26 & 27 October 2004

Preceding the Annual Meetings of the Canadian Association for Physical Anthropology

3D Imaging in Anthropological Research

Acquisition, Analysis, & Dissemination

London, Ontario

Virtual Environment Technologies Centre (VETC)
at the National Research Council of Canada's (NRC)
Integrated Manufacturing and Technologies Institute (IMTI)

A SSHRC sponsored
Image, Text, Sound, & Technology Workshop

Social Sciences and Humanities Research Council of Canada
Conseil de recherches en science humaines du Canada

NRC · CNRC

Western

University of Manitoba

Canada Research Chairs
Chaires de recherches du Canada

3D Imaging in Anthropological Research

Theme

Digital imaging is more and more becoming an integral part of data acquisition and analysis in bioarchaeological research. Many new emerging technologies are now contributing to research dissemination within the field. This has become and increasingly important aspect of bioarchaeological research over the past several decades, with community based reporting equal in importance to academic and more traditional scholarly-based methods. Reports are moving away from the dry analytical lists of data to more overviews of results. Further, many communities want to see such dissemination accessible to education programs for students, and digital media is one of the ways of enhancing the process.

3D imaging presents a number of unique advantages. Once captured, the original object can be returned to its repository for safekeeping and the digital data can be stored. Digital models can be measured, described, projected or reproduced in physical form. The ability to store the digital model means that future researchers can revisit the collection to gather new measurements or observations that the original researchers did not think to collect. Thus, 3D modeling facilitates not only research, but also the ultimate preservation of the objects of study.

This workshop brings together leading developers of 3D technology in Canada, international experts in biological anthropology who make use of these kinds of technologies and the Canadian Association for Physical Anthropology to provide faculty, researchers and their students, the opportunity to be exposed to the latest technological achievements in digital imaging and media as well as the chance to interact and discuss logistical issues with peers and colleagues who have established themselves as leaders in this field.

Tuesday, October 26, 2004

7:45 REGISTRATION & COFFEE

8:15 WELCOME

8:45 The Growing Field of Geometric Modeling: An Overview of Some Recent Theoretical & Methodological Advances & the Current Utility for Morphological Analyses
Tocheri

9:30 3D Imaging and Morphometric Analysis of Phenotypic Variation in the Postgenomic Age
Hallgrimsson et al.

10:15 COFFEE

10:30 Phenotypic Integration of Brain and Skull
Richtsmeier

11:15 Three-Dimensional Scanning in Engineering Anthropology
Corner

12 LUNCH

1:30 Virtual Anthropology and Geometric Morphometrics – Paleoanthropological Applications and the Dissemination of Know-how and Data
Weber

2:15 3D Imaging in Paleoanthropology
Thompson

2:30 Three-dimensional Study of the Midfacial Prognathism in Neanderthals
Vahdati Nasab et al.

2:45 COFFEE

3 Physical and Virtual Tri-dimensional Reconstruction in Mummies of the National Museum, Brazil
Brancaglion Júnior et al.

3:15 Staying Ahead: Imaging Software & Bioanthropological Diagnostics & Reconstruction
Gill-Robinson & Allard

3:30 3D Analysis of Bone Microstructure by Microcomputed Tomography in Anthropological Research: Current Capabilities & Future Possibilities
Cooper

3:45 Assessing the 3D Morphological Concordance of Dental Trait Expression Between the Enamel-dentin Junction & the Outer Enamel Surface of Human Molars Using MicroCT
Skinner & Kapadia

4 TUTORIALS & DEMOS (Finishes at 5:30 pm)

Wednesday, October 27, 2004

8 REGISTRATION & COFFEE

8:45 NRC's 3D Imaging Technology for Museum & Heritage Applications
Taylor et al.

9:30 From Laser Scanning to Virtual Worlds: The Reconstruction of Thule Whalebone House
Levy & Dawson

10:15 COFFEE

10:30 3D Modeling and Database Development for Preservation of and Access to Objects of Human Heritage
Clark

11:15 Modeling a Monument -- 3-D Research and Results in the Temples of Chavin de Huantar, Peru
Rick

12 LUNCH

1:30 Three-dimensional Analysis of Trabecular Bone Growth Patterns in the Human Proximal Femur
Ryan & Krovitz

1:45 Going to the 3rd Dimension: The Use of 3D Imaging Applications to Assess Age-related Relief Changes of the Pubic Symphysis
Sitchon

2 Non-Contact Digital 3D Laser Scanning of Human Skeletal Remains: A Solution for Science, Native Americans & Project Developers
Dore et al.

2:15 When It All Goes to Pot
Allard

2:30 The Attraction to New Techniques: Using Magnetic Resonance Imaging for the Facial Analysis of Twins
Swingler

2:45 COFFEE

3 Developing 3-D Imaging Methods to Characterise Limb Morphology: A Comparison of Forelimb & Hindlimb Morphology in the Mouse
DeLaurier et al.

