



Applications of Digital Photogrammetric Methods for Preservation Documentation of Historic Homes | 2012-11



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Narrative Final Report (Attachment C)
NCPTT 2011 Grants
Grant Number: MT-2210-11-NC-11
The Georgia O’Keeffe Museum

TITLE PAGE

Grant Number: MT-2210-11-NC-11

Project Title: *Applications of Digital Photogrammetric Methods for Preservation Documentation of Historic Homes.*

Organizational Name: The Georgia O’Keeffe Museum

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Project Team: Dale Kronkright – Principal Investigator.

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EXECUTIVE SUMMARY

This project studied whether existing, three-dimensional (3D) digital photo imaging technologies could be easily adopted by historic sites for documenting the condition of buildings and objects.

Traditionally, conservators have relied on 2-dimensional (2D) photography to document and monitor conditions in heritage sites and objects. When a shocking, visual indicator appeared (e.g., a sudden crack in a surface), conservators took notice of what were actually thousands of slow, incremental changes (e.g., tiny fissures and failures in slowly aging materials). Conservators then photographed the area to monitor how deterioration was advancing. Two factors limit our ability to detect and monitor deterioration: our ability detect slow and small “micro” changes, and our ability to compare what humans see using 3D stereo vision to what we recorded in 2D photographs.

3D models can be made using laser scanning and 2D digital photography. For all, there are trade-offs where decisions in the workflow must be made. The finer the resolution –the smaller the area captured by either a laser point reflection or a digital camera sensor pixel - the larger the data set. In practice, the larger the object– an entire historic house or landscape versus a door or wall – the lower your resolution must be OR the more expensive and customized your computer.

This study found two 3D digital photographic technologies –RTI and Photogrammetry – that change the condition-detecting and monitoring paradigm in important and beneficial ways:

- Digital 3D photo images allow us to see and measure 3D volumes and contours in ways that mimic the stereo view of a real-time human examiner.
- They allow us to use a computer to detect very small and slowly occurring changes.
- Because specular, color and texture data is digital, we can selectively highlight details, remove color data, change virtual light sources or colorize contours.
- Photography can be done by anyone with a basic knowledge of digital camera operation and a lap-top computer.
- Photography uses an ordinary, consumer-professional grade, digital camera, not expensive laser scanning equipment.
- Capture photographs are regular, open-format 2D files – RAW, TIFF and JPEG. The capture data is not a proprietary laser-scan file format.
- The user owns their own images and controls their naming, archiving, meta-data and digital management protocols.
- Assembled 3D, computational meshes, solids, and RTI images use open-source software – there are no hidden steps and every transformation of the data is documented and visible.

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INTRODUCTION

Monday, June 25, 2012 began a twelve-week, O’Keeffe Museum Conservation Program summer preservation project. Thanks to the generous financial support of the National Center for Preservation Technology and Training (<http://ncptt.nps.gov/>), The Stockman Family Foundation and New Mexico AmeriCorps Cultural Technology community service program. The Georgia O’Keeffe Museum Conservation Program tested three exciting, and new technologies in “Computational Imaging”.

New Mexico AmeriCorps Cultural Technology (NM-ACT) interns Joey Montoya of Espanola and Greg Williamson of Santa Fe joined Head of Conservation Dale Kronkright and Assistant Registrar Darrah Wills in testing three imaging processes: Reflectance Transformation Imaging (RTI), Photogrammetry and Structured Light Imaging. Each uses different algorithms to construct detailed 3D images and data by assembling regular, 2-D digital photographs.

In conservation and preservation, computational imaging uses the power of today’s laptop microprocessors and digital cameras to create accurate, archival, 3D images and documentation for artistic and cultural objects. From the microscopic texture of a paint brush-stroke to the undulating pitch and volume of a historic adobe wall, computational imaging can document and help monitor the changes in three-dimensional shape, size and deterioration of the historic properties and objects under the care of the Georgia O’Keeffe Museum. Since we preserve, document and monitor everything from historic landscapes and historic structures to O’Keeffe’s paintings, pastels, and drawings, and also to the tiny snail and scallop shells she collected and imaged in her art, automating and increasing the accuracy of our documentation and measurements can help us systematically get better work done, in less time.

