

Unity Hyperlinked Interactive Digital Storytelling

Irfan Prazina*

Supervised by: dr Selma Rizvić†

Faculty of Electrical Engineering Sarajevo
Bosnia and Herzegovina

Abstract

Virtual presentation of cultural heritage is significantly enhanced through the interactive digital storytelling. The common approach is to access the digital stories by clicking the interactive nodes within the virtual environment. We introduce a different method which enables the users to interact with the story and branch to hyperlinked digital content, which can contain virtual environments. The hyperlinked structure implementation is done in Unity. Evaluation of the method is performed through the user feedback analysis. **Keywords:** Interactive digital storytelling, hyperlinked stories, virtual cultural heritage.

Keywords: Digital Storytelling, Hyperlinked Video, Unity

1 Introduction

Storytelling is one of the oldest concepts in history of mankind. Stories are hidden in every aspect of human life. The methods of storytelling are changing and adjusting to the available media and tools. However, the aim remains the same: engage the consumer with the story and make him/her immersed in different space and time. With the development of digital technologies, the presentation of cultural heritage is significantly improved. Nowadays we can virtually travel through time and visit the 3D models of monuments in their original shape. Many tools and techniques are involved in such presentations, one of them digital storytelling. The museums are improving their physical exhibitions adjoining the artifacts with digital stories about their purpose, history and related events and characters. Today the people are used to all kinds of interactions. The time becomes a precious commodity. Very few people read books, most just skim through web sites and can afford to watch only short videos. The hypertext principle has conquered our everyday lives. The aim of this research is to explore how the perception of stories can be enhanced dividing them in short sub-stories hyperlinked in a hierarchical structure. On the example of the Tašlihan application we will discuss the user perception of this concept and its advantages and drawbacks in comparison with the lin-

ear storytelling. The paper is organized in the following way: Section 2 presents the existing concepts of hyperlinked storytelling structures such as hyper-video, in Section 3 we present the overview of our research in this field and introduce the new method of Unity hyperlinked video, Section 4 describes the case study we used as a proof of concept, in Section 5 we evaluate our concept through a user survey and Section 6 presents our conclusions.

2 Related work

One of the most common concepts of hyperlinked story structures is the hyper-video. It was first demonstrated by the Interactive Cinema Group at the MIT Media Lab. Elastic Charles [1] was a hypermedia journal developed between 1988 and 1989, in which "microns" (video footnotes) were placed inside a video, indicating links to other content. Following the Storyspace project, a hypertext writing environment, the HyperCafe, an award-winning interactive film, places the viewer inside a virtual cafe. It is a video environment where stories unfold around the viewer [2]. After these first works, and a rather long period of stagnation, many different methods of hyper-video implementations started to appear with development of Internet, starting in 2010s, most of them for use in advertising and marketing. Nowadays there are several popular tools using hypervideo. In the RaptMedia [3] cloud based editor, the user can create interactive videos and controls are implemented in form of links on the web. The Madvideo tool [4] is used to add tags to video files. Interactivity is implemented via manually inserted interactive tags. The tags can be links to websites, images, or other video clips. In the Open Hypervideo project [5] the contents are linked using annotation-types, such as: Wikipedia Articles, locations, videos, web pages, etc. Video sequences are made out of multiple (cut) video files. In E-Learning-How-Tos [6] the learning process via videos is enhanced using elective contextual data inside the videos. Cacophony, the interactive player for HTML 5 and JavaScript [7] allows creating interactive elements inside videos like story adapting in response to the user input. ClickVID video players [8] allow creating 'hotspots', clickable regions with specific content at designated time. WebM is a video file format made for HTML5 video tagging. Apart from the mentioned fields of application, the hyperlinked storytelling is

*iprazina1@etf.unsa.ba

†srizvic@etf.unsa.ba

used in virtual cultural heritage applications. A Human Sanctuary is a project implemented by the Cyprus Institute, telling the story about the famous Dead Sea Scrolls, with text annotations which offer more details about certain notions mentioned in the video [9]. In the Keys to Rome exhibition [10] the interactive digital storytelling was used to present the reconstructed Roman remains from Rome, Amsterdam, Alexandria and Sarajevo in combination with physical museum exhibits. Most of the mentioned projects use HTML5 and JavaScript as tools to make interactivity in the linear video sequence. Our idea is to try to use the Unity 3D game engine to connect the hyperlinked stories and combine them with interactive virtual models.

