H93 Prediction of Mouth Shape Using Geometric Morphometrics for Facial Approximation

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After attending this presentation, attendees will be introduced to the advantages of geometric morphometrics when applied to facial approximation issues and the possibilities to enhance the accuracy of a prediction with the mouth shape as a practical example.

This presentation will impact the forensic science community by emphasizing the importance of taking the bone morphology into account in a multivariate way prior to the reconstruction of a face based on the skull.

Facial approximation specialists base their research on the principle that the facial form is directly related to the morphology of the underlying bony features. The applicability of such techniques is hindered by a lack of accuracy and reproducibility. The new advances and software availability in the geometric morphometrics field contiguously, with the development of 3D medical imaging, offer many possibilities to enhance the precision of forensic techniques. The purpose of this research is to introduce a semi-automatic face approximation method, using objective analysis strictly based on skull morphology.

Several hundred computed tomography (CT) scans were collected in French hospitals. A homogeneous sub-sample of 140 known age and sex individuals was extracted. The mean age of the sample is 54 years (min = 18; max = 96; SD = 21) and the sex ratio is 1:1. Patients showing pathological or traumatic conditions were excluded. Forty 3D landmarks were collected on the mouth region of each individual directly on the reconstructed osseous and cutaneous surfaces. TIVMI software was used to obtain reliable surfaces, based on the half-maximum height algorithm in 3D (Dutailly *et al.* 2009). The extracted coordinates were imported into MorphoJ software (Klingenberg 2008) for analysis. The 7 cutaneous and 33 osseous landmarks were checked for intra- and inter- observer error and the configurations were normalized with a Procrustes superimposition. The resulting residuals and centroid sizes were used to

study sexual dimorphism (with discriminant function analysis), age trends (with canonical variate analysis), asymmetry (with a Procrustes ANOVA), allometry (with multivariate regression) and covariation between the different sets of landmarks (with Partial Least Squares or PLS analysis). Results indicate the lower facial skeleton is influenced by age (mainly reflected by bone remodeling due to loss of teeth), subtle localized allometry (size-related shape changes) and sexual dimorphism (more pronounced on the mandible and consistent with allometric shape changes). Lips show some specific changes with age (wider mouth and thinner lips in older individuals) and a subtle allometry (mouth corners more posterior and thinner lips when centroid size is high) but no significant differences between males and females. PLS results suggest a good correlation between shape changes of the lips and shape changes of the facial skeleton; significant covariation in the regions studied was detected by this method.

Based on these results, a prediction technique was employed (by multivariate regressions) using principal components of the osseous landmarks configuration and the Procrustes coordinates of the cutaneous landmarks. The mean correlation (r) of the regressions attains 0.69 ($r^2 = 0.48$). Based on its specific morphology, it is possible to extract the shape variables from a skull to make an approximation of the coordinates of the lips. This methodology was applied to 5 CT scans (out of the 140 sub-sample) in order to compare the estimated shape of the lips to the true coordinates. The differences can be evaluated through a Principal Component Analysis in order to visually assess the distance between the true shape and the predicted shape. In terms of metric proportions, distances between landmarks can be calculated and multiplied by the centroid size of the true subject to get appreciable data. For example, the width of the mouth which is the largest measurement that can be extracted from the lips, displays a mean absolute error of 2.3 mm (4.3 % of the mean mouth width in the tested individuals).

This methodology offers an accurate and objective tool to approximate the shape of facial features from the skull. Further assessment of the shape of facial features using outlines or semi- landmarks might enhance the precision of the results. In order to implement this approach, the next step is to develop software for computer-assisted (semi-)automatic technique for facial approximation. **Facial Reconstruction, Stoma, Procrustes Superimposition**

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