Besides helping us to carefully monitor for changes in condition, the documentation greatly improves our disaster-recovery readiness – creating extremely accurate dimensional, color and texture maps of pre-disaster states for our historic structures. We also hope that, with additional, future funding, we will be able to sinter or “print” precise, 3D replicas of O’Keeffe’s paintings and scale models of her homes that will be easily explored and experienced by sight-impaired visitors and enrich their experiences of our museum and historic sites.

To make the documentation useful from a scientific perspective, the source photographic conditions, resolution and algorithmic processing pathways must be carefully documented in a digital “lab notebook”. Further, to facilitate the accurate computer comparison of 3D features of a painting, door, window or landscape over time – to determine if features are subtly changing in ways that indicate underlying deterioration or damage – the algorithms must facilitate the recognition and comparison of brightness, specular reflection and R-G-B feature data in photographs that have been taken years or decades later with different cameras, different lighting conditions and slightly different orientations. These conditions are pretty demanding!

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MATERIALS AND/OR METHODS

Materials - Software and Equipment:

Software:

Photo Editing:

[Adobe Photoshop](#)

Digital Photo Professional (software comes with [Canon EOS camera](#))

Reflectance Transformation Imaging:

[RTI Builder](#)

[RTI Viewer](#)

Photogrammetry:

[Agisoft Photoscan](#)

[Meshlab](#)

[Blender](#)

see review of Blender and Meshlab [here](#)

Equipment:

Camera:

[Canon EOS 5D](#)

[Canon EOS Rebel T3i](#)

[Canon Wide Angle EF 24mm lens](#)

[Canon Macro EF 50mm lens](#)

[Canon Telephoto EF 100mm lens](#)

Tripod:

[Gitzo Tripod](#)

[Vanguard Tripod](#)

Mid-size Ballhead [Really Right Stuff BH-40](#)

Large Ballhead Really Right Stuff BH-55

[Light Stand](#)

[Monopod](#)

Lighting:

[Flash Canon Speedlite 5eight0EX II](#)

Wireless Control:

Transceiver [Pocket Wizard Flex TT5](#)

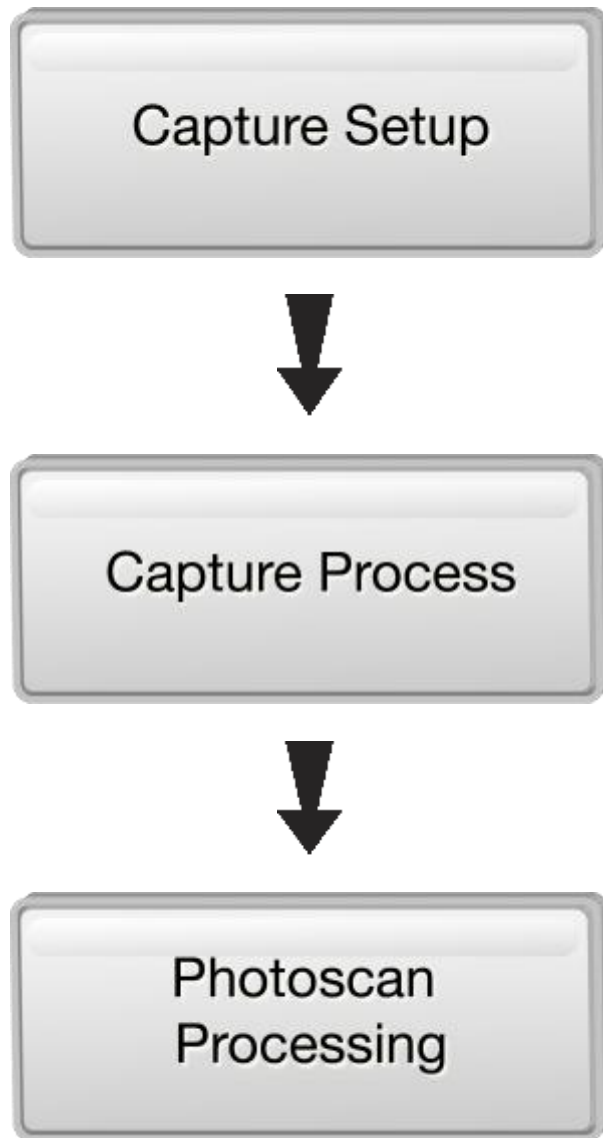
Transmitter [Pocket Wizard Mini TT1](#)

