

WHY UVA?

The members of the UVA team are uniquely positioned to take on the responsibility of initiating a Center for humanities supercomputing because of their strong backgrounds in the requisite disciplines. These include 3D data capture and modeling, remote real-time rendering of visualization, secure distribution of graphical models over the Internet, and new and more efficient forms of acquiring and analyzing the properties of 3D objects. Our multidisciplinary IATH research center has sponsored and developed dozens of award-winning electronic scholarship projects since its founding in 1992, and is widely recognized as a leading organization in the digital humanities.

KEY UVA RESEARCHERS

DEAN ABERNATHY: Associate Director of IATH for Visualization and Assistant Professor of Architecture. Abernathy has been working full-time on 3D modeling of monuments, buildings, and sites since the mid 1990s.

BERNARD FRISCHER: Director of IATH and Professor of Art History and Classics. Frischer founded the UCLA Cultural Virtual Reality Laboratory (www.cvrilab.org) in 1996; the lab moved to IATH in 2004. In 2005, Frischer was given the Pioneer Award of The International Society for Virtual Systems and Multimedia.

GREG HUMPHREYS: Assistant Professor of Computer Science. Humphreys is well known for his DoE-sponsored work on Chromium, software for remote rendering for visualization. More recently, he has been developing a new system of 3D image acquisition based on structured light. Humphreys is a founder and Director of Systems Research of the DoE SCIDAC Institute for Ultrascale Visualization.

DAVID KOLLER: Post-doctoral fellow in IATH and Computer Science. Koller's recent graduate work included the Stanford Digital Michelangelo and Digital Forma Urbis projects, using 3D laser scanners to create the largest 3D cultural heritage datasets. His dissertation addressed the problems of secure dissemination of 3D models, and computer-aided reconstruction of fragmented archaeological artifacts.

JASON LAWRENCE: Assistant Professor of Computer Science. Lawrence is a pioneer in the acquisition of material properties from scanned objects.

WORTHY MARTIN: Associate Director of IATH and Associate Professor of Computer Science and has extensive experience in dynamic scene analysis for model acquisition.

Contact: Prof. Bernard Frischer, tel. (434) 243-4080; cell (310) 266-6935;
e-mail: bernard.d.frischer@gmail.com

PROPOSAL FOR A NATIONAL CENTER FOR VISUAL SUPERCOMPUTING IN THE HUMANITIES



Digital model of ancient Rome (detail)

INSTITUTE FOR ADVANCED TECHNOLOGY IN THE
HUMANITIES (IATH)
DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF VIRGINIA

SUPERCOMPUTING IN THE HUMANITIES

The use of digital tools in the humanities is becoming increasingly important for conservation, education, and research. More and more archaeologists, historians, and other scholars are turning to 3D modeling technology to create representations of the cultural heritage monuments and sites that they study and teach. This transformation of scholarship poses opportunities as well as challenges. Foremost among the latter are collection, preservation, tool development, and distribution.

To date, no single agency has assumed the mission of curating scientific 3D models of cultural heritage monuments. This gap in America's cyberinfrastructure is not surprising, since model makers are confronted by disparate tools and sources, massive amounts of data, and the lack of standards and best practices. They do not generally have access to the necessary knowledge and resources. Right now only a few tools allow the use of 3D models as research instruments, but they are not widely distributed. We can fly through the virtual worlds we create, but our ability to perform useful measurements, simulations, and analysis is limited.

3D models of cultural artifacts are rarely distributed over the Internet because of technical difficulties and intellectual property concerns. It is hard enough for a modern PC to support a real-time visualization for one user of a model as complex as the simulation of ancient Rome created by team-member Bernard Frischer. Using servers to support secured, interactive access by users all over the world is desirable, but it is beyond the resources currently available to humanists.

These challenges to transforming digital humanities scholarship require innovative solutions that rely on supercomputing resources. Accordingly, humanists in the Institute for Advanced Technology in the Humanities (IATH) and scientists in the Department of Computer Science at the University of Virginia propose to create a National Center for Visual Supercomputing in the Humanities. The Center will provide an environment for the highly interdisciplinary, collaborative work necessary to advance digital humanities scholarship.

KEY AREAS OF FOCUS

Our initial efforts will leverage supercomputing resources to enable the acquisition, analysis, and dissemination of 3D cultural heritage models:

ACQUIRING AND PROCESSING 3D DIGITAL DATA FROM CULTURAL HERITAGE SITES. The computational techniques used to process

the raw data from 3D scans of cultural artifacts require immense computing resources, to filter, align, and merge the raw scans into complete 3D geometric models. For example, processing the raw 3D scan data for Michelangelo's David (a two billion polygon mesh surface model) required several days of high-end compute power on a state-of-the-art multiprocessor system (SGI Onyx2). Processing the raw scan data to produce 3D models of the 1,200 fragments of the Forma Urbis Romae (over eight billion polygons) took hundreds of hours of microprocessor time. Team member Jason Lawrence is investigating new methods of surface appearance measurement and modeling that supplement geometric shape information; while this will enable highly realistic visualization and scientifically valid simulation of object material properties, these techniques are also very computationally-intensive. As scanning projects become more ambitious and the demand for fast turnaround increases, supercomputers become the most efficient tools for turning raw acquired digital data into useful 3D models.

SCHOLARLY ANALYSIS OF 3D CULTURAL MODELS. The algorithms we would like to run on 3D cultural heritage models for scholarly analysis are elaborate and will require supercomputing to run efficiently. For example, the software algorithms David Koller developed for automated reconstruction of the 1,200 Forma Urbis fragments take dozens of hours of compute time to execute, and the time required increases exponentially with the number of fragments. An artifact with 50,000 fragments (such as the Assisi frescoes or other complex archaeological fragment reassembly problems) would require supercomputer resources to compute a solution in a reasonable amount of time. The 3D models of ancient sites we are constructing allow a wide variety of insightful simulations, including visibility calculations, traffic and ventilation flow computations, and simulation of weathering. These cultural heritage analyses are complex 4D simulation problems, similar to the scientific applications that scientists are using supercomputers for today.

REMOTE RENDERING FOR SECURE DISSEMINATION OF CULTURAL HERITAGE WORKS. Models of valuable cultural artifacts require secure dissemination to address the concerns of curators and content owners and to encourage their open sharing. Koller's state-of-the-art protected 3D graphics techniques depend on powerful, centralized computing servers that perform remote rendering and distortion of 3D models before returning images to users' client systems. These centralized, secure servers would require very high-performance computing power (i.e., supercomputers) to service a high number of users.