Passing Excellence

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ABSTRACT

This paper describes the research and development of a virtual reality visualization project "Passing excellence" about the world famous architectural ensemble "Kizhi". The Kizhi Pogost is located on an island in Lake Onega in northern Karelia, Russia. It is an authentic museum of an ancient wood building tradition which presents a unique artistic achievement. This ensemble preserves a concentration of masterpieces of the Russian heritage and is included in the List of Most Endangered Sites of the World Monuments Watch protected by World Heritage List of UNESCO. The project strives to create a unique virtual observation of the dynamics of the architectural changes of the museum area beginning from the 15th Century up to the 21st Century. The visualization is being created to restore the original architecture of Kizhi island based on the detailed photographs, architectural and geometric measurements, textural data, video surveys and resources from the Kizhi State Open-Air Museum archives. The project is being developed using Electro, an application development environment for the tiled display high-resolution graphics visualization system and can be shown on the virtual reality systems such as the GeoWall™ and the C-Wall.

Keywords: art, historical restoration, visualization, computer graphics, Virtual Reality (VR)

1. INTRODUCTION

"Passing Excellence" is an artistic visualization research project centered on the world famous architectural ensemble Kizhi. The Kizhi Pogost is located on an island in Lake Onega in northern Karelia in Russia. This historically important site is protected by World Heritage List of UNESCO [1]. Kizhi is an architectural complex with a valuable collection of artifacts and icons that was built in harmony with the surrounding landscape. The site presents an authentic museum of an ancient wood building tradition and is an outstanding example of medieval and post-medieval orthodox settlements; presenting a unique artistic achievement. Kizhi buildings are unique in that all joints and structural elements were made entirely from wood without the use of any metal nails or ties. This ensemble preserves a concentration of masterpieces of the Russian heritage and is included in the List of Most Endangered Sites of the World Monuments Watch, a global program that calls attention to imperiled cultural heritage sites around the world.

Early mention of the Kizhi settlements was found in chronicles from the 15th and 16th centuries. The Kizhi ensemble consists of the 1714 Church of the Transfiguration, the 1764 Church of the Intercession and the Belfry, an octagonal bell tower that was restored in 1874. The Church of the Transfiguration was constructed during the reign of Peter the Great by the master carpenter Nestor. Legend has it that Nestor was so amazed by the church he had created with God's help that he threw his axe into Lake Onega promising never to build another [2, 3]. The church has 22 domes carpeted entirely out of aspen wood which undergoes exquisite transitions in color ranging from amber and silver to black. Sunlight reflects off of these wooden, onion-shaped domes causing them to shine silver and reflect brilliant colors at sunrise and sunset. The unique coloration effect created by a various aspen surface reflections to the northern atmospheric light gave "the fairy tale church" name to the Transfiguration because of its stunning beauty.

Today, the Church of the Transfiguration and the Belfry are closed for the public visitors because of the research and restoration work on the ensemble interior. The interior of the Church of the Transfiguration was largely destroyed during World War II and some of the precious icons inside were lost [4]. The only interior chamber that is open today for

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visitors is the Church of the Intercession that functions as a traditional orthodox church and a museum preserving a collection of saved and restored icons. The interiors of the Church of the Transfiguration and the Belfry are planned to be reopened for the public for the upcoming 300th anniversary of the Church of the Transfiguration in 2014.

Thousands of people currently visiting the site have no opportunity to see the inside design and décor. The largest in North West Russia Iconostasis from the Church of the Transfiguration is being restored in the archives. The icons and the golden frame of the iconostasis were disassembled and moved to different archive locations in the island and in the Museum center in Petrozavodsk. There is a plan to finish their restoration and reassemble the iconostasis structure for the upcoming 300th anniversary and reopening in 2014. However there is no visual material except several black and white old photographs that would describe the iconostasis to visitors of the museum.

