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"THE CONE SISTERS' APARTMENTS: CREATING A REAL-TIME, INTERACTIVE VIRTUAL TOUR"

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Abstract

This paper summarizes and presents the results of a unique collaboration between The Baltimore Museum of Art and the Imaging Research Center at the University of Maryland, Baltimore County, USA. The collaboration yielded a major visualization project that can be presented as both a real-time interactive simulation in the Museum's galleries and a large-scale immersive experience. This visualization of interior living spaces that no longer exist provides a highly detailed record of how Dr. Claribel Cone and Miss Etta Cone, two wealthy Baltimore art collectors and patrons, filled their apartments with their incomparable collection of art by the French master Henri Matisse and other European post-Impressionist and modern artists. The experience provides a rich visual and historic context for museum visitors' understanding and appreciation of the collection that now forms the cornerstone of The Baltimore Museum of Art's permanent holdings.

Keywords: Virtual Reconstruction, Collaboration, Interactive, Visualization, Interpretive, Historical Context, Virtual Tour

Reinstalling The Cone Collection at The Baltimore Museum of Art: Opportunities for New Interpretive Strategies

The Baltimore Museum of Art (BMA), Baltimore, Maryland, USA, is home to The Cone Collection, an exceptional group of 500 works by Matisse, considered the most important and comprehensive holding in the world. Formed by Baltimore sisters Dr. Claribel Cone (1864-1929) and Miss Etta Cone ((1870-1949), The Cone Collection is regarded as one of the world's preeminent collections of modern art, assembled at a time when there were few patrons of the avant-garde. Between 1898 and 1949 they acquired a total of 3,000 works of art that also include artists such as Pablo Picasso, Paul Cezanne, Paul Gauguin, and Vincent van Gogh. Etta, the surviving sister, was persuaded to bequeath the sisters' combined collections to the BMA so that the art could remain in Baltimore. The Cone Collection of art, as well as personal possessions and furniture came to the BMA in 1950. Since its inaugural installation in 1957 in a specially built wing, The Cone Collection has undergone at least three major reinstallations projects—all signaling contemporaneous

changes in museum exhibition design and curatorial viewpoints. In April 2001, the BMA opened a newly renovated and expanded series of galleries devoted to The Cone Collection in honor of the 50th anniversary of the Cone sisters' bequest. This occasion signaled an opportunity for Museum staff to: expand the Collection galleries by forty-five percent, consider an entirely new installation scheme for the collection, and plan new approaches to interpretation for 21st-century museum visitors.

A key goal for the Cone reinstallation was to use innovative interpretive tools to make the distinguished holdings come to life. The Museum wanted visitors to come away from the Museum enlivened by experiences in The Cone Collection. Throughout the Cone Wing, new and more intimate gallery spaces allowed the Museum to exhibit the Collection in a more "domestic" setting akin to the way the Cone sisters lived with their artworks. The reinstallation plan balanced a focus on Matisse as the cornerstone of the Collection with galleries of rotating exhibitions that provide opportunities for continued and subsequent explorations of the Collection's diversity and scope. Brochures, text panels and labels, and an interpretive resource gallery were organized to enhance visitors' experiences in the Museum.

In assessing previous installations of The Cone Collection, museum curators, designers, and educators noted that one of the appealing and popular aspects of the Cone galleries included a small selection of actual furnishings from The Cone Collection. These included furniture, textiles, decorative objects, and paintings and sculpture installed as they might have appeared in the Cone sisters' personal home apartments. In an effort to maintain this historically appealing aspect of the galleries, Museum staff struggled with a plan to represent an accurate view of the Cone sisters' home environment within the gallery setting. The goal was to provide this experience without encroaching on the elegance and purpose of the new galleries, yet to provide a historical context that would resonate with visitors to the Collection.

Solving the Interpretive Dilemma Through a Unique Collaboration

Over the course of an informal conversation and exchange of potential project ideas, The Cone Collection reinstallation project team and the staff of the Imaging Research Center (IRC) collectively acknowledged an opportunity for collaboration that would combine unique resources, experience, skills, and research for the benefit of both institutions. We embarked on a ten-month endeavor to create a visualization of The Cone Collection as it appeared in the Cone sisters' apartments—initially based solely on the existence of thirty-seven black and white photographs from the 1930s and 1940s.

The result was a virtual tour of the Cone sisters' apartments. As pictured here, visitors may navigate the tour—at any pace—through an interactive touch screen. Three other key elements in the interpretive gallery serve to beckon museum visitors: a display of actual furnishings from the Cone bequest that is situated against the opposite wall from the virtual tour, comfortable seating on two sofas, and a cabinet with five drawers filled with assorted objects from the Cone Collection including jewelry, textiles, antique keys, and postcards. All of this was planned as an effort to assist visitors in "situating" themselves within the Cone sisters' apartments.