3 Interactive digital storytelling methodology

“Digital storytelling is narrative entertainment that reaches the audience via digital technology and media.” In [11] Miller states that digital storytelling techniques can make a dry or difficult subject more alive and engaging to the viewers. In order to improve the classical storytelling concept, Glassner defined interactive storytelling as a two-way experience [12], where “the audience member actually affects the story itself”. Manovich introduces the possibility for audience to change the story and offers the concept of an interactive narrative as “a sum of multiple trajectories through a database” [13]. We started our research of interactive video with the interactive video virtual tours [14], where the user is watching video walks through the streets of Sarajevo old town, navigating through decision points. The following was the concept of “a story guided virtual museum”, implemented in the Sarajevo Survival Tools project [15]. The digital story provides the user with the historical context of the siege of Sarajevo 1992-1996, guiding him/her through the virtual museum of objects created by the citizens during that time. The virtual exhibition is divided in thematic clusters and the stories are connecting that clusters. In [16] we introduced and evaluated through user studies the concept of audio guided virtual museum. Here we implemented the audio stories to guide the visitor through the virtual collection of Bosniak Institute exhibits. The user evaluation has shown that visitors were so focused on the story that they have not noticed that movement through 3D environment was not enabled, but they could move only through clicking on hotspots in the pre-rendered images. In the computer animation of the zikr ritual in Isa bey’s tekke1 [17], the animated virtual environment was exported to Unity 3D and adjusted to place the user in the middle of the animation. The user observes the dervish ritual going on around him/her and has a possibility to explore in more detail the highlighted elements. Here the main story is happening in the ritual room semahana and sub stories are connected to highlighted scene el-

ements and activated on mouse click. After the activation every sub story is implemented as a movie. The last improvement of our interactive storytelling concepts was implemented in the Isa bey’s endowment project and united the interior animation of zikr ritual with the exterior virtual environment consisting of the tekke, accommodation area, soup kitchen and water mills. The main story about the endowment and sub stories about particular objects are realized in form of audio stories in corresponding areas [18]. Once the user starts the interactive environment, the main story starts; if the user is detected inside one of these activation areas, a trigger is launched to pause the main story and start the sub-story of the activated area.

3.1 Hyperlinked interactive digital storytelling

The new method we call hyperlinked interactive digital storytelling is based on interconnecting the video file of the main story with sub-stories and the interactive virtual environments using Unity hyperlinks. The method implies structuring the story scenario in such way that it consists of a main story presenting a short summary of the topic and sub-stories offering more details on particular aspects of the topic to the user. While watching the main story, at the time each of sub-stories topics is mentioned, the user can click on a link to watch the sub-story. Sub-stories have the same recursive structure of the main story, as they can also contain their sub-stories. Instead of sub-stories, interactive virtual environments (IVE) can also be linked in this hyper-structure. The general algorithm of this method is displayed in Figure 1.

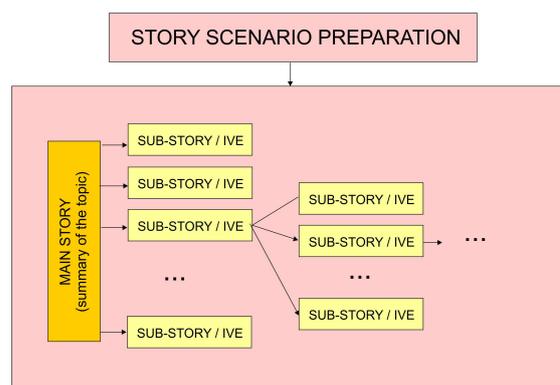


Figure 1: Algorithmic representation of the method

Through this method we aim to achieve the following contributions:

1. optimization of time the viewer spends in the application Most of the Internet users do not have time to watch a story that lasts more then 3-5 minutes. The proposed story structure offers the insight in the information content through the main story and a set

of sub-stories for viewers who have more time and/or are more interested in learning about the object. Also, the users can come back and watch sub-stories according to their time and availability.

