Interactive Virtual Reconstructions: Visualization and User Interface Design for Installations in Public Venues

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Abstract

This paper presents two case studies in which the objective was to accurately reconstruct a historically significant place no longer accessible to the public due to complete or partial destruction of the original environment. In both cases the desire was to present the reconstructions in a public venue for the purpose of enlightenment; to engage the audience in a deeper understanding of the information being presented in a museum environment and to put in context the artifacts seen in a collection with the source in which they originated.

1) A Virtual Reconstruction of the Cone Sisters Marlborough Apartments, Baltimore Maryland, USA. This installation is on permanent exhibit at the Baltimore Museum of Art. It is a detailed reconstruction of the two apartments in which Etta and Claribel Cone lived in the 1930s where they amassed a collection of over 3000 works of art by Henri Matisse, Gaugin, Picasso, and others. This renowned Cone Collection now resides in the Cone Wing of the BMA.

2) The Sun Dagger Interactive. Part of a permanent exhibition on cultural astronomy at the Adler Planetarium and Museum, Chicago Illinois, USA, this interactive application reconstructs the solar and lunar calendar construct discovered on top of Fajada Butte in Chaco Canyon, New Mexico. Believed to be created by the ancient Chacoans, or Anasazi, over one thousand years ago, this assembly of three nine foot stone slabs collimates sunlight into patterns of light and shadow onto a spiral petroglyph in the cliff wall. The patterns mark the year's solstices and equinoxes, and are believed to track the 19-year cycle of the moon.

In both cases extensive research was required to accumulate the necessary data for an accurate reconstruction, each with their own particular methods and obstacles. The resulting datasets for each are very large and could easily overpower the capacity for a museum patron to absorb the information or for an affordable computer system to manage a seamless 3D display of the information. The objective was to build an interactive application in which the viewer can intuitively navigate the reconstructed space with an emphasis on conveying the content of the work in a relatively short amount of time.

The following two case studies present perspectives on the stages of pre-production planning, collection and management of data, interface design, production and technology implementation.

1: A Virtual Reconstruction of the Cone Sisters' Apartments

1.1: Introduction

This real-time 3D interactive simulation recreates the apartments of Etta and Claribel Cone as they appeared in the late 1930s. The project was designed and produced in collaboration between the Imaging Research Center (IRC) at UMBC and the Baltimore Museum of Art (BMA).

Original photograph of Etta Cone's living room circa 1930s (left) and a screen grab from the virtual reconstruction (right).

1.2: Background and History

Etta and Claribel Cone were two sisters who, over a period of 30 years, amassed one of the world's most acclaimed collections of early 20[th] century French art. This "Cone Collection", with its incomparable holdings of work by Henri Matisse and major examples of Picasso, Cezanne, van Gogh, and Renoir, was donated to The Baltimore Museum of Art along with most of the sisters' possessions and furniture in 1950. During their lives, however, the Cone Sisters lived with and displayed their collection in their apartments.

The project meticulously reconstructs the early 20[th] century apartments as they were and gives a glimpse of how the sisters incorporated their collection into their everyday life. This virtual rendition of these original apartments allows viewers to "walk through" the collection as the Cone Sisters did daily.

The Marlborough Apartment building no longer exists as it did during the sisters' lives. In the 1970's the building was entirely renovated to accommodate a center for assisted living. None of the original interior walls remained intact and what once were two apartments owned by the sisters are now numerous rooms with entirely different floor plans.

1.3: Technology and Process

The Virtual Tour of the Cone Sisters' Apartments is presented at the Baltimore Museum of Art as both a real-time interactive simulation and an immersive stereoscopic experience. In each installation, viewers navigate through a 3D model of the Cone Sisters' apartments.

Students working at the Imaging Research Center constructed the 3D model of the apartments and the furnishings inside. Several months of research were required for visiting the original building to take measurements of exterior walls and window openings, and to document small articles and furnishings that remain in the BMA holdings after the collection was bequeathed to the museum. Photographs were taken of these items for both reference in modeling and detailed texture map sources. Original floor plan drawings of the apartment building were discovered through searching city archives. Digital reproductions of the paintings and sculptures were acquired through working with the museum, resulting in an overall collection of thousands of images and measurements. An extensive web site was developed to manage the data and make it accessible to any artist working on the various aspects of the project.

Comparable to the development of 3D games, the models and textures had to be optimized for real-time rendering. Light mapping techniques were used to project shadow textures and lighting effects on the walls and floors. Four channel spatialized audio playback tracks viewers as they move about the apartments.