RTI Highlight Capture Kit

[Highlight Capture Kit](#)

Methods:

Photogrammetry Workflow



Photogrammetry Work Flow - Description of Methods: Capture Setup, Capture Process, and Photoscan Processing

Capture Setup

- 1) The first step is to consider your subject. What is it you are trying to study? Whether you are trying to capture cracks, dents, minute changes in topology, or macroscopic changes in topology, the absolute smallest detail you need to capture can be no smaller than 25 pixels. Taking your camera's resolution into consideration, calculate if the details you are trying to study are at least 25 pixels. This can be done by taking test shots, then bringing those test shots into a photo editor such as Photoshop, or even a free paint program such as Gimp or Microsoft's Paint. All of these programs have the ability to measure distance in pixels. If there is not sufficient detail, either move closer to the subject, change lenses, or do both so that optimal resolution is achieved.



One row of Dennison dots.

- 2) Once your distance from the subject and camera lens are chosen, a horizontal line of known length needs to be placed in the frame with your subject. This allows for accurate distance measuring and scaling in the 3D mesh. A great way to do this is to place Dennison Dots equidistant and level all the way across the subject. Not only do Dennison Dots placed onto the subject help in scaling and measuring along the mesh, but it also helps in the capture process by giving visual cues for the amount of distance to move along the subject. For this to be effective, the distance in between dots should be roughly one third of the total horizontal distance of your photo.



Joey and Greg capture the outside of the kitchen.

Photogrammetry Work Flow - Description of Methods:

Capture Setup, Capture Process, and Photoscan Processing (cont'd)

3) The distance from the subject to the camera and the distance in between your Dennison Dots should now be established. Pick a line that will run the horizontal length of your subject and place the Dennison Dots along this line. Make sure that these dots are not only equidistant, but are also perfectly level.

Capture Process

When capturing images at close range with a wide angle lens, depth of field may be limited and focal distance may be critical for recording condition details. Holding a relatively constant distance from the subject plays an important role in meaningful data capture.

1) Camera distance from subject, choice of lens, and Dennison Dots should be setup as per the previous step.

2) Establish an F-stop that provides full depth of field focus.

3) Set the focus and the depth of field. Once the focus has been established, tape the lens so that the focus stays set and does not accidentally change.

View the *Photogrammetry Calibration* video at:

<http://okeeffeimaginingproject.wordpress.com/2012/0eight/26/capture-process>.

4) Frame your shot starting with your camera horizontal. Establish a point on the center of the frame. Centering on this point for each shot, take three consecutive pictures changing the orientation of your camera for every picture. One orientation is horizontal at 180°, one is a vertical orientation rotating the camera to 90°, and the final orientation is the opposite vertical position rotating the camera to 270°. This changing of orientation allows the software to correct for lens distortion.

View the *Working with Shadows- Photogrammetry Results* video at:

<http://okeeffeimaginingproject.wordpress.com/2012/0eight/26/capture-process>.

5) Using either your center point of focus or the Dennison Dots as a reference, move along your subject by 30%. If done correctly, 60% of your previous frame will be included in your new frame and only 30% of new subject will be introduced into the next series of pictures.

6) Repeat steps 4-5 until the entire subject has been photographed.

Photogrammetry Work Flow - Description of Methods: Capture Setup, Capture Process, and Photoscan Processing (cont'd)

Photoscan Processing

View the Photoscan Processing Tutorial at:

