3D shape analysis for facial identification

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1 Introduction

A problem receiving increasing interest is whether it is possible to quantify in a statistical sense the quality of match of two images of a face, for example of an image captured on a surveillance monitor to an image held in a database. Such a quantitative measure is a prerequisite for facial matching to be used as legal evidence in the same way as other biometric methods of identification such as fingerprinting or DNA profiling. There are many existing systems for automatic facial recognition which select the best available match to a questioned image of a human face to one or more images selected from a database of known people. These systems are successful and widely used in areas such as security surveillance. However, they do not attempt to provide any quantitative measure of quality of match but only give the best available match. In this respect they fall short of a facial identification. The work described here provides a statistically based method which allows a more statistical assessment of facial identification. This is based upon shape analysis of predefined anthropometrical facial landmarks (Farkas, 1994) to provide measures of inter and intra variability of the configurations of measured facial features. This permits quality of matches to be expressed in probabilistic terms.

2 Data and analysis

A data base of 3115 different faces has been collected; each face has been photographed using a 3D digital stereo-photographic Geometrix™ scanner. The scanner simultaneously takes eight digital photographs of the subject's face, each from a different angle (the system was calibrated daily before use to extract the angle information and the relative camera positions). It is these eight images that are used to locate the anthropometrical facial landmark points. The collection of the landmark data was carried out manually; the process involved using the mouse to position a cross-hair over the landmark point in two of the eight images available, a computer program (also developed by Geometrix™) then calculated the 3D positions of the landmark points using the scanner calibration information.

Configurations of facial landmarks have been explored following analytical techniques developed by Dryden and Mardia (1998).

The work outlined in the poster presentation is some preliminary analyses that were carried out to look at the types of variation present in the data set. An exploratory investigation was carried out to examine sixty one different facial landmark points that were available for use; repeated measures were taken by different operators and the intra-observer and intra-observer errors were measured. A subset of thirty out of the sixty one landmark points investigated was chosen for the main analysis. These were chosen based on the consistency of landmark placement (both within and between operators), how useful the landmark point was in discriminating between different face shapes, the visibility of the landmark point in the image data and also the ease of placement (i.e. whether the operators felt the point was well defined, easily recognizable and quick to place).

A subsequent study was then carried out to validate the landmark placement method, an important issue if any methods are to be used in a legal context. To confirm that the thirty chosen landmarks were easily reproducible by multiple operators a subset of ten different faces was taken, each face was landmarked by six different operators, each operator repeated the process three times per face to permit intra- and inter-observer error analysis. Results showed that all but three of the landmark points were consistent enough between operators to be able to classify the ten different faces examined into discernible groups using a Ward's method cluster analysis. Three points which showed differences between operators were all positioned around the tip of the nose, a MANOVA formally tested that inclusion of these three points meant there were statistically significant differences between the mean configurations for each operator.

3 Further direction

The preliminary results show that, for twenty seven anthropometrical landmark points, the possibility of using techniques in shape analysis to aid in facial comparison and identification cases looks promising.

The next step towards quantifying the quality of a facial match is to take the Procrustes registered landmark configurations for these landmarks and try and fit a model to the data in tangent space. A multivariate normal model will be explored. If an appropriate model is fitted the parameters of such can then be applied to calculate the probability that a recovered face (suspect face) came from the same source as a control face (face from crime scene), and the probability that the recovered face came from some other source in the known population of faces. These two probabilities can then be evaluated by means of a likelihood ratio test, a technique developed by Aitken and Lucy (2003) for evaluating matches in trace evidence to present to courts.

References

Aitken, C.G.G. and Lucy, D. (2003) Evaluation of trace evidence in the form of multivariate data. *Appl. Statist*, **53**, 109-122.

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Farkas, L.G. (1994) (ed.) *Anthropometry of the head and face*. New York:, Raven Press.