2. adjusting the form of narrative to the concept familiar to the modern Internet era We created the story structure following the organization of HTML pages with hyperlinks. This concept is natural to the modern human media perception. If proven successful, this concept could offer an alternative form of presentation in literature and movie industry.
3. joining different media in a unique digital storyline The combination of the story about an object with an interactive 3D model of that object could enhance the user perception and immersion in the story The results of the user evaluation will show if we succeeded to reach these aims. They will show us the way we need to follow in our future interactive digital storytelling concepts development.

4 Case study the proof of concept

4.1 The Tašlihan object

The Tašlihan was the largest accommodation facility in Sarajevo during the Ottoman period. It was built between 1540 and 1543 as an endowment of Gazi Husref Bey, governor of the Bosnian province within the Ottoman Empire. It could host 20 people and 70 horses. Aside of Tašlihan was built a huge covered bazaar called Bezistan, with 52 shops. Presently there is only one wall remained of Tašlihan (Figure 2), aside of the hotel Europe garden. The Bezistan is still functional as a trade center.



Figure 2: The remains of Tašlihan, Sarajevo, Bosnia and Herzegovina

The only visualization of the Tašlihan original appearance is a part of the physical model of Sarajevo old town from XIV century exhibited in the Museum of Sarajevo (Figure 3).



Figure 3: Physical model of Tašlihan, Museum of Sarajevo

4.2 Interactive digital story

In Tašlihan application [19], the main story represents a summary of the information about the object, its history and related events and characters. It consists of 7 thematic clusters (MS 1-7). After each thematic cluster the user can activate a link to the sub-story (SS), which describes in more detail a topic mentioned in the main story. For example, in the main story the narrator says that the object was built as an endowment of Gazi Husref Bey. By clicking the link on SS1, the viewer can see the story explaining the concept of endowment in Islamic tradition. The structure of the application is presented in Figure 4. The sub-story SS1 is linked to another sub-story (SS 1-1) and the SS4 is linked to the interactive virtual model of the object. All links are displayed on the right side of

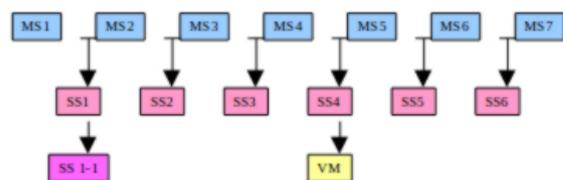


Figure 4: Structure of the interactive digital story

the window with the story player and become clickable after the predetermined time code of the main story video file (Figure 8). In [20] we showed that the storytelling is much more engaging and immersive if there is a character telling the story. Therefore in this project the story is told by Murat Bey, the first associate of Gazi Husref bey, who sponsored the construction of Tašlihan. Digital stories are created using the photos of the present appearance of the Tašlihan complex, as well as the other objects that belong to the Gazi Husref bey's endowment, such as the Begova mosque, as the character who tells the stories, Murad bey, is buried in the yard of that mosque, next to Gazi Husref bey. We also used drawings created by a digital artist and photos of the Sarajevo old town model from the Museum of Sarajevo. In stories creation we followed the principles

of film language grammar and engaged a professional narrator for voice over. 3D model of Tašlihan (Figure 5) was created in Maya and exported to Unity 3D, where textures and illumination were adjusted and optimized for online use. The geometry of the model is based on the scientific work of archaeologists and historians who excavated the remains of the object. Unity 3D has been chosen as we needed to introduce interactivity into a video. In our previous projects we used Flash, but presently it is not supported by all platforms.