Approximately 15,000 polygons make up each room. With a total of 14 rooms, the amount of data that had to be processed for real time rendering had the potential to overload the processing capabilities of the computer. Many of the rooms in the apartments connected with open archways rather than doors. This required the need to be able to see from one room into as many as three others simultaneously. To meet this challenge, a technique was used for culling geometry not only by use of the view frustum but by tracking the camera position and hiding geometry determined to be occluded by walls or other foreground objects.

The interactive navigation of the simulation was developed for a 42" flat plasma display screen with a touch sensitive overlay panel as the input device. The display is wall-mounted for permanent display in the Cone Wing of the Museum. Viewers explore and move about the apartments intuitively by touching objects, doors, and artworks. An interactive floor plan of the building is available as a means to quickly move to a specific room.

The second version was developed to give viewers at the museum a more complete immersive experience. Driven by a network of PCs, the apartments were presented on a sixteen-foot wide by eight-foot high rear projection screen using passive stereoscopic vision and polarized glasses. Gallery visitors navigated through the apartments by using a modified joystick.

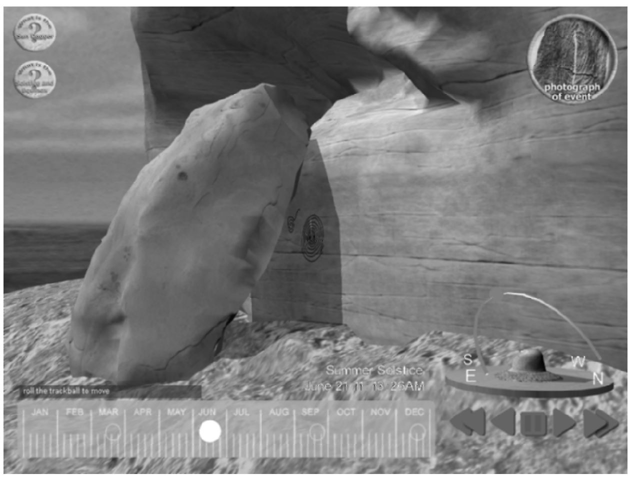
BMA gallery visitors wearing 3D glasses to view the large scale installation. Additional monitors displayed maps and images networked to the main navigation.

The technical requirements included the need to incorporate low-cost hardware and software solutions to bring a virtual reality experience to a large public venue. The Georgia Tech Virtual Environments Group's NAVE[1] was used as a starting point to develop our own system of a networked cluster of PCs and rear-screen passive stereo projection. The screens were constructed in a curve to partially encompass the viewers but allowing for a large standing room area. Four computers were networked together to drive the simulation; two with dual-head graphics cards to render the stereo views, one to operate as a master for positional information, audio, and input devices, and the fourth to display a graphic navigational mapping system of the apartments floor plan giving the viewer's location as well as showing the original apartment photographs.

2: The Sun Dagger Interactive

2.1: Introduction

The Sun Dagger Interactive program is the first phase of an ongoing research project in collaboration with Anna Sofaer, Archeoastronomer and President of The Solstice Project. The product of this work is an interactive real-time computer simulation of the ancient Sun Dagger site on Fajada Butte in Chaco Canyon, New Mexico. The interactive program is now part of a permanent exhibit on cultural astronomy at the Adler Planetarium in Chicago. The exhibit opened on March 20, 2002.



A screen grab of the interactive. The shadow cast on the cliff wall is nearing summer solstice.

2.2: Background and History

Fajada Butte stands prominently in the south entrance of Chaco Canyon in New Mexico, rising 135 meters above the valley floor to an elevation of 2018 meters. The butte is difficult to climb, and there is neither water nor soil on it. Yet from bottom to top there are many examples of Indian rock art carved and painted on the cliffs. The butte is a natural site for astronomical observations, with its clear views to distant horizons.

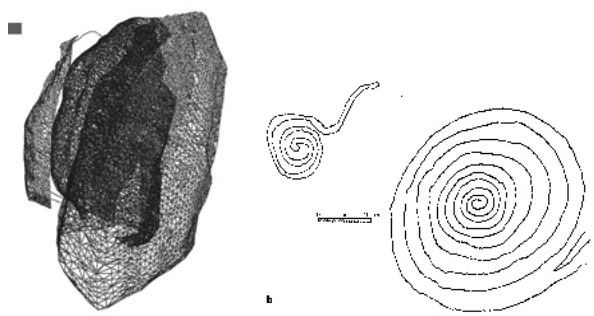
Near the top of this isolated butte, three large stone slabs collimate sunlight in vertical patterns of light onto two spiral petroglyphs carved on the cliff behind them. The light illuminates the spirals each day near noon in a changing pattern throughout the year; marking the solstices and equinoxes with particular images. Near noon at summer solstice, a narrow vertical form of light moves downward through the center of the larger spiral. At the equinoxes and winter solstice, corresponding forms of light mark the spirals.

