

Designing the Next Generation Virtual Museum: Making 3D Artifacts Available for Viewing and Download

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Abstract

A search for “virtual museum” on the web returns a variety of fundamentally different websites. From sites that host photo collections to those with “interactive” QuickTime tours, the common thread with current online virtual museums is that they use a form of innovative digital media to present content. The Virtual Hampson Museum Project is a next generation virtual museum that provides high-resolution, 3-dimensional data of scanned artifacts from the Native American collections at the Hampson Archeological Museum State Park in Wilson, Arkansas. The Virtual Hampson Museum Project uses close range 3D laser scanning to document and digitally archive over 500 artifacts from the collections in Wilson. While the collections at Hampson are known by most in the archeological community, they are not widely known to the public. Visitors to the online museum can view the artifacts in full 3D within their browser window using tools available in Adobe Reader. Additional high and low resolution versions of the artifacts are available for download in a number of common 3D formats (VRML/X3D, OBJ and PDF). Interested researchers, and others, can use a free software package that permits very detailed analysis to be conducted on one’s own computer. They can perform a range of measurements, create cross-sections and do comparative analyses of the artifacts. Under Creative Commons license, the 3D objects can be reused in other visualizations and 3D contexts. This paper will present the challenges in compiling, distributing, and presenting a large number of 3D datasets in an online environment. By combining 3D laser scanning for digital artifact curation and the internet as a distribution platform, the Virtual Hampson Museum Project goes beyond typical online virtual museums and provides accurate 3D data of museum artifacts for public viewing and use and provides users the necessary tools to explore, view, and even analyze the Virtual Hampson collection.

Keywords: virtual museum, 3D laser scanning, 3D models, 3D artifacts, online collection

1 VIRTUAL MUSEUMS

In the top ten search results for “virtual museum” on Google, there are entries ranging from the Virtual Museum of San Francisco to the Virtual Museum of Minerals and Molecules. Werner Scheweibenz states that virtual museums are still “under construction” and that they lack a generally accepted definition and definitive terminology. Scheweibenz goes on to provide a “working definition” of virtual museums as a “logically related collection of digital objects composed in a variety of media ...it has not real place or space, its objects and the related information can be disseminated all over the world.”¹

Scheweibenz’s definition alludes to the inseparable link between virtual museums and multimedia. According to Wikipedia, pioneer online museums (pre-2000) were developed in a time when “web pages were simpler, bandwidth was scarce and there were limited

multimedia technologies available within web browsers.”²

The first graphical interface for the internet, the Mosaic Browser, wasn’t even introduced until 1993, and Adobe Flash, the most popular multimedia venue on the web today, came along only in 1996. The progression of virtual museums over the last 20 years has been inextricably tied to simultaneous advances in computing, the internet, and data acquisition techniques.

Today, online virtual museums are becoming more immersive and interactive, promoting richer visitor experiences with their collections using the latest in multimedia innovations. While some are more successful than others, those at the top are seen as not only using the latest and best technology but employing those resources effectively. The Virtual Museum of Canada is one of the best examples of a media-rich yet easy-to-use virtual museum boasting over 225 different exhibits with embedded digital videos, QTVRs,

²“Virtual Museum,” *Wikipedia, The Free Encyclopedia*. Wikimedia Foundation; http://en.wikipedia.org/wiki/Virtual_museum (accessed May 25, 2009).

¹Werner Scheweibenz, “Virtual Museums,” *ICOM News* 3 (2004): 1.

animations, 3D models, games and much more. Other virtual museums are not as successful and ultimately become plagued by the technology that drives them. For example, some sites overuse Flash technology, which can lengthen a website's load time and affect its overall performance. Others boast the latest in 3D object viewing technology but then do not offer the proper plug-in that allows users to view the content. In these instances, the technology restricts information access and in the case of the internet, most visitors will simply move on.

The Virtual Hampson Museum is a next generation virtual museum that provides hundreds of accurately scaled, photorealistic 3D representations of artifacts. The Virtual Hampson Museum has been designed so that users of all ages and backgrounds can easily access and view the collection, regardless of differences in browser type, platform, or connectivity speeds. The museum employs the latest Adobe 3D PDF technology, which allows visitors who have the latest version of Adobe Reader to view and manipulate the artifacts directly in their browser window. Adobe 3D PDFs offer object measurement capabilities as well as cross sectioning, an advantage not available in other standard 3D formats. However, users also have access to the artifact models in other 3D formats such as OBJ and VRML and can download any of the desired models for use in their own applications under Creative Commons Licensing. The Virtual Hampson Museum is very successful in providing multiple avenues of access to an amazing collection of 3D artifacts. In creating the first museum of this kind, however, the development team has encountered numerous challenges that will be discussed more fully here.

