

Cultural Heritage Digitalization in BiH: State-of-the-Art Review and Future Trends

Belma Ramić Brkić¹[✉](mailto:brkic@ssst.edu.ba)^[0000-0002-8205-0137], Marijana
Ćosović²^[0000-0003-3398-3157], and Selma Rizvić³^[0000-0001-7085-7104]

¹ University Sarajevo School of Science and Technology, SSST,
Hrasnicka cesta 3a, 71000 Sarajevo, Bosnia and Herzegovina
belma.ramic@ssst.edu.ba

² University of East Sarajevo, Faculty of Electrical Engineering,
Vuka Karadžića 30, 71126 Lukavica, East Sarajevo, Bosnia and Herzegovina
marijana.cosovic@etf.ues.rs.ba

³ University Sarajevo, Faculty of Electrical Engineering,
Zmaja od Bosne, 71000 Sarajevo, Bosnia and Herzegovina
srizvic@etf.unsa.ba

Abstract. Cultural heritage sites in Bosnia and Herzegovina (BiH), a country rich in religious buildings and ancient structures, are in constant need of preservation and reconstruction. In addition, tangible cultural heritage has been subject to war destruction and the only feasible option for reconstructing some of them is digitalization. On the contrary, the intangible cultural heritage encompassing oral traditions and expressions, traditional skills, as well as science and habits related to nature and world are a vital expression of cultural heritage and in the need of preservation. Over the past years, with the availability of technology and the identified research interest and the potential, significant progress has been made towards the preservation of cultural heritage. Motivated by these facts, this state-of-the-art report summarizes recent trends and discusses its value to the society. This paper therefore, gives an overview of the tools and the current state of digitalization of cultural heritage sites in BiH in an attempt of contributing to its preservation.

Keywords: Cultural heritage · Digitalization · Digital storytelling · Virtual museum.

1 Introduction

Bosnia and Herzegovina is a country with a very rich and long history, a country rich in cultural heritage, both tangible and intangible. Unfortunately, a number of cultural sites were seriously damaged or completely destroyed during the recent war in Bosnia and Herzegovina (BiH). According to Hitchner, approximately 2771 cultural monuments such as the Mostar Bridge, mosques and tekkes, Orthodox and Catholic churches, were damaged or destroyed [6].

Furthermore, in October 2012, several key National cultural institutions such as the National Museum of Bosnia and Herzegovina and the Historical Museum of Bosnia and Herzegovina (among others) closed their doors for the public visitors. It was a result of the governmental apathy, financial issues, lack of training among others. Due to such poor conditions of government institutions, the Archaeological Lexicon of Bosnia and Herzegovina was last updated in 1988. The four-volume book is composed of descriptions of geographical characteristics such as "close to a broken tree", a description that has changed significantly over these years (from 1988 to Today) [10].

In an attempt of BiH's cultural heritage preservation, a number of researchers started working in this direction. Today we have virtual reconstructions of medieval Bosnian gravestone "stećak" (Figure 1), Sarajevo City Hall Vijećnica (Figure 2), as well as virtual heritage application of Sarajevo Old town "Virtual Sarajevo - Baščaršija" [15]. Sarajevo City Hall represents the first project and initial application of computer graphics in virtual cultural heritage developed by the Sarajevo Graphics Group under the mentor-ship of Prof. Selma Rizvić [7].



Fig. 1: Stećak from Donja Zgošća [15]



Fig. 2: Sarajevo City Hall [7]

In this paper we present an overview of the work done in an attempt to preserve the cultural heritage of the country. A large number of researchers are working on implementing the latest trends in the digitization process. Many others work as autonomous attempts, published locally. In the following sections, we will present the currently implemented projects and methods used to preserve the tangible and intangible cultural heritage in BiH, as well as the machine learning techniques that apply to the cultural heritage domain. We will also provide a discussion about the work done, but also point out future trends and tasks to be completed.

