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Selma Rizvić, Aida Sadžak, Emir Buza
(Faculty of Electrical Engineering,
University of Sarajevo)
Alan Chalmers
(Warwick Digital Laboratory,
University of Warwick, UK)

VIRTUAL RECONSTRUCTION AND DIGITALIZATION OF CULTURAL HERITAGE SITES IN BOSNIA AND HERZEGOVINA

Abstract: Bosnia and Herzegovina is very rich with the cultural heritage sites. These historical sites nowadays look quite different from their original appearance, as a lot of time has passed from the moment of their construction. In addition, some of them were seriously damaged or completely destroyed during the recent war. This paper presents our experience in the digitalization of Bosnian cultural heritage, with the key purpose of preservation, reconstruction and virtual heritage applications. We describe virtual reconstructions and sun simulation of medieval Bosnian gravestone "stecak", virtual reconstruction of destroyed Sarajevo City Hall Vijećnica and virtual heritage application "Virtual Sarajevo – Baščaršija".

Keywords: virtual reality, visual perception, digital storytelling

CCS: 1.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism – Animation, Virtual Reality

1. Introduction

Cultural heritage is an extremely valuable set of material, traditions and knowledge that can be used to better understand the past itself. However, even nowadays there are still some significant difficulties to manage, preserve and disseminate cultural heritage sites. The use of virtual reality technology in cultural heritage is contributing decisively to reducing these difficulties [Mar01].

Bosnia and Herzegovina was founded in 11th century. The rich and turbulent history of this country, where the East meets the West, has left cultural heritage objects of different cultures and religions. There is a pressing need now for the preservation of both tangible and intangible heritage to enable future interpretations.

Although our research is just an initial application of computer graphics in virtual cultural heritage, it is being recognized and welcomed by the people from the cultural heritage sector.

The rest of the paper is organized as follows: Section 2 presents our work in preservation, reconstruction and interpretation of medieval Bosnian gravestone stećak; Section 3 describes virtual reconstruction of destroyed Sarajevo City Hall Vijećnica and in Section 4 we introduce our Virtual Sarajevo – Baščaršija project.

2. Stecak – Bosnian Gravestone

Virtual restoration can be used to improve the understanding of a site without resorting to interventions which are often traumatic for the original artefact. Objects which no longer exist, or objects that are damaged can be reconstructed digitally and the 3D model can then be viewed in its correct historical context.

The Warwick Digital Laboratory, University of Warwick and the Faculty of Electrical Engineering, University of Sarajevo have embarked on a joint venture to develop a system capable of achieving the three dimensional computer reconstruction and interactive high-fidelity visualization of Bosnian heritage sites. Such a system will enable archaeologists and historians to evaluate hypotheses concerning site utilization, structure, contents and development of the area.

The best known, and certainly the most valuable, monuments of medieval art in Bosnia and Herzegovina are the Stećaks. *Stećaks* are monumental gravestones, usually stone monoliths of different shapes and sizes. [Bes82].

Figure 1 shows the famous Stećak from Donje Zgošće, from the second half of 14th century. It is assumed that the Bosnian king Stjepan II who died in 1353, was buried under this stećak. This monument is currently located in the botanical garden of the BH State Museum in Sarajevo.

Figure 1: Stećak from Donja Zgošća, one of the most beautiful of the Stećaks is displayed in the botanical garden of the BH State Museum in Sarajevo

2.1. Digitalization. Methods such as 3D scanning and rendering with high fidelity graphics offer a faithful way to recreate scenes from the past. In many cases, such as with the Stećak from Donja Zgošća, the modeling of complex objects and surfaces using modeling packages and artists alone is not sufficiently accurate. Laser scanners provide a method of capturing accurate information about object's surfaces.

Since less illuminated scan areas produce better results, the stećak was scanned with a Minolta 910 laser scanner during the night because of the intense light in that part of the botanical garden during daylight. Given that, the textures captured by this scanner were not satisfactory, and so the decision was made to assigned the appropriate accurate textures later in the Maya software.

Individual scans, created by laser scanning method, were later connected together in a polygonal mesh by using the “Stitcher” software tool provided with the laser scanner, see Figure 2. This software package performs automatic data registration, editing of captured scan data (fill holes, decimate, smooth), merging scans into a single "watertight" mesh, and exporting to a variety of 3D data formats. The final polygon mesh was then exported as a Maya OBJ file.