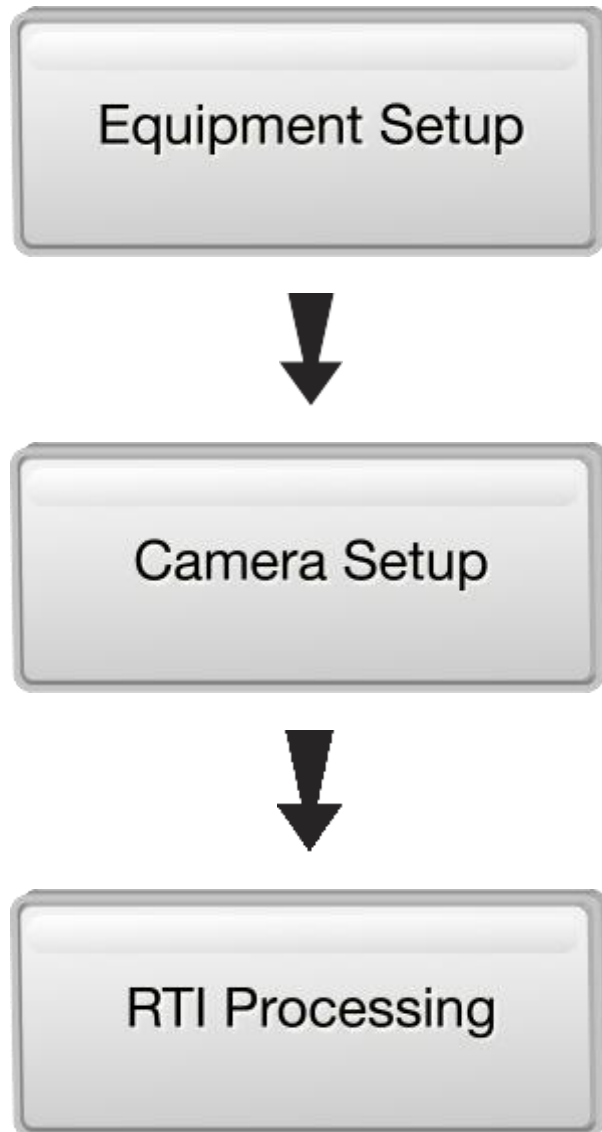
<http://okeeffeimaginingproject.wordpress.com/2012/0eight/26/photoscan-processing>.

Summary

- 1) Interface navigation and how to build the geometry of the mesh and align the photos.
- 2) Adjust the preferences.
- 3) Export RAW photo files to JPG.
- 4) Mask the photo to edit elements out of the picture.
- 5) Aligning the photos creates the point cloud.
- 6) Look at 3D model.
- 7) Go to Workflow to build the geometry of the photo.
- 8) The build geometry step is the longest step – can take several days or hours depending on quality of images, quality of mesh, number of photos.
- 9) Build texture in workflow option to view the texture of the building in 3D.
- 10) Can now save and export the mesh or the 3D model.

Methods:

RTI Workflow



RTI Workflow – Description of Methods

Equipment Setup, Camera Setup, and RTI Processing

Equipment Setup

1) Check batteries in camera and flash. Once the RTI capture sequence starts, touching the camera or moving it in any way is prohibited.

2) Assemble tripods and light stands.

2a) Be sure to secure or weigh down tripods with sandbags.

3) Assemble flash, battery pack, and receiver to mono-pod.

View the *Flash Assembly Tutorial* at:

<http://okeeffeimaginingproject.wordpress.com/2012/0eight/26/equipment-setup>.

4) Test flash to make sure wireless signal is working.

5) Secure camera to tripod making sure it is level.

6) Setup subject to be photographed.

7) Measure art using a measuring tape.

8) Measure and cut a length of string at least twice the length of the widest part of the subject being photographed.

9) Attach this string to the end of the flash.

9a) This will not only ensure correct distance of the flash from the subject, but will also help in aiming the flash in the correct direction.

RTI Workflow – Description of Methods

Equipment Setup, Camera Setup, and RTI Processing

Camera Setup

- 1) Determine correct lens size for framing and focus.
- 2) Align black spheres accordingly.
- 3) Align spheres in such a way that will allow you to easily crop them out of the photo.
- 4) Check that spheres are correct size. They should occupy at least 250 pixels of the picture. If unsure, take a picture and export photo into photo editing software to measure the sphere's diameter.
- 5) The center of the sphere should be level with the surface of the subject being captured.
- 6) Attach camera to computer using USB cable. Since touching the camera is not allowed, all shots will be taken remotely.
- 7) Start camera operating software and open a live view window.
- 8) Adjust ambient lighting in the room to the minimum amount that will still allow clear vision of subject and possible obstructions in the room. Subject and user safety is the top priority.
- 9) Focus the shot and take a picture, then open photo in editing software.
- 10) Check histogram to make sure even balance of color and light.
- 11) Continue taking test shots adjusting F-stop, shutter speed, flash light intensity, and ambient lighting until well lit even coloring is achieved in the test photo.