2 Implemented projects

There are various cultural heritage applications: virtual museums, virtual presentations of objects that do not exist any more, important archaeological remains, serious games for cultural heritage, among others. Storytelling is becoming increasingly important as an addition to these applications. According to Rizvic, "every object, site or artefact is better perceived and understood through the adjoining story." [15]

This concept is recognized by the physical museums as they now offer their exhibitions combined with the digital content. This results in the increase of their visibility as well as in the number of visitors.

Here are some of the virtual exhibits in BiH ([12]):

- Virtual Museum of Traditional Bosnian Objects, the Museum of Sarajevo [14];
- Sarajevo Survival Tools, the Historical Museum of Bosnia and Herzegovina [2], sample Figure 3;
- Virtual Museum of Genocide upon Bosniaks;
- Bosniak Institute Virtual Museum [22];



Fig. 3: Sarajevo Survival Tools Virtual Museum: Cookers exhibit [12]

Sarajevo Survival Tools and Virtual Museum of Genocide upon Bosniaks belong to a relatively new term *dark tourism Virtual Museums*. These exhibits allow visitors to visit sites of death, disaster and tragedy [9].

Even though, visitors prefer interactive content over the static movie or pre-rendered installation, a number of studies has shown that visitors also tend to get bored quickly and hence leave the virtual environment before seeing all that is offered. The concept of a digital story was first introduced in the Sarajevo Survival Tools project where it received positive user feedback [16]. In choosing the real or virtual avatar to present the information to users, it was reported that participants better react to human avatar. The study showed that "a real avatar's representation in virtual heritage storytelling applications has greater impact on user's perception of information" [20].

Continuing in this direction, Rizvic et al. [18] created a set of guidelines to address *Interactive Digital Storytelling* (IDS) presentation of cultural heritage. To develop a new IDS method, hyper-storytelling, authors resorted to engaging experts from various fields and based on it raised following questions: how to maximize user's involvement in virtual presentation and maintain the level of educational entertainment at the same time by providing motivation for users to view content systematically. The experts come from computer science, psychology, communicology, film and visual arts, literature, and human-computer interaction field of research. The 4D virtual application of known cultural heritage site developed previously by the authors served as a sample IDS application for interdisciplinary team to help identify points of improvement in new methodology. Objectives of the evaluation process included information perception, digital storytelling concept evaluation, interactive virtual environment evaluation as well as overall user satisfaction. The hyper-storytelling IDS application guidelines contributed by the interdisciplinary panel encompass engaging professionals for all content fields and at the same time creating unique visual identity. It was suggested that the content should be divided into, short, dynamic, and informative sub stories presented by the characters that easily communicate emotion hence increasing educational entertainment and help solving narrative paradox. In addition, guidelines recommended platform independent IDS application.

3 Preservation of Tangible Cultural Heritage in BiH

The tangible cultural heritage is defined by the UNESCO [3] as: "The legacy of physical artefacts (buildings and historic places, monuments, etc.) of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations."

Virtual Sarajevo project is composed of panoramic photographs, video walk-throughs, virtual models of cultural heritage objects, and stories that marked

this area [13]. The stories in particular were created using digital storytelling techniques such as storyboarding, off sound track recording, editing and post-production. This project represents the first documented attempt of digitalization and representation of BiH's tangible and intangible heritage.

For the reconstruction of "stećak", methods such as 3D scanning and rendering with high fidelity graphics (an image with high resolution) were used [15]. Damaged parts were reconstructed using 3D modelling techniques.

Virtual model of Vijećnica was created using basic geometry and compound objects such as cubes and Boolean operations. Textures were edited in Photoshop and then applied to the 3D model. The model had to be optimized for web presentation [7].

For the model of Baščaršija, authors used VRML browser to browse around the streets of the old town. In this project, authors for the first time introduced the concept of stories - "short movies capable of dramatizing historical events and providing lesser-known historical contexts for particular objects and events from the past of Sarajevo" [15].

