Available online at www.sciencedirect.com
ScienceDirect
Forensic Science International 178 (2008) 112–118
Forensic Science International
www.elsevier.com/locate/forsciint

A test of individuality of human external ear pattern: Its application in the field of personal identification

Ruma Purkait *, Priyanka Singh

Department of Anthropology, Saugor University, Saugor, MP 470 003, India

Received 15 January 2008; received in revised form 29 January 2008; accepted 23 February 2008
Available online 18 April 2008

Abstract

A preliminary study has been undertaken to test the individuality of human ear patterns and its probable use in profile view facial image recognition. Anthropometric measurements on 12 inter-landmark linear distances have been carried out for both left and right ears of 700 male and female individuals. A 12-dimensional feature space has been framed to represent each ear pattern as a feature vector with the measured inter-landmark distances as its components. The Euclidean distances in such a feature space amongst all possible pairs of ear patterns of both male and female individuals have been computed. Very few pairs have distances which fell below the safe distinction limit. The undistinguished pairs were further examined by direct superimposition of their images. None of the ear patterns is found to be exactly the same in morphology to the other. Even the left and right ears of the same individual are not identical. Thus, the present study reconfirms the individuality of ear patterns. For establishment of identity, a questioned profile view facial image can be compared with a control one on the basis of the ear pattern visible in it.

Keywords: External ear; Individuality; Euclidean distance; Feature space; Personal identification

1. Introduction

The problem of personal identification as investigated by forensic anthropologists is basically exploring the field of Biometrics. Biometrics is the method of identifying or verifying the identity of an individual based on his physiological and behavioural characteristics [1]. Fingerprints have been playing a key role in criminal identification problems for a long time and have been recognized as a powerful as well as a foolproof identifiable feature. This is because of the complexity of fingerprint patterns that can have innumerable variations. In fact, the word fingerprint has become an icon for identification/uniqueness. Thus, with the emergence of DNA technology, identification based on DNA comparison has been termed as DNA fingerprinting. However, DNA fingerprinting for criminal identification can only be made when evidence left at the scene of a crime is a specimen of blood, hair, skin cells, or other form of genetic material. Such personal traits may not always be available at crime scenes and often a forensic investigator has to depend on photographic evidence consisting primarily of facial images.

Identification from facial features is frequently used by law enforcement agencies for surveillance and monitoring crime. Though personal identification by comparison of two front view facial images has received the widespread attention of forensic scientists, the same is not so for comparisons between two profile view facial images. The main reason is that a front view facial image incorporates most of the distinguishing facial features, while a profile view one does not. However, the ear pattern, as visible in a profile view facial image, may possess a unique characteristic suitable for personal identification. It is commonly believed by anthropologists and also suggested in the literature [2–8] that the shapes and characteristics of the human external ear are widely different and may be so distinguishable that it is possible to differentiate between the ears of all individuals. Thus, the ear pattern, if visible in a profile view facial image, may be explored for personal identification. A forensic anthropologist's opinion on personal identification based on comparison of ear patterns will be acceptable to a court of law when that opinion, based on the certitude that ear patterns are unique, is supported by empirical data. The present work is motivated in this direction and a

* Corresponding author. Tel.: +91 7582 264438; fax: +91 7582 224575.
E-mail address: r.purkait@gmail.com (R. Purkait).

0379-0738/$ – see front matter
doi:10.1016/j.forsciint.2008.02.009

suggestion towards profile view facial image recognition has been proposed.

1.1. Principle

An ear pattern is not a simple one and is characterized by a complex distribution of various features. Thus, an identity of two ear pattern images can only be established by a properly superimposed image that can show both holistic as well as feature-wise matching. For a large sample size, for example 1000 ears, there would be 499,500 possible pairs, and comparison by direct superimposition for each pair is obviously a formidable task. However, if two ear patterns differ in respect of only a limited number of features, their non-identity can always be confirmed. For example, if we consider an ear pattern as a two-dimensional vector, the two components of which are the ear width and the ear length, each ear pattern can be represented as a point in a two-dimensional plane as shown in Fig. 1.

Here, two hypothetical ear patterns, one 3 cm long and 2 cm wide and the other 2 cm long and 3 cm wide, have been represented by two points, A and B, respectively. Even though the lengths of the feature vectors OA and OB in the feature space are equal, their representative points are well separated by a Euclidean distance of about 1.414 cm. However, such a feature vector will fail to distinguish amongst a large number of actual ear patterns. The more the dimension of feature space is increased, the more will be the distinction capability of the feature vector.

