H112 Anthropological Facial Approximation in 3D (AFA3D) – Computer-Assisted Estimation of Facial Morphology Using Geometric Morphometrics

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The goal of this presentation is to describe a new method that produces three-dimensional (3D) facial approximations using geometric morphometrics.

This presentation will impact the forensic science community by proposing an objective tool for facial approximation based on statistics and craniometrics.

According to the Scientific Working Group for Forensic Anthropology (SWGANTH), the aim of facial approximation is to estimate the antemortem facial appearance, suggest the identity of the person, and capture public attention. This study seeks to improve accuracy and reliability of the facial shape estimation process. Quantitative evaluation of the morphology of both facial features and soft tissue depths (STD) was performed through 3D measurements of Computed Tomography (CT) exams.

Five hundred CT-scans of French adult subjects (known age and sex) have been collected in medical centers after approval of ethical committees (265 males, 235 females; age range: 18-96 years; mean=52; sd=20). DICOM files were treated with TIVMI (Treatment and Increased Vision for Medical Imaging, developed by Bruno Dutailly, UMR 5199). This software (freely downloadable at http://www.pacea.u-bordeaux1.fr/TIVMI/) allows for the 3D surface reconstruction of both osseous and cutaneous faces of the patients, using the Half-Maximum Height algorithm. Cranial and facial landmarks (n=178) were collected using reference planes based on the Frankfurt Horizontal in order to enhance their repeatability and reproducibility.

Because the sample contained several partial exams (approximately 2/3 of superior and inferior faces for 1/3 of complete exams), eyes, nose, mouth and ears regions were studied independently. Geometric morphometrics offered objective form quantification in 3D through Procrustes superimpositions; asymmetry, influence of age, sexual dimorphism, and allometry were evaluated. Partial Least Square (PLS) analysis was used to evaluate the covariation between bone and skin matrices (landmarks configurations). Results allowed for the definition of four bony matrices optimally correlated with the facial organs matrices (eyes, nose, mouth and ears). Soft tissue depths were explored in parallel, which enabled the estimation of the corpulence of the 500 individuals, based on the literature. Regression formulas were elaborated using craniometrics, age, sex and corpulence, in order to predict subject-specific STD at 59 landmarks (right and left included).

The module AFA3D has been integrated to TIVMI. It requires the 3D coordinates of 78 skull landmarks that can be positioned directly in the module (on a surface reconstructed from CT or laser scanner). The landmarks may also be imported in AFA3D, if previously digitized. The user can specify sex, age (under or over 40 years) and corpulence (normal or overweight) if such factors are known. A geometric morphometric routine superimposes each facial region of the referential on the unknown subject, and computes Principal Component Analyzes on both osseous and cutaneous parts. Principal Component (PC) scores of the skull configurations of the unknown, along with the biological factors, are used to estimate the PC scores of the facial organs. PC scores are thus transformed into 3D coordinates with the PC coefficients to render the shape of the eyes, nose, mouth and ears independently. Once the STD predicted with the formula, AFA3D produces a total of 100 skin landmarks. A neutral synthetic face is then used (for more objectivity), and distorted according to the target landmarks. The distortion (developed in collaboration with the LaBRI, UMR 5800) allows for a smooth warping of the global face, and a more precise deformation at the anatomical landmarks around the facial organs.

Mathematical validation on 17 subjects is proposed, using a leave-one-out resampling. Each individual is thus treated after being excluded from the reference sample. A comparison of the standard error of the estimate induced by traditional facial reconstruction guidelines indicates that the approximation performed by AFA3D enhances the accuracy of the technique. Theoretical reliability is also assessed, if the cranial morphology of the subject falls into the variability of the French population.

AFA3D produces an estimation of the face shape, which is an objective basis for facial approximation. The next step, suggesting identity of the person, may be performed with computer-assisted forensic art. The 3D surface can be exported to other software, refined, and individualized according to the case investigated, before public diffusion. Further tests will have to be performed in order to validate the resemblance and the recognition potential of faces approximated with AFA3D.

Facial Reconstruction, Facial Reproduction, TIVMI

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