2 PROJECT BACKGROUND

The Virtual Hampson Museum project began in summer of 2007 with the mission to digitally document the amazing collection of whole pottery vessels and other associated artifacts located at Hampson Archeological Museum State Park in Wilson, AR. The Hampson Museum Collection represents one of the world's most extraordinary collections of American Indian artistic expression and is also a major source of data on the lives and history of late pre-Columbian peoples of the Mississippi River Valley. The collections at the museum are the result of extensive excavations of the Nodena Site, and excavations at other sites in the region by Dr. James K. Hampson, as well as work by others, including the University of Alabama and the University of Arkansas. The collection is particularly renowned for the nearly 1,000 complete pottery vessels that are the result of the care in excavation techniques employed by Dr. Hampson and others (see fig. 1).

Yet while the museum and its collections are well known in selected archeological circles, its extraordinary materials are not widely known. The

Virtual Hampson Museum Project was initiated to improve the visibility and accessibility of these materials, making them more available to both the public and scholars.

3 DATA ACQUISITION AND MODEL PROCESSING

The Konica Minolta VIVID 9i laser scanner was chosen to scan and document the collection. The VIVID 9i is a close range laser scanner that produces high resolution, photorealistic 3D models of objects. The unit has a scan range of 0.5–1 meter and can capture micron level detail of small objects. The system was used in conjunction with a calibrated turntable to help automate the scan process.



Figure 1. *Samples of Native American pottery found at Hampson Archeological State Park.*

At the beginning of the project, it was clear that a professional lighting setup similar to that used for product photography was necessary to capture accurate RGB information for the artifacts. By uniformly lighting the object from all directions with a combination of white light fluorescent bulbs, we were able minimize the effect of shadows across the object and eliminate the impact of ambient light from the surrounding environment. The result is a more accurate capture of the true color of an object's surface (see figure 2 for setup with VIVID 9i). Smallwood et al. provide more details on this setup.¹

At the beginning of the scan process, the turntable is calibrated with the system software, in this case, PolyWorks (from InnovMetric Software), such that a

¹S. Smallwood et al., "Lighting Systems in Three Dimensional Non-Contact Digitizing," paper presented at the 37th Annual International Conference on Computer Applications and Quantitative Methods in Archeology (CAA), Williamsburg, Virginia, USA, March 22–26, 2009.

single 360° rotation of an object, comprised of six scans, is automatically aligned. The object is placed on the turntable and a series of rotations are conducted depending on the size and complexity of the object. For a standard water bottle, a rotation is performed around the top and bottom of the object and then the object is laid on its side and a single shot is acquired of the base or underside of the object. In this case, a total 13 scans were acquired. A scan typically consists of hundreds of thousands of individual points that have XYZ surface information as well as RGB color information.



Figure 2. Scan Setup with VIVID 9i and professional lighting rig.

All objects are initially processed in Innovmetric's PolyWorks suite. Following scan completion, the individual scans and/or rotations for an object are aligned to one another using N point pairs. Following complete alignment, a single scan is selected and locked, and a global best fit alignment is performed to fine tune the alignment. Due to the significant overlap between scans, a reduce overlap function is additionally performed to remove extensive areas of overlap and prepare the model for meshing. While the lighting setup used during the scan process minimizes color or hue inconsistencies, slight variations in brightness may still occur between scans on an object (see figure 3). Because Polyworks does not have built-in functionality to adjust a scan's color or RGB value, objects that need additional color correction will need to be exported at this stage and adjusted in Rapidform XOR (from INUS Technology). In Rapidform, the processor can adjust the hue, brightness, contrast, and other color properties of a scan. Despite the more advanced color editing tools in Rapidform XOR, some artifact models cannot be accurately color corrected; any model where the color is judged as not accurately representing the original artifact will have the color completely removed from the final digital product.

Following alignment and optional color correction, a polygonal mesh of the object is created. Following mesh completion, additional cleanup and hole-filling is required. Data spikes are removed from the model, holes are filled, and some objects undergo additional partial or whole smoothing as needed. Once a model is processed, it is ready for web preparation (see section 5).