3:15 3D Modeling and Rapid Prototyping Applications in Biological Anthropology
Hoppa & Allard

3:30 CLOSING REMARKS

3:45 TUTORIALS & DEMOS (Finishes at 5:15)

Abstracts

The Growing Field of Geometric Modeling: An Overview of Some Recent Theoretical and Methodological Advances and the Current Utility for Morphological Analyses

Matthew W. Tocheri

Department of Anthropology & Partnership for Research In Spatial Modeling, Arizona State University, Tempe, Arizona USA 85287-2402

DAY 1
Tuesday
October 26, 2004

8:45—9:30 am

The diverse pursuits of scientific inquiry attempt to understand the surrounding natural world. These pursuits are fueled by the ability to repeatedly observe and measure naturally occurring phenomena. In the fields of comparative and functional anatomy, such phenomena are observed and measured in one, two, or three dimensions. These three dimensions (3D) relate to orthogonal directions in space – length, width, and depth – while time is often considered as a fourth dimension. This multidimensional reality is highly complex, making the extraction of information that is consistent over many trials and by different observers, a significant hurdle to understanding. Traditionally, these multidimensional data are reduced into 1 or 2D to facilitate hypothesis testing and scientific analyses.

Geometric modeling, while being a relatively new discipline, is deeply rooted in the history of classical mathematics and geometry. It is defined as the process of constructing and representing free-form curves, surfaces, and volumes and provides the foundation of computer-aided design and computer-aided geometric design (Farin, 2002; Farin and Hansford, 2000; Mortenson, 1997). Its rapid development over the past three and a half decades is largely due to the increasing power of computers. Combining the mathematics of analytic and differential geometry, as well as topology, vectors, matrices, and linear algebra to name a few, geometric modeling is not possible without the computational power of modern computers (Farin, 1995, 2002). The growing field of geometric modeling is essential to the manufacture of automobiles, ships, aircraft, buildings, household appliances, medical diagnostic equipment, and even blockbuster movies and video games.

In this paper, I provide a brief overview of some of the theoretical and methodological advances in the field of geometric modeling. Emphasis is placed on how these advances impact physical anthropology, particularly studies of morphology. This overview is therefore divided into two sections. In the first section, certain aspects of geometric modeling, including the history of its development as well as some of the mathematical underpinnings, are discussed.

Mathematical concepts are covered as needed to illustrate the foundation of current and developing geometric modeling techniques. In the second section, select applications of geometric modeling techniques that have current utility in morphological research are described and detailed. The goal of this section is to introduce techniques that allow for 3D data, which has morphological and functional meaning, to be efficiently extracted using basic approaches of geometric modeling. The methods presented should provide students and researchers with a grasp of what raw 3D data represent, and how they can model and extract information that pertains to their specific research goals and interests.

3D Imaging and Morphometric Analysis of Phenotypic Variation in the Postgenomic Age

Benedikt Hallgrímsson
Steve Boyd
Dave Cooper
Frank Jirik

Dept. of Cell Biology & Anatomy, Faculty of Medicine, University of Calgary, Calgary, Alberta, CANADA

The study of the genetic and developmental basis for phenotypic variation is a central issue in both evolutionary biology and the study of genetically complex diseases. As investigators in addressing this issue probe the complexities of the genotype-phenotype relationship using current molecular and bioinformatics tools, there is now a new emerging need for quantitative assessment of phenotypic variation, as recognized by initiatives such as the mouse phenome project. This emerging area presents both opportunities and challenges for investigators with expertise in morphometric techniques. The principal problems are throughput, standardization, as well as data storage and dissemination. Means to increase rates of throughput in the collection of phenotypic data are essential if phenotypic analysis is to keep pace with the rapid growth of genetic data. Similarly, standard but flexible means of collecting and disseminating phenotypic data are essential for phenotypic databases to be used for

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9:30—10:15 am

data mining and post-hoc investigations. In this paper, we use examples from ongoing work in our lab on the developmental genetics of craniofacial variation as well as our collaborative contributions to ongoing work on the genetics of bone and joint disease to outline some of the solutions to these problems that we are beginning to develop. Our approach as well as much of our work is directly relevant to biological anthropology, especially for understanding the developmental and genetic basis for evolutionary change in primates.

