On-A-Slant Virtual Village: Constructing a 3D Stereo Imaging Exhibit

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ABSTRACT

This paper summarizes the technology used by the North Dakota State University (NDSU) Archaeology Technologies Laboratory (ATL) to build a three-dimensional (3D) stereographic exhibit for public entertainment and education. The exhibit is based on archaeological, historical and ethnographic records of the On-A-Slant Virtual Village, a Native American village site situated on the grounds of Fort Abraham Lincoln State Park in central North Dakota, USA. The village was occupied between the 15th and late 18th Centuries by the Mandan Indian tribe and was abandoned in 1781 following a devastating smallpox epidemic. The construction and implementation of this exhibit required the use of a variety of technologies. The village reconstruction was generated using Alias' Maya Unlimited 3D authoring software. We used a Minolta Vivid 900 3D non-contact laser digitiser to generate 3D models of artefacts recovered from the On-A-Slant site. Four of these models were then embedded within a 3D reconstruction of the village. The simulation was also populated with avatars depicting Mandan Indians engaged in a variety of daily tasks, as well as animated dogs and horses. Using Maya's rendering software and three distributed rendering networks consisting of 182 computer processors, we created over 30 000 individual TIFF images. The entire rendering process lasted 3 weeks and ran 24 hours a day. These images were then cropped using the automated batch tools of Adobe Photoshop to create over 30 000 stereo projection frames – 15 000 for the left eye and 15 000 for the right eye. The stereo projection frames were then imported into Adobe Premier video editing software where a surround sound audio track was added that incorporates narrator voiceovers and ambient environment sounds.

A video file was exported from Premier for both the left and right eyes. Using Adobe Encore DVD production software and equal-length exported video files; separate DVDs were created for each eye. For the exhibit, these DVDs are played back on two separate synchronized DVD players, each of which is connected to a separate projector of the VizEverywhere dual, polarized-light projection system. When viewed through polarized light glasses, the video display appears as an immersive stereo image. The use of 3D stereo imaging further heightens the realism for the audience by creating an immersive as-though-you-were-there experience. The end product of this project is a high-detail, 12 minutes stereo image documentary that portrays the daily life of the Mandan people in the year 1776.

INTRODUCTION

This paper summarizes the technology used by the North Dakota State University (NDSU) Archaeology Technologies Laboratory (ATL) to build a three-dimensional (3D) stereoscopic exhibit for public entertainment and education (On-A-Slant, 2005). The exhibit is based on archaeological, historical, and ethnographic records of On-A-Slant Village, a Native American village site on the grounds of Fort Abraham Lincoln State Park in central North Dakota, USA.

1. SITE BACKGROUND

On-A-Slant Village was one of seven to nine Mandan Indian villages along the Missouri River in central North Dakota during the 18th century. The Mandan people were sedentary farmers whose main crops where corn, squash, and sunflowers. Mandan dwellings were earth lodges that were constructed of logs, a willow-branch thatch, and a thick outer earthen layer. The Mandan abandoned On-A-Slant, and the other villages, after the devastating small pox epidemic of 1781. The remaining Mandan people moved farther up the Missouri River, establishing new villages near those of the friendly Hidatsa tribes.

The On-A-Slant Village was named for the ground on which it stood. The site is bordered by a steep ravine on one side, the river on another, and a log palisade around the other sides. These defenses protected the village from raids by the Sioux and other more by war-like tribes of the northern plains. On-A-Slant Village had been visited by Euro-American traders and explorers in the 18th century. Along with several other Mandan villages, On-A-Slant had been plotted on maps as early as 1719.

2. SITE SELECTION

The years 2004-2006 marked the bicentennial anniversary of the Corps of Discovery Expedition led by Meriwether Lewis and William Clark into the vast land purchased by the United States from France in 1803. This land, known as the Louisiana Purchase, covered the middle third of what is now the United States. It began at the Gulf of Mexico in the south and stretched to what is now the U.S.-Canadian border in the north, and westward from the Mississippi River to the Northwest Pacific coast. To celebrate the accomplishments of the expedition, each state through which the Corps passed is hosting a commemorative "Signature Event". In North Dakota, that event took place October 22-31, 2004, and was entitled the "Circle of Cultures Signature Event".

Funding for signature events was legislated by the U.S. Congress to facility event organization. The Circle of Cultures was organized by the Fort Abraham Lincoln Foundation (FALF), a private, non-profit, fundraising organization dedicated to the preservation of archaeological and historical sites found on the grounds of the Fort Abraham Lincoln State Park (FALSP). FALF President Tracy Potter wanted a special exhibit for the event, and contacted the ATL, about creating a 3D virtual reality exhibit that would highlight the use of state-of-the-art technology for giving the general public an enhanced understanding of the past.