RTI Workflow – Description of Methods

Equipment Setup, Camera Setup, and RTI Processing

RTI Processing

View the RTI Processing Instructional Tutorial at:

<http://okeeffeimagingproject.wordpress.com/2012/0eight/26/rti-processing>.

Summary of processing captured RTI images:

- 1)** Select and name a project folder and a JPG/ export file.
- 2)** RTI captured image folder – RAW or DNG files.
- 3)** Open in Photoshop and export into JPG exports folder.
- 4)** Open RTI Builder Program – name the project, open project folder.
- 5)** Images are loaded; select an image to add - fine tune the window around the black sphere.
- 6)** Detect Spheres – uses edge detection and can resize the shape of the object in the image.
- 7)** Highlight Detection – determines the center of the highlights in the image.
- 8)** Crop out all of the unnecessary elements of the image.
- 9)** Download the PTMfitter.exe program - Open the RTI Viewer to find Finished Files.
- 10)** Choose to relight the image via specular enhancement to focus on the shape of the art and bring out the details with the adjusted lighting. Every pixel contains color data, surface normal data and calculates what the pixel would look like at different lighting conditions.
- 11)** When you relight the image you can examine the surface to see minute details – can see cracks in paintings and brushstrokes.

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RESULTS AND DISCUSSION

The purpose of this project was to test three imaging processes: Reflectance Transformation Imaging (RTI), Photogrammetry and Structured Light Imaging. Each uses different algorithms to construct detailed 3D images and data by capturing and assembling regular, 2-D digital photographs.

The following six objectives and results were addressed during this project.

- 1) Can off-the-shelf, high-end, consumer-grade digital cameras, and open-format digital photographs, combined with a consumer-grade lap-top computer be used to capture and assemble detailed, data-rich 3D images?

Absolutely – for both Photogrammetry and RTI processes there is a moderate amount of photography, and a whole lot of software.

Photogrammetry Process - Findings indicate that you can use an off-the-shelf laptop, and a high end consumer-grade camera, but you will need a lot of RAM and a good sized external hard drive to be able to capture the images in the highest resolution possible. This is the archival starting point. The process involves assembling many, many, overlapping photos to put together and assemble the point cloud.

RTI Capture Process - This was streamlined so that any laptop can handle the computations and provide 3D-rich data and images. We used 4 GB of RAM on Mac Book Pros, Sony EOS, and Canon Mark II camera with EOS capture software with no special upgraded RAM or software.

- 2) Is 3D imaging capture and processing techniques for RTI, photogrammetry and structured light imaging mature enough to be used, right now, in the summer of 2012, to capture accurate, detailed and digitally-rich condition information for works of art, historic objects and heritage architectural sites and features?

Structured Light Imaging - No. There are a few proprietary file formats, capture and assembly sequences available, some using laser technology. There are no open source or open file format capturing assembly software systems that are easily adaptable with a fully mature user interface. We had to set aside structured light capture since the two conditions of no open file format and a fully mature user interface weren't there.

RTI – Yes. It's totally mature. From the images, we could see microscopic protrusions (reaction between alkaloid pigments and moisture moving through the paint film, creating soaps that eat their way through the paint film) which are very difficult to see, in the surface of the paint. Shooting using RTI, the resolution is good enough to zoom in and see these micro protrusions and map them out for the first time. RTI can be used right now. It is being used at the O’Keeffe and is fully integrated in the documentation and conservation process at the Museum.

Photogrammetry – Yes, it’s possible to adopt it right now and integrate it into a preservation and conservation program, with the right amount of training and expertise. Using a consumer-grade laptop and camera to capture images, you still have to build the skill sets to get reliable and accurate 3D, photogrammetric photos and learn how to manipulate and look at the data you have. There is no robust training program out there to teach users how to take measurements and align point clouds, so it takes time to build the skill set necessary to understand and implement the photogrammetry work flow.