Audio stories were used to compensate the lack of 3D movement ability in the Bosniak Institute Virtual Museum project [22]. In a performed study, 79% of respondents did not notice that there was no allowed movement in the virtual environment. Specifically, when asked "Were you able to move in the 3D environment?", they replied affirmatively.

In the virtual reconstruction of existing *Travnik Fortress*, most preserved medieval Bosnian facility, the author used traditional methods of graphics pipeline such as data acquisition, modelling, texturing and rendering [8]. However, they showed new ways of inhabiting the virtual environment. In the project they created two scenes to be immersed with the real-time environment. One includes a narrator telling a story about the history of a fortress, and another one includes a short animation of soldiers playing chess. The identified drawback of both scenes and used softwares (Quest3D and X3D) was the lack of Z or depth coordinate for full user experience.

The Cathedral Church of the Nativity of the Theotokos in Sarajevo built in 1874 represents one of the most important and most beautiful monuments of the Orthodox Culture in BiH. In an attempt of its digitalization, a high-quality multimedia presentation of the interior and exterior, web presentation, DVD, panoramic photos and physical 3D model, prototype for creation of souvenirs, were created [5]. In this project Flash technology was used for the first time, which allowed faster loading and more efficient display of the entire 3D model.

As part of the Master thesis project, student Mirsad Festa at the University Sarajevo School of Science and Technology did a complete multimedia 3D presentation of the Butmir Neolithic culture. Excavated partial objects were precisely modelled to show how the objects looked originally, Figure 4, [1].

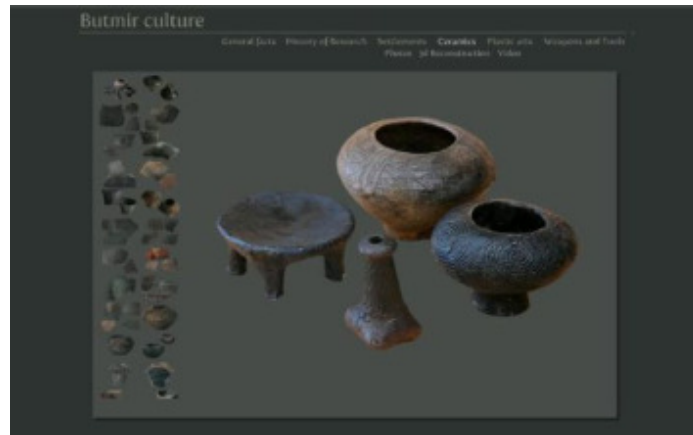


Fig. 4: Butmir Neolithic culture [1]

In [19] author presents interactive virtual 3D presentation of the archaeological site, Tašlihan, in Sarajevo that is implemented in Museum of Sarajevo and on-line (Figure 5). Several presentation forms are used: documentary story, interactive digital story and serious game. Author explores how 3D reconstruction of the disappeared cultural heritage benefits from the storytelling presentation approach. Steps in creating the interactive virtual presentation consists of creating a high-quality 3D virtual model, designing the interactive digital story and the serious game. Additionally, documentary story was created appealing to more traditional users.



Fig. 5: Tašlihan [19]

Faculty of Electrical Engineering, University in Banja Luka is a partner in a European Union's Horizon 2020 research and innovation program with a goal of creating a unique Virtual Research Environment (VRE) in South-east Europe and the Eastern Mediterranean (SEEM). The project facilitates regional interdisciplinary collaboration, with special focus amongst others, on scientific community of Digital Cultural Heritage. A set of tools and services are designed for facilitating work regarding cultural and historical heritage. The applications that are in development by a BiH partner are Content-Based Image Retrieval and Classification in Cultural Heritage as well as creation of Cultural Heritage Repository (CHERE). CHERE is a set of multiple standalone applications/services used for scanning, processing and displaying of 3D objects. It acts as a repository of digitized entries, allowing for efficient data creation from one side and easier data access from the other side. In addition, it allows work with panoramic and 360 degree images hence creating interactive virtual tours.

