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The National Center for Preservation Technology and Training ([NCPTT](#)) Grant Project

A Comprehensive Training Program for 3-D Digital Rock Art Documentation and Preservation

Abstract

Reflectance Transformation Imaging (RTI) is the most significant imaging breakthrough for archaeological and heritage documentation and preservation since stereo photogrammetry. Based on internationally developed, state-of-the-art, open source and freely available software, RTI provides flexible, very cost effective tools and methods for the on-site, three-dimensional (3D), full-color digital capture of rock art, petroglyphs and artifacts, with accuracy measured in the microns. This grant will provide essential funding to put these techniques in the hands of archaeology and conservation professionals through training, video podcasts, do-it-yourself guides and online dissemination materials, in an economical and comprehensive program.

Narrative

We propose a comprehensive training program for 3D digital rock art documentation and preservation, based on state-of-the-art computational photography techniques that are emerging as the next generation of cultural heritage tools for use both in the field and in museums. Over the past several years, an international consortium of archaeologists, museum conservators and computer scientists have worked to develop a suite of capture, processing and semantic provenance tracking technologies. The most mature tool in this suite, [Reflectance Transformation Imaging \(RTI\)](#), has proven to be of tremendous value for creating digital surrogates of cultural heritage objects of remarkable quality. Used alone or in combination with stereo photogrammetry, RTI is extremely effective in the documentation and [analysis of rock art](#). This project will bring key experts in these field domains together to produce a self-contained program that puts these techniques in the hands of archaeology and conservation professionals, non-technical Native American audiences, and the interested public. This will be accomplished through video podcasts, do-it-yourself guides and online dissemination materials, delivered by an economical and community driven process.

This [NCPTT](#) proposal is a collaboration between Cultural Heritage Imaging (CHI), a

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501(c)(3) non-profit corporation, rock art scholars, preservation technologists, and digital researchers from the nation's leading industry and research organizations. Employing a combination of public and private funding within a charitable, collaborative research environment, CHI achieves its goals by working alongside these experts to generate innovative solutions delivering advanced digital imaging techniques to cultural heritage professionals worldwide. The proposed NCPTT project will develop a comprehensive program in onsite and online training of cost-effective, easy-to-use tools to digitally capture empirical data from rock art and petroglyph sites nationally. This raw data is designed to yield 'born-archival,' 3-dimensional (3D), digital representations that disclose, through transparent and precise mathematical enhancement, features unseen for thousands of years, without the need of specialists or specialized equipment.

Designed from the beginning with assistance from cultural heritage practitioners, this next generation family of work practices are crafted to be compatible with current working cultures and digital imaging skill sets. The goal is to democratize technology and foster widespread adoption of robust digital documentary methods by greatly reducing the barriers of cost and technological complexity that characterize many current 3D methodologies.

RTI's documentary usefulness has been demonstrated in many natural science and cultural heritage subject areas and offers significant advantages suggesting widespread future adoption. RTI enables robust 'virtual' examination and interpretation of 'real world' subjects possessing surface relief features. RTI information may also be mathematically enhanced. RTI enhancement has been shown to disclose surface features that are impossible to discern under direct physical examination. There is a growing family of enhancement functions that use RTI color and 3D shape data to aid the examination, analysis, communication and interpretation of scholarly material. RTI's ability to interactively display the enhanced interplay of light and shadow in the image is used by the human perceptual system to reveal fine details of the subject's 3D surface form. This ability to efficiently document color and true 3D shape information is the source of RTI's documentary power.

For many documentary purposes, RTI also offers cost and precision advantages over other 3D scanning methods. Reflectance information can be captured with widely available and relatively inexpensive digital photographic equipment. RTIs can be captured over a large size range, from several square meters to millimeters and can acquire a sample density and precision that most 3D scanners are unable to reach. RTIs can capture the surface features of a wide variety of material types, including highly specular reflective material such as jade or gold.