The interns had a steep learning curve and it took a lot of experimenting with the processes to get reliable and accurate photos. For example, the photos we shot of a wall of a house overlap each other by 60% and are taken in a sequence following a parallel line to the building. This overlap allows triangulation to create the 3D system, with the interns learning how to manipulate the resolution, distance from the subject, and estimate the number of photos to assemble to get reliable and accurate photogrammetric photos, without processing time taking several days.

3) In only eight weeks time could two graduate students and two collections technicians, with no prior experience in 3D imaging of any kind, become fully conversant and self reliant in capturing and assembling 3D images under the guidance of a conservator and 3D imaging engineers?

A resounding yes!

The summary data for this project was produced by two people that came with special skills. Greg Williamson has a background in software programming and image processing, while Joey Montoya has a background in digital photography and imaging. One of the data collection technicians dropped out of the project and the other technician had only limited time.

Carla Schroer and Mark Mudge, from Cultural Heritage Imaging, trained both interns. Williams and Montoya learned what software to use and what is available. At the end of the eight weeks, both interns were able to build an RTI and a 3D mesh using the photogrammetry skills they learned. This is quite an accomplishment since it takes time to build the skill set to master the photogrammetric process to create accurate 3D models.

One of the keys to this is that it pays to learn the photo end of the process really well. You have to shoot with a fixed lens and aperture and the focus cannot change. Plus, you have to make decisions before the image capture as to what the resolution will be, what lens to use, determine lighting conditions, and whether to use a tripod or handhold the camera.

The point is, the better the capture when shooting in RAW format, the higher the quality of the 3D images. These images have to be as good as they can be to create a powerful data set in the form of archival images you can assemble and use for the years to come.

In eight weeks, the two grad students got the logic of the process down and created great, consistent data sets to be used archivally. They could reliably hand hold the camera to do photogrammetry, do the flash manipulation in RTI and consistently build very high quality 3D assemblies.

4) To learn if the capture and processing of metadata (the digital capture conditions and digital pathways and transformations leading to the assembly of condition-detail-rich 3D images) could be

completely open-source and open-format, with no proprietary file formats or data pathways. In this way, scientifically valid digital lab notebooks can be kept and evaluated for their validity, replication and value. Further, with no proprietary files or computational pathways, all steps and all images belong to and reside with the public trust agency of the resource, rather than a private or commercial entity with no legal, public trust fiduciary requirements and restrictions.

With the Blender and MeshLab software we used, we could manipulate 3D data using an open source format. Canon camera EOS software was enough to do ambient light checks, checks histograms, and convert RAW images to a digital negative. It accomplished all of this, so proprietary software or file formats are not a must.

One of the goals of the program and the major advantages is that for 3D imaging to be scientifically valid for conservation and preservation purposes, you want the whole pathway to be as transparent as possible, so that's why open source and open formats are important. There are sophisticated laser scanning hardware/software systems that create detailed 3D surrogates, but they are proprietary. The files you end up with are proprietary and these files can be transformed like a PDF, but cannot be shared. Data capture and manipulation pathways are hidden, so we don't know how it occurs or what's going on inside.

We've incorporated proprietary programs like Adobe Creative Suite 6, which allowed us to batch process raw photos into digital negative formats (DNG formats) and saves all the captured metadata (date taken, exposure, aperture, color temperature of white balance, color calibration, DNG formats.) You can use the camera software but it is a more accelerated process using Adobe Creative Suite 6. The pathway and file format is open and can be used forever. We did not have to resort to a proprietary software system and have an intermediary step where the image is proprietary and then have to make something else from it.

While looking at a few additional software programs we didn't completely learn what allows more open source data sets. One software program was Open Source, a file and cloud compare software program. Another was software that the Bureau of Land Management uses to compare deterioration and damage of a landscape over time. This software uses proprietary file formats and processing pathways. The results are spectacular. The answer is there will undoubtedly be more developments in software so that if the data set is good enough, it will allow users to do amazing things and stick to an open file format.

The only time we used any proprietary software was when we employed Photoshop to manipulate the data to create a blueprint of one of the meshes.

