H60 Three-Dimensional Digital Data Acquisition: A Test of Measurement Error

Denise To, MA, Department of Anthropology, Arizona State University, Box 87-2402, Arizona State University, Tempe, AZ*

The goal of this research project is to present to the forensic community the results of a study that compared linear measurements taken with 3D digital techniques with those taken on dry bone by hand.

The use of 3-dimensional (3D) digital technology is a growing method for acquiring and processing scientific data among the many subfields of forensics, including physical anthropology. This poster presents the results of a study that questioned the comparability of measurements taken of skeletal material through the traditional method of inspecting bones by hand with calipers with a new method of analyzing bones virtually on a computer. Three-dimensional digital data acquisition of human skeletal material, captured either by computed tomography, magnetic resonance imaging, ultrasound, or laser assisted stereo modeling creates a quasi-permanent virtual record of the bone for which many types of analyses can be performed. This includes measurements of simple variables such as length, width, and circumference, but also permits researchers to study those that have been nearly impossible to obtain in the past (or at least not without great difficulty), such as surface area, volume, degree of angle, and curvature. One question that arose with the increased practice of taking digital measurements was whether those taken through the digital medium were comparable to those taken manually on dry bone. The null hypothesis that there is no significant difference in measurement is a crucial assumption for many 3D data research designs.

Twenty femora were used from Arizona State University's (ASU) archaeological collection of Nubian skeletons. Each skeleton was selected randomly (though bones with poor preservation were omitted). For each femur, three linear measurements were taken macroscopically by the author with digital calipers and an osteometric board. They were the maximum head diameter (mhd), the maximum mid-shaft circumference (msc), and the maximum length (ml). After macroscopic evaluation, each femur was then digitally analyzed at ASU's Partnership for Research in Stereo Modeling (PRISM) laboratory. This was done by first scanning the bone with a Cyberware Model 15 high-resolution laser scanner that captured cortex data with a high-density "wire" mesh of triangles. Each triangle was generated at 300 microns enabling extreme detail of the bone surface to be digitally rendered. The wire mesh is then modeled by adding topography to create a 3D virtual replica. This digital model was saved in an *.xml* format, creating a permanent duplicate of the bone (barring loss of the digital file). Using research software developed at the PRISM laboratory, the same three measurements were once again taken on each bone by selecting beginning and end points on its virtual replica. To further test error, both measurement trials were repeated one month later by author, making a total of four trials. This study was conducted "blind" with each femur labeled with different catalogue numbers so no bias of memory could influence measurement.

All measurements were entered and statistically processed with the *Statistica* software program. Each femur had three independent observations taken during four separate trials. If the 3D imaging created an exact virtual replica, then the specific observation for each measurement should be identical for all four trials. To test the null hypothesis that there is no statistical difference in both measurement techniques (H_0: ---$_1$= ---$_2$), the mean score of the manual trials was compared with the mean score of the computed trials using a paired *t*-test (at an alpha level of 0.05). Separate tests were conducted for each of the three measurements. In addition to the *t*-test, a one – way ANOVA was conducted using the scores of all four trials, with a subsequent Scheffe's test to identify the significantly different trial. Again, separate tests were conducted for each of the three measurements.

The results of this study are important, as 3D knowledge becomes more valuable and accessible to researchers. A similar focus was generated decades ago with the increasing use of radiographic technology. In physical anthropology, studies of skeletal maturation, morphological change, and sex determination have been conducted using measurements of bones from radiographs with the goal of creating aging and sexing standards to be used with dry bones. With the knowledge that radiographs increase the magnitude of a subject by approximately 5%, studies employing radiographs allowed researchers access to a revolutionary way to study human biology. Three-dimensional knowledge may follow radiographic technology in a similar manner, and perhaps with even greater applications. While this study focused only on quantitative data from skeletal material, researchers at PRISM are currently using 3D stereo modeling of quantitative and qualitative data on a wide array of materials such as archaeological artifacts, intra-cellular organisms, diatoms, and fossils. In forensics, 3D knowledge may have many applications not just in physical anthropology, but also in criminalistics, engineering science, and pathology / biology. Testing the comparability of measurements taken through the computer with those taken the old fashion way is crucial in fostering a new generation of research.

3-Dimensional Digital Data Analysis, PRISM, Physical Anthropology