Fig. 1: BMA gallery visitor using the interactive touch screen on permanent display in the Cone Wing.

The Imaging Research Center

The IRC at UMBC is a state-of-the-art, computer-based research and production facility specializing in high-end animation and visualization. Established in 1987, the IRC operates in conjunction with UMBC's academic programs in Imaging and Digital Arts and provides a forum for faculty, researchers, corporate partners, and students to push the boundaries of digital media. IRC projects have included animation, interactivity, and production work for The Discovery Channel, The Minnesota Orchestra, PBS, MIT, The Family Channel, and Interactive Children's Television.

Shared Goals and Planning

Immediate trust was established between the two organizations based on the following shared goals that formed parameters around our joint project.
The purpose of our project was to:
Advance public understanding of The Cone Collection through an intimate look at the Cone sisters' home environments, the original venue for the Collection
Provide a unique form of interpretation for the Museum's audience that was respectful of the
Museum audience's needs and interests
Cone sisters and the surviving Cone family
Works of art
Scholarship and accuracy
Advance the IRC's mission to explore new technological boundaries with visualization
Advance the BMA's mission in exhibiting and interpreting The Cone Collection

Furthermore, the BMA and IRC developed specific objectives to achieve these broader goals. We agreed upon the following:
To make the technology transparent
To develop a non-linear program

To create a user-friendly interface

To delay decisions on hardware and software until we had accomplished the goals of our project

Historical Context Provided Through Technology

The Cone sisters lived with their collection in luxury apartments at the Marlborough Apartment building in Baltimore during the first half of the 20th century. The visualization project meticulously reconstructs major portions of these apartments as they were and gives insight to how the sisters incorporated their collection into their everyday life—filling every wall space with paintings and loading every piece of furniture with sculpture, exotic textiles, and treasures from world travels.

A critical factor in the development of this project was the extensive renovations of the Marlborough Apartment building in the 1970s, which included the destruction of most interior walls. Since the apartments no longer exist as they did during the sisters' lives, the project based its visualization on photographs of the Cone sisters' apartments and a rediscovered 1908 blueprint of the building.

The virtual rendering of the Cone sisters' apartments allow viewers to "walk through" and experience the artworks of Matisse, Picasso, and others as the Cone sisters did daily. Until recently, visitors to the BMA have only viewed this extraordinary collection within the formal gallery setting of the Museum. Now, as a result of this collaborative venture, visitors can explore the Cone sister's apartments, viewing their paintings and sculptures in this domestic setting, as well as works on paper, stashes of laces, and letters and photographs they exchanged with artists.

Fig. 2: Original photograph of Etta's living room, circa 1930, from the collection of the Baltimore Museum of Art

Fig. 3: Virtual reconstruction of Etta's living room. Screen grab from the interactive installation.

Time Table of Production

The respective project teams operated within a limited time frame to complete this project. The participants initiated discussions in June 2000, and the first two phases of the project were completed by April 16, 2001, the grand reopening day of The Cone Collection. The most recent phase of the project was completed in August 2002.

The Virtual Tour has advanced in three stages. The first two versions were presented at the events for the grand reopening: a permanent wall-mounted interactive display and a large-scale immersive environment that was on display for two weeks. During the opening events, over 5,000 thousand people visited the new galleries.

The third and current version of this project is an update to the permanent display. It incorporates changes to the navigation interface based on visitor observations, improvements to the lighting scheme and texture maps, and the inclusion of embedded interactive modules. Through these modules, visitors can select unique objects throughout the apartments, enabling them to read diaries and letters, open a cabinet of drawers containing Picasso drawings, or unlock a trunk filled with textiles that unfold before their eyes.

The development of the project utilized the skills, expertise, and creativity of project co-directors Dan Bailey and Alan Price from the IRC. Approximately thirty people were involved in the extensive recreation of the Cone apartments including IRC staff, graduate and undergraduate students, and BMA curators, educators, and collection managers. Using the photographs and floor plans, a total of thirteen rooms were reconstructed for the project. More than 1,800 digital objects–including furniture, carpets, and works of Art—were modeled to precise dimensions and specifications within the 3D spaces. Much attention was given to the accuracy of placement of objects in each room.

Technology and Process

Asset Management

Students working at the IRC constructed the 3D model of the apartments and the furnishings inside. Several months were spent on initial research that included taking measurements of exterior walls, building footprint, and window openings as well as documenting small articles and furnishings in the BMA holdings. Photographs were taken of these items for both references in modeling and detailed texture map sources. Original floor plan drawings of the apartment building were discovered through searching Baltimore city archives at the Enoch Pratt Library. Digital reproductions of the paintings

and sculptures were acquired 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.

