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The Use of Photoanthropometry in Facial Mapping

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Abstract: In forensic practice, there is a frequent demand for comparison of facial images of perpetrators and suspects. Photoanthropometry is the science of measurements from precisely defined marker points of the face and is commonly used to provide opinion evidence of identity from examination of facial pictures. In facial mapping, it is based on quantitative analysis on measurements of the distances and angles between anatomical facial landmarks and the generation of indices based on them.

Key words: Photoanthropometry, techniques, measurement, facial alignment, superimposition

INTRODUCTION

In 1871, physical evidence in the form of a comparison between two photographs (a daguerreotype and an albumen print) was presented and heard in an English court in at the time very famous Tichborne Claimant case. The first documented use of photographic superimposition in a legal context has been back to 1937 where comparisons were made between photographs of two recovered skulls and antemortem photos of two missing women for the Buck Ruxton case (Porter and Doran, 2000; Glassman, 2000; Kleinberg *et al.*, 2007; De Angelis *et al.*, 2009).

In forensic practice, there is a frequent demand for comparison of facial images of perpetrators and suspects. Medical examiners, forensic anthropologists or other forensic experts are asked to express a judgment about the possibility that a criminal visible in an image can be identified as a known person/suspect. This type of evidence is called facial mapping and within it experts provide opinion evidence of identity from examination of evidential facial pictures. Among the analytic techniques used for the study of facial features for forensic purposes are anthropometrical facial comparisons (photoanthropometry) (Goos *et al.*, 2006; Oxlee, 2007; Kleinberg *et al.*, 2007; Roelofse *et al.*, 2008; De Angelis *et al.*, 2009; Davis *et al.*, 2010; Stavrianos *et al.*, 2010).

PHOTOANTHROPOMETRY

Photoanthropometry is the science of measurements from precisely defined marker points in various zones of the face or inspecific anatomical areas as these appear in photographs. In facial mapping, it is based on quantitative analysis on measurements of the distances and angles between anatomical facial landmarks and the generation of indices based on them. The technique traces its roots to traditional anthropometric methods. The aim of photoanthropometry is to compare metrically the proportional relationships of one photograph to another, rather than assess absolute visual differences and similarities as in morphological comparisons (Iscan and Loth, 2000; Kau *et al.*, 2007; Davis *et al.*, 2010).

Anthropometry itself has been studied for many years and has evolved with the advent of new technology and computing power. When anthropometry shifted from a direct (measured on the subject) to an indirect (measured on images of the subject) approach by taking 2D pictures enabling the storage of permanent records, face recognition started to attract the attention of biometric, pattern recognition and computer vision communities. More recently because of the limitations of 2D approaches and with the advent of 3D scanners, face recognition research has shifted from 2-3D with a concurrent improvement in performance (Smeets *et al.*, 2010).

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The effective use of absolute measurement of features or dimensions demands a detailed knowledge of the geometry and metrics associated with camera systems and recording media. Once the camera data is known and calibrated, trigonometric values can be calculated along the horizontal plane (x-axis), the plane from the foreground to the apparent horizon (y-axis) and the vertical plane (z-axis). Anthropometry is based on measurement of the living and deals with a three-dimensional structure. In the living, the anatomical landmarks used for the measurements can be palpated and located precisely. When photographs are involved, the process becomes essentially two-dimensional. However, this creates one critical disadvantage in the loss of depth information when transforming a 3D object into a flat surface like a 2D photo. Furthermore, distortion due to lighting and focal length of lenses are other problems that are hard to standardise (Iscan and Loth, 2000; Aeria *et al*., 2010).

A key element in the use of photoanthropometry is the formulation of indices based on proportions rather than absolute size. As in all analyses, the landmarks used for indices must be clearly visible and defined if they are not standard sites. An important consideration for this approach is not to limit an analysis to preset or traditional landmarks. The quality and angulation of the image may dictate the use of unusual points that can be clearly defined and located on both images. A number of anthropological soft tissue landmarks are marked on the facial image and the distance between two landmarks is measured. Since, absolute size is not reliable without a scale, proportionality indices must be calculated from these measurements to insure that the values are comparable. By relying on relative proportions, the index functions to eliminate the incomparability resulting from absolute size differences between images. Normalized indices are calculated for each measurement, taking each measurement as a percentage of the largest available measurement. An index is created as follows:

$$\frac{\text{Smaller dimension}}{\text{Larger dimension}} \times 100$$

It is now accepted that anthropometry indices are not suitably discriminating to positively identify an individual and facial indices comparison is currently only used to test for elimination. If the anthropometry indices of the two images are deemed by the experience of the expert to be suitably dissimilar then the two images are determined to not show the same person (Iscan and Loth, 2000; Moreton and Morley, 2011). The techniques that are used in photoanthropometry include:

Measurement. Due to the fact that commonly images under comparison are different in scale, any photoanthropometry comparison must be based on actual measurement after the correct scales have been established. However, this demands detailed knowledge of the recording camera which is not generally available to the analyst. Nevertheless, accurate work can be achieved on the original imagery by calculating the ratios between facial landmarks (Fig. 1). However, it is important to note that from this evidence alone the analyst could not say that the two were the same because these ratios may be shared by many in the population (Iscan and Loth, 2000; Oxlee, 2007).