4 DESIGNING THE VIRTUAL HAMPSON MUSEUM

One of the most prevalent issues affecting the design of the Hampson website was the question of how best to convey or deliver 3D objects in a 2D environment. The Virtual Hampson Museum was designed using a combination of Adobe Flash, pre-set object animations, and Adobe 3D PDFs. In addition to conveying 3D content, it was essential that the site be dynamic, allowing for material to be added and updated periodically. Adobe Flash was chosen for its ability to deliver rich multimedia content as well as the ability to interface with a dynamic MySQL database. Preset object animations that displayed the 3D artifacts from different viewing angles were seen as the best means to instantly convey the true 3D quality of the collection. While VRML, X3D, and other web 3D viewers were considered, it was decided that these viewers should not be part of the primary navigation of the site, as they can restrict information access if the user chooses not to download the required plugin. Instead, the Hampson website features an optional Adobe 3D PDF that loads in a second browser window and requires Adobe Reader 8.1 (or higher) for viewing.



Figure 3. (top) Photo of artifact. (bottom left) Brightness variation between scans—note variation is not present on object in photo. (bottom right) Completed model with brightness variation corrected in Rapidform.

Adobe 3D PDFs were chosen because they have several advantages over the more traditional 3D viewers. The Virtual Hampson Museum is intended for the general public as well as for scholars interested in studying the collection, and a PDF was thought to be more universally recognized and accepted by museum visitors. It is also cross-platform (Mac and PC) and cross-browser compatible (Internet Explorer, Firefox, Chrome, Safari, and others), whereas other viewers tend to operate on a more limited range of configurations. Finally, it retains the scale of the artifacts carried over

from the digitization process, allowing end users to actively measure and perform cross sections on the artifacts, a functionality that is currently unparalleled by any other free 3D viewing application (see figure 4 for PDF cross sectioning and measurement capabilities).

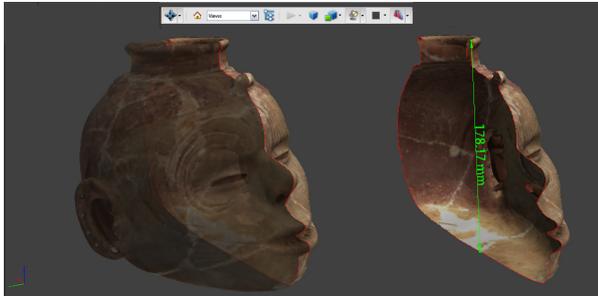


Figure 4. Measurement and cross section PDF functions within a browser window. (left) Cross section of artifact with half of model shown transparent. (right) Cross section with measurement.

In addition to the object animations and the 3D PDF viewer, the models are also provided in other standard 3D formats, including a low resolution VRML and OBJ file and a high resolution OBJ file. In addition to providing the files themselves, users are also referred to free compatible viewing software for each file type in the “About the Models” section of the web site. The high resolution OBJ files are the original, high resolution mesh for each object and are provided for research scholars interested in more detailed metric analyses. Again, a free downloadable viewer, in this case Rapidform BASIS or Explorer, is suggested for viewing the high resolution files. An additional discussion of the functionality of the BASIS viewer is provided below. In total, each artifact is available for download in four different formats (High resolution OBJ, low resolution OBJ, VRML, and PDF) from the Virtual Hampson Museum. A variety of download options is provided to the user in an effort to streamline access to the digital Hampson collection (see figure 5 for final layout).

Finally, all downloaded materials on the Virtual Hampson Museum website are provided for public use and consumption under Creative Commons Attribution-Noncommercial-Share Alike 3.0 Unported License. Creative Commons is a set of standardized copyright licenses that define “the spectrum of possibilities between full copyright and public domain” and is particularly suited for defining ownership of materials via the internet.¹ The Creative Commons Attribution-Noncommercial-Share Alike 3.0 Unported License for the Virtual Hampson Museum allows visitors to use any of the downloaded materials in their own non-commercial applications with proper attribution or accreditation to the museum.

¹“About Creative Commons,” *Creative Commons*. <http://creativecommons.org/about/> (accessed May 25, 2009).

5 PREPARING 3D MODELS FOR THE WEB

After the models have been initially processed (see section 3), they are then prepared for the web. To create the downloadable files for each artifact, Rapidform 2006 is used. An essential part of the process is to preserve the original image detail of the artifact for the decimated or low resolution models. When the object is scanned by the VIVID 9i, the color or RGB information is tied to the individual vertices of the model (XYZRGB). When the model is decimated at this stage, reducing the triangle and vertices count, the color information is also decimated (see figure 6) leaving a unrealistic appearance. In the workflow developed for the Hampson Museum, prior to decimation, Rapidform 2006 is used to extract the RGB information from the original model and assign it to a separate JPG file. The model can then be decimated and the original image texture preserved and reapplied to the reduced model.