Figure 5: The interactive 3D model of Tašlihan

4.3 The Unity hyperlinked story structure implementation

The screen appearance of the Tašlihan application is displayed in Figure 8. Here we briefly describe the implementation of the method. Unity 3D supports the video reproduction via MovieTexture tag. The MovieTexture can be assigned to a plane, as a common texture, and video reproduction can be controlled by three MovieTexture methods (Play, Pause and Stop). For our hyper linked stories and sub-stories we needed the current playing time, not supported by the MovieTexture, so we implemented an internal timer for each plane with the MovieTexture. The timer uses Unity Time class which stores elapsed time in seconds since start of the application. To get current video time ($T_{current}$) you have to subtract the starting time of video ($T_{start_of_video}$) and the sum of time when video was paused (T_{in_pause}) from the time since application was started ($T_{elapsed}$).

$$T_{current} = T_{elapsed} - T_{start_of_video} - T_{in_pause}$$

Explanation of the application's algorithm is given in Fig. 6. When the application is started the main story's video is played, and in the appropriate moment (time stored in the start time attribute of a sub-story's class) notification is presented and link to a sub-story is highlighted. Sub-stories are stored in the list, and sorted by their starting time. If a user clicks on the link, current story's video is stopped, its plane is deactivated (no longer visible), sub-story's plane is activated (now visible) and sub-story's video is played. If sub-story has one or many sub-stories than same process is repeated as for main story. At any moment when a user is watching sub-story he can

click the back button which takes him back to the main story. If that happens sub-story's video is paused, the sub-story's plane is deactivated (no longer visible), the main story's plane is activated (now visible) and the main story's video is played. Along with these controls a user can pause and rewind video. If the pause button is clicked the video is paused via `MovieTexture.Pause()`, the elapsed time in moment of the click is stored in timer's variable called `pauseStart` and pause button is converted to the play button. The play button resumes the video and calculates time spent in pause using earlier `pauseStart`, this time is used to calculate `Tcurrent`. If rewind button is pressed the video is stopped via `MovieTexture.Stop()`, this resets video to start, our timer is also reset and then `MovieTexture.Play()` is called. Unity scripts are used to implement the algorithm. Each plane has the script attached. The script do all actions regard plane activation/deactivation, video play/pause and timer calculation. In the script each story's data is stored in `Story` class. `Story` has attributes: name, start time, end time, link button, plane. We use these data to know exact time when to notify a user and which plane to activate. The data about each story is tuned so the transition from a current story to a sub-story is as smooth as possible. The start time of a sub-story is (manually) determined in a way that we know when context of the sub-story is mentioned in the parent story, in that moment sub-story becomes relevant, and that moment is time when sub-story should start. The start time and end time is measured in the timescale of the parent story.

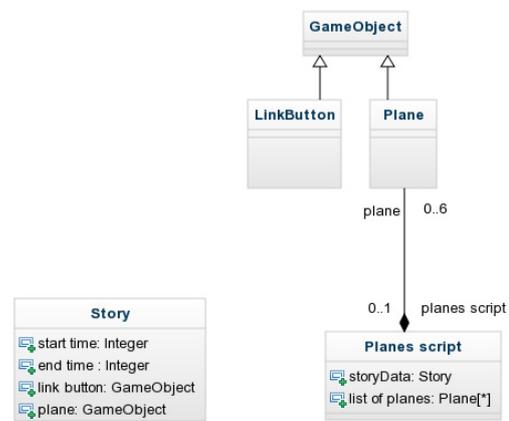


Figure 7: Class diagram

Description of each Story's [Figure 7] attribute:

- name – short Story title,
- start time – time when the story is mentioned in the parent story. We use this time to notify a user that he can click to the link of this story,
- end time – time when story stops being relevant to the parent story and time when notification is closed,

