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CULTURAL HERITAGE  
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## Case Study Report

1. case study: **Visualization of White Bastion fortress based on 3D Spatial Documentation of Material Cultural Heritage And Interactive Digital Storytelling**
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3. Report submission date: 20th August 2016
4. Author(s) name, position/status and affiliation, contact details; expertise/research interests (max. 100 words per contributor).  
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Research areas: Computer Graphics, Computer animation, Virtual Heritage, Multimedia, Virtual Reality, Broadcast Design, Interactive Digital Storytelling, Virtual Museums, Digital Humanities
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6. Acknowledgement of support and funding received: coproduction of digital stories with BH Radio television
7. Type of case study: *descriptive*
8. Up to 6 keywords: virtual reconstruction, virtual reality, user immersion, interactive digital storytelling
9. Summary Report (max. 200 words): what has been studied, why and how; key findings.

White bastion fortress has been standing in defence of Sarajevo since medieval period. In time it was changing together with various dominations upon the city. 4D virtual presentation aims to display the historical development of this cultural heritage object through digital storytelling combined with interactive 3D models of the Bastion in various time periods. These models contain digitized findings from the site and their 3D reconstructions. In this case study we define and implement a new method of interactive digital storytelling for cultural heritage. User evaluation studies show the advantages and drawbacks of this method.

Key findings can be summarized as follows: interactive 4D visualization helps the archaeologists to verify their assumptions on the appearance and development of the fortress through history. Online implementation raises the awareness of general public about this valuable cultural heritage site. Interactive digital stories enhance immersion of virtual visitors in the past and convey the documentary information in modern and attractive way. The project provides foundations for creating new interactive museum exhibitions of remains found on the White Bastion site.

10. Description of aims: White bastion case study aims to present the historical development of this cultural heritage object using virtual reality and interactive digital storytelling, in order to support archaeological research of the site and raise awareness of general public.

11. Rationale: Why was this study needed? Who is likely to benefit?

This study was proposed by the leading archaeologist of the White bastion excavation in order to visualize their hypotheses on the appearance of the object in different historical periods. There was also a need to inform the Sarajevo citizens and tourists about the cultural importance of the fortress and facts from its history. Benefits of this work will be enjoyed by the archaeological scientists, museum professionals and visitors of the site, as well as internet visitors of the project. BHRT will broadcast a documentary about White bastion created from digital stories within the project, which will benefit their viewers.

12. Detailed information about the cultural heritage object/site used in the study (type of object, title, subject, date, ownership, techniques/media, dimensions, description, etc) or reference to a monographic study/standard catalogue.

The fortification known as „White Bastion“ is one of the most impressive and important historical sites in Sarajevo. It is located on the southeast outskirts of the City, with an overview on the city valley (Figure 1). Through history it had a very significant and strategic position. The fortification is a part of the dominant defence walls that were surrounding the old city of “Vratnik”.



*Figure 1. Bijela tabija (White bastion) fortress, Sarajevo, Bosnia and Herzegovina*

The value of the historical site presents the various strata, starting from medieval until the present time. During the archaeological excavations there were found the remains from medieval fortification from 14th century, Ottoman period (17th century) when the fortification was expanded and some new objects were built. During Austro-Hungarian rule the part of the fortification and the object inside the walls were demolished and destroyed and a new group of objects was built. During the early excavation (Figure 2), a significant number

of artefacts was found (Figure 3), registered and conserved for the purpose of the exhibition hosted in Museum of Sarajevo.