There were two reasons for selecting On-A-Slant Village for the event's virtual reality exhibit. First, as the fundraising arm of FALSP, FALF could guarantee ATL personnel access to, and documentation about, the site. Second, the Corp of Discovery rested near the abandoned village site on its expedition up the Missouri River. He was told that the people who had lived there had moved farther upriver (Jenkinson and Ronda, 2003, p. 59). Third, it was the friendship of the Mandan Indians, along with the Hidatsa tribes, that allowed the Corp to survive the harsh winter of 2004-2005.

Any virtual reality (VR) model simulating a place in the past can only represent a single slice in time. Such a model, therefore, constitutes a "simulation slice" of a site as it might have existed at one time in its changing history. We selected a simulation slice that would be representative of the Mandan people near the time of the Corps of Discovery expedition. For symbolic value, we chose the year 1776, when On-A-Slant was home to approximately 1,000 people and the village was at the height of its prosperity. This time slice, is thus well represented in the archaeological record and in ethnohistorical accounts. Furthermore, we chose to highlight village life as it may have been in late summer to show the gardens and stress the agricultural subsistence of the Mandan.

3. STEREOGRAPHIC VIDEO VS. INTERACTIVE ENVIRONMENT

Work to develop "On-A-Slant: A Mandan Village in Virtual Time and Space" took place at the ATL over thirteen months, although the pace of work accelerated significantly over the last couple of months before its debut. An early decision was required as to whether the exhibit should take the form of an interactive 3D environment accessed at computer kiosks and much like a modern 3D video game, or whether it should be delivered as a traditional animated 3D film. Working with the FALF, we identified five criteria on which to base the decision.

The first of these criteria is that the exhibit must have an immersive "wow" factor. In other words, it must be sufficiently impressive for the viewers to suspend their disbelief and actually feel as though they are viewing another time and place, one that is before the arrival of the Corp of Discovery.

The second of the criteria was that the exhibit must be educational. It must relay factual information about the people and place of the On-A-Slant Village. In other words, it must be a successful example of an informal educational experience. Along with adults and families, several thousand school children would be bussed to the event as a class field trip.

Third, the exhibit must be easy for Signature Event visitors to experience so that it is accessible to the widest audience possible. The virtual village exhibit would have an audience with a diverse background, ranging in ages from young children to elderly adults, and while many visitors would have basic computer skills, many others would not.

The fourth of our criteria was that the technology behind the virtual village exhibit be easy to maintain by novice, volunteer operators. The exhibit would need to be designed to operate without close supervision of the technicians who developed it. Virtual village exhibit developers could not count on the volunteer operators having the training necessary to troubleshoot complex computer problems.

The last of our criteria was that each visitor should have a limit to the amount of time each is allowed to experience the exhibit. Over ten thousand visitors were expected to attend the Signature Event, allowing visitors to spend as much time with the exhibit as each desired could cause many other visitors to not have access to it.

After comparing the capabilities and limitations of an interactive option with that of the traditional animation, we chose to develop a virtual village exhibit that was based on traditional 3D animation technology used in films.

While interactive environments certainly have a "wow" factor for teenagers and young adults, we felt that many other age groups would be frustrated by the skills necessary to operate such game-like environments. Interactive 3D environments also require a fair amount of computing power to display a quality 3D image at a real-time frame rate. Reliable software, such as game engines, for delivering this content on these platforms was also expensive, and we felt that less expensive options were not 100% reliable at the time. We also knew that if the 3D kiosks crashed during the Signature Event, there was a real possibility that the virtual village exhibit would not be available for the remainder of the event's run. Additionally, interactive 3D environments are generally self-directed experiences. Thus, we could not guarantee that the user would be exposed to a significant amount of educational material in the time allotted for each visitor, which we estimated should be under ten minutes.

4. DISPLAYING THE STEREOSCOPIC VIDEO

In developing a traditional 3D animation version of the virtual village, we chose to follow the techniques established by Paul Bourke and David Bannon (Bourke and Bannon, 2002), although we differed from their methods in four important ways. First, our stereoscopic projection was setup as a front projection system. Second, we removed the need for the use of a computer by replacing it with a single push-button DVD synchronization box that was developed by Dave Jones Design (Jones, 2002). Third, while we performed the procedures designated by Bourke and Bannon for generating stereopair images, we did not generate them using the same software. Unlike Bourke and Bannon, who used PovRay, we created our stereopair images using Alias' Maya Unlimited 3D authoring software (Alias, 2005). Lastly, while Bourke and Bannon created their DVD's using Apple digital video and DVD production software, we did our DVD production using Adobe's Digital Video Collection software on a Windows-based PC system. By using these techniques, we were able to develop a stereo-projection, virtual village exhibit that was simple for volunteers to operate, and required no technical support.