Digitalization of the so-called Fojnica Armorial ("Fojnički Grbovnik") is a project initiated by a local priest and his monastery in an effort to make it publicly available and preserve the original [4]. The project, led by enthusiasts and self-taught experts, has complied with all the main goals of digitalization, such as: preserving the original and facilitating access to the broader public through both printed and electronic media.

4 Preservation of Intangible Cultural Heritage in BiH

The term Intangible cultural heritage is defined by the UNESCO [3] as: "The practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage."

Mevlevi dervish ritual in Isa bey's Tekke was presented using computer animation. A visitor was placed in the center enabled to interact with the digital content being provided [17]. The digital content (the stories) are triggered by the user movement and gaze direction.

Zmijanje embroidery has been included in 2014 on the UNESCO list of the intangible cultural heritage. Specific embroidery technique comes from villages in area Zmijanje on mountain Manjača in Bosnia and Herzegovina. Amongst different digital collections the Museum of the Serbian Republic has important Zmijanje embroidery digitalized collection (53 artefacts). The Museum has a large archeological collection with a plan to create virtual and interactive online museum as well as scientific archive of very precise models for archaeologists.

Most recently, Selmanovic et al. managed to recreate the diving tradition from the Old Bridge in Mostar, Bosnia and Herzegovina using Virtual Reality [21]. Upon watching 360° video stories about the tradition and history, completing the quiz evaluation, users are enabled to virtually jump off the bridge. In conclusion, the authors reported "It is clear that in the concept of preservation of the intangible elements of this heritage that VR has been the superior medium in comparison to more traditional methods."

5 Machine learning applied to Cultural Heritage

Machine learning techniques and in particular deep learning techniques such as Convolutional Neural Networks (CNN) are mostly used techniques for image classification. Use of high resolution data, such as remote sensing images, could be useful for the process of generating 3D models. In particular, aerial images could be used for generating the heritage building 2D plans. Furthermore, field photographs as well as local knowledge could be used to create vertical structures. Acquiring images of BiH cultural heritage sites for CH dataset repository in conjunction with remote sensing image classification could lead in the direction of wider adoption of 3D cultural heritage models generation.

Authors in [23] use split-brain auto-encoders, a special form of traditional auto-encoders that use cross-channel prediction in order to tackle colorization task for self-supervised learning image representation. Self-supervised prediction is concerned with prediction of labels that are generated from vast amount of available raw data such as remote sensing images. For training of split-brain auto-encoders benchmark dataset for remote sensing image classification without image labels is used. SVM classifier with RBF kernel as well as CNN are used for remote sensing image classification on AID dataset and authors have reported results similar to the state of the art results.

Pilipovic et al. [11] perform remote sensing feature extraction and classification using pre-trained and fine-tuned CNN. CNN is pre-trained on ImageNet datasets and also fine-tuned for the task of scene classification in remote sensing images. This is motivated by the absence of the large labelled dataset of remote sensing images that is usually manually labelled hence, being a very expensive and time consuming task. In addition, CNN is used for feature extraction followed by a linear SVM classification. In this paper two modern CNN architectures were used: ResNet and SqueezeNet. Authors have shown that the features extracted using CNN pre-trained on ImageNet dataset can be used for reliable remote sensing scene classification. The authors obtained a classification accuracy of over 94% using a fine-tuned ResNet.

6 Discussion

All modern societies in one way or another are required to protect and preserve their cultural heritage. Reasons are numerous but most important ones are reinforcement of sense of identity, education and historical research. Countries which were subjects of wars and conflicts guard their cultural heritage sites with special attention since during war times there is a direct correlation between loss to cultural heritage and loss of cultural identity [24].

Storytelling is one way of preserving cultural heritage (tangible and intangible) through reliving stories that are usually in the case of tangible heritage accompanied by the cultural heritage site model. In the case of storytelling about intangible cultural heritage, customs, traditions, and experiences can be conveyed to the general public. A number of user studies reported here suggest that stories enhance users' virtual experience. However, researchers are still trying to find a way to motivate users for longer virtual visits. Numerous studies presented here show that users do not watch all stories. The latest research includes serious games as an attempt to somehow be considered as a reward for invested effort in watching all the stories [21].

