

# Digital Technologies for Cultural Heritage Presentation in Bosnia and Herzegovina

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**Abstract**— For centuries Bosnia and Herzegovina has been a country where East meets the West. Therefore it is very rich with remains of various cultures, nations and religions. Some of these remains are in very bad condition, some have completely disappeared. Digital technologies offer a great potential in preservation and presentation of cultural heritage, enabling better understanding of the common past. This paper provides an overview of 10 years long work of researchers gathered around the Sarajevo Graphics Group and through their projects offers an insight into various applications of Internet and IC technology as a new media for cultural heritage presentation.

## I. INTRODUCTION

Illyrian, Roman and Slav tribes have inhabited this region ever since the Neolithic period. Remains of human settlements were found in Butmir near Sarajevo. Bosnia as a country was first mentioned in the tenth century AD, in the work of the Byzantine emperor and writer Constantine Porfirogenetus. In the medieval European circles Bosnia was extremely appreciated: it had a royal family, palaces, strong and powerful nobility and a unique culture. Ottoman and Austrian Hungarian occupations left traces of their cultures in architecture, infrastructure and lives of people.

The Ottoman Empire offered shelter to the Jews who fled the Spanish and Portuguese Inquisitions. Many Jews settled at that time in the Ottoman province of Bosnia and Herzegovina. Hence the original Jewish community of Sarajevo was Sephardic, and Bosnia hosted Europe's largest Sephardic Jewish community after Spain.

The rich and turbulent history of Bosnia and Herzegovina left us with many cultural heritage objects and sites. Preservation and presentation of this heritage will enable us to better understand our past. Digital technologies offer a new media for exploration and analysis of cultural heritage. They finally made possible the travel through time. Sarajevo Graphics Group is experimenting with application of these technologies on Bosnian cultural heritage.

Ten years ago the researchers from the Faculty of Electrical Engineering Sarajevo were supported by UNESCO in digitization of the most important Bosnian medieval gravestone, stećak from Donja Zgošća, using laser scanner. It was the beginning of a serious research in digital cultural heritage field in Bosnia and Herzegovina. Today the group includes members not only from ICT, but also archaeologists, digital artists, historians, writers and museum curators, as only a true interdisciplinary team can implement these projects with success.

This paper will offer an overview of projects that have been implemented by Sarajevo Graphics Group, through technologies they used and experience gathered in the process.

## II. CULTURAL HERITAGE DIGITIZATION WORKFLOW

Although the cultural heritage digitization projects differ in application purpose and technologies used, we define a typical project creation workflow, based on our experience (Figure 1).

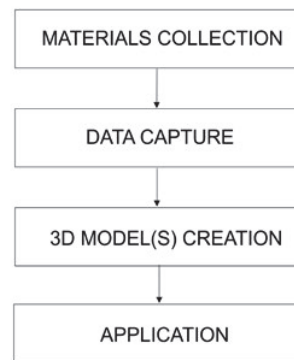


Figure 1. Cultural heritage digitization workflow

Every project starts with collecting materials from historians, archaeologists and cultural heritage protection institutions. Sometimes the information on the objects is obtained from oral histories or memories of people. This step is very important for the success of the project.

Data capture could be performed using various techniques, such as laser scanning, LIDAR (Light Detection and Ranging) data, photogrammetry etc. It is important to note that data captured in this stage needs a lot of post-processing in order to be used in 3D model creation.

The 3D model of a cultural heritage object could be created using classical modeling techniques, mostly in case when no remains of the object are preserved, but it can be also generated using a combination of geometry obtained in the data capturing stage with newly created geometry.

The last step in the workflow depends on the purpose of the cultural heritage digitization project. The 3D model can be textured and rendered to be a part of a digital story, or could be exported in web 3D format and used as interactive virtual environment. There are also models generated for preservation purposes, for education or reproduction using 3D print.

In the following sections we will present our projects within the described workflow and elaborate the digital technologies we used in the implementation.

### III. DATA CAPTURE

Cultural heritage objects with irregular shape, containing carvings or other decorations, can not be easily modeled using classic modeling techniques. Laser scanning offers a great support in capturing all details of object's shape and surface.

Our first encounter with laser scanning was during the UNESCO funded project "Virtual reconstruction of cultural heritage in Bosnia and Herzegovina" in capturing the famous Bosnian medieval gravestone, presently preserved in the Botanical garden of the National Museum of Bosnia and Herzegovina. We used Konica Minolta 910 laser scanner and performed a number of individual scans of surface sections, which were later connected to a single geometric mesh (Figure 2).