One of the steps we want to get to with our historic homes is literally taking the current condition from the 3D solid that is constructed from the mesh and turning it into an accurate 3D blueprint or drawing. This would allow us to be able to rebuild any part of the historic structure exactly as it is, in the event part of it was damaged in a flood, earthquake or storm. The process to do that is proprietary since the pathway is an Adobe pathway and the file is sharable by other blueprint and CAD-like software. The original capture data and original mesh solid would still be open format.

5) To determine if the digital camera images could be captured and formatted archivally, using ISO digital standards (DNG). Then these images could always be used to assemble 3D digital surrogates far into the future, regardless of future improvements or changes in digital cameras, 3D assembly, editing software, computer operating systems and file formats.

We also wanted to determine if ISO standard file formats, in this case the accepted DNG, which is really an enhanced TIF format (where you capture it RAW and have a full resolution TIF plus all captured metadata) can be used to form archival capture sequences that can be used for decades to come to assemble 3D images.

The answer is a big yes and a big plus. Captured images are archival using a file format and capture format that every manufacturer will recognize and build processing around. This will live for as long as people can foresee into the future. What is recommended for ISO standards is to have the original DNG, so you can compress it as little or as much as necessary and also be able to alter the compression without changing the original DNG negative. Without the DNG negative, any changes made would be permanent.

Also, from the original data set we can create as many digital 3D surrogates as we want, yet retain the original DNG negative. An example of this is to show where outlines and rough textures in a building or wall are located, then take a high resolution digital negative file and change it into a low resolution JPG. We then assemble the 3D photogrammetry from that. If you need very high detail, like the length or offset of a crack, you'd be able to assemble just that area in very high resolution. There is a lot of flexibility as long as you have the original DNG capture.

6) Finally, can the digital, photographic, 3D files be computationally compared, by computer software, so that small, slow, incremental changes in condition, often missed by museum and heritage site professionals, be recognized by computer software and highlighted? This would help conservators make better assessments about the active and unstable nature of damage and deterioration to buildings and paintings.

This is the next step. We now have these great digital surrogates and we have captured a lot of detail and the question is: can we take the surrogate and compare it to another surrogate taken years before or years after and have the software highlight the apparent changes in the condition, so that a conservator or preservation professional can inspect it to determine if the changes are accurate?

It certainly looks possible and we would need more than eight weeks to get to know the software better and experiment with it. This website will continue to live and enhance the workflows and show you how our learning curve is advancing from this point on.

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CONCLUSIONS

The principle goal for this project was to test whether computational photogrammetric methods could be used to accurately document and monitor evidence of damage and deterioration using simple, high resolution digital photographs. Traditionally, expensive and complex laser scanning equipment and reconstructive software have been necessary to make accurate measurements of important condition changes in cultural heritage materials. This technology has the potential to put important documentation technologies into the hands of those who may have had difficulty affording the earlier technologies for the preservation of historic sites.

Cultural Heritage Imaging (CHI) developed 3D reconstruction digital computational technologies to be tested in this project and wanted to make the technologies available to as many historic site conservators as possible. The lack of appropriate field testing, however, means that other historic site conservators and preservationists, who obtain the technologies, will have to resolve, on a piecemeal basis, any difficulties they encounter in using them.

This project provided practical results in a short time and helps professionals in the historic site, object, and artwork preservation field to utilize emergent technologies in the most efficient way possible. Our project made these practical results available worldwide in real-time, on the Internet, using a Wiki format. Throughout the project, conservators were able to observe the case study, and post questions and suggestions on the Wiki, to which the team responded during the actual course of the case study.

The geographic distribution of the activity on the Web site includes interest from:

- USA and Caribbean - 9000 views.
- Europe - 4000 views.
- Central and South America - 700 views.
- Asia - 500 views. (China does not report by Chinese government regulation)
- Australia and New Zealand - 400 views.
- Canada - 325 views.
- The Middle East - 200 views.
- India - 70 view.
- Africa - 35 views.

Total of 15,230 views as of today.