Moreover, artificial intelligence and machine learning can potentially assist in creating modern storytelling, as required by young people who are used to the complex multimedia experiences. In addition, as the types of storytelling are evolving from linear to branching and further to organic type of storytelling, we see the increased presence of modern technologies involved. Organic storytelling is fully-interactive storytelling with an unlimited number of outcomes.

Building 3D models requires assembling large amounts of 2D images. For the preservation of existing cultural heritage sites, machine learning algorithms can be employed to classify images produced during the measurement of cultural heritage objects. The same applies to existing artefacts in museum collections and their need for digitalization.

Several challenges have been highlighted as part of this report and are mainly related to the lack of data on damaged or completely destroyed objects of importance for cultural heritage. Many reconstructions of intangible heritage depend on stories that are passed from one generation to another. "Sevdah" represents a traditional Bosnian music and as intangible heritage still poses a challenge in preservation context for the researchers.

7 Conclusions

Virtual cultural heritage presentation could be conveyed to general audience either on-line or in museums keeping in mind that a user needs an appealing and time efficient approach in which information is going to be presented. We are

constantly seeing progress in this direction from the availability of new tools, software and hardware updates, internet connections, and so on.

In addition to all of the above, research presented here, highlights some of the challenges that researchers face in Bosnia and Herzegovina as part of the ongoing digitalization process. One of the most important is the lack of data. Many historical books have been destroyed, making it extremely difficult to find information and images about the original condition of the destroyed or damaged objects in order to re-create them as 3D models.

The main contribution of the paper is an overview of the methodologies for the virtual presentation of cultural heritage which are used in BH projects, with a special emphasis on interactive digital narration. These methodologies can be applied to new projects and serve as an inspiration for new ideas on the preservation and presentation of cultural heritage.

Therefore, what we are looking forward to is an increase in the number of researchers who are turning to this field. They are exploring various avenues in overcoming the pointed challenges. Further, tourist community of Bosnia and Herzegovina is constantly reporting about the increase in the number of tourists. Virtual content could be considered as one of the attraction elements in presenting the rich cultural background. Further research will show whether serious games have and to what extent contributed to the widespread use of cultural heritage applications, or the use of technology itself is more useful and interesting for younger generations, as in the case of virtual diving project.

References

1. Butmir culture. <http://h.etf.unsa.ba/butmir/english/more.html>, online; accessed 12 December 2018
2. Sarajevo Survival Tools. <http://h.etf.unsa.ba/srp>, online; accessed 10 December 2018
3. UNESCO. Tangible Cultural Heritage. <http://www.unesco.org/new/en/cairo/culture/tangible-cultural-heritage/>, online; accessed 4 January 2019
4. Bratic, V., Gadzo, F.: Digitalizacija u Franjevačkom samostanu u Fojnici. Tech. rep., Komparativna književnost i bibliotekarstvo, Filozofski fakultet, Sarajevo (June 2014)
5. Festa, M., Rizvic, S.: Multimedijalna prezentacija Saborne Crkve u Sarajevu. In: Digitization of National Heritage, Old Records from natural and Social and Digital Humanities (2009)
6. Hitchner, R.B.: War and peace: heritage on the front line. *Antiquity* **90**(351), 813–816 (2016). <https://doi.org/10.15184/aqy.2016.76>
7. Hulusic, V.: Optimization threshold in Sarajevo City hall virtual model for efficient web presentation. In: Proceedings of Central European Seminar on Computer Graphics, Smolenice, Slovakia (2007)