Phenotypic Integration of Brain and Skull

Joan T. Richtsmeier

Department of Anthropology, Pennsylvania State University, University Park, Pennsylvania USA

Center for Developmental Disorders, The John Hopkins School of Medicine, Baltimore, Maryland USA

DAY 1
Tuesday
October 26, 2004

10:30—11:15 am

The mammalian skull is a composite, osseous structure that supports major sense organs including the brain. Since the skull is easily decomposed into developmental modules organized around sensory organs, it lends itself readily to analysis by methods of morphological, or phenotypic integration. Due to preservation issues, previous studies of morphological integration focus exclusively on bone, though we know that skull shape is in large part determined by brain growth. We obtained high resolution computed tomography (CT) and magnetic resonance (MR) images of morphologically normal children (N=12) and age-matched individuals with two forms of skull dysmorphology, unicoronal synostosis (UCS) (N=12) and sagittal synostosis (SS) (N=18). Three-dimensional coordinates of 16 biological landmarks located on cortical and subcortical brain structures were collected from 3D reconstructions of MR images, and coordinates of 18 neurocranial landmarks were collected from 3D CT images. Using these data, we statistically compared levels of phenotypic integration in brain, skull, and in the two tissues combined. Analysis of phenotypic integration of skull and brain required that CT and MR images be acquired from an individual during the same 24-hour period.

Phenotypic integration of the neurocranium is high and positive in all three groups, though SS shows lower levels of integration. Phenotypic integration of the brain is also high and positive in all samples, but substantially reduced in SS. Details of integration patterns reveal that when the skull is profoundly different in shape, as in our cases of craniosynostosis, patterns of association follow predictions of morphological integration theory in that most parts of brain (cortical and subcortical features) show strong positive associations with the neurocranium (calvaria and cranial base). However, these tissues are significantly less integrated in SS. Divergence in the specifics of integration patterns suggest differences in developmental dynamics that underlie changes in skull phenotypes.

This study was supported in part by PHS grant 1 P60 DE13078.

Three-Dimensional Scanning in Engineering Anthropology

Brian D. Corner, PhD

US Army Natick Soldier Center (NSC), Natick, Massachusetts USA

DAY 1
Tuesday
October 26, 2004

11:15—12:00 pm

Does it fit? A straightforward question, but one loaded with layers of meaning and nuance. For a physical anthropologist working in the applied field of product design and evaluation, “fit”, in its simplest form, means getting the dimensions and shape of an item right so that it may be used as designed, so that it “fits” the body. Collecting, compiling, and analyzing those body measurements is a hallmark of physical anthropology. The traditional tools of the trade-- calipers, anthropometer, tape measure, and so on, remain central. However, new tools are making their way into the hands of anthropometrists. These tools measure more than relatively simple lengths, widths, and circumferences. Three-dimensional body scanners, or digitizers, have the capacity to capture nearly the full geometry of the surface of the human body in a few seconds. This rich data source provides the applied physical anthropologist with a new capability for visualizing, quantifying, and analyzing human form. This paper begins with a short description of the rise of three-dimensional body scanning, then moves to a discussion of the use of three-dimensional scanning in the design and fit evaluation of products that go on or around a human body.

Virtual Anthropology and Geometric Morphometrics - Paleoanthropological Applications and the Dissemination of Know-how and Data

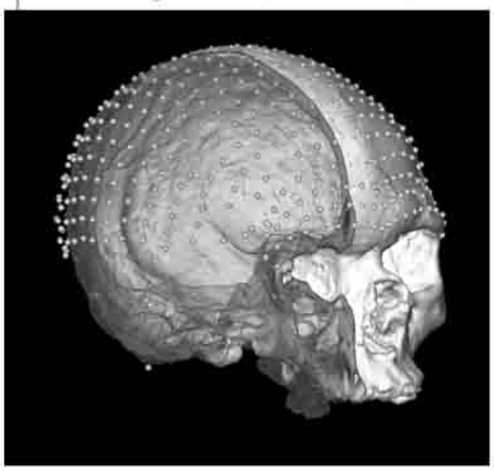
a.o. Univ. Prof. Dr. Gerhard Weber

Institute for Anthropology, University of Vienna, Althanstraße 14 A-1090 Vienna AUSTRIA

DAY 1
Tuesday
October 26, 2004

1:30—2:15 pm

Virtual Anthropology (VA) is the direct study of arbitrarily detailed anatomical data representations in 3D or 4D, particularly fossil and recent hominoids, as digital dissectible structures in "real" visual space. Its components include 1.data acquisition, 2.Geometric Morphometrics (GMM), 3. reference models, 4. processing of object structures, 5. associated data, and 6. virtual and real representations. GMM are analytical and statistical methods; where the Landmark structures (points, curves, surfaces) and the variability of its location in a standardized Cartesian coordinate system are examined. By means of reference models which include statistic parameters (average configuration, variation), for example homologous semilandmarks in previously unattended regions can be produced, missing parts of objects can be completed and anatomical structures can be combined. to object structures. These are then treated as separate units. Procedures include segmentation, virtual endocasts, e-preparation or e-assembly of fragmented objects. Representation of the results can be visualized in a virtual environment (computer screen, immersive environment) or as real object (stereolithographic models).



