric traits is provided in Table 1 (Jain et al., 2004). In this table high, medium, and low are denoted by H, M, and L, respectively. A biometric system may operate either in verification mode or identification mode that depending on the application. First step of any biometric system is the enrollment process. Enrollment process is used to register a new person with the biometric system. In verification, the user claims an identity and the system verifies whether the claim is genuine or not. So verification is one to one matching process and typically used in applications where the goal is to prevent unauthorised persons from using the services. In the identification mode, the system recognizes an individual by searching template of all the users in the database for a match. So, identification is one to many matching process and typically used to prevent single person from using multiple identities.

The human ear is a new class of relatively stable biometrics. Among various physiological biometric traits, ear has received much attention in recent years as it has been found to be a reliable biometrics for human recognition (Bhanu & Chen, 2008). After measurements of a lot of human ear photographs, it has been found that even in the cases of fraternal and identical twins, triplets, and quadruplets no two ears are similar (Iannerelli, 1989). Ear-based recognition is of particular attention because not only it is non-invasive but also not affected by factors such as mood, health and cosmetics (as in faces). It has been found that magnitude of the decidability index of the ear is

Table 1. A brief comparison among biometric traits based on the seven parameters

Biometric Trait	Universality	Distinctiveness	permanence	Collectability	Performance	Acceptability	Circumvention
Ear	M	M	H	M	M	H	M
Face	H	L	M	H	L	H	H
Fingerprint	M	H	H	M	H	M	M
Gait	M	L	L	H	L	H	M
Iris	H	H	H	M	H	L	L
Retina	H	H	M	L	H	L	L
Palmprint	M	H	H	M	H	M	M
Keystroke	L	L	L	M	L	M	M
Signature	L	L	L	H	L	H	H
Voice	M	L	L	M	L	H	H
DNA	H	H	H	L	H	L	L

DOI: 10.4018/978-1-4666-5888-2.ch540

greater than of the face, but not as large as Iris (Prakash & Gupta, 2012). Unlike the face, the ear shape may not be symmetrical, which in turn means that the left and right ears of every person are not the same. Below is a list of eight characteristics which make ear biometrics a popular choice for human recognition (Prakash & Gupta, 2013):

1. 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 (Iannerelli, 1989). Shape of the ear is found to be constant for rest of the life. Therefore the ear is found to be very stable.
2. Colour distribution of the ear is almost uniform.
3. Ear is unchanged by eye glasses and cosmetics.
4. Ear is an excellent case of passive biometrics and does not need much support from the subject. Ear trait can be captured even without the knowledge of the subject from a distance.
5. Size of the ear is smaller than face but larger than iris, retina, fingerprint etc. Hence ear can be acquired effortlessly.
6. Ear is extremely consistent and does not change its shape under expressions like face.
7. Handling background in the face is a tough issue and often it requires data to be captured under controlled environment. However in case of the ear, background is known since an ear always remains fixed at the midpoint of the profile face.
8. Ear can be used in a standalone fashion for recognition or it can be integrated with the face for enhanced recognition known as multi-biometrics techniques.

Ear biometrics is highly accepted biometrics by users in possible access control applications and government security such as visa/passport programs. According to users, the ear biometrics is less hectic than fingerprinting. Moreover, users admitted that they would feel less comfortable while taking part in face image recognition because people tend to care how they look on photographs. Furthermore, in the ear biometrics systems there is no need to touch any devices and therefore there are no problems with hygiene.

It is worth mentioning that ear images are more secure than face images, mainly because it is very difficult to associate ear image with a given person (in fact, most of users are not able to recognize their own image). Therefore, the ear databases do not have to be as much secured as the face databases, since the risk of attacks is much lower.

On the other hand, the ear biometrics is not a natural way of identifying humans. In real life we do not look at people ears to recognize them. Our identification decision is rather based on faces, voice, or gait. The reason is that people lack in words to describe ears. The main task of ear biometrics is to define such terms in context of the computer vision systems; such terms are called 'features'. In ear biometrics based on computer vision systems, the main task is to extract such features that will describe human ears in a distinctive way.

EAR BIOMETRIC SYSTEMS

An ear biometric recognition system can be viewed as a classical pattern recognition system as shown in Figure 1. This system reduces an input image to a set of features and then compares this against the feature sets of other images that are already stored in database known as template to determine its identity or authenticity. Ear recognition can be proficient use a 2D digital image as well as a 3D digital image of the ear. Ear recognition system can be defined by following four steps.

1. **Ear detection or localization:** The first step is to localize the position of the ear in a profile face image. The system normally uses a rectangular boundary to indicate the spatial point of the ear in the side profile of a face image. Ear detection is important because errors at this stage can undermine the utility of the system.
2. **Feature extraction:** During the matching stage, most of the recognition systems extract a salient set of features to represent the ear. Feature extraction step reduces the segmented ear to a mathematical model called as a feature vector that summarizes the discriminatory information present in the ear image.
3. **Matching:** In this matching step the recognition system compares the features extracted from the input ear image with the stored image in the database to establish the identity or authenticity of the ear. In its simplest form, matching generates scores indicating the similarity to other ear images.