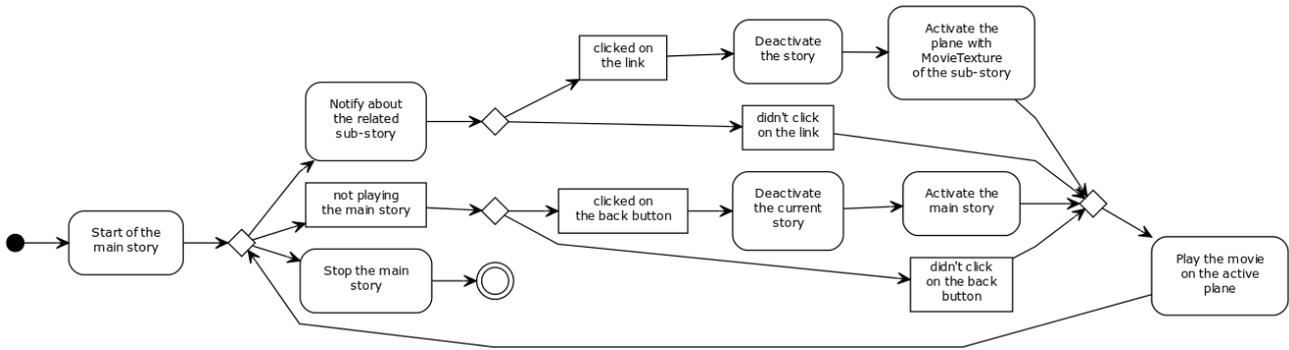


Figure 6: Activity diagram

- link button – the button which switches the parent story and the sub-story. When the story is loaded sub-stories of the current story are loaded and stored in list,
- reference to the plane with video content – we use this reference to activate the story plane.

When implementing a Unity application with video, two issues should be considered: Unity native video format is ogg theora. MovieTexture has limited set of video control methods, there is no support for playing a video from random position (no seek method), no support for current playing time.

5 User evaluation

5.1 Introduction

User evaluation is the main parameter for the success of virtual cultural heritage applications. We performed two user evaluation studies: quantitative evaluation based on customer satisfaction questionnaires and qualitative evaluation based on user interviews.

5.2 Customer satisfaction questionnaires

The initial evaluation of the project was done by 9 users who filled out a customer satisfaction survey. The first group of questions was related to information perception. We have investigated what the users have learned from the application asking them questions about the notions mentioned in stories. We also evaluated the quality of interactive digital storytelling, asking the users to mark the narrative, the video and music in digital stories. The third group of questions was about the interactive 3D model of Tašlihan. Firstly, we investigated if the users got to open the model, as it is positioned as a link in one of sub-stories. Then we inquired about the quality of models geometry, textures and illumination, as well as the navigation through the model. The last group of questions considers the overall satisfaction of users, with emphasis on feeling of im-

mersion. The users could describe what they liked and disliked in the application.

The questions which contained rating of particular aspects of the project were set up according to the positive response bias [21], so the users could rate that aspect from 1-10, but in case 9 or lower was chosen they were offered to answer "What would make it a "10"?".

Although this initial evaluation was performed on an extremely small number of users, the results we obtained are very valuable. Most of the users rated the application and its particular aspects with 10 and felt immersion in the past of the Tašlihan object. But, more important was that they appreciated the concept of hyperlinked stories as a method to present the information on cultural heritage. One of them answered the question "What did you liked the best in the Tašlihan application?" with the following statement: -"widening" of the story in a sense that the viewer who becomes interested in particular part of the story has the possibility to explore it further. Also, I have never seen something similar to this concept of mixing stories and 3D models in a unique interactive application, it's a quite new experience for me. And another one said: "this is much better than reading a tourist guide". Most of the users found as a drawback the long downloading time of the application, some of them would like to see a more detailed 3D model of the object and one of them was missing people in the virtual environment. They also mentioned that some controls over the playback of the stories should be introduced.

5.3 Qualitative data analysis - data coding

One of the most efficient methods of user evaluation is the qualitative analysis of user feedback. It is based on interviews with the users in which they express their experience during the use of the application. This kind of user evaluation is performed according to the following workflow: definition of hypotheses, interviewing the users, data coding of users feedback, analysis of coded answers and comparison with hypotheses.

