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Digitization Techniques applied to the National Cultural Heritage of Bosnia and Herzegovina

(Techniki digitalizacyjne stosowane w ochronie dziedzictwa narodowego Bośni i Hercegowiny)

Słowa kluczowe: dziedzictwo kulturowe, dygitalizacja, Digital Media Centre Sarajevo, dziedzictwo wirtualne, techniki 3D, Bośnia i Hercegowina
Abstrakt: W artykule przedstawiono zarys historii dziedzictwa kulturowego Bośni i Hercegowiny oraz zarys zastosowania technik digitalizacyjnych. Część teoretyczna została uzupełniona o wyniki wywiadu przeprowadzonego wśród wybranych specjalistów.

Keywords: cultural heritage, digitizing, Sarajevo Digital Media Centre, virtual heritage, 3D technologies, Bosna and Herzegovina
Abstracts: The paper presents an outline of cultural heritage history of Bosnia and Herzegovina and an outline of the use of e-technologies. The theoretical part of the article includes the results of an interview given by selected experts.

Background of the Problem

During the war 1992-1995 the national cultural heritage of Bosnia and Herzegovina was target to purposive destruction. The National and University Library of Bosnia and Herzegovina were deliberately burned by Serbian forces. Three months before burning of the National and University Library of Bosnia and Herzegovina, the Oriental Institute in Sarajevo, host institution for one of the largest collections of Islamic and Jewish manuscripts and Ottoman documents in South-Eastern Europe was burned by Serbian forces. 5,263 bound manuscripts in Arabic, Hebrew, Persian and Bosnian written in Arabic script, 7,000 of Ottoman documents that were primary source materials for 500 years of Bosnian history, the collection of 19th century cadastral register and 200,000 of other documents from Ottoman period, including microfilmed copies, disappeared in flames. The printed books collection of the Oriental Institute that was the most comprehensive library in the region was completely destroyed as well as all work in progress [26]. The Library of the National Museum of Bosnia and Herzegovina with collections containing 200,000 of volumes

was successfully evacuated under sniper and shelling fire during 1992. Meanwhile, the National Museum was hit, parts of the Museum collections that were unmovable stayed and were exposed to further shelling and sniper fire [26]. The collections of the Gazi Husrev Bey's Library in Sarajevo were saved thanks to efforts of the library staff who allocated the library collections to 9 different secret locations in the city of Sarajevo during the war 1992-1995.

In April 1992 Serbian forces started destruction of the historic city of Mostar, the main centre of Herzegovina, the south-west region of the country. The Archives of Herzegovina, the institution treasuring past of the region since medieval times, was systematically bombarded and it was severely damaged. The Library of Mostar Catholic Archbishopric, The Library of the Museum of Herzegovina, Mostar University Library, and many other libraries, archives and other memory institutions were destroyed [26].

"Throughout Bosnia, libraries, archives, museums and cultural institutions have been targeted for destruction, in an attempt to eliminate the material evidence (...) documents and works of art (...) that could remind future generations that people of different ethnic and religious traditions once shared a common heritage in Bosnia. In the towns and villages of occupied Bosnia, communal records (cadastral registers, waqf[6] documents, parish records) of more than 800 Muslim and Bosnian Croat (Catholic) communities have been torched by Serb nationalist forces as part of 'ethnic cleansing' campaigns. While the destruction of a community's institutions and records is, in the first instance, part of a strategy of intimidation aimed at driving out members of the targeted group, it also serves a long-term goal" [26].

Still, there is no complete data about the losses on the cultural heritage of Bosnia and Herzegovina during the war. Recovering cultural heritage is still a political issue in Bosnia and Herzegovina which can be seen from the fact that it was an object to planned and purposive destruction known as culturocide[7], from the fact that one of the annexes of the Dayton Peace Agreement deals with the national cultural heritage and from the fact that the guilty of some war criminals was proven by proving their implementation of policy of the culturocide upon Bosnia and Herzegovina national cultural heritage.