The restoration works of the Church of the Transfiguration are undertaken jointly with the State Party of the Russian Federation under the World Heritage guidance. Today the threats to the site are considerable as these especially fragile, wooden churches require constant care and upkeep. However, despite our best efforts, the structures and their textures continue to deteriorate. The political turmoil in Russia, growing tourism, control of the public access and increased development in the area all conspire to threaten the site. Lack of funds is the primary obstacle to preserving the site and provide continuing efforts to improve the state of conservation of the property. In the absence of proper maintenance and implementation of a comprehensive management plan for the property, the misguided effects of past maintenance are aggravating deterioration. It has been estimated that, without appropriate treatment, these magnificent churches and the precious icons they house will be lost within next two decades.

Figure 1. The Kizhi ensemble.

Figure 2. The Church of Transfiguration in 2006.

2. CONCEPT

2.1 Background

The focus of this project is to create an interactive visualization of the history of Kizhi beginning at the 15th Century and progressing through the modern era. “Passing excellence” addresses a very important need to preserve the cultural value of this site and to restore its original state. Contemporary historic restoration projects strive to transmit culture onto future generations by preserving existing and lost buildings, structures, monuments and other cultural objects in the digital format for art, education, entertainment, history and science. A majority of world heritage cultural resources exist in physical form inaccessible for global communication and exchange. Yet current preservation and restoration requires information on these objects to be created on the computer in the digital form or as virtual environment. The idea to visualize the dynamic history of the Kizhi ensemble in real time was inspired by recent research and achievements of the Electronic Visualization Laboratory (EVL) in the field of interactive stereoscopic computer graphics and high-resolution VR and tiled graphic displays as well as by latest advancements in the historic preservation field. The project capitalizes

on the advances of the electronic digital computer technology and high resolution visualization display systems and software to render a culturally important site in its former glory.

The latest computer graphics technology offers great possibilities in the field of historic visualization and reconstruction. Advances in computer graphics have made it possible to create extremely realistic digital images and to transfer and render them quickly in real-time. Using advanced texture mapping techniques, 3-D models can be rendered in highly photo-realistic apparel. Computer generated animations and interactive visualizations can embody highly dynamic and stunning realistic environments which closely resemble photographic images and reflect historic accuracy. These animations can render historical, time-based reconstruction of the lost artifacts, events, objects and actions. The interactive and animation potential of visualization fully unfolds in the creative efforts of historians and archeologists to enliven the past history. Together, these techniques greatly contribute to ongoing efforts which preserve our endangered cultural values.

2.2 Goals

The project was conceptualized to address several artistic, historical and cultural goals:

1. Develop a virtual prototype of the current state of Kizhi complex as an interactive 3-D virtual environment.

2. Develop a virtual model of bygone architecture of the Kizhi ensemble by reconstructing vanished structures, lost interior, iconostasis, updated wooden textures and the like.

3. Create a real time dynamic visualization of the history of Kizhi ensemble and island starting from the 15th century and progressing through today.

   The animation and interactive visualization would restore step by step the dynamics of the architectural changes of the ensemble interior, exterior and the Kizhi island as a time-based sequence based on the historical restoration and research. The visualization will include stages of the monument described in the early chronicles when it existed in its original state of artistic excellence. The ensemble was restored and reconstructed many times during last 300 years and the visual look and feel of the original buildings and coloration of its wooden surfaces were altered by time, weather, deterioration, reconstruction, natural disasters such as fire and storm, and the introduction of new homes or wooden churches south of Kizhi Island.

4. Create an interactive dynamic visualization of the different times of the day, lighting effects and atmospheric conditions of the Kizhi environment.

5. Visualize a process of deterioration of the facades, textures, discoloration of the wooden surfaces as a time-based sequence.

6. Share Kizhi's unique cultural heritage, beauty and dramatic history with the larger international community.

   Viewing historic sites strengthens the visual memory and links a perceptible connection to history that helps with the educational process. Computer visualization of historically significant sites and cultural heritage locations enhances the learning and improves personal experience.

   A remote location, travel distance, limited building access due to restoration efforts and little or no handicapped facilites make the Kizhi ensemble difficult to visit for many Russians, not to mention international visitors. The museum is almost inaccessible during fall through spring months by public transportation (the only snowmobile route lies through the fragile ice on the lake Onega and its shores). During the summer period the island is accessible by boats and hydrofoils running on the river and Lake Onega. The Interior of the Church of the Transfiguration remains mostly closed since 1937 and the re-opening for the general public wont' happen until after 2014. Most of the visitors have not seen the interior of the Church of the Transfiguration and the Belfry and there are no animated or interactive materials or museum resources that recreate their visual beauty.