Ancient Indian societies occupied Chaco Canyon from about A.D. 400 to 1300. These early inhabitants left evidence of a skilled and highly organized society. Between A.D. 850 and 1130 they constructed multistory pueblos, large ceremonial centers, and built an extensive system of roads. The Chacoan people also developed the accurate calender on Fajada Butte, probably for ceremonial purposes. This calender, now known as the Sun Dagger, has been shown to also display the passage of the 18.6 year cycle of the moon.

The first modern observations at the site were made on June 29 1977 by Anna Sofaer of The Solstice Project, who then initiated the studies of the patterns of light on the spirals during the Sun's annual cycle. The computer simulation here shows how the combination of the light patterns and the spirals were used by the ancient people of Chaco to mark accurately the time of the solstices and equinoxes

2.3: Technology and Process

The interactive program displays on screen a 3D recreation of the stone slabs, petroglyphs and cliff wall making up the Sun Dagger construct. The geometry defining the stone slabs was derived from photogrammetry of the site produced on glass plate negatives in 1979. A polygonal mesh was constructed for each stone slab based on the point cloud data provide by the original combination of the plates. A small area of the cliff wall behind the stones was also measured, but the rest of the cliff wall rising overhead was modeled roughly based on photographic reference.



A wireframe rendition of the mesh derived from the original point cloud data and a drawing of the spiral patterns etched into the cliff wall.

Users may interact with the scene by navigating in 3D to explore the site and manipulate several controls to adjust the time of year and time of day. Navigation is achieved by means of a trackball and button. Rolling the trackball allows the user to move in and around the stone slabs to view it from multiple perspectives. The viewer is able to move up close to the spiral petroglyph behind the slabs. The stone slabs will fade to semi-transparent if the viewer moves inside of them so that the viewer can see the relationships between the spiral markings and the stones.

Astronomically accurate positioning of the sun’s light casts shadows of the stone slabs onto the petroglyph to recreate the actual events marked by the ancient calendar system. The viewer can explore these relationships by interacting with several gauges on the screen. Across the bottom of the screen is a slider representing the days of the year. The user can drag an icon representing the Sun horizontally along this slider and see the changing light and angle of the Sun react in real time. The Sun icon changes color when the user moves across a day in which the equinoxes or solstices occur.

A screen grab of the interactive. The shadow cast on the cliff wall is nearing winter solstice.

In the right lower corner of the screen is disk with a 3D model representation of the butte on which the Sun Dagger site is found and the surrounding land. A small marker on the butte indicates the location of the Sun Dagger. Over the disk is an arc representing the path of the Sun in the sky. A model of the Sun moves along the path over the course of the day, casting a shadow on the disk and synchronous with the shadow being cast by the stone slabs on the cliff wall. The viewer can select the Sun model on the arc and interactively slide the model along the path to change the time of day, allowing exploration of the interaction of shadows with the spiral carvings. The altitude of the Sun’s arc changes with the time of year. Below the disk is a traditional set of “VCR” controls that allow the viewer to "play" time in fast forward or reverse, and to pause.

3: Conclusion

In both cases, reconstructions were created of places no longer accessible to the public. In the case of the Cone Sisters’ apartments, the artwork had long since been removed and the building interior demolished. As for the Sun Dagger, in the 1980’s possible vandalism occurred which caused one of the stone slabs to shift, resulting in shadow markings that no longer operate in the way they had for over a thousand years. The national park service has since closed down access to the top of the butte.

The most important aspect of these applications is the user interface design. Over the time since they have been on display in their respective venues they have been successful in engaging visitors to learn more about the subject matter and to prompt further dialogue between one another and with museum docents.

The touch screen system of the Cone display is the most successful. Visitors need only to “point” to a place they want to investigate and the virtual camera will be set in motion. There are no menus or buttons except for a question mark and map icon in the bottom corners. Visitors without any computer experience are able to navigate the scene intuitively. The Sun Dagger interactive is somewhat more complex in its interface, requiring the use of a track ball (or mouse) is the first obstacle in engaging every visitor. Interface elements in the display have immediate and contextual feedback, accelerating the learning process. In both cases, “timers” are built in to the applications that initiate an “auto playback” mode if no interaction is made for over a minute. This allows some viewers to watch passively, but also functions to attract others to interact with the display.

References

1) The NAVE: Design and Implementation of a Non-Expensive Immersive Virtual Environment, Jarrell Pair, Georgia Te c h Graphics Visualization, and Usability Center, Siggraph 200

2) Sofaer, A., Zinser, V., and Sinclair, R. M., 1979. A Unique Solar Marking Construct. Science, 19 October 1979, Volume 206, Number 4416, pp. 283-291.