The cultural heritage digitization in Bosnia and Herzegovina is ongoing within some cultural institutions. Besides, there are some of the projects led by the Sarajevo School of Science and Technology. The project "Bosnian Traditional Objects" was supported by UNESCO as part of the regional cultural heritage preservation activity entitled as "Cultural Heritage: A Bridge towards Shared Future", led by UNESCO office in Venice with the mission to develop cooperation in the regions of Southern and

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[6] See about "waqf" via [13].
[7] Tharaileth Koshy Oommen defines culturocide as one of three factors of insecurity. Accompanied by genocide and ecocide, the culturocide is defined as "… attempts to dismantle the identities of collective" [24, s. 10].

Central-Eastern Europe. The digitization of the cultural heritage has been taking place in the following cultural institutions in Bosnia and Herzegovina: "The Institute for Protection of Cultural-Historical and Natural Heritage of Canton Sarajevo", "The City Library of Sarajevo", "The Bosnian Institute in Sarajevo", "Mediacentar INFOBIRO Digital Archive" and "National Library of Republic of Serbska".

Initiated by the Tempus Project entitled as "Computer Graphic for Media Industry", Sarajevo School of Science and Technology founded the Digital Media Center. The Laboratory for Cultural heritage Digitization of the Digital Media Center works on digitization and multimedia presentation of national cultural heritage. They use computer graphic techniques such as 3D modeling, computer animation, digital story-telling, as well as the 3D technologies like laser scanning and 3D printing. Some of important projects that have been carried out under responsibility of the Digital Media Center, until now, are: "Virtual reconstruction of the Church of the Holy Trinity in Mostar", "Multimedia 3D Presentation and the 3D printout of the Saborna Church in Sarajevo", "Prusac – A Multimedia Virtual Heritage Site", "Virtual museum Svrzo's House", "Virtual Reconstruction of the Viziers Konak[8] in Travnik", "Interactive Digital Media Presentation of Butmir Neolithic Culture", Photo-realistic Reconstruction and Multimedia Presentation of the Medieval Fortress in Travnik", "Isa-bey's Tekke[9] in Sarajevo", "Virtual Reconstruction and Digitization of Cultural Heritage Sites in Bosnia and Herzegovina" [32].

Theoretical Framework

3D models consist of collection of points in three-dimensional space connected using lines, curves, surfaces, triangles in order to present complex geometric objects. The virtual worlds may be created using 3D techniques [21]. Real-time interactive 3D graphics and virtual environments include a lot of multimedia capabilities, such as video and audio. The Extensible 3D (X3D) Graphic is the ISO standard produced by Web3D Consortium which defines 3D scenes using scene-graph approach. The multiple X3D file formats and language encodings are available with an emphasis on XML for maximizing the interoperability with the Web-architecture [6]. 3D scanners, photogrammetry or electronic survey equipment may be used for capturing the geometry of the real world objects. The point data produced in such way are imported into 3D software and become 3D models. The data may be combined in order to present complexity of shapes. The CAD software is mostly used for architectural objects and archaeological sites, but there is a lot of different 3D software available. Mesh Lab is open source software for processing 3D meshes and data produced by 3D scanning. The virtual reality integrates 3D models with the text, images, sounds, etc. for creation of virtual environments in which the users can interact with the virtual reality or with each other. The Virtual Reality

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[8] The residence of viziers, local administrative directors, during the Ottoman rule.
[9] See about "tekke" via [3].

Modeling Language is developed by W3D Consortium from which it is derived the Virtual X3D ISO standard for virtual reality. It provides the system for storage playback and retrieval of real time graphic content. Collaborative Design Activity (COLLADA) is an open standard XML scheme for 3D files exchange between 3D software applications [21].