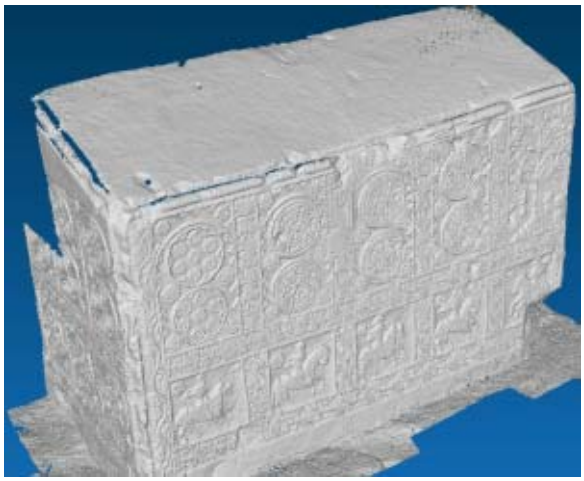

Figure 2: Half of the stećak (without textures).
Multiple scans merged into a single scan using “Stitcher”

The computer model of the stećak was transferred from Stitcher to Maya as a polygonal mesh made up of vertices (Figure 3). Each vertex is a point in three-dimensional space, so is described by three orthogonal coordinates. The points are joined into faces. Any number of vertices can be joined into a face, but the scanner software only uses between three and five points per face.

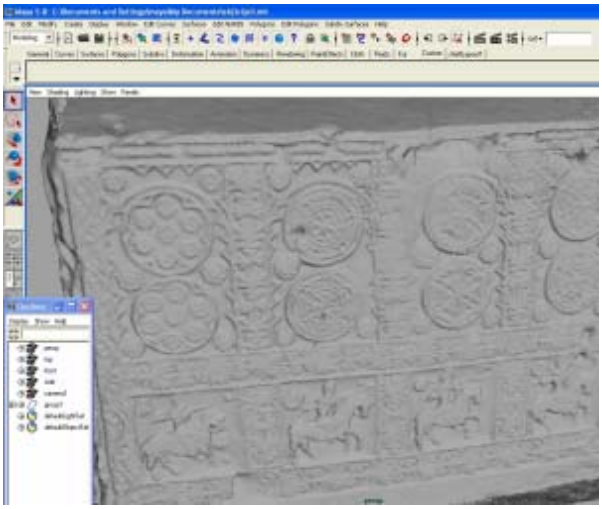

Figure 3: Model of Stećak imported in Maya

Unfortunately the size of the raw data acquired by the laser scanner was simply too large to be manageable in Maya. Maya has a function to reduce the number of vertices in a polygon model. This function works with polygons created in Maya, but does not work with the polygon meshes from the scanner. A variety of methods were investigated using a small

test model to try and resolve this problem: Neither the `OBJ` files exported by the scanner nor Stitcher could be reduced in Maya. The only way to reduce the size of a model was to load the original file in the Stitcher and reduce it there, and then import it back into Maya. This has produced slightly inferior, but still an acceptable quality model.

2.2. Reconstruction. The Stećak has suffered much damage over the years. The worst damage is visible at one corner (Figure 4).

Figure 4: Damaged corner of the Stećak (left), reconstruction (right)

Reconstruction of the damaged part was performed as follows: first, the vertices of the similar texture as the damaged parts were selected and duplicated, and then they were moved in right position on the damaged part. In combination with the use of appropriate polygon modeling operations, the following representation of the damage part of the Stećak was obtained (Figure 4).

2.3. Sun simulation. Stećaks were originally orientated from West to East, as the Bosnian Heretic Christians believed that was the way the deceased person could look at the sunrise. Nowadays, however, most of the stećaks have been moved from their original locations and are now orientated in a wrong way. This is also the case with the stecak from Donje Zgosce which is presently orientated from East to West.

Computer graphics enables us to place the computer model back into its original position and orientation and study how the sun would affect the stećak in its original location. [Sun03,SCM04].

We created in Maya an environment where periods of the day can be presented. The stećak was positioned on a NURBS plane. Its terrain configuration was achieved by the Sculpt Surfaces tool. We applied the Paint Effects tool to model the grass around the monument [Dwe].

The Maya Environment Sky texture was used for creating the sun simulation. This texture enables the user to achieve a realistic environment, with the sun, the sky, the clouds and the ground. It accurately simulates the planet system observed from the Earth's viewpoint.

The Environment Sky texture in Maya has several parameters, such as sun parameters (sun brightness, halo brightness, sun size, blur, elevation, azimuth, sky brightness, ground texture and parameter, air density, dust density, clouds parameters, etc).

We animated the elevation and azimuth of the sun that was linked to a directional light, Figure 5. That way we were able to present the illumination of the stećak from sunrise until sunset [RSACC06].