Our project offers a simple way for our collective rock art story to be comprehensively digitally preserved such that it can be studied and appreciated in a nearby Visitor Center, by people on the other side of the world, and by future generations. This enables controlled access visitor programs, remote scholarship, and reuse of the documentary information acquired in our time by those who follow in our footsteps.

The program would not be possible without leveraging the generous donations of time, resources, and expertise from our collaborative team, including:

Meg Conkey, international rock art researcher and professor of Anthropology, will donate her time to review classroom and web content, specifically with an eye to the needs of rock art documentation and preservation. She will assist in dissemination of produced materials through the [Society for American Archaeology](#).

Carolyn McClellan, Associate Director of the [National Museum of the American Indian \(Smithsonian\)](#), will donate a professional video team to document the workshop proceedings, and will advise and review classroom and web content, specifically with an eye toward education of non-technical and Native American audiences.

Tom Noble and Nefra Matthews, from the [US Bureau of Land Management](#) National Operations Center, bring state-of-the-art photogrammetry expertise to the program. They will donate their time and training materials.

Hewlett Packard Laboratories, Princeton University and the University of California, Santa Cruz are donating expertise to develop and review the soundness of the overall capture and process and analysis methodology.

The Presidio Archaeology Lab of San Francisco will provide the workshop venue and participant lodging.

Cultural Heritage Imaging is donating all indirect costs for the project.

We outline our onsite and online training program in detail in the tasks, deliverables, and dissemination sections.

National Need

There is a critical, national need to raise awareness and education about rock art in the US, and at the same time to empower significantly more 'stewards' of our past than at any time in history. Theft, vandalism, neglect, tourism, natural destructive processes, even some conservation practices, all put rock art at risk. [The Getty Conservation Institute](#) reports that there are tens of thousands of rock art sites in need of documentation and conservation, with very limited tools and "less than a handful of American rock art conservators" to do the work. While improvements in evaluation and assessment techniques are underway, "cultural resource management archaeologists are not in a position to train the next generation of US rock art researchers" in these specialized techniques.

High definition documentation techniques and professional training in their use are required now in order to facilitate the stewardship of these vital heritage sites. From a conservation perspective, most traditional and digital techniques available that have been deployed for rock art documentation are insufficient in terms of information density and assessment usability. The proposed methodology for RTI capture integrates perfectly with best practices in photogrammetry, range data and other remote sensing techniques, and provides the most pragmatic, easy-to-deploy, cost effective heritage management and monitoring strategy available. Sites of significance or at risk will benefit tremendously from RTI capture, with added significance for sites where traditional documentation techniques have failed to [discover hidden etchings](#) and [petroglyphs](#) that can easily be revealed through RTI analysis.

Tasks and Project Schedule:

See the Expertise section for specific tasks and roles for all individuals contributing to the project.

- **March - April 2009** - Logistics and project planning, coordination of activities and plan for program deliverables. Establish dates for workshop, invite participants.
- **March - April 2009** - Develop onsite workshop curriculum and materials. These will leverage existing materials tools and methods from workshops and trainings held at: Worcester Art Museum in Massachusetts; US/ICOMOS conference in San Francisco; University of Minho, Portugal; National Preserve of Tauric, Chersonesos, Ukraine; Eurographics conference tutorial in Heraklion, Crete; Legend Rock State Park, Wyoming; and Paleolithic Petroglyphs of Coa Valley, UNESCO, World Heritage Site, Portugal. Materials will be prepared using web technologies, for use by the participants during the workshop. Technologies and software presented in the workshop will include open source software resources and research developed by CHI and partners: Italian National Research Council, Pisa; Institute for Cultural Informatics, Foundation for Research and Technology, Hellas, Crete; University of Minho, Portugal; Hewlett Packard Laboratories; University of California at Santa Cruz and Berkeley

During this period reviews by technology experts of methodologies and software tool chain will also occur