Museum accession numbers for the artworks were cross-referenced with short-coded names based on their location in the apartments. The locations were then mapped out on a floor plan drawing on the web site. The floor plan also encompassed furniture locations and reference points from which the original photographs were taken. Artists working on the project could access these web pages and click on areas of the maps to see reference photos, textures, object dimensions, and other organizational instructions.

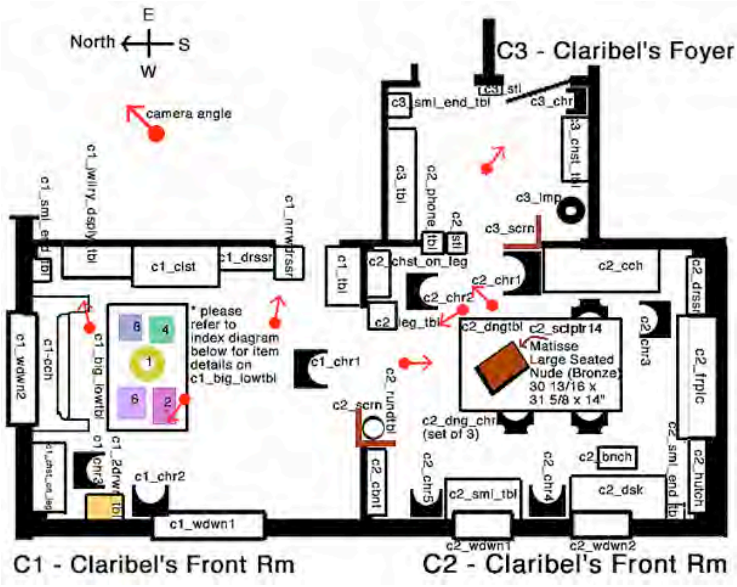

Fig. 4: A sample image map from the production web site depicting a portion of Claribel's apartment. Icons link to photo references and information for each piece of furniture and artwork.

Modeling Piece By Piece

Each item of furniture, including carpets, doorframes, curtain rods, jewelry boxes, and candlesticks, had to be individually modeled and texture mapped. While some furniture still existing in the collection could be used for measurements, many other items were reconstructed based on scale derived from comparisons in the period photographs and wall measurements made of the existing Marlborough building. Since the size of the canvases hanging on the walls were well known and catalogued by the BMA, these served as an informative reference for scale

Textures mapped on the surface of the 3D models were derived from digital reproductions of the sculptures, paintings, and their frames. In many cases color samples of textiles on furniture or wall coverings no longer existed. Small areas of pattern were sampled from the old black and white photographs and reworked into larger patterns for mapping on the models. Colorizing of the textures was based on research provided by BMA curators and decisions made relative to other existing textiles in the collection indicated the sister's choices in color schemes. Light mapping techniques were used to project shadow textures and lighting effects on the walls and floors.

The final dataset consists of 1,800 3D objects with over 1,030 texture maps. There are 165 paintings and thirty-seven sculptures, all of which are catalogued in an integrated database allowing users to call up information on each work of art by touching it. The entire model of the apartments and their contents is made up of nearly a quarter-million polygons.

Optimization for Real-Time Simulation

The amount of data that had to be processed for real-time rendering of the apartments and objects had the potential to overload the processing capabilities of the computer. With approximately 15,000 polygons in each of the fourteen rooms, the virtual tour is comparable to 3D game development, and models and textures had to be optimized for real-time rendering.

Many of the rooms in the apartments are 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.

Fig. 5: A screen grab from the real- time display. This view of Claribel's front room shows the complexity of the space with views into two adjacent rooms and a long hallway.

Interface Design

The interactive navigation of the simulation was developed for a forty-two-inch flat plasma display screen with a touch-sensitive overlay panel as the input device. The simulation runs on a 2GHz Pentium 4 Dell computer equipped with an NVIDIA Quadro2 Pro graphics card. An NEC Technologies' 42MP2 plasma display with Smart Technologies touch-screen overlay completes the set-up. The screen 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.

In the large-scale installation, four-channel spatialized audio playback tracks viewers as they move about the apartments. Ambient street sounds can be heard near the windows, the piano in Etta's living rooms can be heard from down her long hallway, and the prose

of Gertrude Stein's "Two Sisters" is recited when you enter Claribel's print room, where Vallotton's portrait of Stein hangs with Matisse's renderings of Etta and Claribel.

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. To do this we assembled our own system of a networked cluster of PCs and rear-screen passive stereo projection. Viewers wear inexpensive polarized glasses to view the 3D effect. The screen was 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 a final computer to display a graphic navigational mapping system of the apartments' floor plan.

The touch-screen system of the Cone display is one of the most successful aspects of the installation. 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.