7. Contribute into the international scientific restoration work of this site.

   The project can be presented in scientific, artistic, and historical research exhibitions and public venues to increase public awareness of the international value of Kizhi and ancient traditions in wood architecture. The exhibitions contribute to the active efforts of the international conservation community to support this heritage resource. The high-resolution interactive visualization would allow geographically remote groups to view and work simultaneously on the large format displays to find appropriate solutions for historic preservation and the study of the site.

8. Contribute to the body of knowledge about computer visualization and virtual reality for arts.

2.3 Proposal

The realization of the project began with the proposal to request a funding to get detailed photographs, architectural and geometric measurements, textural data, and video surveys of the ensemble and to visit the Kizhi State Open-Air Museum of History, Architecture, and Ethnography archives. The proposal was funded by a small travel grant from the University of Illinois at Chicago Office of Vice Chancellor of Research for Art and Humanities (OVCR-AAH) in the summer of 2006. The requested funds partly sponsored travel expenses for two people for a short visit to Kizhi. This project is being developed in collaboration with a computer science researcher Robert Kooima, a specialist in the field of data visualization and real-time 3D graphics in Electronic Visualization Laboratory (EVL).

3. HISTORICAL STAGES OR RESTORATION

The Kizhi Pogost is the oldest in Lake Onega area. The ensemble architecture was refined gradually over a period of 300 years.

1. The first mention of the Kizhi settlements was found in chronicles in 1496 that mention the Church of the Transfiguration and the Church of the Intercession on Lake Onega. The Belfry was first mentioned in chronicles in 1616 and here the first description of the Transfiguration and the Church of the Intercession was given, "wooden church with domed cover with bell tower and bells…" Those first churches were lost due to the severe thunderstorm with lightning that cause a fire in the end of the 17th century. The bell tower was the only structure to have survived the fire [4, 5].

2. Second generation churches were build in the same place from wooden logs. The bell tower and the Church of the Transfiguration were connected with a passageway which allowed inside communication during long winter months.

The Church of the Intercession was rebuilt first after the fire in 1694 and then later in 1749 and 1764. It was a different structure from the original church that included two parts for winter and summer. It did not match the Transfiguration and Belfry in style and was rebuilt several times. The first update added the single dome roof in 1749 and the second nine-domed cover in 1764. The nine-domed cover was the best solution; organically uniting both churches into a harmonious and balanced ensemble. The new Church of the Transfiguration was rebuilt in 1714. The bell tower was rebuilt only 250 later in 1862 but did match in style with the surrounding churches and was again rebuilt in 1874. The last version was covered with the plywood and defined the contemporary silhouette of the Belfry.

3. From 1818 until 1824 the Church of the Transfiguration was covered with the plywood and the domes were covered with iron surfaces colored in bright green. The Church of the Intercession was covered with the plywood in 1865, but the onion-shaped domes were left with the original aspen cover. In 1870 the exterior walls of the Church of the Transfiguration were re-covered with fresh plywood and colored in white oil paint. In 1871 the interior walls were covered and new floors were laid. After the Russian revolution, the ensemble was recognized as a historic architectural monument and preserved as a state property. The churches remain functional and served the parish until 1937 when the Church of the Transfiguration was officially closed and last priest was shot.

During World War II, the iconostasis of the Church of the Transfiguration was disassembled and moved to the nearby

bell tower in the village Kurgenitsi, and then to Finland in 1943. After the Soviet victory the icons were returned to Kizhi museum in Petrozavodsk in 1944. Unfortunately, the top part of the iconostasis icons that formed the painted ceiling of the Transfiguration called “the Sky” was lost to the fire. The Kizhi Pogost was declared to be a state reserve in 1945. The aim of the preserve was to transfer the unique monuments of secular architecture such as peasants’ houses to the island area.