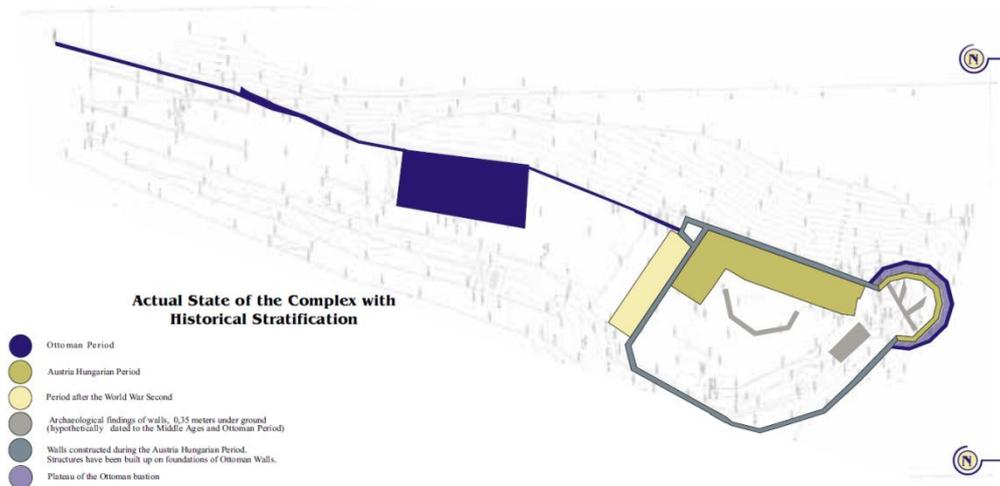


Figure 2. Actual state of the complex with historical stratification [1]



Figure 3. Artefacts found on the site

13. Brief description of the visual record created, incl. access information and copyright.

The project consists of 10 digital stories (Intro, Medieval period, Ottoman period, Austro-Hungarian period, the mosque, military music, Hećimoglu Ali pasha, gunpowder magazine, reconstruction in 1889, the end), 6 interactive virtual models of the fortress and presentations of selected digitized and virtually reconstructed archaeological findings. It is online at <http://h.etf.unsa.ba/bijelatabija/>

BHRT documentary movie can be seen at

<https://www.youtube.com/watch?v=8L-ehpgzV1Q>

Copyright: Sarajevo Graphics Group & BHRT

14. Methodology: Step-by step description of methods and techniques (this section may need to be broken down).

4D virtual presentation of White Bastion was created within a workflow of following methods and techniques:

#### 14.1. Materials collection

In consultations with historians and archaeologists, all available literature from historical sources was studied and drawings and blueprints of the archaeological remains were collected.

#### 14.2. Design of the application and interactive digital storytelling concept

Chief archaeologist has sketched 6 following assumed appearances of White Bastion in medieval, Ottoman and Austro-Hungarian period:

##### First phase: medieval period

The fort was rectangular in plan with square corner towers and a gate house midway along the north perimeter wall.

##### Second phase: Ottoman period 1448-1450

Introduction of a garrison of timar holders for whom a mosque was built, houses of the imam and two muezzins. Ditch filled with water dug in front of the fort, mobile wooden bridge

##### Third phase: Ottoman period first half of the 18th century

The bastion in the south-east corner was built. No ditch.

##### Fourth phase: Ottoman period

No mosque, octagon which purpose is still to be discovered. Additional gate on the west wall.

##### Fifth phase: Austro-Hungarian period

Demolition of buildings within the ramparts; the central area was then levelled, new groups of buildings were erected.

##### Sixth phase: Austro-Hungarian period

The addition of the walls with cannon embrasures on the top of the bastion.

Main topics for digital stories have been identified. Based on our previous interactive digital storytelling research [2], [3], [4], [5], [6], [7], we designed a new concept of stories content and distribution and their relations with interactive 3D environments of the fortress. Archaeological findings from the site, kept in the Museum of Sarajevo, were analysed and most significant ones were selected for digitization and virtual reconstruction.

#### 14.3. Digitization of archaeological findings

Chief archaeologist identified 22 objects found on the White Bastion excavation site for digitization. Digitization was performed in the Museum of Sarajevo through COSCH STSM of Fotis Arnaoutoglou from "Athena" Research Center, Xanthi, Greece. Objects were digitized using photogrammetry. Obtained models were cleaned and adjusted. Geometry was exported as low and high quality meshes in OBJ format (Figure 4).



*Figure 4. Review of digitization results*

#### 14.4. Virtual reconstruction of archaeological findings

Using digitized findings as starting point, virtual reconstruction of each object was created in order to offer the users insight in their original appearance (Figure 5)



*Figure 5. Virtual reconstruction of selected artefacts*

Reconstructions were created in 3ds max and exported into fbx format.

#### 14.5. 3D modeling

Six 3D models of White bastion, identified in step 1 of this workflow, were created in Cinema 4D (Figure 6). Objects were modelled using classic modeling techniques. They were mapped with textures created from original photos from the site.



Figure 6. Six 3D models of White bastion

#### 14.6. Digital terrain creation

3D models of White Bastion were placed onto a digital model of the original terrain. It was created based on Digital Elevation Model over Balkans area from the GMES RDA project. The geotiff map was then imported in Global Mapper - GIS application for reading and conversion of different kinds of spatial datasets (Figure 7). Terrain model was exported in VRML format and imported in Cinema 4D (Figure 8).

