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A Survey on Human Ear Recognition

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ABSTRACT
This paper presents an efficient ear recognition technique which derives benefits from the local features of the ear and attempt to handle the problems due to pose, poor contrast, change in illumination and lack of registration. Recognizing humans by their ear have recently received significant attention in the field of research. Ear is the rich in characteristics. This paper provides a detailed survey of research done in ear detection and recognition. This survey paper is very useful in the current state-of- art for those who are working in this area and also for those who might exploit this new approach.
***Keywords* -**Biometrics, Ear Recognition 2D &3D, Physiological Characteristics, Behavioral Characteristics

I. INTRODUCTION

The presence of loop-holes in almost all the conventional security system has forced the researcher to switch towards the ear biometrics system. The prime reasons behind their inclination are due to the presence of all the properties i.e. universality, uniqueness, permanence and collectable in nature in ear biometric. Also ears are not variable in its appearance during the change in pose and facial expressions. Alphonse Bertillon was the first individual to unveil the power of ear biometric for recognizing the criminal in jail [1]. Ear has a reputation of stable biometric feature that does not vary with time. Research also shows the evidence that slight ear size variation do happen as the person ages. Generally, this happens due to the sagging nature of the skin and muscles as person ages. Nixon studies reveal that recognition rate is not affected by aging [2]. In this paper, we start with discussing the anatomy of human ear, freely available ear database, different method used in ear recognition, the problem faced in ear biometrics and the applications related to it. Biometric based system 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. Biometric recognition refers to the automatic recognition, based on physiological and /or behavioral characteristics of an individual. By using biometrics, it is possible to establish an individual's identity based on "who he or she is" rather than by what he or she possesses likes smart card or what he or she remembers likes password.

In the identification mode, the system recognizes an individual by searching template of all the users in the database for a match. Identification is typically used to prevent single person from using multiple identities.

Human ear due to its consistent behavior over the age, has gained much popularity in recent years among various physiological biometric traits. 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 [2].

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 [2]. 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 [3].

- Size of the ear is smaller than face but larger than iris, retina, fingerprint etc. Hence ear can be acquired effortlessly.
- 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 [3]. Shape of the ear is found to be constant for rest of the life. Therefore the ear is found to be very stable.

Table No.1 Comparison among Biometric Traits Based On the Essential Seven Parameters

Biometric Trait	**Universality**	**Distinctiveness**	**Permanence**	**Collectability**	**Performance**	**Acceptability**	**Circumvention**
Ear	Medium	Medium	High	Medium	Medium	High	Medium
Face	High	Low	Medium	High	Low	High	High
Fingerprint	Medium	High	High	Medium	High	Medium	Medium
DNA	High	High	High	Low	High	Low	Low
Retina	High	High	Medium	Low	High	Low	Low
Iris	High	High	High	Medium	High	Low	Low
Signature	Low	Low	Low	High	Low	High	High
Keystroke	Low	Low	Low	Medium	Low	Medium	Medium
Voice	Medium	Low	Low	Medium	Low	High	High

- Ear is unchanged by eye glasses and cosmetics.
- 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
- Colour distribution of the ear is almost uniform.
- 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

Ear biometrics can be 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.

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.

II. EAR BIOMETRICS SYSTEM

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 modules.

¬ **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.

¬ **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

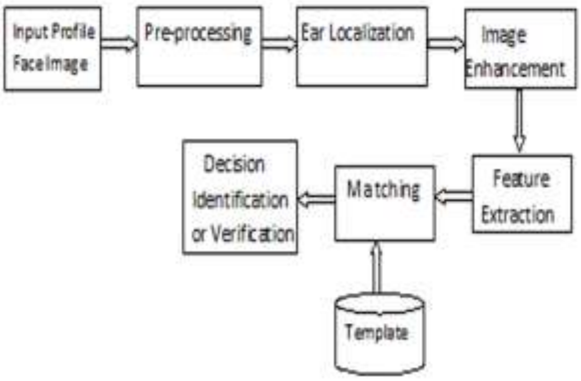

Fig 1: Building Block Figure of a Usual Ear Recognition System

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.

Dcision: The recognition system uses the match scores to provide a final conclusion. In the verification mode, "yes" indicates a genuine match while "no" indicate an impostor. In the identification mode, the output is a potential matching identities ranked by match score. All biometrics systems suffer from two type of error. First one is a false acceptance and second one is a false rejection. First one happens when the bio- metric system authenticates an impostor. The second error occurs when the biometric system has rejected a valid user. The accuracy of biometric system is determined by combining the rates of false acceptance and rejection.