4. The new restoration of the churches was conducted by architect Opolovnikov in 1949-1959. The goal was to restore the original state of Kizhi churches as they were built from the original log structures. The plywood covers were removed from the exterior and interior and iron covers were taken down from the domes. The iconostasis was restored in 1950 by specialists from Tretiakov Gallery in Moscow.

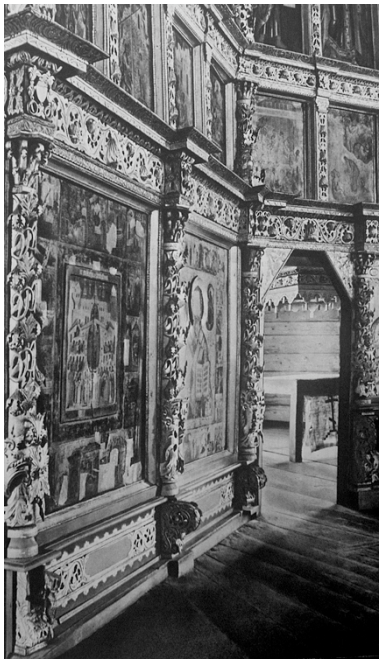

Figure 3. Details of the iconostasis. Photo was taken before disassembling.

5. The iconostasis was dismantled and a "supporting" metal frame was installed inside the church. Engineering repairs were made to strengthen the Church of the Transfiguration in 1980.

The current condition of the Church of the Transfiguration remains insecure and endangered. The recommendation for restoration of Kizhi Pogost was approved by ICOMOS, the International Council on Monuments and Sites.. The current restoration plan of the Transfiguration is conducted by chief architect Uri Popov, head engineer Alexander Kuusela and includes an exchange of 20-30% of the deteriorated logs. The seven levels of the Transfiguration will be lifted one by one by special mechanical jacks to replace rotten logs with the new ones. This method was selected as the safest because it allows for stopping the restoration at any time with no damage to the monument [6].

4. MUSEUM VISIT

4.1 Plan

The work on the project started with the preliminary research of the history of Kizhi structures using various informational materials available on the Internet to develop the onsite work plan. Today the museum area consists of 91 structures on the Kizhi island including the Pogost ensemble (considered the heart of the museum) along with nine structures on the three satellite islands next to Kizhi. The original plan for the project was to restore all structures and

visualize their historical relocation and constructive evolution. However, due to the limited one-year timeframe for the development, the current project includes the visualization of the main ensemble with the prospect of potential expansion. The next step was to collect the material such as detailed photographs, architectural and geometric measurements, textural data, interview historians and restoration specialists, and get video surveys of the ensemble during our visit the Kizhi State Open-Air Museum of History, Architecture, and Ethnography and its archives.

During the initial visit to Kizhi the following tasks were accomplished:

- Observational (referential) photographs were taken of exteriors & interiors of the Church of the Transfiguration, the Church of the Intercession, the Belfry, and the surrounding territory enclosed in the wooden fence.

- Detailed, high resolution photographs of exterior textures of the main monuments were taken using Konica Minolta DiMage A-2 8Mgpixel camera. These high resolution photographs documented wooden surfaces, logs, plywood, aspen cover for domes, details of the doors, entrances, outside decor, window and door construction details all of which will be used for later reconstruction and computerized texture mapping.

- Textures of the interiors of main monuments, such as wood walls, floor surfaces, iconostas and icons, selected folk furniture, textiles, utilitarian objects as well as methods of transportation (wooden boats) were all documented using a digital camera (Konica Minolta DiMage A-2 8-megapixel).

- The current condition of the ensemble structures was studied and documented.

- Geometrical measurements of the existing structures were taken in order to develop a clear understanding of those that were lost over time.

- Digital documentation of the geometry data of all buildings was made.

- Interviews were conducted with historians and restoration specialists about the development of the Kizhi Pogost, interior of the churches, icons, paintings, restoration procedures, plans, process and techniques.

- Interviews were conducted with historians and restoration specialists and information regarding the deteriorating condition of the wood surfaces was collected.

- Local museum personnel were contacted in order to establish lines of digital communication.

- Panoramic, high resolution photographs of the surrounding landscape were taken in order to develop the background of the digital environment.