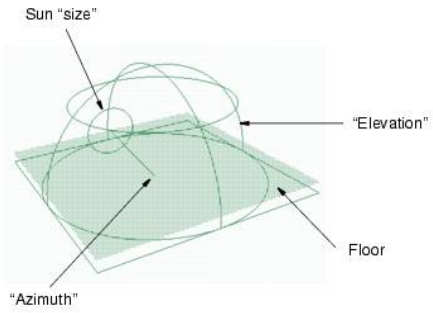

Figure 5: Environment Sky texture in Maya

We positioned the sun in our simulation according to that orientation and rendered the animation. Then we rotated the stećak to achieve its present orientation and rendered the animation again. Figures 6 and 7 present the illumination of the carvings and shadows in both cases, in wide shot and in close-up.

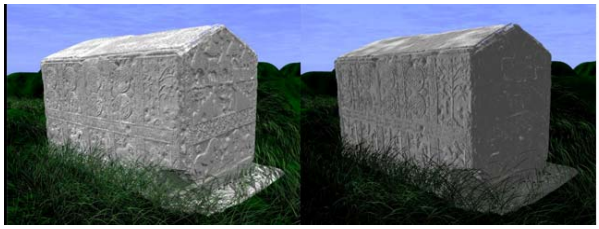

Figure 6: Incorrect orientation (left)
and correct orientation (right), 15:00 – wide shot

Figure 7: Incorrect orientation (left)
and correct orientation (right), 11:00 – close up

Clearly visible is the difference in the appearance of the carved ornaments shadows in case of the correct and incorrect orientation.

It is now up to the archaeologists to draw conclusions about this difference and to compare different scenes presented in the carvings in both cases. There is also a possibility to observe the object at different time of the day and for any year by changing the azimuth and elevation parameters in the simulation.

This simulation has shown the great potential and advantages of using such computer graphics techniques in the visualisation of heritage sites and objects. Archaeologists are now able to use this virtual model for verifying their assumptions related to the position of the stećaks and the influence the sun may have had on the perception of these ancient monuments.

3. Virtual reconstruction of Sarajevo City Hall

The Sarajevo City Hall known as Vijećnica (Figure 8), is a graceful Moorish revival building constructed in the heart of the old city during the period of the Austro-Hungarian Empire. It was destroyed in the Serb artillery bombardment on August 25/26, 1992. Priceless collections of manuscripts, old books, magazines, archives and other materials (documentary heritage of B&H) disappeared in the fire. The building is now under reconstruction.

Figure 8: Present appearance of Vijećnica

Virtual model of Vijećnica (Figure 9) was made in 3ds max software. Before modelling, we visited the site, took many detailed photographs, measured the object and later on validated the created model. The object was modeled using basic geometry (standard primitives) and compound objects – cubes and Boolean operation. The textures we used for object mapping, were created using the photographs. Since we choose to model highly visited site, taken photographs had to be edited in Photoshop in order to remove unnecessary details, such as shadows and people, from images.

Figure 9: Virtual model of Vijećnica

We performed significant optimization of this model to make its size suitable for Internet presentation [Hul07]. Using a visual perception experiment, we showed that a signifi-

cant optimization of VRML model can be achieved using 3ds max Optimize modifier and exporting the model in x3D by Vizx3D software.

Through a storytelling virtual heritage application [SRD07] we explored how the story told by an animated and a real character influences a viewer's perception of information and investigated whether it is distractive enough to make him/her fail to notice any decrease in rendering quality. We created combinations of stories told by real and animated character in a virtual environment and rendered the scene at different rendering qualities. User study was performed to verify our assumptions. The results showed that when engaged by a real character telling a story, viewers have better perception of informations told in the story, than when the story is told by an animated character.

4. Virtual Sarajevo – Baščaršija project

Sarajevo, the capitol of Bosnia and Herzegovina, has been inhabited since 5000 years ago. The first neolythic settlements in Butmir have been followed by Illyrians, Romans and Slavs. The city was governed by the Ottomans and Austro-Hungarians and has always been a place where the East meets the West. Many people call Sarajevo the European Jerusalem, as there are, next to each other, mosques, Catholic and orthodox churches and Jewish synagogues. Mutual respect of the different religions and nations is a part of the everyday life.

The goal of the Virtual Sarajevo-Bascarsija project was to present the old part of the town to visitors through the Internet. The content created for this presentation is multimedia. In this section we present the techniques and technologies used for creation of this content and its web implementation.

4.1. The content. The user is provided with multimedia content: panoramic photographs (Figure 10), video walkthrough files of the streets and the stories about the particular objects and events, so as the complete virtual model of Baščaršija. Navigation is by means of a VRML browser. A collection of cultural heritage object models is also presented at the site.

Figure 10: Panorama of Sebilj Fountain

Video walkthroughs provide the user with the real feeling of space. We created a set of several video files captured from the real environment using a digital video camera to present a photo-realistic atmosphere of Baščaršija's streets to the viewer.

