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An Review on Ear Recognition Techniques Based On Local Texture Descriptors

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***Abstract*—** Ear biometric is considered as one of the most reliable and invariant biometrics characteristics. Ear recognition is an active area of research and automatic ear recognition is one of the challenging areas in biometric and forensic domains. Human ear contains large amount of unique features for recognition of an individual. The Ear biometric is unhurried as one of the majority unswerving and invariant biometrics approach. Ear appreciation is an active area of enquiry and instinctive ear recognition is one of the challenging areas in biometric and pathological provinces. When compared with the other biometric based recognition, human ear recognition system is universally accepted by various researchers. There are different approaches and descriptors that achieve relatively good results in ear biometric recognition. In this study, presents an overview of different local texture descriptors in the field of automatic ear recognition. Further, we have compared the various feature descriptor extraction techniques and discuss the recognition rate and accuracy for different problems.

***Keywords*—** Ear Biometric, Physiological and Texture Characteristics, Recognition, Local Descriptors

I. INTRODUCTION

The principle idea behind biometric is the verification or identification of a person based on unique characteristics. Biometric system mainly uses physiological and behavioral characteristics for the recognition of an individual. Ear, a physiological biometric trait used in forensic applications. The external anatomy of an ear [1] is shown in Figure 1. The structural patterns like helix, lobe, concha, crus of helix etc. differ in shape, relative position, and appearance from person to person. Ear have certain benefits compared to other biometric modalities. According to medical reports [2] the structure of an ear is stable in the age group between 8-70. Ear does not change with expressions unlike face biometric [3]. Ear is a contactless biometric and it is immune from hygiene problem that occur in contact biometric like iris, retina etc. Ears smaller size and more uniform color distribution make it faster to work. The main problem with biometric is occlusion with hair, ear ring, specs and ear phones.

A typical ear recognition system consists of three main steps: i) ear normalization, ii) feature extraction and iii) classification. Ear normalization mainly normalizes the ear image in to a standard size. The feature extraction module extract features from ear and helps to design an effective classifier for recognition.

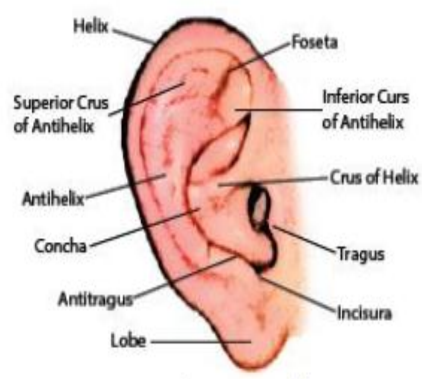

Figure 1. External Ear and its parts

Majority of ear biometric research is in feature extraction and classification. In real scenario, a big obstacle for ear recognition is to find an effective descriptor to represent the ear structure, which can be affected by change in illumination, pose, noise and occlusion.

Section II describes the related works. Section III involves the structure of ear recognition. Section IV explains the comparative study of existing techniques and the conclusion is discussed in Section V.

II. RELATED WORK

Geometric techniques uses ear geometric features such as shapes, curve and relations between ear parts. Early works on ear biometrics is based on geometric features [2]. The French criminologist Alphonse Bertillon et al is considered to be first suggested the possible use of ear as a means of personal identification as part of his new scientific method of criminal identification. Depending on the feature extraction techniques, 2D ear recognition is classified into geometric/statistical, local, holistic/global and hybrid approaches [5]. Burge and Burger et al. developed the first computerized system based on geometric approach. They used graph matching algorithm based on vornoi diagram of curves from extracted contours [6]. Moreno et al. developed an ear recognition system based on geometric features such as ear shape and wrinkles [7]. Mu et al. also used geometric features for their classification. Geometric methods are not effective in situations such as poor quality image, occlusion, lighting and pose. Holistic techniques such as principal component analysis (PCA), Force Field Transform, independent component analysis etc. extract features from the ear structure as a whole [8].

Hurley et al. developed one popular approach for ear recognition which used force field transformation. This technique calculates the force field from input ear image by treating pixels as Gaussian force field [9]. Victor and Chang et al. used PCA for ear recognition. PCA is used for dimensionality reduction [10]. Zang et al. developed a system with ICA feature and a neural network for classification. Compared to PCA, their system achieved a better rank-1 recognition rate. Currently lots of works in ear biometric is based on image texture features. Texture analysis is a local descriptor which extracts features from local areas of ear structure [11]. Nanni and Lumni extracted gabor features from the selected color spaces. They achieved a rank -1 recognition rate of 84 % on UNDE database. P Flug et al. used Local Phase Quantization Features (LPQ) alone for texture extraction and achieved a rank - 1 recognition rate of 93.1% [12]. Benzaoui et al. used Binaries Statistical Image Features (BSIF) which is a 256bin dense descriptor where a binary code is generated by convolving a filter trained by independent component analysis.

Grey Level Co-occurrence Matrix (GLCM) and Local Binary Patterns (LBP) are texture descriptors that are computationally simple compared to Gabor features which are computationally more demanding. Plug et al. used a hybrid technique by combining different texture features like LPQ, BSIF, LBP and HOG. They achieved a better recognition rate when compared to their previous work which uses LPQ alone [13]. Jacob and Rajuet et al. conducted experiments on IITD II database by combining features like GLCM, LBP and Gabor filter with rank- 1 recognition rate 94.1%. However, hybrid approaches are computationally complex than holistic or local technique.