Figure 2. Laser scanning of stećak from Donja Zgošća

The obtained data generated such a complex model that we finally used only the 5% quality of the scanned point cloud for producing the mesh, as the full quality scan was not manageable on our workstations. This scanner had not captured the texture or color information on the object.

In our later work we used the hand held laser scanners, such as Z Scanner 900, for scanning the bronze portion of the monument to Franz Ferdinand and Sophie (Figure 3). In this case we used the full quality scanned data, while the post processing was done in the scanner portable software, as well as in 3ds max.



Figure 3. Laser scanning of the monument fragment

Laser scanning has not proved suitable for objects with hollow parts, as the scanners could not capture those parts with great accuracy.

### IV. 3D MODEL CREATION

Although our first 3D model of a cultural heritage object, stećak from Donja Zgošća, was generated using laser scanning [1], most of the models in the next projects were created using classical modeling techniques, mainly because we had no remains of those objects available for

data capture. We created models of objects that do not exist any more, as they were destroyed or demolished, such as Isa bey's endowment [2,3], the Church of the Holy Trinity in Mostar [4], Vizier's Konak in Travnik [5] (Figure 4).



Figure 4. a) The Church of the Holy Trinity in Mostar, above, b) Vizier's Residence in Travnik, below

The models of Roman objects created for enhancing the European museum exhibition "Keys to Rome", were also created using classic modeling techniques, but some preserved fragments were digitized using photogrammetry and added to the geometry of the models.

The 3D model of the monument to Franz and Sophie, (positioned until 1919 on the edge of the Latin bridge in Sarajevo), was created as a combination of laser scanning the preserved parts and modeling the rest of the object. The laser scanned data were subjected to some post processing in order to serve as a part of the 3D geometry [6].

3D models of medieval gravestones and stone monuments in the "Digital Catalog of Stećaks" project were created by photogrammetry and improved by post processing in 3ds max [7]. The post processing resulted in creating accurate geometry of the objects with all surface characteristics built in.

Virtual reconstruction of the Sultan Murat IV fortress in Sjenica, Serbia, was created only from the oral history [13]. This fortress was completely demolished in 20<sup>th</sup> century and today at its place stands an elementary school. We interviewed a person who remembers the fortress object from his childhood and created the 3D model based on the information from these stories.

### V. APPLICATIONS

The main application of our virtual cultural heritage project was presentation of the valuable objects and sites to the general public through Internet. Our aim is to enable the visitor to travel to the past and learn the historical facts, while being immersed in the virtual environment in a way as close as possible to reality.

For this purpose we used several web 3D technologies, such as VRML, x3D and Unity, as well as some that only simulate 3D environments, such as Flash. One of the most important aspects of user immersion in the virtual environment is the quality of interaction that the environment provides while the user is browsing around. Apart from navigation, we introduced digital storytelling in our applications, in order to teach our visitors the historical context of presented cultural heritage objects and stories about events and characters related to them. Combination between navigation and storytelling was a

very interesting variable for evaluating the user's perception of the environment.

#### A. Interactive Virtual Environments with Storytelling

The first concept of interactive virtual environments with storytelling we implemented in the "Virtual Museum of BH Traditional Objects" [8]. This project is presenting the exhibition of objects from every day's life of people from different cultures that have been living in Bosnia and Herzegovina for centuries. These objects are not easy to understand for Internet visitors from all over the world if they are not accompanied by stories about their origin, purpose and way of use. Therefore, we presented every object through text, gallery of photos, digital story and an interactive 3D model. The objects are accessed by clicking on panels representing each of them in a joint virtual environment.

The main disadvantage of this concept was that users do not visit all available objects, but after some time they get tired and leave the virtual museum. For that reason, in our next virtual museum project, the Sarajevo Survival Tools (Figure 5), we introduced a digital story guiding the visitors through the exhibition [9].



Figure 5. Sarajevo Survival Tools virtual museum

In the Virtual Museum of Bosniak Institute, we experimented with reducing the freedom of movement to the visitors by implementing the virtual environment in form of rendered images with hotspots, while at the same time providing the audio stories about the objects and collections. It was interesting to find out that the users were not aware of movement limitations, as they were paying more attention to the stories [10].