Burn-in of the plasma screen was another consideration. If an image remained on the screen for too long it would be burned permanently into screen. Consequently, timers are built in to the application, initiating 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.

Fig. 6: BMA gallery visitors wearing 3D glasses to view the large-scale installation of the virtual tour. Additional monitors display a map giving the viewer's location, as well as showing the original apartment photographs.

The Benefits of Localized Collaboration

The success of the project relied entirely on the combined efforts of the BMA and IRC. By working together closely, we were able to create a finished product that tightly integrates historically accurate information with an intuitive computer-driven interface. A constant line of communication allowed for the abbreviated timeline in which the project was completed. With an interest taken by administration in both institutions at the onset of the proposed collaboration, we were able to begin working in an open and creatively driven environment from the first stages of development to the final installation.

The artists working on the project benefited from visiting both the original building to take reference photographs and the Museum to view The Cone Collection as it now exists. Additionally, being situated in Baltimore meant the IRC team was part of the environment in which the sisters lived and the same local culture as the Museum. This brought not only interest and understanding to the project, but also an exciting energy among team members.

The project introduced a first wave of technology-based information systems to the Museum. By working with the University's IRC, the Museum was able to play a creative role throughout the process. This close collaboration also ensured that the final product

was carefully tailored to match the physical space in which it was displayed, the context in which it supports the Collection, and the demographics of its visitors.

For the IRC, the project provided the ever sought after creative challenge of designing visualization methods for education that push the boundaries of conventional approaches, providing applied solutions from in-house research and professional experience for students in the Center's programs. Witnessing the level of scholarship and expertise practiced by every representative from the Museum was an educational and eye-opening experience for many of the undergraduate students.

Without the IRC's emphasis on designing solutions that exploit the use of off-the-shelf hardware and its recombination and customization, much of the work would not have been possible within the budget constraints that existed for the project. Most importantly, this was a new project for both the BMA and IRC, and we were able to work together with open minds as we experimented with ideas for interactivity, navigation, and physical installation without the common constraints of having already established any standardization for input devices or interface design, which is sometimes the case with other institutions, whether it be the museum or the company developing the visualization system. Working without these constraints made the project more exciting to develop and resulted in a system that is unique and well integrated with its environment.

Background on the Imaging Research Center

The Imaging Research Center is located on the campus of the University of Maryland, Baltimore County. This state-of-the art computer-based research and production facility, started in 1987, functions in conjunction with graduate and undergraduate schools of the Imaging and Digital Arts Program. The IRC has developed and installed multiple and diverse visualization facilities providing a forum for faculty, researchers, corporate partners, and students to integrate and push the boundaries of digital media. The IRC specializes in high-end computer animation and visualization.

Through the IRC internship program, graduate and undergraduate students are provided with real-life professional projects that they work on under the direction of the IRC directors. Internship projects provide experience with animation, interactivity, and

production. Internship projects have included works for The Discovery Channel, The Family Channel, CNN, PBS, and The Baltimore Museum of Art. Students learn that ideas and teamwork are the most important aspects for utilizing evolving technologies. This philosophy will serve them well as boundaries of the arts merge between disciplines—film, video, photography, interactive multimedia, and performance. This internship program bridges the gap between school and the professional world.

The University of Maryland, Baltimore County

The University of Maryland, Baltimore County, (UMBC) is Baltimore's public research university. Medium-sized and historically diverse, UMBC emphasizes the synergy between technology and the humanities. One of the nation's top producers of information technology graduates, the university has gained a reputation as a powerhouse in technology workforce development. UMBC's connections with Baltimore span the disciplines. From lead paint removal to teacher training, collaboration with the arts to collaboration with business, UMBC is closely tied to the culture and development of Baltimore. The university's arts programs in dance, music, theater, and visual arts have attracted regional and national attention. UMBC visual arts faculty have a diverse background in the fine and applied arts, spanning art history, computer art, film, graphic design, photography, video, printmaking, drawing, and painting. Their research and creative endeavors center on the interdisciplinary aspects of the late 20th-century digital and time-based art forms and are regularly on view in both national and international forms of exhibitions and publications.

Background on The Baltimore Museum of Art

Founded in 1914, The Baltimore Museum of Art is Maryland's largest art museum. The BMA features an internationally renowned collection of more than 85,000 objects ranging from ancient mosaics to contemporary art. In addition to The Cone Collection of post-Impressionist and modern art, major areas of strength include contemporary art, the arts of Africa, Old Master paintings and sculpture, European and American decorative arts, textiles, and works on paper from the Renaissance to the present day. The BMA has one of the largest urban sculpture gardens in the U.S. Recently named one of the top twenty-five museums in the U.S. by Travel Holiday, the BMA presents several major exhibitions each year as well as special exhibitions from the Museum's vast collections.