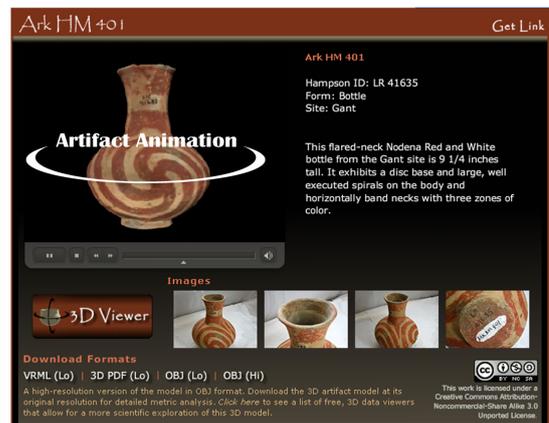


Figure 5. Final design for viewing artifacts in the Virtual Hampson Museum.

Once an artifact has been completely processed and the color quality is deemed acceptable, the models are imported into Rapidform 2006 and the RGB data is extracted to a JPG. If the color information does not accurately reflect the original artifact, the RGB data is stripped from the model and the model is published as gray scale. From here, the high resolution OBJ file is exported. The models are then decimated or reduced to a standard polygon count of 25,000 triangles for full color models and 100,000 triangles for gray scale models and the low resolution OBJ file is exported. The low resolution OBJ is then imported into Vivaty studio and used to generate the VRML file. The VRML is then imported into Adobe Acrobat and used to generate the 3D PDF. The video animation for the artifact is prepared using the high resolution OBJ file in PolyWorks IMInspect. All videos are rendered as AVIs in 800 x 600 resolution and later converted in a batch operation to Flash FLV format with 400 x 300 resolution.

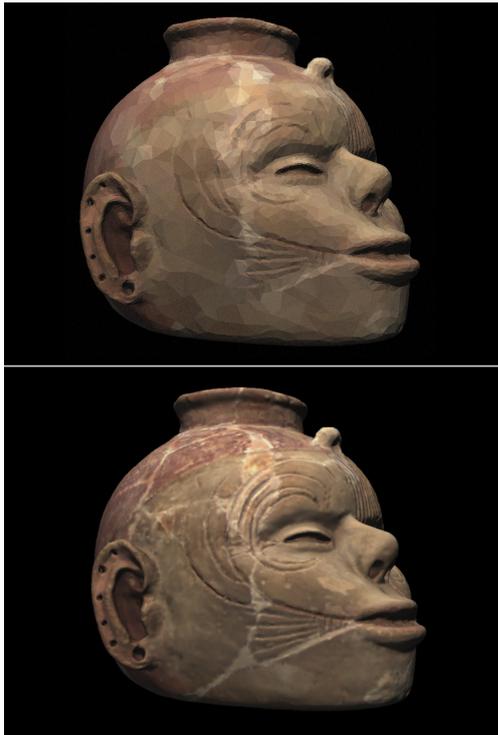


Figure 6. (top) Decimated object with color information not preserved. (bottom) Decimated object with original color image preserved and reapplied.

6 HIGH RESOLUTION MODELS AND THE ADVANCED VIEWERS

While the 3D PDFs are good for approximate measurements, the high resolution OBJ files are the most accurate representation of the original object. These can be downloaded along with the free Rapidform BASIS or Explorer viewer for more detailed metric analysis. BASIS is a reduced version of the complete Rapidform 2006 product that provides users with measurement and analysis tools. These include 2D measurements, 3D surface measurements, radius, angle, volume and more (see figure 7). In addition, users can also create more detailed cross sections and view an object's curvature map, which can be very useful for defining finer surface details. Both BASIS and Explorer are excellent applications for more detailed explorations for each artifact.

7 PROJECT CHALLENGES AND LIMITATIONS

The Virtual Hampson Museum project has encountered numerous challenges since its inception in 2007. As discussed above, the biggest challenge in the beginning was determining the appropriate lighting conditions for scanning the artifacts. However, even with the introduction of the lighting system, it was determined that subtle changes in an object's shape coupled with how it was positioned on the turntable could still produce variations in brightness between scans. As a

result, scans still required additional color balancing or adjustment, which could only be efficiently processed in the Rapidform XOR software. It is recommended that those interested in accurate color/RGB acquisition using the VIVID 9i laser scanner have a software solution such as Rapidform that can adjust the color properties of individual scans.

