E82 Craniofacial Analysis of 3D Computed Tomography (CT) Models and a New Method for Dense Facial Tissue Depth Mapping: A Collaboration Between Forensic Science Researchers and Forensic Art Practitioners

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After attending this presentation, attendees will understand how the quantitative and morphological analysis of 3D CT models can enhance facial approximation research by facilitating researcher-practitioner collaborations.

This presentation will impact the forensic science community by presenting new craniofacial relationships for the enhancement of facial approximation methods based on 3D CT skull and face models. In addition, new methods will be presented that facilitate comprehensive analysis, viewing, and sharing of 3D data.

Although facial approximation is described as a collaborative endeavor between anthropology, anatomy, and art, forensic artists have rarely been included in research. The exclusion of artists from research efforts has led to a lack of standardized protocols with many artists still using outdated standards and tissue depth tables. By including artists in craniofacial research, it can be ensured that the data being collected is relevant to facial approximation methods and encourage the incorporation of new data into facial approximation protocols. The use of 3D digital models generated from pre-existing CT scans allows the artists to have access to the valuable data they need: the simultaneous visualization of the craniofacial skeleton and facial features. These 3D models can be easily shared for morphological analyses and to gather input from artists to guide the collection of measurements by the researcher.

3D skull and face models were generated with the Mimics© software from publicly available de-identified head CT scans from The Cancer Imaging Archive at http://www.cancerimagingarchive.net. Bone and skin pixels were segmented at a threshold of 226 Hounsfield units and adjusted as needed to segment thin or less dense areas such as the maxillae and medial orbital wall. Instead of using the pre-programmed Optimal 3D reconstruction setting with contour interpolation, a custom setting was applied using gray value interpolation with no matrix or triangle reduction. This method results in more dimensionally accurate, high resolution models and also recovers features on superior and inferior surfaces that are normally truncated or stair-stepped with the optimal setting. Although the process is time-consuming, the generation of high quality 3D skull and face models allows the transfer of the Stereolithography (STL) models to external software for additional analyses and, more importantly, to the forensic artist for collaborative research.

The Simulation Module of Mimics© is used to place bone and skin landmarks to collect linear distances and angles. Morphological assessments are made using the free software tools 3D Slicer, MeshMetric, and MeshLab and has revealed many inconsistencies with facial approximation guidelines. Preliminary measurements indicate previously unrecognized bone-to-skin associations. For example, the distance between the left and right infraorbital foramina is significantly correlated with both the width of the mouth (r=0.48, p <0.01, n= 32) and the width of the nose (r=0.56, p <0.001, n=33). In addition, one individual with a bifid nasal spine was identified who has extremely high tissue depths for the entire subnasal/mouth region, suggesting that the identification of morphological indicators may be important for informing the application of appropriate metric data in facial approximation methods.

Because the exported skull and face models are in correct orientation to each other, a dense, objective facial tissue depth mapping method was developed using the publicly available software MeshLab. The face model is hollowed and cropped and then sampled against the skull using the Hausdorff distance filter. The tissue depth values can be saved in the vertex quality field of exportable Polygon (PLY) files representing the sampled face points and closest skull points. MeshLab filter scripts were also developed that allow for the separation of sampled face points and corresponding skull points into separate PLY files representing 1mm depth increments. All of the data generated for one head can be viewed simultaneously in MeshLab, including the 3D skull and face STL files, skull and face tissue depth PLY layers, as well as the 3D landmark coordinates collected from Mimics© (saved with the .xyz extension in a text editor). The ability to view all data in one free program greatly enhances the ability to exchange information and conduct more comprehensive analyses of craniofacial morphology.

Facial Approximation, Computed Tomography, Forensic Art