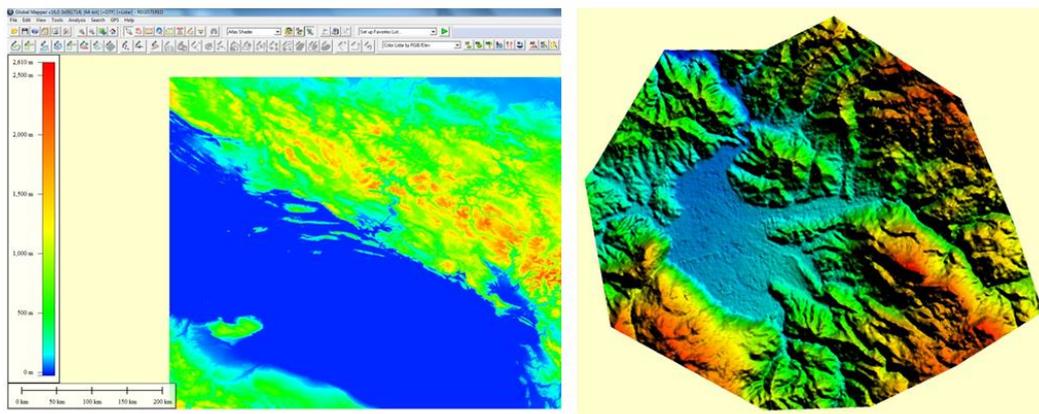


Figure 7. Digital Elevation model of Balkans in Global Mapper with extracted Sarajevo area



Figure 8. Sarajevo area map and terrain in Cinema 4D

#### 14.7. Digital stories production

Digital stories were created in coproduction with BH Radio television. Scenarios were written by a famous Bosnian writer. Original music was composed.

Preproduction phase included location planning, creation of book of shooting, collecting archive footage and actor casting. Costumes for the actor were selected from the National Theatre in Sarajevo fundus.

Shooting of footage for the stories was done at the location of the fortress remains (Figure 9) as well as at the hill across and a graveyard nearby. Particular attention was paid to the shots which will serve as backgrounds for video effects of fortress reconstruction.



*Figure 9. Location shooting*

Production phase also included drone shooting, voice-over recording, graphics design and computer animation, animation of drawings and editing. In postproduction we did the sound production and color correction.

Finished 11 stories were edited together as TV documentary and uploaded on Youtube for use in the online application.

#### 14.8. Interactive virtual environments creation

3D models of the fortress with terrain were exported from Cinema 4D and imported in Unity 3D, to add interactive functionalities and stories. During the export the following issues have aroused:

- adding stories to 3D models produced too large files difficult to view online
- additional player needs to be installed for viewing the application

After some experimenting with WebGL and HTML5 we decided to export the scenes from Unity to Web GL format. Interactive virtual environments contain digital stories and virtual reconstructions of archaeological findings (Figures 10 and 11).