Recent advances in computer graphics enable creation of realistic models based on very high quality photographs. The methods developed in order to perfect and display such models are intended for conventional computer graphics rendering, not for real-time displays in immersive virtual reality systems. Even if the integration of realistic models in real time virtual environment is achieved, the resulting captured environment look stays still static while the display of additional elements such as shadows, vegetation, hills etc. is very difficult. But, the perception of realism can be enhanced by adding 3D sound. Real time audio simulation requires still new and untested algorithmic solutions to allow this integration. The emphasis in enhancing realism in virtual environments is on interactive manipulation of photorealistic elements. The realistic and highly interactive virtual environments are difficult to develop and implement. The solution may be achieved through an iterative, user-centered approach that takes into account the application as well as the user needs [10].

Presentation of some projects done using 3D techniques
Medieval Fortress in Travnik: The Photo-realistic Reconstruction
and Multimedia Presentation

The project was carried out as thesis work of Vanja Jovišić under supervision of Prof. Dr Selma Rizvić. The interdisciplinary approach was necessary, so the author contacted professionals from different fields of culture and science such as local museum staff, architects, historians etc. The cooperation was informal due to the fact that cultural heritage digitization activity is not legally regulated in Bosnia and Herzegovina. This caused plenty of difficulties during the project planning and realization.

Techniques used were the combination of 3D reconstruction technique with various visualisation methods such as photo-realistic high-resolution renderings, video-composition of animated sequences from 3D environment with video-sequences presenting everyday life in the fortress making up interactive virtual environment with user-friendly interactive interface.

The focal point of the project was simplification of 3D modeling process using photogrammetric data acquisition and processing concepts.

The static nature of 3D models was overcome by adding of interactivity and usage of various presentation models in the virtual environment. The photo-realistic reconstruction of the fortress from the Ottoman times was the intention, but other periods were also presented using different media techniques. The final product of

the project is a multimedia CD-ROM with textual content in Bosnian and English languages enriched with audio and video content, photographic materials with detailed information about this site and its history. These parts were presented in different technologies: HTML, Flash, CSS, JavaScript and XHTML.

For the on-line presentation, it was necessary to make the content optimization, especially for video and audio elements. Software used for virtual modeling was 3d Studio Max and virtual reconstruction of the object together with its environment was based upon existing architectural plans [28].

Virtual modeling was done in a few phases:

- Object modeling;
- Terrain modeling (for terrain modeling a lot of application were tested with the best results obtained using 3 Digital Elevation Model (3DEM) application; the tool Dream Scape Terra was used for modification of imported data and terrain adjustments;
- Lighting and sky adjustment (it was done using Dream Scape Sun light tool that was adjusted to the option the Global Illumination and soft shadows; the indirect lightening was created using Dream Scape Sky;
- The terrain textures were created using Dream Scape that enabled photo-realistic impression, and the graphic manipulation with a lot of photographs and adjustments to the objects was done too;
- Texture baking, which is the process of pre-calculation of specific information and storing it in the texture was done using UVW mapping. The baked textures were applied to object based on saved UVW data.

Challenges in camera animation process were how to make the continuous scenes flow that are located in different places of the fortress and how to enable users to see the objects from many perspectives [28].

Video composition of rendered animated sequences was done using video editing software Premier Pro 2.0 and After Effects. Scenes were put together with animated sequences, audio background was done. The content was titled for both versions: Bosnian and English. The final sequence was exported in the high quality .avi format and Flash Video (.flv) format. For the virtual environment the pre-rendered fly-troughs with 3D space as well as their combination with live video-footage to the interactive virtual environments were tested and compared. In the first case, the realistic impression provided by video sequence has drawbacks in controlled conditions of user experience. On the other hand, the interactivity of real-time virtual environment suffers from slowness and lack in realism [28].

For the first phase of the project, the pre-rendered animation combined with the other types of media content was chosen. In another phase, the interactive environment was developed using Quest 3D software. This software offers many options for output format from Web to stand-alone applications [28].