Examples for paleoanthropological research are given in this paper, e.g., the segmentation and analysis of the inaccessible endocranial cavity, the background of missing data routines, the reconstruction of skulls, the comparison of cranial geometry, or the application of micro-CT. VA is entirely based on electronic data which can be easily shared with other researchers. In 1999, we started to publish a digital archive of fossil hominids to promote the discussion on a highly delicate problem in paleoanthropology, i.e., the accessibility of fossil specimens. Meanwhile, we have released CD-ROMs of five e-fossils, all available at the web for everyone (http://www.anthropology.at/virtanth/webshop.php). We will provide a summary of our experiences. As a perspective for the future it is clear that paleoanthropology will strongly profit if we succeed to organize a functioning framework in the form of a database archive for restructuring data resources such as detailed digital representations of rare or precious specimens together with their documentation.

3D Imaging in Paleoanthropology

Jennifer L. Thompson

Department of Anthroplogy & Ethnic Studies, University of Nevada (UNLV), Las Vegas, Nevada USA

DAY 1
Tuesday
October 26, 2004

2:15—2:30pm

The goals of paleoanthropologists include: describing fossil hominid morphology, documenting size and shape variables as they pertain to questions of sexual dimorphism and species identification, and to interpret these data within broader contexts such as phylogeny and ontogeny. Paleoanthropologists traditionally use subjective visual descriptions to describe morphology and use linear and non-metric traits to document size and shape. The introduction of 3-D imaging techniques has clearly added a different dimension to these traditional analytical methods. However, they are not without their limitations, at least as currently employed. Using the Le Moustier 1 adolescent Neanderthal as an example, this paper will discuss some of the pros and cons of both traditional and 3-D techniques for the analysis of fossil hominid specimens.

Three-dimensional Study of the Midfacial Prognathism in Neanderthals

Hamed Vahdati Nasab,

Donald C. Johanson

Department of Anthropology, Arizona State University & Institute of Human Origins. Tempe, Arizona USA

Geoffrey A. Clark
Department of Anthropology, Arizona State University.

Facial morphology has a prominent role in explanation of human evolutionary history. The mid face including of nasal, maxillary, and zygomatic region, because of their importance in mastication, have been studied intensively. Neanderthals demonstrate unique facial morphology, which deviates them from the general face of hominids (Rak 1986, Churchill 1998). Enormous nasal cavity (anteroposteriorly) and large-roots anterior dentition due to the carrying a heavy load are responsible for this unique facial morphology. In contrast with generalized faces, in Neanderthals the zygomatic and the maxilla have become sagittally oriented representing the projected midface among them (Aiello and Dean 1990).

This research will be geometric morphometrics three-dimensional study of the surface data. The data will be collected from the midface of modern and fossil hominids, through computer scanner. The second step will be using computerized techniques,

William H. Kimbel
Department of Anthropology, Arizona State University & Institute of Human Origins

Pushpak Karnick
Department of Computer Science, Arizona State

which will transform the raw facial data to the comparable curvatures to investigate the degree of similarity and matching of these curvatures in different hominids. I will examine the midfacial characters to see if there is any consistency of pattern between European Neanderthals and their modern followers. Previous ancestral hypothesis will then be examined using this new method.

DAY 1
Tuesday
October 26, 2004

2:30—2:45pm

Physical and Virtual Tri dimensional Reconstruction in Mummies of the National Museum, Brazil

Antônio Brancaglion Júnior
Museu Nacional / UFRJ BRAZIL

Iugiro Roberto Kuroki
CDPI - Centro de Diagnóstico por Imagem, RJ/Brazil

Jorge Roberto Lopes do Santos
INT - Instituto Nacional de Tecnologia - Ministério da Ciência e Tecnologia

Jorge Vicente Lopes da Silva - CenPRA - Centro de Pesquisas

Renato Archer
Ministério da Ciência e Tecnologia

Our work presents studies in human and animal mummies from the Egyptian Collection of the National Museum, Federal University of Rio de Janeiro, Brazil. CT images allow us to characterize cultural aspects of the mummification rites, to recover biological information and to evaluate their preservation.

The reconstruction of the objects in virtual space (or their specific parts) is one of the most amazing results of this project, providing also the possibility of physical replication based on rapid prototyping techniques. In this case rapid prototyping uses DICON files obtained from CT scanning. The archives are transformed to STL images by tri-dimensional modeling image programs. These images can be printed in 3D, segmented and even changed in their dimensions in post-processing. These prototypes are sufficiently detailed and accurate to be useful both for museographic / didactic use and for scientific research, conserving materials for future analysis without fear of damage.

DAY 1
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3:00—3:15pm

Staying Ahead: Imaging Software and Bioanthropological Diagnostics and Reconstruction

Heather Gill-Robinson
Travis Allard

Department of Anthropology
University of Manitoba
Winnipeg, Manitoba
CANADA

DAY 1
Tuesday
October 26, 2004

3:15—3:30pm

A recent project to completely re-examine six bog bodies from the Archaeologisches Landesmuseum, Schloss Gottorf, Schleswig Germany, involved Multi-slice Computed Tomography (MSCT) to image skeletal structure. The images were then examined for diagnostic and reconstructive purposes using both Mimics and 3D-Doctor as the principal image analysis software packages. This paper will explore the use of both software products for three-dimensional reconstruction, using images from the Windeby Child skull, and the humerus and femur from the Dätgen body. Reverse engineering software such as RapidForm offer significant advantages for 3D reconstructions of skeletal material. These reconstructions offer researchers unique insights about skeletal morphology not as apparent when solely using image analysis software.