The next step in our research of interactive digital storytelling for cultural heritage was the Isa bey's endowment project. In that project we implemented two concepts: interactive computer animation and spatial interactive storytelling [3]. In the recreated environment were the objects that the founder of Sarajevo, Isa bey Ishaković, has built for public benefit on the bank of river Miljacka. There was a soup kitchen, water mills, an accommodation facility and a derwish tekke<sup>1</sup>. These objects do not exist any more and the surroundings have been significantly changed. Within the virtual reconstruction we recreated the derwish ritual «zikr», that was going on inside the tekke. The user is placed in the middle of a computer animation of the ritual, where the narrator is explaining the characteristic parts, with a

<sup>1</sup> Derwish are Islamic sufi believers who gather in places called „tekke“ to discuss about religion and perform the ritual prayer called „zikr“

possibility to click on highlighted objects and see them explained in more detail in digital stories. Outside of the tekke, the user listens to the audio story about Isa Bey's endowment and, while navigating around the individual objects, the stories about them are triggered by proximity sensors.

Advantages and drawbacks of all mentioned interactive storytelling concepts led us to the work in progress: the recursive interactive story guided virtual museum [11]. The aim of this concept is to convey the information about cultural heritage to the users according to the amount of time they plan to dedicate to the visit. The stories are branching to more detailed stories using hyper-video.

#### B. Augmented Reality

Augmented reality (AR), according to Merriam-Webster Dictionary, is "an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device (such as a smart phone camera)". In virtual presentation of cultural heritage this technology has a great potential, providing the mobile device users the additional information over their camera images. In that way we can recreate appearance of our surroundings from different time periods and bring the forgotten cultural heritage objects back to collective memory.

Our Sarajevo Time Machine project was a pilot application created to show the potential of AR to cultural heritage professionals. We created simple 3D models of 6 selected objects in Sarajevo down town and stories about them. This content can be viewed on the mobile device display using the Layar open source AR platform. In this way the users can see on their screens the objects that used to exist in places where they stand and there is no physical trace of them today. The objects are shown in the 4D interactive map on the project web site, according to the time periods of their origin (Figure 6).

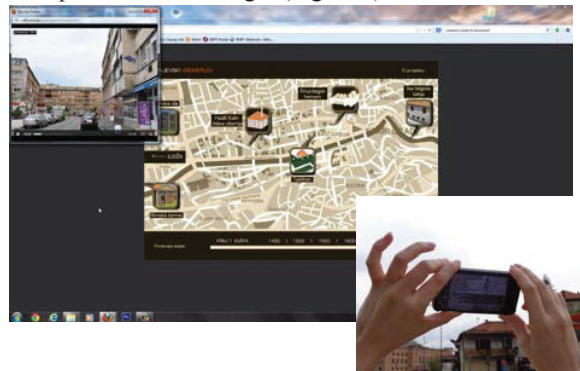


Figure 6. Sarajevo Time Machine project

## VI. ENHANCING MUSEUM EXHIBITIONS

Our successful virtual museum projects earned us the invitation to join the EU FP7 Network of Excellence "Virtual Museum Transnational Network V-MusT.net". This network has a goal of establishing a new research discipline that would integrate the knowledge in application of digital technologies for enhancing museum exhibitions and presentation of cultural heritage. In the last year the consortium has organized an international

multimedia exhibition on Roman culture “Keys to Rome” [12]. This exhibition is held at the same time in Rome, Amsterdam, Alexandria and Sarajevo, with aim to present different parts of Roman Empire through a combination of physical exhibits and digital content. Roman objects that remained in all four locations were virtually reconstructed and the 3D models of museum artifacts were positioned inside. Using digital installations, the exhibition visitors could walk through Roman villas and temples and collect objects connected through a common digital story. Besides the exhibits from the physical location of the exhibition, they could see the other three exhibition locations virtually.

In Sarajevo the exhibition was held in the newly restored City Hall (Figure 7). It contained the physical exhibits from the archaeological sites in Ilidža near Sarajevo kept in the National Museum of Bosnia and Herzegovina and the Museum of Sarajevo. We recreated the Roman villa and thermal baths from Ilidža, as well as the Early Christian basilica from Cim near Mostar. The visitors could browse these virtual environments using the Admotum natural interaction setup (Figure 8). When they would find an object of interest they could transfer it to the Holobox installation and explore it in detail using the Leap motion sensor. All physical exhibits had their virtual models connected with exhibits from other three locations within the Matrix mobile application.