- **May 2009** - Cultural Heritage expert curriculum content reviews, followed by edits and revisions based on feedback.
- **June or July 2009** - Hold 2 day workshop in The Presidio, San Francisco and the CHI laboratory. Photogrammetry specialists arrive one day early to fine tune workshop content, logistics and delivery. The workshop will be video recorded by a professional crew provided by The National Museum of the American Indian.
- **July - September** - Creation of edited video suited for web distribution. Edit training content and integrate video for do-it-yourself web distribution.
- **September** - Final reviews, edits, revisions.
- **October - November** - Dissemination through various channels (see dissemination section). Final analysis, report.

Dissemination of Research

All training content, reports, software and other support materials will be made available on the Cultural Heritage Imaging website. Materials produced under this program will be released under [Creative Commons](#) licensing. Agreements have been made to widely distribute and promote the program on many highly visited organization websites, including:

- [Society for American Archaeology \(SAA\)](#)
- [Presidio Trust](#)
- [World Archaeological Congress \(WAC\)](#)
- [Society for Historical Archaeology \(SHA\)](#)
- [National Museum of the American Indian \(Smithsonian\)](#)
- [International Symposium on Virtual Reality, Archaeology and Cultural Heritage \(VAST\)](#)
- [Computers Applications and Quantitative Methods in Archaeology \(CAA\)](#), both international and North America chapter

The results of this work, including the analysis of the effectiveness, production process and final reports, will be published and presented at international and national conferences such as the Society of American Archaeology, National Preservation Conference, CAA and VAST.

Deliverables

2 day workshop for 15 participants with lodging provided

■ **Day 1 lab in CHI facility, San Francisco**

- Train participants in Reflectance Transformation Imaging (RTI) capture. This includes: equipment setup; image and metadata management; image and data quality assessment; and documentation of empirical provenance.
- Train participants in RTI processing including: instruction on how to use the software; best practices for metadata management and documentation of empirical provenance.
- Train participants in analysis of results: use and function, data and feature discernment, enhancement, critical assessment, extraction
- Train participants in capture of stereo photogrammetry
- Demonstrate results from both techniques as well as possibilities for combining and extending the techniques
- Demonstrate automatically generated drawings from RTI data
- Provide training materials and necessary software for processing in a downloadable format

■ **Day 2 Onsite in The Presidio of San Francisco**

- On-the-ground reality capture using skills learned in Day 1. Will include onsite problem solving including: common issues with image capture; negotiations; embedding capture into existing site management plan workflows.
- Participants will be encouraged to use their own cameras and computers
- We will also discuss distribution and sharing including: dissemination strategies such as online, kiosk, and print; reaching wider audiences; and information management.

■ **Training Materials**

- Web technology based materials for capture and processing of RTI and capture of Photogrammetry data with a focus on Rock Art. These will be used during the workshop and cover the topics mentioned above. Also included will be the software necessary for processing RTI

■ **Videos of workshop**

■ **Web Based Do-it-yourself guide**

- Incorporates in-class materials, edited video and step-by-step instructions. Includes instructions for downloading and installing RTI software

■ **All produced materials will be made available under a Creative Commons license to allow for wide dissemination**

Expertise

The lead organization for the project is [Cultural Heritage Imaging \(CHI\)](#), 501(c)(3) non-profit organization dedicated to advancing the state of the art in digital capture, documentation, scholarly use, and public enjoyment of the world's historic and artistic CH. For the last six years, CHI has worked alongside experts from leading industry and research organizations to deliver advanced digital imaging solutions to CH professionals both in the US and worldwide. For this project, the CHI team will collaborate with the University of California at Berkeley, U. S. Bureau of Land Management National Operations Center, The Presidio Archaeology Lab, The National Museum of the American Indian, Hewlett-Packard (HP) Labs, Princeton University, and The University of California Santa Cruz.