3D Analysis of Bone Microstructure by Microcomputed Tomography in Anthropological Research: Current Capabilities and Future Possibilities

Dave M.L. Cooper

Departments of Archaeology and Medical Science
University of Calgary
Calgary, Alberta CANADA

DAY 1
Tuesday
October 26, 2004

3:30—3:45pm

Microcomputed tomography (micro-CT) is the first efficient and non-invasive technique capable of visualizing and quantifying the internal microstructure of bone. By facilitating a shift from 2D to 3D analysis, micro-CT has had a profound impact on bone research over the last decade. While most commonly associated with the analysis of trabecular architecture, high resolution scanners have also made the analysis of cortical bone porosity possible. To date, the direct impact of micro-CT has been modest for Biological Anthropology. However, due to the tremendous potential for the discipline, and the increasing availability of this technology, the role of micro-CT in anthropological research will certainly grow. This presentation provides an overview of the current capabilities of commercially available micro-CT scanners, highlighting possible anthropological applications including analysis of biomechanical adaptation, age-at-death estimation, and paleopathological diagnosis. Relevant examples from the Literature and ongoing studies at the University of Calgary 3D Morphometrics Laboratory will be presented. Finally, the next-generation of micro-CT scanners, on the technological horizon, will be discussed and their potential significance for Biological Anthropology examined.

Assessing the 3D Morphological Concordance of Dental Trait Expression Between the Enamel-dentin Junction and the Outer Enamel Surface of Human Molars Using MicroCT.

Matthew M. Skinner

Hominid Paleobiology Doctoral Program, Center for the Advanced Study of Human Paleobiology, George Washington University Washington, DC USA

Rasesh Kapadia

SCANCO USA Inc., Wayne, Pennsylvania USA

DAY 1
Tuesday
October 26, 2004

3:45—4:00pm

The capability to image the enamel-dentin junction (EDJ) in 3D would facilitate the assessment of the taxonomic and phylogenetic signal present in EDJ morphology, the characterization of the growth and development of the inner enamel epithelium (which dictates the shape of the EDJ) in fully formed teeth, and improve our understanding of the contribution of the inner enamel epithelium to occlusal crown morphology.

This paper presents preliminary results of a project evaluating the precision and accuracy of using micro-computed tomography to image the EDJ and enamel cap in 3D and digitally separate these tissues for morphological comparison. Ten human upper molars and ten lower molars were selected based on their collective variation in occlusal morphology, particularly in regard to relative cusp size and the presence and size of accessory cusps. Each tooth was microCT scanned using a SCANCO CT40 scanner. 2D slice images were stacked into a 3D reconstruction using VG Studio Max. Wireframe models of both the outer enamel surface (OES) and the EDJ were imported in GIS software (ArcView 3.2) for comparative analysis of dental trait expression.

Results confirm that microCT is capable of non-destructive 3D imaging of both the OES and EDJ with sufficient resolution to make detailed comparisons of morphological concordance between these two tissues. The influence of relative enamel thickness on the manifestation of EDJ morphology is also discussed.

NRC'S 3D Imaging Technology for Museum & Heritage Applications

John Taylor
J-A Beraldin
G. Godin,
L. Cournoyer
S.F. El-Hakim
F. Blais
É. Paque
M. Rioux

Visual Information Technology Institute for Information Technology
National Research Council of Canada
Ottawa, Ontario,
CANADA
K1A OR6

http://www.iit-iti.nrc-cnrc.gc.ca
john.taylor@nrc-cnrc.gc.ca

DAY 2
Wednesday
October 27, 2004

8:45—9:30 am

In 1981, the National Research Council of Canada (NRC) commenced research on the development of 3D imaging technology. In 1984, several Canadian museums and art galleries including the Canadian Museum of Civilization and the National Gallery of Canada started collaborating with NRC on the development of the museum and heritage applications of the technology. Subsequently, international heritage institutions in France, the UK, Italy, USA, Israel and China also became interested and participated in applications development projects. As a result, the museum and heritage sector became the main driving force for the development of NRC's 3D imaging technology.

This work has resulted in the development of a complete suite of 3D imaging technology tools and expertise, which have become internationally recognized as representing the state of the art for 3D heritage recording applications. The technology suite includes the development of three high-resolution laser scanner systems as well as software for the preparation of accurate 3D models and for the display, analysis, and comparison of 3D data. Tools have also been developed for cost effective interactive display and content based (shape searching) retrieval of 3D data and for image based 3D modeling of complex environments. The systems have been used to scan and prepare accurate 3D models of archaeological and ethnographic collections, archaeological sites, buildings, paintings, sculptures and natural history specimens for archival documentation, research, conservation, and replication as well as for immersive 3D VR Theatre and web display applications.