Figure 7. Keys to Rome exhibition, location Sarajevo



Figure 8. Admotum digital installation

## VII. USER EVALUATION

One of the most important methods for measuring the success and quality of virtual cultural heritage projects is the user evaluation. We are using the customer satisfaction methodology with questionnaires and the qualitative analysis of user interviews.

Ritual Zikr in Isa Bey's tekke

interactive animated story

Evaluation - film + interactive story

Personal data

1. How old are you?
2. Do you have problems with your eyesight? :
3. Do you have a hearing problem?
4. Whether you are an experienced computer user? For what you use computer the most. (work, games, mail, Skype, etc.)?

After watching the film, and interactive stories users need to respond (preferably in detail) the following questions;

1. Have you heard of Isa Bey tekke?
2. Do you know what a tekke?
3. Which order of dervishes gathered in this tekke?
4. What did you learn from the examined films / animations?
5. Did you feel like you were in a tekke?
6. What is missing?
7. What bothered you?
8. What did you like the best?

9. Have you had problems with navigation in the interactive environment?
10. Have you used a site map (house in the upper left corner of the screen)?
11. Would you be back again to look at what you missed?

12. What is better for learning about the object? A film or interactive form?
13. Why?
14. Do you have any recommendations to improve the interactive form?

Thanks for your cooperation!

Figure 9. Example of a questionnaire for user evaluation

The questionnaires we use usually contain questions related with the following topics: general information on the user (age, profession, familiarity with use of computers, sight and hearing impairments, familiarity with the reconstructed object), usability of the application (UI, navigation, immersion, interaction), obtained information (quality of digital storytelling) and positive/negative impressions (Figure 9).

Interviews were conducted in such a way that the users would talk about their experience with the application, being occasionally directed with some questions from the interviewer about the same topics covered in the questionnaires. The qualitative data obtained in the interviews were converted into quantitative form by the process of data coding. Coding extracts values for quantitative variables from qualitative data (interviews and questionnaires) to perform quantitative or statistical analysis [14] (Table 1). The process of coding does not affect data subjectivity or objectivity. Based on the research question we need to answer through the particular user study, we formed a number of hypotheses and explored if they were confirmed by the coded answers. Such a user evaluation of the interactive “zikr” ritual animation in the Isa Bey’s endowment project is presented in [15].

Based on all our user studies, we can conclude that the feedback of the users to our virtual cultural heritage projects is very positive. They appreciate finally being able to visualize the remains of objects they visit at the archeological sites, to virtually explore those objects and learn about their history, about events and characters related to them. The users familiar with computer games

easily adjusted to these applications, while the less experienced users expressed some concerns about navigation methods that we have taken in account and corrected in the next projects. The use of digital storytelling has significantly enhanced the feeling of immersion and the amount of obtained information on the objects.

Question	Code	Possible value	Answer
Have you heard of Isa Bey tekke?	I1	yes no	15 5
Do you know what is a tekke?	I2	yes no	18 2
Which order of dervishes gathered in this tekke?	I3	right wrong	16 4
Did you feel like you were in a tekke?	E1	yes no	15 5

Table 1: Category I questions

Question	Code	Possible value	Answer
Have you had problems with navigation in the interactive environment?	N1	yes no	4 11
Have you used a site map (house in the upper left corner of the screen)?	N2	yes no	12 3
Would you be back again to look at what you missed?	N3	yes no	14 1
What is better for learning about the object? A movie or interactive form?	E2	movie inter. form equal	2 6 2

Table 1. Example of data coding in qualitative user evaluation

The user studies showed us what aspects of virtual environments were most important for their perception and it was not always the same as what we considered as important in the process of project development. For example, they considered more important the quality of navigation then the realism of displayed environments.

## VIII. CONCLUSION

The overview of virtual cultural heritage projects implemented by Sarajevo Graphics Group shows our experience in using different digital technologies for cultural heritage digitization, presentation and preservation. We described the main methods of data capture, 3D model creation and presentation of those models in various web 3D and augmented reality technologies.

Considering the rapid development of 3D technologies, there is a serious issue of technologies becoming obsolete. Sustainability and life span of virtual cultural heritage is a problem addressed by many scientists and research groups. There is still no universal solution except structuring the projects in such way that the technology related parts can easily be upgraded.