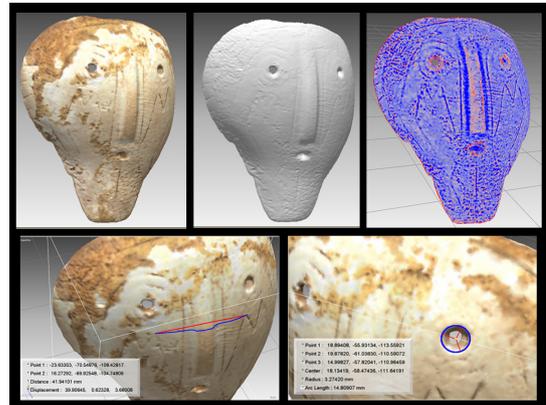


Figure 7. Rapidform BASIS Viewer. (top left) Shell mask artifact shown in full color. (top center) Shell mask artifact shown in gray scale. (top right) Shell mask artifact curvature map used to delineate finer incisions on artifact surface. (bottom left) 3D Surface Measurement. (bottom right) Radius Measurement.

It was also difficult to obtain complete models of some of the artifacts in the collection. For the VIVID 9i to accurately record data for an object, the laser beam has to be returned to the unit's sensor. When scanning ceramic vessels such as bowls and jars with steep interior walls, it was difficult if not impossible to obtain complete data for the objects' interior. The laser's acute angle of incidence on steep and/or concave surfaces made it difficult for the laser to return to the unit and for the surface to be measured. Narrow-mouthed bottles and jars were also problematic because there was simply no access to the interior surface data. As a result, there are several items in the collection that do not have recorded interiors (see figure 8). Another major hurdle for the project team was determining the optimal workflow for processing the models and preparing them for the website. A key focus in creating the low resolution downloads was for them to retain a strong visual resemblance to the original object. During the decimation process, it is not uncommon for an object's surface geometry to be reduced by more than 90%. For example, the original high resolution file for the headpot shown in figure 7 has 647,169 triangles. The low resolution version has 25,000 triangles, which is more than 96% data reduction! Again, one of the key approaches to retaining an object's identity is by preserving the original detail in the color or texture data and reapplying that to the decimated forms as discussed above. The project team also identified key options when generating the VRMLS and PDFS that enhanced

the quality of the low resolution models. These included specifying smooth versus flat polygon faces and generating double sided objects so that the back sides of triangles could be rendered in viewing applications. While the quality of the low resolution models was retained, the models do not render the same in *all* of the different viewing software available. If a viewing application applies additional texture compression, particularly mip-mapping to the image texture, the model is not rendered correctly (see figure 9). Because the problem occurs on the software side, this was not a problem that the project team could easily troubleshoot. As a result, in the “About the Models” section of the website, the team has provided a list of viewers that have been tested and found to work well with the artifacts from the virtual museum.

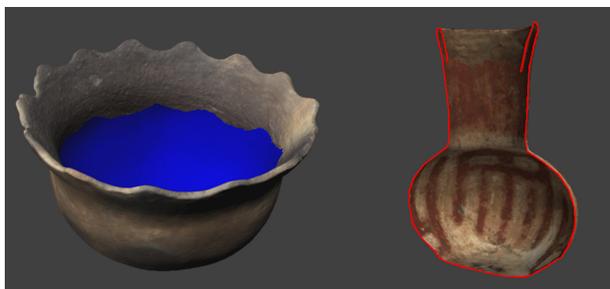


Figure 8. (top) Scanned bowl missing interior data (shown in blue). (bottom) Cross section of bottle depicting absence of interior.

8 CONCLUSIONS

To date, over 500 artifacts have been scanned by the Virtual Hampson project team and over 300 are currently available online. While the project has encountered numerous challenges throughout its course, we believe that the Virtual Hampson Museum is unlike

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“Virtual Museum” *Wikipedia, The Free Encyclopedia*. Wikimedia Foundation. 25 May 2009 http://en.wikipedia.org/wiki/Virtual_museum.

any other on the web today. By combining 3D laser scanning for digital artifact curation and the internet as a distribution platform, the Virtual Hampson Museum Project provides unparalleled access to hundreds of highly accurate 3D artifacts.



Figure 9. (top) Correctly rendered water bottle. (bottom) Bottle rendering with mip-mapping compression.