H92 Improving Forensic Facial Reproductions Using Empirical Modeling

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After attending this presentation, attendees will understand the benefits of using empirical modeling to produce more accurate soft facial tissue thicknesses that are used in facial reproductions.

This presentation will impact the forensic science community by presenting how empirical modeling improves the accuracy of forensic facial reproductions and can have a positive impact on the identification rate of unknown skeletal remains.

Forensic facial reconstruction has been used for many years to identify skeletal remains. The face of the unknown person can be reproduced based on the soft facial tissue thickness, which overlays the bony structure of the skull. Currently, forensic artists place average facial tissue markers at 21 specific anatomical locations on the skull and use clay to model the face based on the length of the markers. The purpose of this study was to develop a new method for estimating the facial soft tissue thickness at the 21 traditional craniometrical landmarks used in forensic facial reconstruction. This newly developed method uses a non-parametric modeling technique to predict the facial tissue depths based on a unique skull input.

Computed Tomography (CT) images of 100 American White male subjects' skulls were used to build a database of facial tissue thicknesses and input predictors for the non-parametric model. The inputs to the model are various cranial bone thicknesses and measurements along specific anatomical lines, which are then used to predict the facial tissue thicknesses at the traditional landmarks using a Non-Parametric Kernel Regression model. The tissue and bone measurements were performed using a software package being developed at the Center for Musculoskeletal Research (CMR) at The University of Tennessee. Hetero-Associative Kernel Regression (HAKR) and Inferential Kernel Regression models were built using the measurements from the 100 male subjects.

Two results were computed for each model; one including age, height, weight and BMI as predictors in the model and the other removing them from the model. This was done because, in many cases, the demographics of an unknown skull are not known. The Root Mean Squared Error (RMSE) when not using the demographics as an input to the model was 2.21mm for the HAKR architecture and 2.19 mm for the inferential model. When including the demographics, the RMSE for the HAKR architecture was 2.04mm and 1.89mm for the inferential architecture. The HAKR and Inferential model's RMSE were both less than the currently used tabled tissue thickness RMSE from the actual measured tissue thicknesses of 3.07 mm. The developed inferential model provided forensic facial tissue thickness approximations with an average of 38% less error when using demographics or 29% less error when not using demographics. The error reduction is based on the tabled tissue thicknesses that are used in facial reconstructions today. The average prediction uncertainty from the LOOCV was computed to be 19.7% for the HAKR model and 20.5% for the inferential model.

Three male skulls from the William Bass Donated Collection at The University of Tennessee were used to visualize the model's performance. A certified forensic artist performed the facial reconstructions. The facial reconstructions using tabled tissue thicknesses were compared to the reconstructions of the same subject using the inferential model's predicted tissue thicknesses. The reconstructions were then compared to an actual photograph of each respective subject. The results show an overall more accurate representation of the actual subject face when using the empirical model tissue thicknesses. The findings from this pilot study have shown a proof of principal for using non-parametric empirical modeling to predict facial soft tissue thickness. This technology has the promise, with further research, to produce more accurate forensic facial reproductions. More accurate facial reproductions will hopefully have a positive effect on the identification rate of unknown skeletal remains.

Facial, Reconstruction, Modeling