H108 Automatic Skull Landmark Determination for Facial Reconstruction

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The goal of this presentation is to present new methods for determining landmark positions on skeletal remains.

This presentation will impact the forensic community by making the facial reconstruction process more objective by lessening the requirement for user judgment in determining the initial landmark locations.

When building a computer based facial reconstruction in ReFace, key locations need to be indentified on the questioned/found skull. These key locations, or landmarks, are used in the reconstruction and are historically selected manually by the ReFace user. After attending this presentation, attendees will understand a number of principles regarding the automatic determination of landmarks on skulls or any similar three-dimensional shapes.

The automatic landmark determination will also reduce the time and effort required to set up a facial reconstruction. The goal is not to

take the user out of the loop. To this end, the user will be able to review and override any or all automatically determined locations. This may be necessary for unusual skulls or where skull material is missing.

Automating the detection of key locations involves the use of a prediction algorithm that is trained using existing data. For the purposes of skull landmark determination the ReFace database of known skulls (over 400 CT scans containing both skull and soft tissue information) are used as the training data. The known skull landmark locations have been previously entered into ReFace by the system developers using their best judgment regarding these locations.

A three-dimensional shape descriptor was developed to characterize any point on the skull and provides a training basis for the prediction algorithms. The shape descriptor is generally spherical and has sub regions separated by angles and radial layers. At any location on the skull the shape descriptor counts the number of three-dimensional model points in each sub region, with the result being an array of numeric values. The quantity, shape, and size of the shape descriptor sub regions are controlled by control variables with inputs for the initial radius, the number of angular sectors and the number of layers. Different configurations of the control variables were evaluated based on location determining capability. Performance and other results will be presented.

When a new questioned skull is to be analyzed by ReFace, the system can compare the results of the shape descriptor evaluation at various points on the questioned skull with the algorithms trained by similar evaluations on the known skulls. Several different algorithms were evaluated and will be reviewed during the presentation, including boosting and cost based methods.

Depending on the concentration of points on the three-dimensional model, skull data can be large in size. Larger models will take longer to process so the algorithm needs to perform efficiently and the amount of the skull that is evaluated should be reduced as much as possible. Using information about the known skulls in the ReFace database, the landmarks were normalized within the skull's bounding region in order to provide an initial guess with respects to the location of the landmark and the volume of possible locations. The normalized estimate allows a region much smaller than the overall skull to begin a more detailed exploration of the location. Other methods to address and improve performance will also be presented.

An example case in which the methods described are used to build a successful face reconstruction will be presented. The presentation will show the capability of automatically determining the location of the skull landmarks within a few millimeters of the correct location.

Skull, Reconstruction, Algorithmnstruction, Algorithm

 ** Presenting Author*