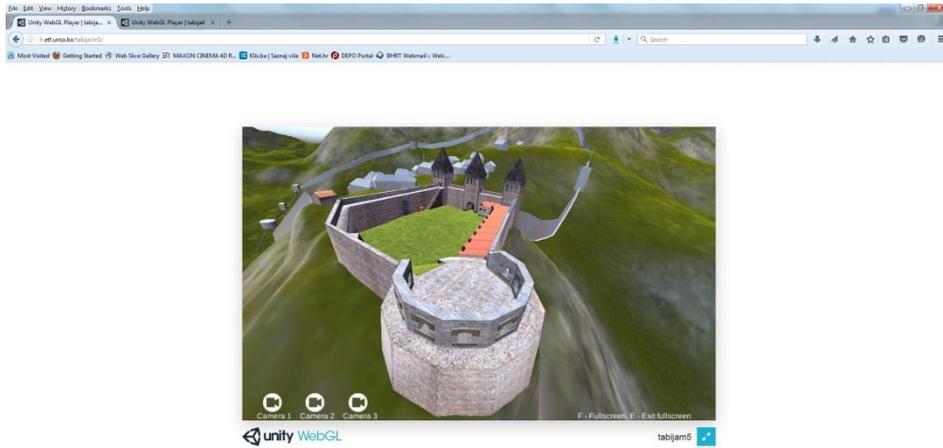


Figure 10. An interactive virtual environment of White Bastion

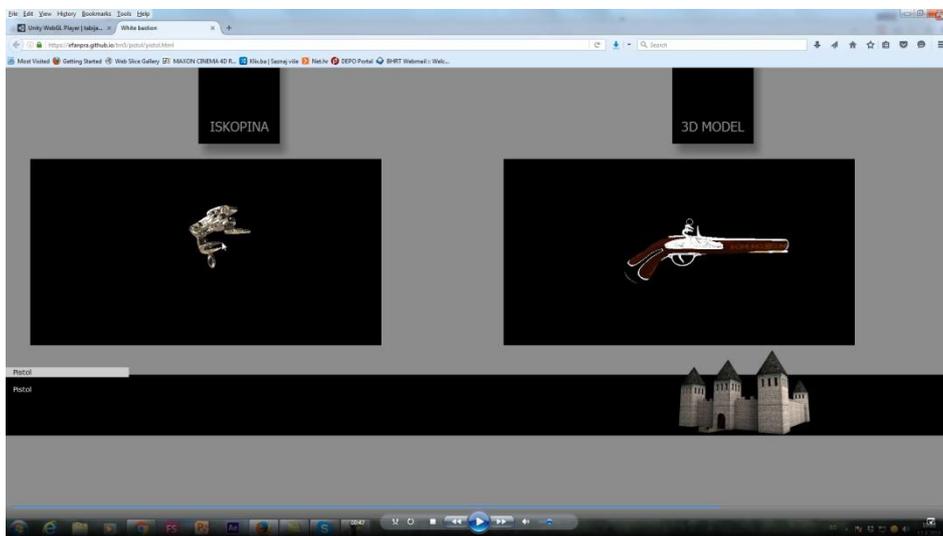


Figure 11. Interactive presentation of a pistol (left: museum artefact, right: virtual reconstruction)

#### 14.9. Web site design and implementation

Online interactive application of White Bastion is implemented through a web site which, apart from the previously mentioned digital content, contains some information on the project and an interactive animation of White Bastion in time (Figure 12).

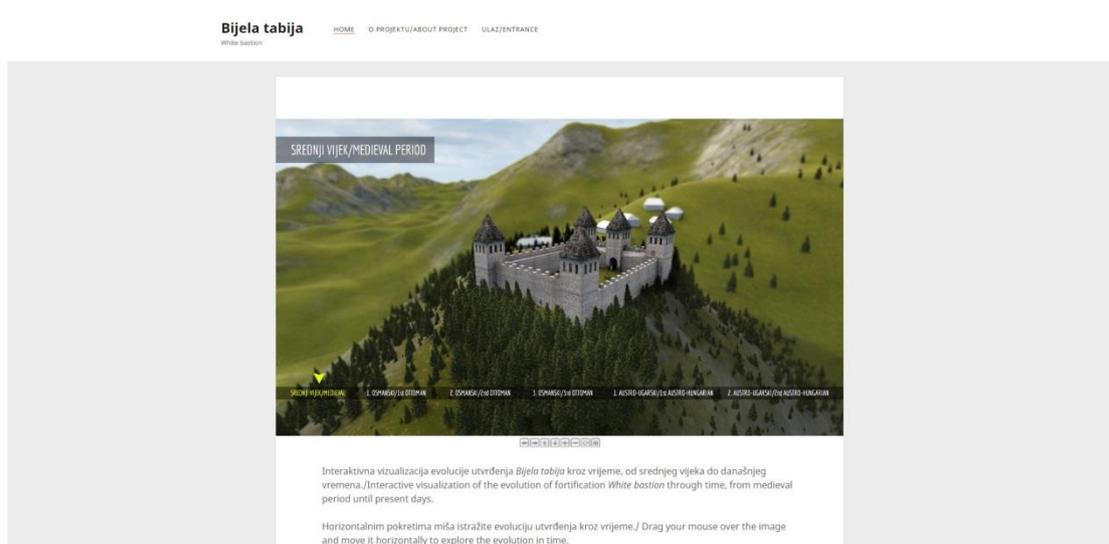


Figure 12. Home page with interactive animation

Navigation page contains links to digital stories and interactive virtual environments (Figure 13).