2. Subjects and method

The present study incorporates feature-wise comparison of pairs of ear patterns in a 12-dimensional feature space. The components of such a feature are the inter-landmark distances as shown in Fig. 2:

(i) physiognomic ear length (1–2),
(ii) physiognomic ear breadth (3–4),
(iii) morphological ear breadth (ear base length) (5–6),
(iv) length of tragus (7–8),
(v) height of tragus (base of tragus – 9,

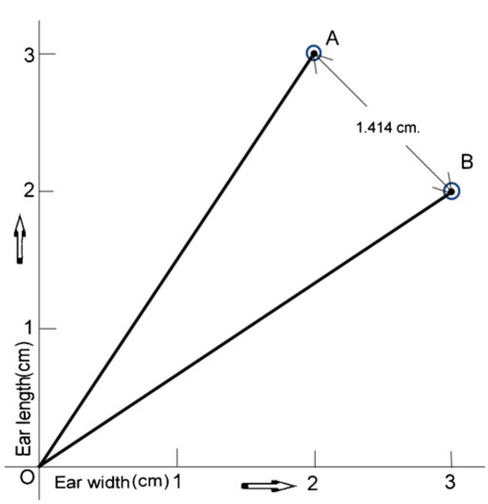

Fig. 1. Ear pattern as a two-dimensional vector.

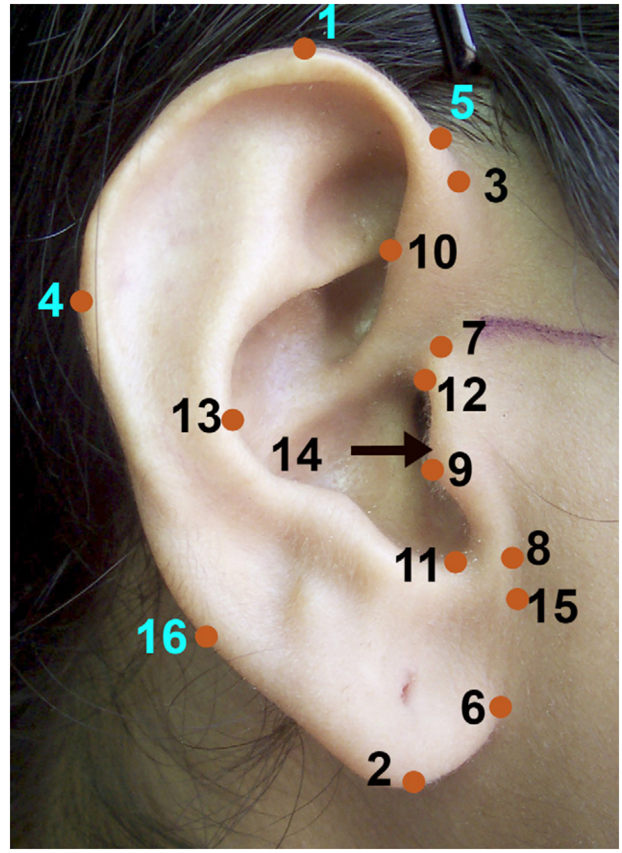

Fig. 2. Landmarks of the external ear: (1) superaurale, (2) subaurale, (3) preaurale, (4) postaurale, (5) otobasion superius (6) otobasion inferius, (7) deepest point on the notch on upper margin of tragus, (8) lowest point on the lower border of tragus, (9) protragion, (10) concha superior (the intersection of the lower edge of the anterior end of the crus antihelicis inferius and the posterior border of crus helicus, (11) incisura intertragica inferior (the deepest point in the incisura intertragica), (12) incisura anterior auris posterior (the most posterior point on the edge of incisura anterior auris), (13) strongest anthelical curvature, (14) deepest lateral border of external auditory meatus, (15) lobule anterior (ear attachment line is drawn joining the otobasion superior and inferior. The point on this line just below the incisura intertragica where the cartilage ends is the landmark) and (16) lobule posterior (the most posterior point on the margin of lobule perpendicular to lobule anterior).

(vi) conchal length (10–11),
(vii) conchal width (12–13),
(viii) conchal depth (9–14),
(ix) lobular length (11–2),
(x) lobular width (15–16),
(xi) protrusion at superaurale level and
(xii) protrusion at tragal level.

In case each ear pattern differs from the other, their representative feature-points in the feature space must be separated from each other. Thus, the Euclidean distances in feature space between all possible pairs of the samples of ear patterns were quantitative measures of their dissimilarities and those were computed for comparison. The distribution of such distances for a large sample size will give a quantitative indication of the nature of variations of ear patterns amongst different persons. The pair that failed to be distinguished by 12-dimensional feature space was further compared by direct superimposition using Symmetry Perceiving Adaptive Neuronet (SPAN) software [9]. It may be noted that an ear feature, so defined, does not distinguish between left and right ears. It therefore allows a comparison between right and left ears of the same individual for study on ear asymmetry.