The great advantage of the ATL-enhanced Bourke and Bannon stereoscopic display technique is that it is extremely efficient. Once set up, the display system can be controlled easily by a novice operator who has received less than a minute's worth of training. The simplicity of the system allows it to be extremely stable, thus requiring no technical support training for the operator. This ease-of-use and stability factors are very important in small museum settings where there are neither personnel nor the funding to devote to the operation and upkeep of a stereoscopic 3D visualization system.

Control of the entire stereoscopic playback system is done through a single push-button. The push-button is connected to a DVDPlay synchronization device (Jones, 2002). This device is a programmable microcomputer ($750 U.S.) that sends out a black burst signal to two commercial DVD players. The DVDPlay device contains no moving parts such as a hard drive or operating system, and thus it is very reliable. The DVD players used in the ATL system were Pioneer DVD-V7400's ($800 US each), the European equivalent of which can be found on the Dave Jones Design Web site. These players were recommended by Bourke and Bannon because each DVD player is capable of being synchronized through an outside signal. In our case the signal was provided by the Dave Jones Design DVDPlay device. This device was specifically created to interface with these players, using black burst.

Each DVD player contains a DVD disc of the same type that one might rent from a video store. One DVD disc contains a 3D rendered video file created to for the right-eye. The DVD disc in the other DVD player contains a 3D rendered video file created for the left-eye. Should either disc be viewed through a traditional television setup, the audience would notice that the video presentation is slightly off-center. Each video file is of exactly the same length in frames, and must contain an audio track that is used for DVD synchronization.

Black burst synchronization allows each of the DVD players to advance one frame of the video at the same moment. Without synchronization, the video playback of each DVD can be off by several frames. If the DVD players are not on the same frame number of the video playback, the stereoscopic effect of the movie is lost.

In our system, each of the DVD players is connected to a separate high-end DLP projector. For this particular application of the technology, we chose to use a CyViz (formerly VizEverywhere) Viz3D passive-stereo projection system (Viz3D, 2005). The system consists of two DLP projectors mounted in an adjustable metal bracket, with a separate polarized light filter covering each lens. The Viz3D system requires a special silver-lined screen to preserve the polarization of light when it is reflected back to the viewing audience.

The final step in the viewing process occurs when the polarized light is blocked by a pair of polarized filter glasses worn by the audience members. The left lens blocks the light meant for the right eye, and the vice versa for the right lens of the glasses. Each of the audience member's two eyes thus receives a custom video created specifically for that eye.

5. DVD PRODUCTION

The production pipeline needed to produce the eye-specific video files required several different software applications and operators who knew how to take advantage of each software application's capabilities. A discussion of the rendering process is beyond the scope of this paper, but those interested in learning more about the creation of stereoscopic video should visit the Bourke and Bannon Web site. The production pipeline went as follows: 1) Maya Unlimited – the following were modeled in Maya: terrain, vegetation, people, objects, and animals; 2) Maya Software Render – Individual frames were rendered using a network of over 80 rendering computers; 3) Adobe Photoshop 6.0 – used for various imaging needs, texture mapping and batch image cropping of rendered images; 4) Adobe Audition 1.0 – edited audio files, created 5.1 surround sound; 5) Adobe After Effects 6.0 – used in creation of Rolling Credits; 6) Adobe Premier Pro 7.0 – put individual rendered frames in order, added surround sound audio, exported completed AVI video files, and surround sound WAV files; and 7) Adobe Encore 1.0 – provided a controlled DVD authoring environment for frame-specific placement of AVI files, WAV files, and DVD chapter markers. Total cost of all software used is $1,450 – academic pricing.

6. CONCLUSION

The goal of the On-A-Slant Virtual Village exhibit was to create an engrossing and educational experience that appealed to a wide audience, while keeping the exhibit easy to operate and maintain. By following the techniques of Bourke and Bannon, and altering them with techniques of our own, we were able to accomplish our goal. More than 9,000 visitors saw the virtual village exhibit during the Circle of Cultures Signature Event. It is now slated to be put on permanent display at the Fort Abraham Lincoln State Park Museum in the summer of 2005.

7. ACKNOWLEDGEMENTS

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