This presentation will offer an overview of the technology and its museum and heritage applications

From Laser Scanning to Virtual Worlds: The Reconstruction of Thule Whalebone House

Richard M. Levy, PhD.
MCIP, AIA Assoc.,
Faculty of Environmental Design,
University of Calgary,
Calgary, Alberta,
CANADA
rmlevy@ucalgary.ca

Peter C. Dawson, PhD.
Department of Archaeology,
University of Calgary,
pcdawson@ucalgary.ca

DAY 2
Wednesday
October 27, 2004

9:30—10:15 am

The development of laser scanning technology has created new techniques for capturing, preserving and analyzing objects, artifacts and sites. Computer reconstruction of a Thule whalebone house is used as a case study of how archaeological research can benefit from this new technology, with issues in data translation, computer modeling and virtual world construction considered. This paper will also focus on opportunities to use virtual reality (VR) technology to create virtual laboratories for testing research alternatives. Finally, the advantages of different platforms for presenting three-dimensional (3D) content as interactive worlds is explored.

3D Modeling and Database Development for Preservation of and Access to Objects of Human Heritage

Jeffery T. Clark
Charles Musiba

Department of Sociology and Anthropology,
North Dakota State University,
Fargo, North Dakota,
USA

Wes Niewoehner
Department of Anthropology
California State University, San Bernadino, California

Preservation of the physical remains of the past is essential for developing an understanding of human history, prehistory, and biological evolution. Such collections are essential for understanding human prehistory and biological evolution. Access to those remains for both scholarly study and public appreciation is also of paramount importance for an informed society. Such collections are typically housed at a small number of universities and museums scattered around the world and are not easily accessible to outside researchers, let alone the public. Travel to repositories can be costly and difficult, and is generally not an option for many people around the world. Moreover, many rare and irreplaceable fossils and artifacts are curated in countries where social and political unrest put their safety in jeopardy, or where collections can be cut off from researchers with the turn of political events.

DAY 2
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10:30—11:15 am

Current technology now presents us with the opportunity to provide some correction to these problems. Laser scanners and sophisticated software can be used to create three-dimensional (3D) models of the external shape and surface characteristics of nearly any object, and computer tomography (CT) scanners can be used to model both exterior and interior surfaces of objects. These models can be archived, along with associated contextual data, in an Internet-accessible, relational database. Databases of this sort significantly improve access to, analyses on, and preservation of material objects to human biological and cultural heritage.

Modeling a Monument -- 3-D research and results in the temples of Chavin de Huantar, Peru

John Rick

Department of Anthropological Sciences, Stanford University, Stanford, California USA

DAY 2
Wednesday
October 27, 2004

11:15—12:00pm

Over the last decade, the monumental 3000-year-old temple site of Chavin de Huantar, tightly nestled in a narrow highland valley, has been the scene of extensive digital data collection that documents the site's internal and external architecture, topography, and graphic art. This data has been used to produce GIS, CAD, and various VR models in a variety of resolutions and with various purposes. Foremost among these has been a strategy of 'virtual fieldwork' in which the examination of a combination of high precision and photorealistic models allows both the sensory experience of being present in the site and the ability to understand spatial relationships. The research team has been able to come to understandings of the construction, engineering, and architectural sequence that would have been conceptually impossible without the digital methodologies. Ultimately these models will be used in a novel form of publication involving 'live' models that allows the reader to be a full participant in the research process.

Three-dimensional Analysis of Trabecular Bone Growth Patterns in the Human Proximal Femur.

Timothy M. Ryan

Department of Anthropology, The Pennsylvania State University
Center for Quantitative Imaging, The Pennsylvania State University
University Park, Pennsylvania USA
tmr21@psu.edu

Gail E. Krovitz

Department of Anthropology, The Pennsylvania State University,
Department of Anthropology, University of Colorado at Denver
Denver, Colorado USA
gek10@psu.edu

