**Virtual Skeletons in Three Dimensions:**
**The Digital Library as a Platform for Studying Anatomical Form and Function**
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Recent advances in three-dimensional digitizing hardware and software now make it possible, practical, and economical to scan and archive complexly shaped objects in a digital library for study and research. These objects can easily include a full range of separate skeletal elements from a variety of large and small sized species as well as elements linked together and animated as joint complexes. Archiving anatomical materials to a national digital library will have wide ranging educational implications because it will make a broad range of study and research materials available to students of anatomy hailing from a wide number of disciplines, across the K-12 to graduate school levels. The materials can include skeletal elements from those species most commonly used in teaching and research (e.g., human, primate, mammal, lower vertebrate) as well as materials from rare or endangered or even extinct species that would otherwise be unavailable to most students.

The most useful technologies for digitizing skeletal materials are three-dimensional laser scanning and high resolution X-ray computed tomography (HRXCT). Both technologies are ideally suited for this task because of their noninvasive and nondestructive natures. Costs for digitizing vary dramatically between the two techniques, and this project will assess the relative benefits of low versus high resolution scans produced by laser scanning versus HRXCT. These technologies are presently available on the UT Austin campus in the Physical Anthropology Computer Imaging Laboratory and The High Resolution X-ray Computed Tomography Laboratory (http://www.ctlab.geo.utexas.edu/). Specimens that will be scanned and archived include humans, chimpanzees, and baboons.

Archiving skeletal objects themselves as raw data to the web with no informative or comparative context may prove useful to some users, but a software interface that serves to teach identifications, comparative morphology, and function will certainly serve to extend the benefits of these data sets to a much larger number of users across all educational levels. This project proposes to design and implement a "discovery" software interface that spools out the data along low to high resolution formats depending upon the kinds of questions that the users asks, and what sorts of answers the user provides. The "discovery" interface will offer an interactive framework for investigation and study that will benefit both beginning and advanced users, and ensure return visits to the site. This work draws on a previous National Science Foundation grant to the PI, "A Laboratory Curriculum For Physical Anthropology on CD ROM," that resulted in a CD ROM released in 1998 (Wadsworth Publishing Company). (See http://www.dla.utexas.edu/depts/ anthro/kappelman/vlabs/vlabs.html)

One critical issue that will need to be addressed is how to handle the delivery of these large data bases to the users. We are currently experimenting with a CD-web hybrid programming interface that posts the program instructions to a web site but delivers the raw data files to the user on a CD ROM. This delivery system effectively circumvents the unacceptably long down-load times across low speed networks. We also plan to investigate video streaming, and will take advantage of a new system installed on the UT Austin campus this year.

A critical component of the "discovery" program interface will include self-evaluation and build on work that is being carried out under a current National Science Foundation grant to the PI, "Developing Computer-Based Multimedia Examination Formats for the Sciences." (See

http://www.dla.utexas.edu/depts/anthro/kappelman/vexams/vexam.html) Virtual examinations draw from the full range of materials, and are presented to the student in the form of multiple choice, matching, and interactive problem solving questions. The questions are integrated with 2D images, sound, video clips, and 3D animations. Exams can include "linked and looped" as well as "expert-nested" questions that truly evaluate the exact level of each individual student's expertise. Grades are automatically calculated and reported as the last screen of the exam for immediate feedback to the student. This latter project also receives generous support from the Intel Corporation. (See http://www.utexas.edu/computer/itc/intel)

Recent advances in three-dimensional digitizing hardware and software now make it possible to significantly alter the definition of a national digital library so that it goes far beyond digitizing traditional materials such as hard copy text, images, and video. The universal availability of digitized holdings of skeletal teaching and research materials via the web within a "discovery" learning and evaluative context will greatly expand the reach of anatomy to encompass those students and instructors whose access to these materials has been limited because of circumstances beyond their control. Providing broad access to critical materials that are otherwise unavailable to students is one of the central goals of a national digital library.

Related links:
http://www.dla.utexas.edu/depts/anthro/kappelman/kapp.html
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