- A panoramic video of the surrounding landscape using HVR-Z1U Sony HDV camera was acquired to serve as the development reference.

- Detailed descriptions and classification of all pieces of architecture of the island topography was developed by studying plans from the museum archives and topographical maps of the island.

Lack of time and access to archives was an obstacle for taking high resolution digital photographs of the iconostasis icons during the visit to Kizhi. The high resolution digital scans of the icons are part of the Museum Information Database "The Church of the Transfiguration". In agreement with museum personnel, the access to icon collection digital database would be considered for the interior stage of the project development.

5. DEVELOPMENT AND IMPLEMENTATION

5.1 Modeling and texturing

The 3-D models and objects are being built using Autodesk Maya software. The models are based on the architectural restoration plans, geometrical data from the island and archives along with high resolution and archival photographs taken during the initial island visit. Some of the measurement data on the photographs of the architectural plans is unclear. To determine the correct size and proportion, accurate numbers are calculated using geometry and mathematic formulas based on measurements in the photos. Sketches of the fundamental structure including 3-D sizes (width, length and height) provide the groundwork for digital 3-D modeling. The size discrepancies caused by restoration and time are being ignored for the sake of symmetry. The 3-D models present the original symmetric structures before geometric transformation (the original symmetry of the Church of the Transfiguration were lost due to numerous restorations). The modeling does not include levels of deterioration of the wood logs and latest support structure implemented providing the Church with engineering support. It also does not include the flaws of the surfaces of destroyed walls, corners, and constructive elements. Rather it redesigns the original state of constructive elements of the church with geometrical precision and symmetrical balance. The modeling also generalizes fine details such as frames of the windows, supportive constructions, elements inside the rooftop of the Belfry and utilitarian objects. The textures are being designed using Adobe Photoshop software to achieve historic accuracy in color and level of details based on the photographical data from the island. Some of the texture photographs are done using digital montage and image adjustments techniques to match in coloration, style and resolution.

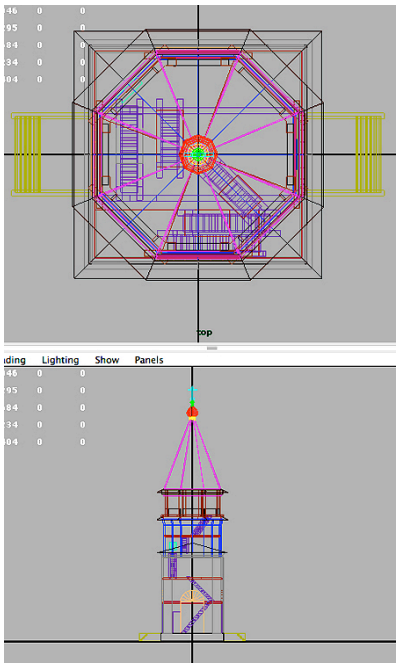

Figure 4. 3-D model of the Belfry in Maya GUI.

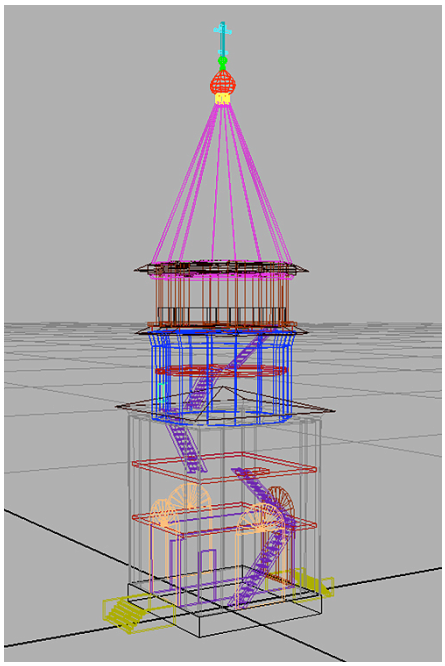

Figure 5. 3-D model of the Belfry in Maya GUI.