III. EAR IN 2D BIOMETRICS

The first well known technique for ear detection was proposed by M. Burge and W. Burger [7] and was based on deformable contours. It has detected ears with the help of an adjacency graph built from the voronoi diagram of its curve segments using canny edge map. D. J. Hurley et al. [8] have used force field technique to get the ear location. The image is transformed to a force field by treating the pixels as an array of mutually attracting particles that act as the source of a Gaussian force field. Here Gaussian force is used as a generalization of the inverse square laws which govern the electrostatic, gravitational, and magneto static force fields. This technique is only applicable when a small background is present in the ear image. P. Yan et al. [8] have used manual technique based on two-line landmark to detect ear where one line is taken along the border between the ear and the face while other line is considered from the top

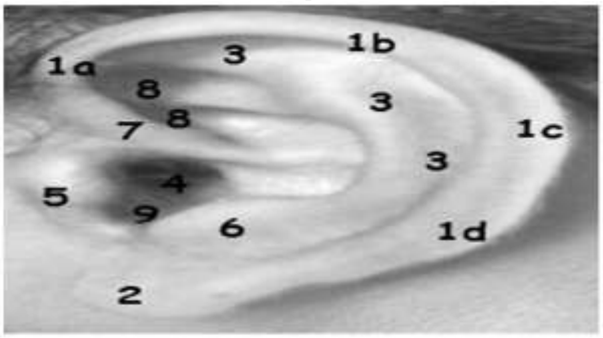

Fig 2: External ear anatomical parts as 1a, 1b, 1c, 1d Helix Rim, 2 Lobe, 3 Antihelix, 4 Concha, 5 Tragus, 6 Antitragus, 7 Crus of Helix, 8 Triangular Fossa, 9 Incisure Intertragica.

Of the ear to the bottom. An ear detection technique in 2D side face image was presented by S. Ansari and P. Gupta [8] based on edges of outer ear helices. The accuracy of this technique is reported to be 93.34% on IIT Kanpur database. This technique is based on only outer helix curves and does not use any structural information present in inner part of the ear. Thus, its failure chances are high if the helix edges are poor. Another technique is based on skin-color and contour information proposed [11]. It detects ear by approximately estimating the ear location and by improving the localization using contour information. In this technique assumes that the ear shape is elliptical and fits an ellipse to the edges to get the accurate position of the ear. An automatic ear detection techniques proposed [12] is based on template matching. In this technique, an ear template obtains a suitable size by resizing the created template. Resizing is based on the size of the skin part of profile face image and works well when profile face includes only facial parts. More recently, a novel technique is proposed [13], known as image ray transform. It is based upon an analogy to light rays. The accuracy of this technique is reported to be 99.6% for enrollment across 252 images of the XM2VTS database.

Most of the well-known techniques for 2D ear recognition can be broadly classified into following types:

a) Appearance Based Techniques
b) Force Field Transformation Based Techniques
c) Geometric Features Based Techniques

IV. EAR IN 3D BIOMETRIC

Ear recognition techniques in 3D are based on either only 3D ear data or both 3D and 2D ear data. In [14], an ear based system for human recognition has been proposed which includes automated segmentation of the ear in a profile view image and ICP based 3D shape matching for recognition. The technique has achieved 97.8% rank-1 recognition rates with 1.2% EER on UND-J2 database. Since it has made use of nose tip and ear pit boundary for ear detection, it may not work properly if the nose tip or the ear pit is not clearly visible. However, due to pose variations, one cannot always assume the visibility of nose tip or ear pit. The technique proposed in [15] has first detected ear from 2D profile face image using the Cascaded AdaBoost detector and then has extracted corresponding 3D ear data from co-registered 3D image. It has computed local 3D features from the ears and has used them for initial matching whereas ICP based technique has been used for final matching. It has achieved 93.5% rank-1 recognition rates with EER of 4.1% on UND-J2 database. The technique proposed is performed low in case of occlusions and large pose variations. Collaboration of face and ear is a good choice of biometric traits because of their physiological structure and location. Also, both of them can be acquired nonintrusive. To exploit these advantages, there exist few multi-biometric techniques which are based on ear and face.

V. CONCLUSION

Although several algorithms for ear detection and recognition have been proposed in the literature, but there are no commercial biometric recognition systems at this time that openly use features of the ear for human recognition. But the performances of ear recognition algorithms have been tested on some standard ear datasets and experiments suggest that the ear images can result in good recognition accuracy on ideal image. However, the performance of ear recognition methods on non-ideal images obtained under varying illumination and occlusion conditions is yet to be established. In this review paper, we have given a brief overview of the ear biometric recognition system and different approaches for ear recognition were discussed. So newcomers can easily understand the ear biometrics recognition system process. We have considered detection stage and recognition stage of the two main stages in an ear recognition system. We have also separately discussed the 2D and 3D ear image detection and recognition technique in literature review. Further, we categorized the 2D ear recognition systems into appearance based techniques, Force Field Transformation Based Techniques and Geometric Features Based Techniques. The ear biometrics can be used for passive identification. Till now the ear detection and recognition systems are limited to controlled indoor conditions. Must be the ear biometrics need to be tested outdoors. The main application of ear recognition is personal identification in unconstrained environments. This includes applications for smart surveillance, but also the forensic identification of perpetrators on CCTV images or for border control systems.

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