A very positive feedback of our users shows that the virtual presentation of cultural heritage is appreciated and offers the knowledge on our past in a modern and up-to-date way. Through our projects we brought many forgotten objects back to the collective memory. Virtual travel to the past was equally exciting for all generations and backgrounds of our users.

There is still a lot of work to do in discovering the most immersive way of cultural heritage presentation. We find the interactive digital storytelling as a powerful tool for conveying information to the virtual and real visitors. The use of digital technologies for enhancing the museum collections results with development of a new profession – digital curators. They will have enough knowledge about the potential of digital technologies to invent new ways of organizing museum exhibitions. Virtual museums will not replace the physical museums, but attract more visitors to them. Virtual cultural heritage projects will enhance the development of cultural tourism. Better understanding of the past will improve our perception of the present.

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## REFERENCES

- [1] Selma Rizvic, Aida Sadzak, Emir Buza, Alan Chalmers - Virtual reconstruction and digitalization of cultural heritage sites in Bosnia and Herzegovina, Cetinje, SEEDI 2007, *Review of the National Center for Digitization*, 82 – 90, Publisher: Faculty of Mathematics, Belgrade, Serbia, ISSN: 1820-0109J
- [2] Selma Rizvić, Aida Sadžak, Anis Zuko, Isa bey's Tekija in Sarajevo - reviving the reminiscence of the past, *Review of the National Center for Digitization*, Publisher: Faculty of Mathematics, Belgrade, Issue: 15/2009, pg 64-72, ISSN: 1820-0109
- [3] S. Rizvic, A. Sadžak, M. El Zayat, B. Žalik, B. Rupnik, N. Lukač, Interactive Storytelling About Isa Bey's Endowment, *Proceedings of SEEDI 2013*, Zagreb, Croatia
- [4] B. Ramić-Brkić, Z. Karkin, A. Sadzak, D. Selimovic & S. Rizvic, Augmented Real-Time Virtual Environment of the Church of the Holy Trinity in Mostar, *Proceedings of VAST 2009*, ISBN 978-3-905674-18-7, pg 141-148
- [5] V. Jovišić, Virtual Reconstruction Of The Viziers' Konak In Travnik, Master Thesis, Sarajevo School of Science and Technology, 2009
- [6] G. Radošević, S. Rizvić, Spomenik Ferdinandu i Sofiji - od laserskog skena do interaktivnog 3D modela, *Drugi međunarodni simpozij "Digitalizacija kulturne baštine Bosne i Hercegovine, Sarajevo"*, maj 2010.
- [7] S. Rizvić, A. Sadžak, Digitalni katalog stecaka, *Drugi međunarodni simpozij "Digitalizacija kulturne baštine Bosne i Hercegovine"*, Sarajevo, maj 2010

- [8] S. Rizvić, A. Sadžak, Multimedia techniques in virtual museum applications in Bosnia and Herzegovina, *International Conference on Systems, Signals and Image Processing (IWSSIP)*, 2011, pp 1-4 ISBN 978-1-4577-0074-3
- [9] S. Rizvic, A. Sadzak, V. Hulusic, A. Karahasanovic, Interactive digital storytelling in the Sarajevo survival tools virtual environment, *Proceedings of the 28th Spring Conference on Computer Graphics*, Pages 109-116, ACM New York, NY, USA ©2012, ISBN: 978-1-4503-1977-5
- [10] S. Šljivo. Audio Guided Virtual Museums, in Proceedings of Central European seminar on Computer Graphics, Smolenice, Slovakia, 2012
- [11] S. Rizvic, Story Guided Virtual Cultural Heritage Applications, *Journal of Interactive Humanities*, Vol. 2: Iss. 1, Article 2, ISSN: 2165-7564, 2014
- [12] International multimedia exhibition on Roman culture, Keys to Rome, [www.keys2rome.eu](http://www.keys2rome.eu)
- [13] I. Skalonjic, Interaktivna miksmidijalna virtuelna rekonstrukcija tvrdave Sultana Murata IV u Sjenici, *Masters thesis, Faculty of Electrical Engineering Sarajevo*, 2014
- [14] C.B.Seaman. Virtual Qualitative Methods in Empirical Studies of Software Engineering. *IEEE Transactions on Software Engineering*, Vol. 25, No. 4, 1999.
- [15] M. Huseinovic, R. Turcinhodzic, Interactive Animated Storytelling In Presenting Intangible Cultural Heritage, *In Proceedings of the Central European Seminar on Computer Graphics*, Smolenice, Slovakia, 2013