## A59 Interactive Resources for Craniofacial Identification

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**Learning Overview:** After attending this presentation, researchers and practitioners of craniofacial identification methods will be familiar with free and/or open-source resources for interacting with 3D craniofacial reference data generated from Computed Tomography (CT) scans in both digital and physical formats.

**Impact on the Forensic Science Community:** This presentation will impact the forensic science community by introducing an interactive 3D craniofacial reference dataset and detailed workflows for viewing and processing 3D models, which will enhance training/education efforts by increasing exposure to a large range of craniofacial variation, facilitate collaborative efforts between researchers and practitioners of craniofacial identification methods, as well as initiate discussions for standardizing reference data.

3D digital models of skulls and faces were generated from de-identified, publicly available CT scans at The Cancer Imaging Archives website. Landmarks were collected to describe facial feature dimensions and positions relative to bone landmarks, for comparison to traditional facial approximation guidelines, and to derive new predictive regressions or positional predictions. The dataset has been transformed to a common orientation and coordinate system to allow viewing along aligned planes (Frankfurt Horizontal, coronal plane, and midsagittal plane), resulting in distances and positions between landmarks across a single axis, two axes, or all three axes, that are translatable to 2D and 3D methods of facial approximation, as well as craniofacial superimposition.

A workflow for dense Facial Tissue Depth Mapping (FTDM) has been developed with open-source software, which utilizes the geometric relationships between the face mesh and skull mesh to calculate distances for every face point and colorizes and stores the depths within the face and skull meshes as a "vertex quality." The workflow can be applied to any 3D bone-skin models derived from CT or cone-beam CT. The resulting output is a set of red-green-blue colorized Polygon File Format (PLY) meshes and point clouds from which tissue depth information can be read and interacted with in 3D in Meshlab. The FTDMs have also been "split" into smaller models representing 1.0mm-depth increments to facilitate viewing of a specific depth over the entire face and/or skull or across multiple individuals.

Because of the steep learning curve associated with 3D programs, an .html viewer was developed that opens within a web browser from local files, using the open-source 3DHOP platform. The interactivity is more straightforward and less daunting than available software packages, with clear icons and sliders with specific functions to adjust views (direction, transparency, and color), place points, collect measurements, and even clip skin away from the skull along the aligned planes. The ability of practitioners and researchers to interact with a large dataset of digital faces and skulls in 3D, by viewing transparent skin over the bone in correct anatomical position, provides an opportunity for enhanced training and a more objective understanding of the relationship of the face to the underlying craniofacial skeleton.

Further, all Stereolithography (STL) files are 3D printable and can be further clipped and edited for 3D printing to use physical models in training, classroom, or workshop settings. Full skull models could be printed at actual size for sculpting exercises. 3D Slicer's "EasyClip" tool allows cutting at specific landmark coordinates (x-, y-, or z-). Face shells generated during FTDM can be clipped and "thickened" in Meshmixer to the minimum tissue depth to allow printing of skin over bone. Models can be generated and printed for training on specific facial features or to simultaneously visualize bone and skin, including models with faces clipped along the midsagittal line to reveal bone features on one side and corresponding facial features on the opposite side. Profile prints, mimicking radiographs, could be generated from a midsagittal profile (by clipping 1mm–2mm on either side of nasion) of the original face model, resulting in "printed skin" and bone as empty space. Such a model set would allow a detailed study of the nose in profile, utilizing examples from numerous individuals, easily exposing trainees/practitioners to a wide range of anatomical variation, both digitally and physically.

The digital and physical learning environments and increased exposure to a large range of craniofacial variation may lead to more anatomically accurate representations of the human face, establish new venues for collaboration between researchers and practitioners, and ultimately contribute to large, standardized reference datasets for craniofacial identification efforts.

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**Craniofacial Identification, Facial Approximation, 3D**