8. Jovisic, V.: Augmented real-time virtual environments. In: Proceedings of Central European Seminar on Computer Graphics, Smolenice, Slovakia (2009)
9. Kaelber, L.: A memorial as virtual traumascapes: Darker tourism in 3d and cyberspace to the gas chambers of Auschwitz. *e-Review of Tourism Research* **5**(2), 24–33 (2007)
10. Lawler, A.: Bosnia and Herzegovina: Cultural heritage on the brink. In: *Digging in the crisis*. (2013)
11. Pilipovic, R., Risojevic, V.: Evaluation of convnets for large-scale scene classification from high-resolution remote sensing images. In: *IEEE EUROCON 2017 -17th International Conference on Smart Technologies*. pp. 932–937 (July 2017). <https://doi.org/10.1109/EUROCON.2017.8011248>
12. Rizvic, S.: Story guided virtual cultural heritage applications. *Journal of Interactive Humanities* **2**(1) (2014)
13. Rizvic, S., Sadzak, A.: Digital storytelling - representation of Bosnian intangible heritage in the Virtual Sarajevo project. In: *VAST'08: Proceedings of the 8th International Conference on Virtual Reality, Archaeology and Cultural Heritage*. Eurographics Association (2008)
14. Rizvic, S., Sadzak, A.: Virtual museum of Bosnian traditional objects. In: *Proceedings of South East European Digitization Initiative, Sarajevo, Bosnia and Herzegovina*. (2010)
15. Rizvic, S., Sadzak, A., Buza, E., Chalmers, A.: Virtual reconstruction and digitalization of cultural heritage sites in Bosnia and Herzegovina. In: *SEEDI 2007, Review of the National Center for Digitization* pp. 82–90 (2008)
16. Rizvic, S., Sadzak, A., Hulusic, V., Karahasanovic, A.: Interactive digital storytelling in the Sarajevo Survival Tools virtual environment. In: *Proceedings of Spring Conference on Computer Graphics, Smolenice, Slovakia*. (2012)
17. Rizvic, S., Sadzak, A., Zayat, M.E., Zalik, B., Rupnik, B., Lukac, N.: Interactive storytelling about Isa Bey's Endowment. In: *Proceedings of South East European Digitization Initiative, Zagreb, Croatia*. (2013)
18. Rizvic, S., Djapo, N., Alispahic, F., Hadzihalilovic, B., Cengic, F.F., Imamovic, A., Okanovic, V., Boskovic, D.: Guidelines for interactive digital storytelling presentations of cultural heritage. In: *9th International Conference on Virtual Worlds and Games for Serious Applications, VS-Games 2017, Athens, Greece, September 6-8, 2017*. pp. 253–259 (2017), <http://doi.ieeecomputersociety.org/10.1109/VS-GAMES.2017.8056610>
19. Rizvic, S.: How to breathe life into cultural heritage 3d reconstructions. *European Review* **25**(1), 39–50 (2017). <https://doi.org/10.1017/S106279871600034X>
20. Sadzak, A., Rizvic, S., Dalton, C., Chalmers, A.: Information perception in virtual heritage storytelling using animated and real avatars. In: *Proceedings of Central European Seminar on Computer Graphics, Smolenice, Slovakia* (2007)
21. Selmanovic, E., Rizvic, S., Harvey, C., Boskovic, D., Hulusic, V., Chahin, M., Sljivo, S.: VR Video Storytelling for Intangible Cultural Heritage Preservation. In: *Sablatic, R., Wimmer, M. (eds.) Eurographics Workshop on Graphics and Cultural Heritage*. The Eurographics Association (2018). <https://doi.org/10.2312/gch.20181341>
22. Sljivo, S.: Audio guided virtual museums. In: *Proceedings of Central European Seminar on Computer Graphics, Smolenice, Slovakia* (2012)
23. Stojnic, V., Risojevic, V.: Evaluation of split-brain autoencoders for high-resolution remote sensing scene classification. In: *2018 International Symposium ELMAR*. pp. 67–70 (Sept 2018). <https://doi.org/10.23919/ELMAR.2018.8534634>
24. Wijesuriya, G.: Cultural heritage in postwar recovery. In: *Stanley-Price, N. (ed.) Papers from the ICCROM FORUM* (2005)