III. STRUCTURE OF EAR RECOGNITION

In general, the left and right ears of a person are similar to such an extent that makes matching the right ear to the left ear (and vice versa) with automatic techniques perform significantly better than chance. Yan and Bowyer et al. reported a recognition performance of around 90% in cross-ear matching experiments. They observed that for most people the left and right ears are at least close to bilateral symmetric, though the shape of the two ears is different for some [17]. Similar findings were also reported by Abaza and Ross in [18]. The literature suggests that the size of the ear changes through time [19, 15 and 16]. Longitudinal studies from India and Europe have found that the length of the ear increases significantly with age for men and women, while the width remains relatively constant. How ear growth affects the performance of automatic recognition system is currently still an open research question. The main problem here is the lack of appropriate datasets captured over a long enough period of time that could help provide final and conclusive answers. Some initial studies appeared recently on this topic, but only featured images captured less than a year apart.

A. *Chronological Development of Ear Recognition*

The chronological development of ear recognition techniques can be divided into a manual (pre-automatic) and automatic era. During the pre-automatic era several studies and empirical observations were published pointing to the potential of ears for identity recognition. One of the biggest contributions to the field during this era was made by Iannarelli in 1989, when he published a long-term study on the potential of ear recognition. Iannarelli’s seminal work included more than 10, 000 ears and addressed various aspects of recognition, such as ear similarity of siblings, twins and triplets, relations between the appearance of the ears of parents and children as well as racial variations of ear appearance [11]. The 1990s marked the beginning of automatic ear recognition. Various methods were developed during this time and were introduced in the literature. In 1996, for example, Burge and Burger used adjacency graphs computed from Voronoi diagrams of the ears curve segments for ear description and in 1999 Moreno et al. presented the first fully automated ear recognition procedure exploiting geometric characteristics of the ear and a compression network.

In 2000 Hurley et al. described an approach for ear recognition that relied on the Force Field Transform, which proved highly successful for this task. A year later, in 2001, the Forensic Ear Identification Project (FEARID) project was launched, marking the first large-scale project in the field of ear recognition. With the beginning of the new millennium, automatic ear recognition techniques started to gain traction with the biometric community and new techniques were introduced more frequently. Applied principal component analysis (PCA) on ear images and reported promising results. In 2005 the Scale Invariant Feature Transform (SIFT) was used for the first time with ear images, raising the bar for the performance of the existing recognition techniques. In 2006 a method based on non-negative matrix factorization (NMF) was developed by Yuan et al. and applied to occlude and no occluded ear images with competitive results. In 2007 a method based on the 2D wavelet transform was introduced by Nosrati et al., followed by a technique based on log-Gabor wavelets in the same year]. More recently, in 2011, local binary patterns (LBP) were used for ear image description, while later binaries statistical image features (BSIF) and local phase quantization (LPQ) features also proved successful for this task.

B. Ear Recognition Approaches

Techniques for automatic identity recognition from ear images can in general be divided into techniques operating on either 2D or 3D ear data. Here, we focus only on 2D approaches and refer the reader to other reviews, such as [16], for a detailed coverage of the field of 3D ear recognition. A typical (2D) ear recognition system operates on images or video footage captured with commercial of-the shelf cameras, surveillance systems, CCTV or similar everyday hardware. In a fully automatic setting, the system first detects a profile face in the input image and segments the ear from the detected region.

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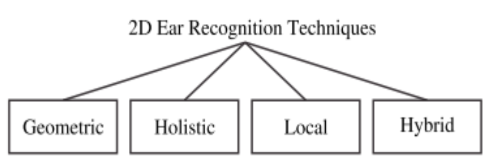

Figure 2. Taxonomy of 2D ear recognition approaches

Ear is then aligned to some predefined canonical form and processed to account for potential variability in illumination. Features are extracted from the pre-processed image and finally identity recognition is conducted based on the computed features using a suitable classification technique. Depending on the type of feature extraction technique used, 2D ear recognition approaches can be divided into geometric, holistic, local and hybrid methods, as illustrated in Fig. 3. Geometric techniques exploit the geometrical characteristics of the ear, such as the shape of the ear, locations of specific ear parts and relations between these parts. Holistic approaches treat the ear as a whole and consider representations that describe the global properties of the ear. Local approaches describe local parts or the local appearance of the ear and exploit these descriptions for recognition. The last category of hybrid approaches covers techniques that do not strictly fit into any of the other categories and usually comprises methods that combine elements from all categories or rely on multiple representations to improve performance.

IV. COMPARATIVE STUDY

It includes the comparison table that contains existing techniques for ear recognition and their accuracy/ recognition rate for the various problems. From this study, it is clear that the Geometrical feature extraction method obtained high level of accuracy when compared with the other existing techniques.

Table 1. Comparative Study of Ear Recognition Techniques

Author	Problem	Technique	Accuracy/EER/ RR
Asmita Kamble	Unique in indiduals approach for the automated human identification	Automated human identification using 2D ear imaging	N/A
Asmaa Sabet Anwar	Recognition based on geometrical	Geometrical features extraction like (shape, mean, centroid and Euclidean distance between pixels).	Accuracy= 98%
J David	Feature space is reduce the dimension of pattern	Gaussian attractors	N/A
Anika P Flug	Gallery images in order to locate matching identity	Unsupervised clustering scheme	99.01% with a penetration rate of 47.10% 3.11% penetration rate 31.7%
Kyong Chang	Lower recognition performance	Face recognition algorithms	90.9 percent in the analogous

	using ear image	based on principal component analysis (PCA)	
Zhichun Mu	Color analysis and ear match	Edge-based ear recognition method	recognition accuracy=85%
Michał Chora	Counter detection and normalization	Discrete geometrical algorithms	N/A

V. Conclusion

Automatic ear recognition is an emerging method for biometric security. In this survey, I studied the various ear recognition techniques based on the local texture descriptors. It will help to provide the conceptual platform for future investigation. An effective feature extraction is required for obtain the desired accuracy in future work.

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