5.2 Realization

The visualization is being created using the application development environment Electro [7] which is designed for use on both cluster-driven tiled displays and desktop systems. Electro provides an easy-to-use scripting system for interactive 3-D applications spanning multiple processors and displays such as tiled display [8], Varrier™ [9], Personal Varrier, and C-Wall [10]. Visualization recreates virtual environment of the ensemble and the island landscape, animated historical evolution and the interactive application controlled by the user for exploration of interior/exterior details and selected stages in historical reconstruction.

To visualize realistic virtual environment the project includes two parts of the development. The first part is to create the exterior of the ensemble and surrounding environment (monuments, textures, topographical terrain of the island, surrounding environment, atmosphere, vegetation, lightning effects, landscape) based on the 5 following stages of historical reconstruction;

16th century first construction (lost in fire at the end of the 17th century. See chapter 3 above for details)
17-18th century reconstruction of churches built from logs
19th century architectural restoration stage that covered churches with plywood and domes with iron surfaces
20th century removal of the plywood and iron covers (current stage)
21st century plans for complete restoration of the structures and interior including iconostasis

The project is being developed in the reversed chronological order from the current stage. The 3-D models and textures of the previous stages are the next step to create a time based historical visualization.

The second part is to recreate the realistic virtual interior of the ensemble based on the digital database of icon collection from archives including historical visualization of the sky part of iconostasis lost during World War II (See chapter 3 above for details).

5.3 Implementation steps

- Design digital 3-D models of the Church of the Transfiguration, the Church of the Intercession, the Belfry, and the surrounding territory enclosed in the wooden fence.
- Design model of the island terrain based on the topographical maps and plans from the archives.
- Develop high resolution exterior textures based on the photographic data that utilize computer graphics techniques such as lighting on a per-pixel basis, bump mapping for richer, more detailed surfaces and lightning representation.
- Develop high resolution interior textures and digital representation of utilitarian and interior objects.
- Create an animated visualization of different times of the day, seasonal, lighting and atmospheric conditions.
- Develop interactive animation to restore the dynamics of the architectural changes on the museum area from the 15th century progressing through today.
- Finish postproduction processing including sound, demo and final output for tiled display, Varrier, and the C-Wall stereoscopic displays.

This development approach is based on the latest achievements in computer graphics techniques such as pixel-controlled lighting and bump mapping. Using per-pixel lighting calculations, developers can precisely control light and shading effects to render subsurface scattering effects and generate realistic images. Bump mapping, a technique that simulates the bumps or wrinkles in a surface without the need for geometric modifications, results in a richer, more detailed surface representation to visualize the details of the deteriorating wood with possible historic accuracy and photorealistic rendering. These techniques will allow realistic re-creation of the material properties of the structures under different lightening effects with higher resolution and accuracy.

6. CONCLUSION

The goal is to create a historical visualization of the ensemble exterior and the environment by the summer 2007. At this stage the project will be given to the museum to request the existing digital photographs of the iconostasis and icons of the interior of the Church of the Transfiguration from the computer database. The next step will be to develop the

visualization of the original iconostasis including the original “sky” part lost during World War II and the complete interior of the Church of the Transfiguration, Belfry and the Church of the Intersession.

We successfully already obtained visual material in the form of high resolution photographs, architectural and geometric measurements, textural data, video surveys and historical information from the Kizhi State Open-Air Museum which is now being implemented in the design of 3-D model of the ensemble. The result visualization will enliven passed history of Kizhi masterpiece and share it with a larger multicultural community. The project strives to advance the development of historical restoration in an artistic direction. The utilization of the latest research in computer graphics technology for artistic practice and historic restoration can foster the advancement of history and cultural transmission.

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For more information see
http://www.evl.uic.edu/rlk/electro/
http://kizhi.karelia.ru/

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8. EVL tiled display is 100-megapixel display, an11×5 array of 1600×1200 pixel LCDs.
9. Varrier™ is a head-tracked autostereo virtual reality display, which consists of 35 LCD panels tiled in a 7x5 configuration with a 6'x8' footprint. The display eliminates the need to wear special glasses to see the stereoscopic image, and yet still affords the user an effective sense of immersion.
10. The C-Wall or Configurable Wall is a high-quality, tracked, circularly polarized passive stereo wall based on the CAVELib™ software.