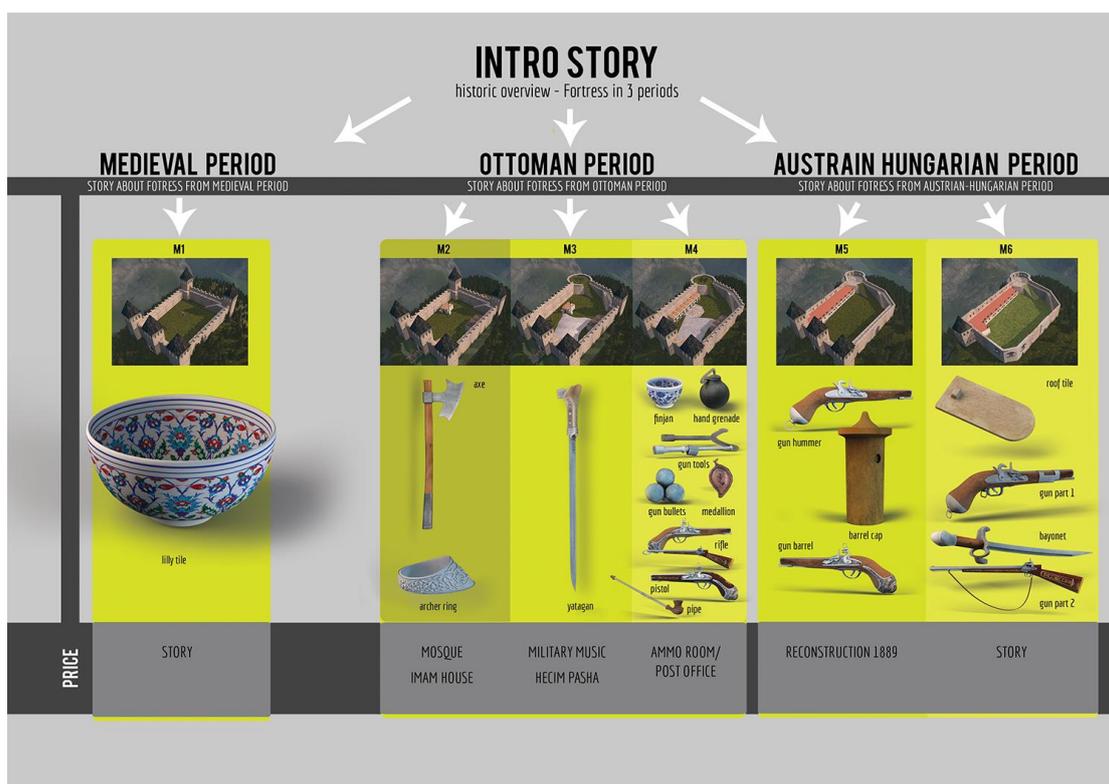


Figure 13. White bastion application navigation page

#### 14.10. Content integration

All digital stories, interactive environments and virtual reconstructions are accessible through the project web site. Project contains 10 digital stories (Intro, Medieval period, Ottoman period, Austro-Hungarian period, the mosque, military music, Hećimoglu Ali pasha, gunpowder magazine, reconstruction in 1889, the end), 6 interactive virtual models of the fortress and presentations of 22 selected digitized and virtually reconstructed archaeological findings.

#### 15. Technologies, tools, software/hardware used:

In this project we used Cinema 4D, Adobe Photoshop, Global Mapper, Adobe Premiere Pro, Sound Forge, Adobe After Effects and 3ds max on standard Windows based PC platforms.

#### 16. Analysis:

At the beginning of the project we considered the idea of using laser scanners for obtaining the accurate record of fortress remains, believing it would be helpful in creating virtual reconstructions. That idea was abandoned for lack of funding. However, it seems that the scanned record of the site would not have been very helpful in creating virtual environments, as the present appearance of the fortress significantly differs from its shape in any of historic periods we described. It could have been used only for determining the precise dimensions of the fortress, which was done from blueprints.

#### 17. Standards employed; data formats and protocols:

Digital stories were rendered in Quicktime .mov format, picture size HDTV 1080 25, codec MP4. Web site is created in WordPress. Interactive environments are in Web GL.

#### 18. Description of outcomes and issues:

During the project workflow we identified the following issues:

- illumination of 3D virtual environments for interactive use

In modelling phase illumination of virtual scenes was performed in Cinema 4D. However, Unity 3D did not support exported lights, so illumination had to be done again. We are not fully satisfied with Unity 3D illumination model, as the scenes look less realistic than in Cinema 4D.

- format conversions of reconstructed objects

Museum objects digitized using photogrammetry were supposed to be imported in Unity 3D interactive virtual scenes. We had to make several format conversions to obtain satisfactory mapping of objects in Unity 3D.