Isa-bey's Tekke in Sarajevo

The project was the diploma project of student Anis Zuko at the Computer Science Department of the Faculty of Electrical Engineering in Sarajevo [30]. The project was presented by Selma Rizvić in Belgrade 2009, during the SEEDI (South-Eastern Europe Digitization Initiative) conference. The project is very fascinating, both, from the technical point of view (3d modeling, collection and digitization of different kinds of files including photographs and oral presentations), as well as from the cultural point of view. It is crucial for the community not to lose memory of its origins and traditions. Memory is often expressed through places, buildings, squares where people have met, worked, prayed, shared their lives.

The virtual reconstruction of Isa-bey's Tekke is consisted of three models: exterior of the object and two rooms inside of the object.

The models were created in several phases:

- collecting of materials,
- object modeling,
- creating and mapping of textures,
- scenes illumination,
- environment creation,
- cameras positioning,
- scenes exporting in Web 3D technology VRML.

Having in mind the fact that the object does not exist any more and that literally there is no information about its appearance, the project team had to simulate the tekke's appearance by interior of Sinan's tekke in Sarajevo. This approach was acceptable due to the fact that all tekkes have simple and similar interiors [30].

Object modeling was done using 3ds Max software. The classic modeling techniques such as polygonal modeling were applied. The object's environment modeling was a big challenge. The chosen solution for the environmental modeling contains the combination of terrain model (hill) and the panoramic photograph of the present environment mapped on a cylinder.

Mapping was done using 3ds Max UVW mapping modifier following the geometry of objects [30].

VRML does not offer very sophisticated illumination options, so that the Omni lights were used for most scenes illumination. In order to enable users with the possibility to see different parts of scenes using menu of viewpoints, the cameras in 3ds Max were created and exported as viewpoints to VRML. In such a way the scenes became interactive meaning that users have been able to move inside the virtual environment using VRML browser, free-ware player that is installed as a plug-in to the Internet browser. VRML Anchor nodes are used for environment transition as well as for providing the extra information on particular parts of digital environment. Web presentation is done in Bosnian and English languages.

Two image galleries were created containing rare old photos and postcards of the tekke. Out of the exterior tekke's model, a small 3D printout was created using Z Corporation 310+ printer, with dimensions 9.5 x 7 x 4.5 cm. The print was done, out of the VRML version of the model. Very good quality of the printout was an inspiration to create the prototype for the souvenir presenting the Tekke [30].

The second phase of the project is planned to develop digital model of whole architectonic complex that was endowed by Sarajevo founder, Isa-bey Ishaković. The complex contained many other objects such as "musafirhana", i.e. the shelter for pilgrims and travelers, "imaret", i.e. the public kitchen where food was prepared and distributed free of charge, etc.

Virtual Reconstruction and Digitization of Cultural Heritage Sites in Bosnia and Herzegovina
Stećak

The best known and the most valuable medieval monuments in Bosnia and Herzegovina are stećaks – monumental gravestones, the monoliths of different shape and size.

The stećak from Donje Zgošće, from 14th century, is being considered as one of the most important stećaks because it is assumed that Bosnian king Stjepan II was buried under it. This monument is currently located in the botanical garden of the National Museum of Bosnia and Herzegovina [29].

The stećak was scanned with Minolta 910 laser because the daylight was too intensive, but the textures captured in such a way were not satisfactory, so the textures were later finalized using the Maya software. Scans were put together in polygonal mash using Stitcher software laser scanner performing automatic data harvesting and captured scan data editing, merging scans into unique mesh and exporting it to various 3D data formats. The final product was exported as Maya OBJ file. The computer model was exported from Stitcher to Maya as polygonal mash made up of vertices, each one of vertexes forming a point in three-dimensional space, described by three orthogonal coordinates. The points were put together using three to five points per face. The original size of the file was reduced using Stitcher software [29].