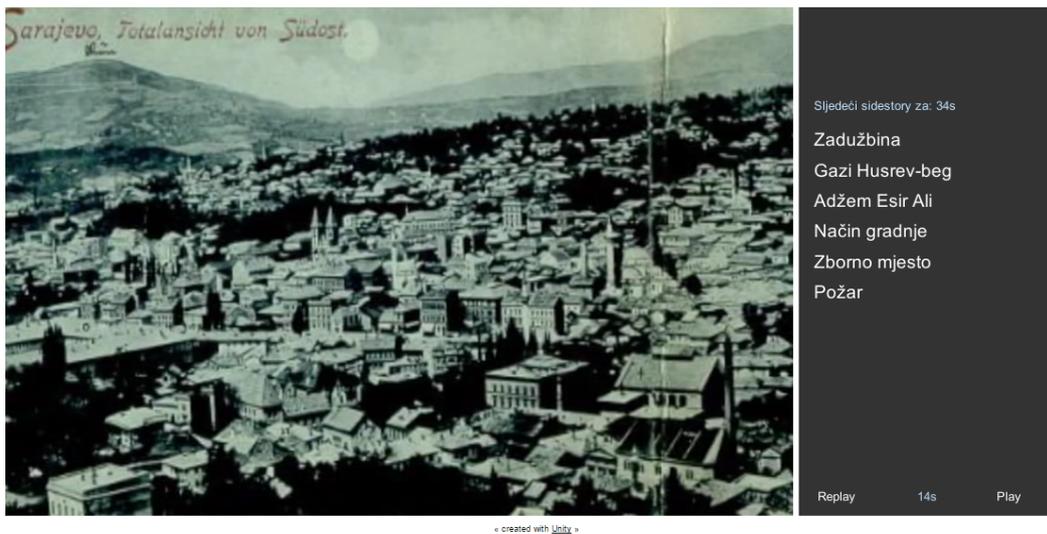


Figure 8: The Tašlihan application main story

5.3.1 Experiment design

The user experience practice has shown that 7 users will find approximately 80% of problems of an interface or application [22]. User selection included different nationalities (Spanish, Indian, Azeri, Chinese) and various academic backgrounds (Computer Science, Historians, and even some Colour Science student, etc). Five of them were experienced computer users. Average age of users was 29 years old

| Question | Code | Possible value and number of answers |
|--|------|---|
| How interesting and engaging you found stories in the application? | Q6 | Very interesting (2) Quite interesting (2) Interesting (2) Intermediate (1) Not interesting (0) |
| Did you see a common line between them? | Q7 | Yes (7) No (0) |
| How immersive you found the application? | Q14 | Very immersive (2) Moderately immersive (3) Slightly immersive (1) Not immersive (1) |

Table 1: Illustration of data coding

5.3.2 Evaluation process and results

Qualitative data analysis is based on data coding [22]. It is a process of extracting qualitative data into quantitative form. The possible values of the qualitative data are created according to the given answers. Since participants often use different terms for the same notion or same words for different notions, it is important to perform coding as

accurate as possible, without losing too much information. The data analysis was performed in two steps: defining the hypotheses and grounding the evidence. We defined the following hypothesis:

- H1: users learn more from interactive storytelling than from linear story
- H2: interactive storytelling application makes users immersed in the past
- H3: users prefer interactive over linear storytelling

The hypotheses were generated using the constant comparison method [23]. After coding the questions (Table 1), each of them representing a particular section, we went through the data looking for patterns. At the end of the analysis we obtained the following level of hypotheses confirmation (Table 2) These results show that we still

| Hypothesis | Percentage of confirmatory answers |
|------------|------------------------------------|
| H1 | 78.30% |
| H2 | 62.50% |
| H3 | 50.00% |

Table 2: Hypothesis confirmation results

have to work on the interactive digital storytelling methods in order to motivate the majority of users to choose it over the linear storytelling. At the end we will quote some of the user statements we find valuable for the future research: "It supplies 3D model that allows the user to get the feeling about the building. Compared with a normal presentation, makes the user involved with the environment" "The interactive form gives freedom to select certain part of information the participant would like to listen

to again.” ”It is nice how information is displayed, the mixture of old images and 3D reconstruction. If I would need to imagine, from the current picture of the site nowadays, how it was the building before, it would not be possible for me”.