The team used and developed protocols for three imaging processes: Reflectance Transformation Imaging (RTI), Photogrammetry and Structured Light Imaging. Each uses different algorithms to construct detailed 3D images and data by assembling regular, 2-D digital photographs.

The team successfully met the six objectives they set out to test and concluded that:

- 1) Off-the-shelf, high-end, consumer-grade digital cameras, and open-format digital photographs, combined with a consumer-grade lap-top computer were successfully used to capture and assemble detailed, data-rich 3D images. For Photogrammetry, the findings indicated that you have to beef up the RAM memory and also add a good-sized external hard drive to be able to capture the images at the highest resolution possible. The RTI process was streamlined to also use consumer-grade equipment.
- 2) 3D imaging capture and processing techniques for RTI and photogrammetry is mature enough to be used, right now, in the summer of 2012, to capture accurate, detailed and digitally-rich condition information for works of art, historic objects and heritage architectural sites and features.

RTI is totally mature and is currently being used at the Georgia O’Keeffe Museum and is fully integrated in the documentation and conservation process at the Museum.

It is possible to adopt photogrammetry and integrate it into a preservation and conservation program, with the right amount of training. It takes time to build the skill set to accurately capture images to get reliable and accurate 3D photos.

Structured light imagings is currently the only process that is not yet mature enough, since it has no open file format and a fully mature user interface isn’t available.

- 3) In only eight weeks time, two graduate students with no prior experience in 3D imaging of any kind became fully conversant and self reliant in capturing and assembling 3D images under the guidance of a conservator and 3D imaging engineers. Both Joey and Greg came to the program with skills in software programming, image processing, digital photography and imaging. This helped them tremendously and they rapidly learned the CHI software to successfully create great and consistent data sets, in the field, to be used archivally.
- 4) We learned that the capture and processing of metadata (the digital capture conditions and digital pathways and transformations leading to the assembly of condition-detail-rich 3D images) can be completely open-source and open-format, with no proprietary file formats or data pathways. In this way, scientifically valid digital lab notebooks can be kept and evaluated for their validity, replication and value. Further, with no proprietary files or computational pathways, all steps and all images belong to and reside with the public trust agency of the resource, rather than a private or commercial entity with no legal, public trust fiduciary requirements and restrictions.

The only time during the project that we used proprietary software was when we employed Photoshop to manipulate the data to create a blueprint of one of the meshes. Throughout the process, we didn’t have to resort to a proprietary software system and have an intermediary step where the image is proprietary and then have to make something else from it.

- 5) We can use ISO standard file formats, in this case the accepted DNG, which is really an enhanced TIF format, where you capture it RAW and have a full resolution TIF, plus all captured metadata, which can be used to form an archival capture sequences that can be used for decades to come to assemble 3D images.

Captured images are archival using a file format and capture format that every manufacturer will recognize and build processing around. This will live for as long as people can foresee into the future. What is recommended for ISO standards is to have the original DNG, so you can compress it as little or as much as necessary and also be able to alter the compression without changing the original DNG negative. Without the DNG negative, any changes we make would be permanent.

- 6) The next step is that we now have these great digital surrogates and we've captured a lot of detail. Can we take the surrogate and compare it to another surrogate taken years before or years after and have the software highlight the apparent changes in the condition? Subsequently conservators or preservation professionals could then inspect these surrogates to determine if the changes are accurate.

It certainly looks possible. Further research and additional time would be needed to get to know the software more fully.

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<http://www.si.edu/MCIImagingStudio>

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<http://www.blm.gov/nstc/library/pdf/TN428.pdf>

Resource for Stereo Photogrammetry.

Neffra Matthews

Tom Noble

Hyperspectral Imaging

http://www.nap.edu/openbook.php?record_id=11413&page=120

Alternative Resources for Stereo Photogrammetry.

Royal Society of Chemistry

<http://www.rsc.org/chemistryworld/News/2012/April/medieval-art-illuminated-manuscript-near-infrared-spectroscopy-analysis.asp>

Resource for Hyperspectral Imaging.

The Getty Institute

http://www.getty.edu/conservation/our_projects/science/lighting/lighting_component2.html

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[_http://cct.newmexicoculture.org.](http://cct.newmexicoculture.org)

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REFERENCES

There are no references since this project was based on original research.