There were a lot of damages on stećak, the biggest one at the one of the corners. The damage was virtually repaired by selecting and duplicating of verticals and moving them to new position.

Originally, the position of stećaks was from West to East. Using the computer graphic, the object was returned to its original orientation and it is possible to examine how the Sun would affect it in its original location.

Using Maya software the environment with apparent periods of day was created. The Maya Environment Sky texture application was used for Sun simulation. In such a way, the users are enabled with the possibility to change the azimuth point

and the elevation parameters in order to observe the object during the different parts of the day on its original position [29].

Sarajevo City Hall – Vijećnica

Sarajevo City Hall – Vijećnica is positioned in the city centre. It was built during Austro-Hungarian rule. "It was destroyed in the Serb artillery bombardment on August 25/26, 1992" [29, s. 87]. Until that day, the National and University Library of Bosnia and Herzegovina was situated in Vijećnica. Now, the object is under the reconstruction process.

The virtual model of the object was created using 3ds Max software. Previously, the site was photographed in details and measured. The object was created using basic geometry, compounding of objects, the cubes and Boolean operation. The textures used for object mapping were created with photographs edited in Photo Shop. The model optimization was performed in order to adjust the size for Internet presentation. The significant optimization of VRML model was done with 3ds Max Optimize modifier. The model was exported to x3D using Vizx3D software. With story-telling applications, the exploration on influence of viewer's perception on information presented was done. The result of this user-study showed that the perception is improved if the story is told by real rather than by animated characters [29].

Virtual Sarajevo – Baščaršija Project

Baščaršija is a part of the old Sarajevo city. The goal of the project was to make it virtually accessible worldwide. The content provided was consisted of panoramic photographs, video walk-through files, stories about selected objects and events.

The navigation is done with VRML browser. The video files were captured from the real environment using the digital camera. The project part entitled as "Stories" is consisted of short movies with the possibility to dramatize historical environment of objects and events. The audio description enhances video presentation of the content.

It is planned for the content to be updated by adding the Old Orthodox Church, Cathedral of the Jesus' Hart, the Old Jewish Synagogue, walk-through all Baščaršija streets etc.

The database of the project was implemented in XML. The data is stored against criteria of sizes, extensions, content description, and paths of multimedia and panoramic files. Each file is described with XML file tags.

There is a possibility of expansion of the project to all important cities in the country [29].

Conclusion Remarks

There are two focal points of the cultural heritage digitization projects in Bosnia and Herzegovina. The first one is research on possibilities of digital techniques applied to the cultural heritage content. This approach is the main feature of the Digital Media Center's projects. The second focal point is planned cultural heritage preservation through digitization that is taking place within some of the cultural institutions in Bosnia and Herzegovina such as libraries and museums.

In order to ensure the longevity of the digitization activity in Bosnia and Herzegovina it is needed, besides permanent utilization of the newest trends in the information technology, to connect these efforts to main memory institutions of the national importance. In such a way the digitization activity would become well and long-term planned and it would ensure the common identity of such activities. Besides, the cultural heritage digitization would not be an excessive activity that exists thanks to individual efforts, but well controlled activity regulated from the state level and recognized as the national interest.

The cultural heritage digitization in Bosnia and Herzegovina has bright future. With up to now realized projects the Digital Media Centre obtained good references. It is planned to get the corresponding infrastructure for systematic digitization and digital preservation of cultural heritage in Bosnia and Herzegovina.

Nevertheless, the process itself must be constituted in a multidisciplinary way including different institutions whose primary goal is to preserve cultural heritage. First step should be the formation of the body responsible for validation and standardization of digitization activity in Bosnia and Herzegovina.

From the technical point of view, the digitization is the response against destruction of cultural heritage since it enables its virtual reconstruction. Besides, the digitization opens the possibility for cultural heritage to be multimedia presentable and for knowledge about tradition and culture of people to be shared worldwide. Consequently, it abets the development of cultural tourism.

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