Definition of anatomical landmarks commonly used for facial comparison:

- Endocanthion (right) is the point at the inner commissure of the right eye fissure
- Endocanthion (left) is the point at the inner commissure of the left eye fissure
- Exocanthion (right) is the point at the outer commissure of right the eye fissure
- Exocanthion (left) is the point at the outer commissure of left the eye fissure
- Midnasal point is midpoint between the endocanthions
- Subnasale is point where the nasal septum meets the philtrum
- Alare (right) is most lateral point of the right nasal wing
- Alare (left) is most lateral point of the left nasal wing
- Stomion is midpoint at the crossing of the vertical facial midline and the horizontal labial fissure between gently closed lips
- Gnathion is most inferior point of the chin

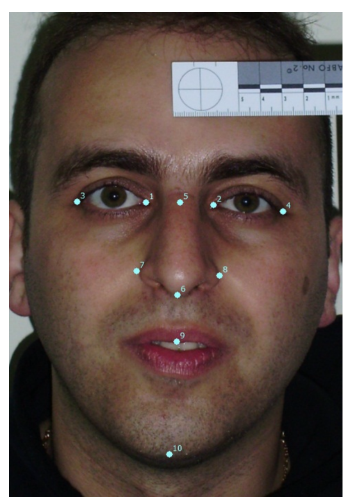

Fig. 1: The location of some of the anatomical landmarks commonly used in facial mapping

Facial alignment: Another technique used is facial alignment. The facial pictures are carefully scaled using the distances between landmarks in the vertical plane and in the horizontal plane. These are then equally carefully aligned and lines drawn through as many landmarks as possible (Iscan and Loth, 2000).

Superimposition: Superimposition of one picture upon another is a further method of testing the reliability of morphological analysis. The most common methodology used is to utilize tracings of one of the images and superimpose it upon the other. As with any research of this kind, great care must be taken with both the scaling and enlargement, particularly when the differences in geometry of the two pictures under comparison are marked. No attempt should be made to rectify the geometry as in this way there is a risk to actually attempt to make one picture fit into another or vice versa (Iscan and Loth, 2000; Oxlee, 2007).

DISCUSSION

The facial mapping methods can be used by the lay observer and/or an experienced anatomist who can confirm the findings using objective interpretational skills. However, the identification photographs have not been widely used as a source of identification. One reason may be the misalignment of facial features caused by the vertical axis distortion and the size of most ID documents. Moreover, facial images are subject to further distortion caused by the focal length of the camera lens and subject distance despite the advantages of newly developed digital capturing devices that produce better quality images. The proportions of the face are not fixed, absolute characteristics. The features of the face are dynamic and changeable and easily altered by various physical factors (Porter and Doran, 2000; Kleinberg *et al*., 2007; Moreton and Morley, 2011).

Moreton and Morley (2011) do not agree that only horizontal proportions should be used as facial proportions in the vertical plane undergo image distortion. Vertical facial indices are the only proportions to remain stable if there are horizontal angular orientations between two images. However, this only holds true if both images are taken face on and it is only the horizontal angle which is changed. The current study shows that both vertical and horizontal proportions are influenced significantly by changes in vertical camera angle. They concluded that a holistic approach, utilizing a set of proportional indices in a multivariate analysis approach may add more robustness to photoanthropometry techniques.

Kleinberg *et al.* (2007) analysed distance and angular measurements derived from a set of four landmarks on a database of 120 male police recruits concluding that the comparison of video images and photographs using anthropometric proportions from the chosen landmarks even under nearly ideal conditions, appears to be of limited value in identification cases. The concluded that measurements between facial features alone may be insufficient to distinguish between individuals because it is quite possible to obtain small measurable differences even in the same individual taking into account the numerous variables that can obtain when such images are produced.

Traditionally, the primary sources of craniofacial measurement have been direct anthropometry, Two-Dimensional (2D) photography and cephalometry. Recently, Three-Dimensional (3D) technologies such as laser scanning and 3D-stereophotogrammetry have been systematically utilized for anthropometric assessment instead of the traditional direct calliper-based measurement. Although, the direct anthropometric technique is non-invasive, displays technological simplicity and is a low-cost approach, it is time consuming, requires adequate training of the examiner and proper instrumentation and depends on patient cooperation for reliable results as a result, this method may be impractical in the clinical setting. Moreover, the direct technique does not provide a permanent record other than a list of numbers at the end of data collection. Hence, technological advances in this area have focused primarily on developing non-invasive devices and more efficient anthropometric indirect techniques to allow their use in the daily clinical routine (Aynechi *et al*., 2011).

Kovacs *et al.* (2005), Ghoddousi *et al.* (2007), Wong *et al*. (2008) and Fourie *et al*. (2011) concluded the degree of accuracy of the 3D-stereophotogrammetry systems were was found to be very satisfactory and found that the digital measurements performed were reliable, precise and unbiased relative to direct anthropometry.

CONCLUSION

The use of facial measurement remains a critical point for facial comparison as its accuracy is debated due to the fact that can be influenced by various factors ranging from the technical data of the camera to the orientation or expression of the face. Further researches are required to test the reliability of the photoanthropometry data in facial mapping. Furthermore, most researches in facial mapping are done under the best possible conditions regarding position of the face, lighting conditions, quality of the image and visibility of facial features. Future projects may need to examine the performance in facial comparison for less optimal conditions and should include larger sample of face data that would allow performing one to many comparisons.

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