The proposed project is a collaboration between staff at Cultural Heritage Imaging (CHI), rock art scholars, including archaeologist Dr. Margaret Conkey, and Carolyn McClellan of the National Museum of the American Indian. In addition Bureau of Land Management (BLM) image-based 3D documentation researchers Neffra Matthews and Tom Noble along with digital imaging researchers Tom Malzbender from HP Labs, Dr. James Davis from the University of California, Santa Cruz (UCSC), and Dr. Szymon Rusinkiewicz from Princeton will participate in the project.

Rock Art and Cultural Heritage Experts:

Margaret Conkey

Professor of Anthropology and Director of the Archaeological Research Facility, UC Berkeley. Professor Conkey has been an active researcher in the field of Paleolithic and prehistoric art ever since her graduate work. In addition to many papers regarding the interpretations of Paleolithic art, and her empirical work with portable art, Conkey has recently been directing a field project, "Between the Caves", in the French Midi-Pyrénées. The project has been documenting the differential distribution of Paleolithic artifacts across the open-air landscapes of a region within which there are numerous well-known Paleolithic cave sites, especially those with cave and portable art. She earned her MA and PhD degrees in Anthropology from the University of Chicago. Since coming to Berkeley in 1987, she has received three awards for excellence in teaching, and an Educational Initiatives Award for the development of a multimedia teaching program and laboratory. She has served as Chair of the Anthropology Department, and has also filled numerous administrative positions on campus including 13 years as the Director of the Archaeological Research Facility. She has recently been elected as the President-Elect of the Society for American Archaeology.

Project Role: Principal Investigator (16 hours)

Tasks: Advise and review classroom and web content, specifically with an eye to the needs of rock art documentation and preservation. Assist in dissemination of produced materials through the Society for American Archaeology.

Carolyn McClellan

(Cherokee Nation) Associate Director, Community and Constituent Services, National Museum of the American Indian (NMAI) in Washington, DC. She received her BA in Anthropology from the University of Arizona and her MA in Anthropology from the University of Oklahoma, with an emphasis in American Indian studies. McClellan has had a lengthy career in cultural resource management during her tenure with the Bureau of Indian Affairs and the Bureau of Land Management. Her areas of interest are repatriation, using close range photogrammetry to document petroglyph and pictograph sites, creating collaborative relationships between tribal colleges, the museum and other entities and community outreach.

Project Role: Content adviser and reviewer (16 hours)

Tasks: Content adviser and reviewer (16 hours)

Trainers and Materials Development:

Mark Mudge

President and co-founder of Cultural Heritage Imaging (CHI). 6 years experience applying 2D and 3D imaging techniques to cultural heritage material, including authoring multiple papers in the field. Member of international scientific committees and reviewer of journals in the cultural heritage and technology field. Prior to CHI, taught advanced computer graphic modeling and animation techniques from 1993 to 2001 to more than 800 students in the San Francisco Bay area at both the Academy of Art University and the Expression Center for New Media. B.A. in Philosophy from New College of Florida.

Project Role: Lead technologist and Trainer (120 hours)

Tasks: coordinate with collaborators, consult with computer graphics researchers to refine image capture methodology, organize and write materials for classroom and web distribution, present material and work with students during training

Carla Schroer

Executive Director and co-founder of Cultural Heritage Imaging. 6 years experience applying digital imaging in the cultural heritage field. An additional 20 years experience in the software industry, directing a wide range of software development projects including Sun Microsystems' Java technology, object oriented development tools, and desktop publishing. Holds a B.A. from New College of Florida with a concentration in Computer Studies.

Project Role: Trainer and Development of course materials (120 hours)

Tasks: Organize course materials, consult with computer graphics researchers to refine capture methodology, present material and work with students during training, organize and write materials for web distribution, overall workshop coordination.

Marlin Lum

Imaging Director for Cultural Heritage Imaging. Experience in graphic design, photography, streaming video-immersive technologies, 3D modeling, and web development in both the corporate and nonprofit sectors. B.A. in Fine Arts from Loyola Marymount University; M.A. in Computer Animation and 3D modeling from Academy of Art University.