DAY 2
Wednesday
October 27, 2004

1:30—1:45 pm

Ontogenetic changes in the human femur associated with the acquisition of bipedal locomotion, especially the development of the bicondylar angle, have been well documented. The purpose of this study is to quantify changes in the three-dimensional structure of trabecular bone in the human proximal femur in relation to changing functional and external loading patterns with age. Eleven juvenile femoral specimens from the skeletal collection of the Norris Farms 36 Cemetery, Illinois (700 years BP), were scanned on the high-resolution X-ray computed tomography (CT) scanner at the Center for Quantitative Imaging at Penn State University. The individuals ranged in age from prenatal to 3 years old. Serial CT scan slices were collected for the entire proximal femur of each individual with voxel resolutions ranging from 0.017 to 0.043 mm depending on the size of the specimen. Spherical volumes of interest were defined within the proximal femur and the bone volume fraction, trabecular thickness, and trabecular number were calculated in three dimensions. Fabric anisotropy was calculated using the star volume distribution and mean intercept length methods. Clear differences can be seen in bone structure between the younger and older individuals in the sample. Bone volume fraction, trabecular thickness, trabecular number, and degree of anisotropy decrease between the age of 6 months and 12 months, with the lowest values for these parameters occurring in individuals older than 12 months and who are presumably walking bipedally. After 12 months, the bone is distinctly thinner, less dense, and more isotropic, or not oriented. By age 2-3 years the bone volume, thickness, and degree of anisotropy increase slightly and certain regions in the femoral neck become more anisotropic corresponding to the thickening of the inferior cortical bone of the neck. These results suggest that trabecular structure in the proximal femur reflects the shift in external loading patterns associated with the initiation of unassisted walking in infants. Therefore, analyses of the ontogenetic development of trabecular bone in humans could prove to be another useful tool for interpreting the evolution of bipedalism in early hominids. The current study demonstrates the utility of high-resolution CT data for three-dimensional quantification, visualization, and data archiving in biological anthropology and anatomy.

Going to the 3rd Dimension: The Use of 3D Imaging Applications to Assess Age-related Relief Changes of the Pubic Symphysis

Myra L. Sitchon

Department of Anthropology
University of Manitoba
Winnipeg, Manitoba
CANADA

DAY 2
Wednesday
October 27, 2004

1:45—2:00pm

Age at death estimates derived from skeletal remains are important for reconstructing patterns in mortality, fecundity, and longevity of past populations. The estimation of age at death also assists in the identification of an unknown individual in a forensic context. Most estimates are derived from the qualitative assessment of gross morphological changes to the skeleton. The main drawback to the visual scoring approach is the inability to identify age-related skeletal changes in older adults. Digital imaging technology may potentially overcome this problem with the ability to identify traits on the bony surface that are indistinguishable to the human eye. Further, subjective analyses associated with current methodologies may be replaced with standardized quantitative approaches offered by imaging applications, thereby improving the accuracy of age at death estimates. This study presents a topographical analysis of morphological changes that occur in the pubic symphysis using three-dimensional (3D) imaging technology and applications. Digital elevation data is acquired through 3D laser scanning of the pubic symphyseal surfaces of individuals from various age categories. A Geographic Information System (GIS) approach is applied to analyze the topographic surface of the pubic symphysis in three dimensions. The resulting data is compared between different age groups to test the validity of this approach in skeletal aging. Implications of measurement of linear and volumetric data from 3D models of skeletal features for age at death estimation purposes are discussed.

Non-Contact Digital 3D Laser Scanning of Human Skeletal Remains: A Solution for Science, Native Americans, and Project Developers

Christopher D. Dore
Patrick Stanton
Malcolm Hooe
Donn R. Grenda
Jeffrey H. Altschul

Statistical Research, Inc.
PO Box 31865
Tucson, Arizona USA
85751-1865

cdore@sricrm.com

In response to Native American objections to photography and photogrammetric mapping of human remains, non-Contact digital 3D laser scanning was used as a field documentation tool at an archaeological site in Los Angeles, California. Prior to implementing the 3D scanning program, the process was explained and approved by government agencies, Native Americans, archaeologists, and the project developer. The key objectives for all parties were: (a) more efficient excavation, (b) better data quality, and (c) minimal handling of the remains.

DAY 2
Wednesday
October 27,
2004

2:00—2:15pm

The scanning was used to document approximately 125 sets of human skeletal remains plus additional scans of associated artifacts, isolated bone, and other features. Skeletal remains and features were scanned *in situ* during the excavation process at point spacing less than one millimeter. Scan data were then assembled, cleaned, and scaled on-site and then paper copies of these data were returned to excavators for annotation and labeling. Finally, the annotated drawings were digitized to create polygons to which database information was attached in a geographic information system. The implementation of this scanning tool met the ethical and scientific objectives of all parties.

Within the laboratory, the scanned data underwent bioarchaeological analyses. The digital models allowed the examination and manipulation of fragile bone without risking further damage. Pathologies were easily enhanced, documented, and studied. Metric data were measured more accurately from models than directly from bone that had dried or been damaged during removal. Access to information that would have been difficult or impossible to attain through other means, such as craniometrics from digitally reconstructed crania, was made possible. Finally, rapid prototype technology allowed reproductions of skeletal remains and associated artifacts to be manufactured from the digital models so that scientists and the public alike had a tangible record of reburied materials.