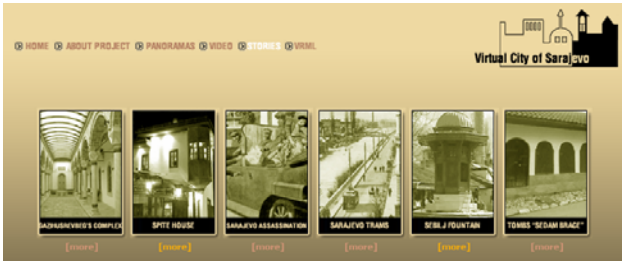

Figure 11: Stories thumbnails in Virtual Sarajevo project

As presented in [FMSK04], every place has its "genius loci", the spirit of the place. This means that we have a different perception of the place if we know a story related to that place. In our project "Stories" are the short movies capable of dramatizing historical events and providing lesser-known historical contexts for particular objects and events from the past of Sarajevo. The audio description helps to significantly enhance all aspects of the video (Figure 11).

4.2. Web implementation. A database keeps all the information about sizes, extensions, descriptions and paths of the multimedia and panoramic files. The database itself is implemented in xml and each file shown on the web page is described by xml file tags

The advantages of using larger databases are that the complete objects are kept in the database, such as multimedia files of the video clips and panoramic photographs. When accessing these data, they are first read from the database, then forwarded to the service for streaming (in case of the video files) and subsequently packaged and sent to the web. This enables the internal administration of new and old files through the same mask and reduces the communication to the database only. In case of any changes it is sufficient to update the database, and this will complete the process for the other service information. On the other hand, the administration is not left only to the internal platform but is made possible through the web support. All changes made in the database are automatically reflected on the whole site.

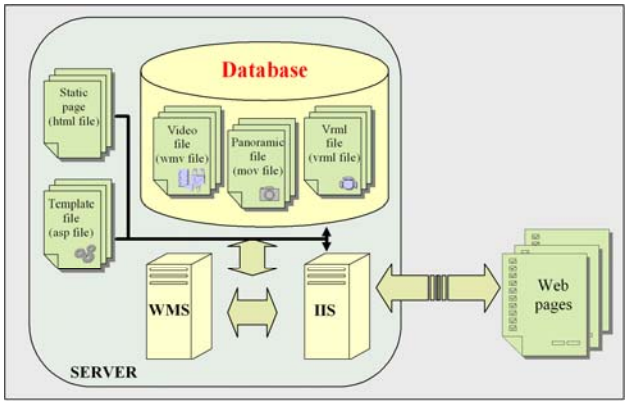

Figure 12: Database comprises all information of multimedia files, panoramic photographs and virtual model

The virtual model with the complete content becomes a database content. Depending on the location chosen by the client, most information and templates for the virtual file will not be read in with the whole content. This means that only the information that is sufficient for representation of the particular part of the virtual model with all the required objects will be read. Communication is now two-sided, i.e. the user through interaction with the database constantly receives new objects and templates for representation enabling him/her much faster "jumping" from one location to the other. Therefore this is a 'cluster' way of reading in where only a temporary cluster is being read in, the one that is to be shown and any adjacent clusters. This means that the user who is 'strolling' along the virtual model constantly receives information regarding his/her temporary position in the model and consequently in the database which initiates reading in of the next cluster to be presented. A schematic representation and structure of the site is given in Figure 15.

The project will shortly be updated with the additional cultural heritage objects such as the Old Orthodox church, the Cathedral, the Old Jewish Sinagogue, video walkthroughs through the remaining streets of old Bascarsija and some more stories about the important historical events.

Furthermore, we hope to be able to expand this project to the whole of Bosnia and Herzegovina, including other interesting cities such as Mostar, Travnik, Bihac, Banja Luka, Tesanj, Trebinje, Visegrad etc. This will provide web users with a significant collection of information about Bosnia and Herzegovina and its unique cultural heritage.

5. Conclusions

Virtual heritage research in Bosnia and Herzegovina has just started with the significant work in preservation, reconstruction and interpretation of cultural heritage objects. Our experience shows that the combination of laser scanning and 3D modeling techniques enables us to create a collection of virtual models with different application possibilities.

We have explored applications such as interactive CD's with all the data about certain objects containing panoramic photos, video walkthroughs, stories and interactive 3D models. We have also developed web applications of the same data, optimized for Internet use.

In addition, we have expanded our virtual heritage applications with real and animated avatars telling stories from Bosnian tradition and history of the objects presented in virtual environment. This has the further benefit of enabling us to perform research into the visual perception of computer animation and verify our assumptions through user studies.

Our virtual models are helping the archaeologists to discover how certain objects might have looked like in the past using different variations of 3D models and lighting simulations.

As described in the paper, each of these projects still has significant future work ahead. In general, we plan to continue and expand our virtual heritage research and present the rich Bosnian culture and tradition to the world audience.

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srizvic@etf.unsa.ba