Project Role: Trainer and primary web designer for dissemination (240 hours)

Tasks: Present material and work with students during training, modify materials for web distribution, design web pages and navigation structure, overall workshop logistics.

Michael Ashley

Development Director for Cultural Heritage Imaging. Co-founder of the Media Vault Program at UC Berkeley. Dr. Ashley has more than 16 years of experience in cultural heritage informatics management and education and is an expert in digital heritage preservation. Chair of the IT and Communications Task Force for the World Archaeological Congress and on the Society for Historical Archaeology Website Advisory. An archaeologist by training, he was the Media Team specialist for the Çatalhöyük Research Project for more than 7 years and has worked on several heritage preservation projects worldwide.

Project Role: Trainer and Development of course materials (120 hours)

Tasks: Organize course materials, present material and work with students during training, organize and write materials for web distribution, coordination of dissemination of materials.

Neffra Mathews

Geographer, National Operations Center, Bureau of Land Management. She is a photogrammetrist by profession and has spent much of her career producing maps from aerial photography. More recently she has utilized aerial mapping techniques on pictures taken from lower altitudes to produce very detailed maps of a number of sites. Before going to work at BLM, Neffra worked as a geologist for the Defense Department. Neffra received a M.S. in geology from the University of Kentucky.

Project Role: Trainer and Photogrammetry content specialist (48 hrs)

Tasks: Prepare materials for capturing photogrammetry, travel to San Francisco and deliver training to class participants. Review materials.

Tom Noble

Cartographer, National Operations Center, Bureau of Land Management. For the last eight years, has been utilizing close range or non-traditional photogrammetry techniques to accurately document and model in 3D subjects from cliff faces to dinosaur tracks to rock art panels. B.S in Civil Engineering from Oregon Institute of Technology.

Project Role: Trainer and Photogrammetry content specialist (48 hrs)

Tasks: Prepare materials for capturing photogrammetry, travel to San Francisco and deliver training to class participants. Review materials.

Computer Graphics Researchers

Tom Malzbender

Senior Research Scientist in the Media and Mobile Systems Lab within Hewlett-Packard Laboratories. Tom works at the intersection of computer graphics, computer vision and signal processing. He has developed the techniques of Reflectance Transformation, Polynomial Texture Mapping and Fourier Volume Rendering. Tom also developed the capacitive sensing technology that allowed HP to penetrate the consumer graphics tablet market. His recent work on imaging the Antikythera Mechanism led to the deciphering of this ancient astronomical computer.

Project Role: Computer Graphics Researcher. (16 hours)

Tasks: Suggest data capture requirements that could lead to better 3D data extraction, review materials

Szymon Rusinkiewicz

Professor, Department of Computer Science, Princeton University. His work focuses on acquisition and analysis of the 3D shape and appearance of real-world objects, including the design of capture devices and data structures for efficient representation. He also investigates algorithms for processing complex datasets of shape and reflectance, including registration, matching, completion, symmetry analysis, and sampling. In addition to data acquisition, his research interests include real-time rendering and perceptually guided depiction. He obtained his Ph.D. from Stanford University in 2001.

Project Role: Computer Graphics Researcher. (16 hours)

Tasks: Consulting on 3D data capture, extraction, and analysis.

James Davis

Associate Professor, Department of Computer Science, University of California, Santa Cruz (UCSC). He received his PhD from Stanford University in 2002. His research expertise is in computer graphics, machine vision, and sensing systems for building digital models of the real world. This work has resulted in over 50 publications, patents, and invited talks. He is additionally interested in applying technology to address global social issues, and has developed an award-winning course around this theme.

Project Role: Computer Graphics Researcher (16 hours)

Tasks: Consulting on 3D data capture, extraction, and analysis, review prepared materials