- time and resources consuming global illumination rendering for computer animations

Our goal was to display the past of White Bastion in such realistic way that the users would feel immersion in our virtual environments as they are traveling through the past. This could be obtained only by using global illumination based renderers. These renderers take a lot of time for their calculations which results in very long rendering time of each frame.

Here are the solutions to overcome these problems:

- use of Unity 3D as intermediate application for light and camera setups
- use of OBJ format for small objects geometry
- use of compositing instead of rendering the whole scenes whenever possible

#### 19. Evaluation:

The most important indicator of the success of the project is user evaluation. We designed a user study covering the following topics:

- user personal data (to identify the target group where the user belongs)
- information perception
- interactive digital storytelling
- interactive 3D models

- overall user satisfaction

The users were asked to fill out a questionnaire and some of them were interviewed. User evaluation was performed following qualitative user experience methodology. We established the following hypotheses:

H1: Users learn about cultural heritage objects from virtual cultural heritage presentations

H2: Through interactive virtual cultural heritage presentations users feel immersion in the past

H3: Users prefer interactive cultural heritage presentations over documentary movies

All three hypotheses were confirmed through users answers. In their comments a number of users expressed some advantages and drawbacks of this approach. Most of them reported to feel more engaged and pay more attention in interactive presentations. They appreciated the possibility to explore the interactive virtual environments (IVEs) which they could not do in a movie. They like the combination of digital stories and models because “models are described by stories and can display the information from stories”.

#### 20. Significance to COSCH and future work enabled:

Within the project we identified the following cultural heritage/humanities research questions:

- interactive or linear storytelling?
- Unity or Web GL?
- stories with characters or documentary stories?
- edutainment value
- overall user satisfaction
- archaeological research questions

We have shown how a cultural monument can be virtually reconstructed and presented to the general public, raising their awareness of its historical value and significance. A guide to good practice resulting from this project can be used for creating similar projects in the future.

#### 21. Conclusions:

In this case study we implemented a new concept of interactive virtual cultural heritage presentation containing a combination of digital storytelling and IVEs. We can conclude that this form of presentation is more attractive and engaging for majority of users who feel immersed in the past and learn better the information about the presented object and its history. Digital storytelling needs to be carefully tailored and introduction of one or more characters is highly appreciated. The projects need to be implemented by multidisciplinary teams of professionals from all involved disciplines, with particular emphasis on graphics design and visual arts, as these elements are main attractors for viewers.

A lot of work still remains in discovering a concept appreciated by all user target groups. From evaluation survey results we could see there are still some users who prefer traditional communication forms. Some problems with navigation in IVEs need to be solved to attract more users to interactive presentations. We still need to research what should be the ideal duration of individual story units and how they should be interconnected between each other and with IVEs.

However, we believe that time of these communication forms is coming and we need to work in direction to accommodate users to perceive cultural heritage in the same way they perceive millions of online bits of information bombarding them every day.

Digital technologies and storytelling are powerful tools for finally implementing the eternal idea of traveling to the past.

## 22. References:

[1] The White Bastion, Program of structural repairs, preservation, restoration and revitalization, Institute for the protection of cultural-historical and natural heritage of Canton Sarajevo, 2013

[2] V. Hulusić, S. Rizvić, Story Guided Virtual Environments in Educational Applications, Transactions on Edutainment IX, Lecture Notes in Computer Science Volume 7544, Springer Verlag 2013, pp 132-149

[3] S. Rizvic, A. Sadzak, M. El Zayat, B. Zalik, B. Rupnik, N. Lukac, Interactive Storytelling About Isa Bey's Endowment, Review of the National Center for Digitization, Faculty of Mathematics, Belgrade, ISSN: 1820-0109, Issue: 25, Date: 2014, pp 66-74

[4] 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, ACM New York, NY, USA ©2012, ISBN: 978-1-4503-1977-5, pp 109-116

[5] Selma Rizvić, Aida Sadžak, Mohamed El Zayat, Borut Žalik, Bojan Rupnik, Niko Lukač, "Interactive storytelling about Isa Bey's endowment", Review of the National Center for Digitization, ISSN: 1820-0109, Issue: 25, pp 66-74, 2014

[6] S. Sljivo, Audio Guided Virtual Museums, In Proceedings of Central European Seminar on Computer Graphics, Smolenice, Slovakia, 2012

[7] S. Rizvic, I. Prazina, Taslihan virtual reconstruction - Interactive digital story or a serious game, Proceedings of IEEE 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games) ISBN 15: 978-1-4799-8102-1, 2015, pp.1-2

## 23. List of Appendices:

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