When It All Goes to Pot

Travis Allard

Department of Anthropology
University of Manitoba
Winnipeg, Manitoba
CANADA

DAY 2
Wednesday
October 27,
2004

2:15—2:30pm

The purpose of this study is to examine the method and expectations for virtual reconstruction in anthropology using a simple flower pot. The flower pot is broken and scanned using a Polhemus Fastscan handheld scanner. Virtual reconstruction is attempted using RapidForm. This project explores a methodology for using the principals of reverse engineering for 3D virtual reconstruction in anthropology. Post-processing techniques are also explored from a theoretical and practical view-point.

The Attraction to New Techniques: Using Magnetic Resonance Imaging for the Facial Analysis of Twins

Sarah Swingler

Department of
Anthropology
University of Alberta
Edmonton, Alberta
CANADA

DAY 2
Wednesday
October 27, 2004

2:30—2:45pm

Magnetic resonance imaging (MRI) is an important and relatively new technology that could have many advantages for anthropologists. Up to this point however, MRI has not been widely utilized within the field of physical anthropology. I will be presenting the preliminary findings from my Masters research involving a study of facial tissues, including bone, using MRI. To do this I will be comparing the similarity of craniometric points on, and between, sets of twins for the purposes of comparing twin variability in facial morphology. I will also be evaluating the usefulness of this technique to future anthropological studies.

MRI produces high resolution images of the structure of any organ or tissue in the body. MRI technology is based on the use of magnetic fields and radio waves and therefore, does not harm participants that volunteer for this procedure. The MRI machine constructs a magnetic field and uses radio waves to read the resonance or excitement of hydrogen atoms to map thin slices, or segments, of the body. This can be done in a specific localized area, for instance, the head. MRI is used primarily in the medical fields for diagnosis on patients and research purposes, but of what use can it be to physical anthropology?

I will be presenting the findings of my research using MRI to compare the similarity of the faces of twins. The twins, all over the age of 18, were scanned at the MRI research facility at the University of Alberta hospital. The images were then compared to look at the location of craniometric markers placed on the face for the duration of the scan. The results of this research are applicable to work done in forensic contexts on facial approximation.

Developing 3-D Imaging Methods to Characterize Limb Morphology: A Comparison of Forelimb and Hindlimb Morphology in the Mouse

April DeLaurier
T. Mohun
M. Bennett
M. Logan

Division of Developmental Biology
National Institute for Medical Research
The Ridgeway, Mill Hill
London,
UNITED KINGDOM

DAY 2
Wednesday
October 27, 2004

3:00—3:15pm

The vertebrate limb is comprised of a number of structures, including bone, muscle and tendon that develop in a precise manner and form complex associations in three-dimensional space. The developing mouse limb is commonly used as a model for studying the role of genes in tissue patterning, evolution, and disease in man. However, a comprehensive reference for the normal patterning of limb structures in the mouse model is lacking. Therefore, the aim of this project is to create a detailed 3-D reference model of the bone, muscle, and tendon of embryonic mouse limbs as a resource for comparative studies. We are using optical projection tomography (OPT), which allows the visualization of tissues through a combination of 3-D modeling and reconstruction of "virtual" sections. Using OPT we have analyzed muscle and tendon patterning by fluorescent immunohistochemical labeling of these tissues in wild-type mouse embryonic forelimbs and hind limbs at day 14.5 of gestation. We are also developing methods for visualization of skeletal elements in 3-D. Using OPT we have created virtual serial sections and interactive 3-D models of limbs which give the user control of the positioning and magnification of the specimen. This method has tremendous advantages over traditional 2-D microscopy, as it allows the study of limb structures from a variety of perspectives. The ultimate objective of this project is to make this data available as a permanent public resource available to the wider scientific community for comparative study of limb tissue patterning.

3D Modeling and Rapid Prototyping Applications in Biological Anthropology

Robert D. Hoppa
PhD
Travis Allard

Department of
Anthropology
University of Manitoba
Winnipeg, Manitoba
CANADA

DAY 2
Wednesday
October 27, 2004

3:15—3:30pm

Digital imaging and particularly 3D imaging is emerging as an important anthropological tool with respect to online training and real-time feedback, online research and collaboration, virtual collections and public dissemination. More and more, digital imaging is becoming an integral part of data acquisition and analysis in human osteological research. One of the newest tools in anthropological research is 3D object printing. Stereolithography has seen limited use, but the costs have often been prohibitive. New developments in 3D object printing have begun to make this technology more accessible to osteological studies. The benefits of such technology includes the creation of on-demand replicas, model extrapolations of fragmentary remains, replicas for training and/or display purposes as well as the ability to print files acquired off site at relatively low cost.

Organizing Committee & Sponsors

Organizing Committee

Andrew Nelson
Department of Anthropology, University of Western Ontario

Robert D. Hoppa
Department of Anthropology, University of Manitoba

Christine White
Department of Anthropology, University of Western Ontario

Gian Vascotto
Integrated Manufacturing and Technologies Institute, NRC

Sherman Lang
Integrated Manufacturing and Technologies Institute, NRC

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