6 Conclusions

The Tašlihan application aims to present to the Internet users a cultural heritage object which does not exist any more, except the remains of one of its walls. In this presentation we used the hyperlinked interactive digital storytelling combined with the 3D virtual environment. This concept offers to the users an overview story about the history of the object, hyperlinked with sub-stories about some events and characters from its history, together with the possibility to virtually explore the reconstruction of the object. The application structure is implemented in Unity 3D. The initial user evaluation of the application shows that this concept could be appreciated by the viewers and can create the feeling of immersion. The main drawback of the Unity implementation is the long downloading time. In the future work we need to decide whether the links to sub-stories should be active all the time, or should be activated after the key notion is mentioned in the main story. We also need to introduce some controls for users to play-back the stories. The thorough user evaluation needs to be performed on a larger groups of viewers, with different professional backgrounds, ages and computer literacy.

7 Acknowledgment

The interactive 3D model of Tašlihan was created by Bojan Kerouš as a part of his graduation project at the Faculty of Electrical Engineering Sarajevo.

References

- [1] G. Davenport H. Brndmo. Creating and viewing the elastic charles. *Hypermedia Journal, Hypertext: State of the ART*, 5:43–51, 1989.
- [2] I. Smith N. Sawhney, D. Balcom. Hyperface: Narrative and aesthetic properties of hypervideo. *Hypertext '96 Proceedings, ACM, New York*, pages 1–10, 1996.
- [3] The raptmedia editor. <http://www.raptmedia.com>. Accessed: 2015-03-01.
- [4] The madvideo tool. <http://www.themadvideo.com>. Accessed: 2015-03-01.
- [5] Open hypervideo as archive interface, interface design, 2012.
- [6] E-learning-how-tos. <http://learn.articulate.com>. Accessed: 2015-03-01.
- [7] Cacophonys player. <http://www.cacophonyjs.com>. Accessed: 2015-03-01.
- [8] Clickvid players. <http://www.clickvid.co.uk>. Accessed: 2015-03-01.
- [9] A human sanctuary project, cyprus institute. <http://public.cyi.ac.cy/scrollsDemo>. Accessed: 2015-03-01.
- [10] S. Rizvić, D. Pletinckx, S. Pescarin. Keys to Rome The Next Generation Virtual Museum Event. South East European Digitization Conference SEEDI 2014, Belgrade, Serbia, 2014.
- [11] C. Miller. Digital Storytelling. *Elsevier*, 2008.
- [12] A. Glassner. *Interactive Storytelling*. A. K. Peters, 2004.
- [13] L. Manovich. *The Language of New Media*. 1st MIT Press pbk. ed, Cambridge, Mass, 2002.
- [14] N. Kraljic. Interactive video virtual tours. *In Proceedings of CESC G*, 2008.
- [15] S. Rizvić, A. Sadžak, et al. Interactive Digital Storytelling in the Sarajevo Survival Tools Virtual Environment. *SCCG*, 2012.
- [16] Sanda Šljivo. Audio Guided Virtual Museums, Central European Seminar on Computer Graphics, Bratislava, Slovakia. 2014.
- [17] Merisa Huseinović, Razija Turčinhodžić. Interactive animated storytelling in presenting intangible cultural heritage. 2013.
- [18] S. Rizvic, A. Sadzak, et al. *Interactive Storytelling about Isa Bey Endowment, Review of the National Center for Digitization*. Faculty of Mathematics, Belgrade, 2014.
- [19] Taslihan interactive storytelling application prototype. <http://h.etf.unsa.ba/han/sd/Build.html>. Accessed: 2015-03-01.
- [20] S. Rizvic, A. Ferko, A. Sadzak, et al. *A Piece of Peace in sWARajevo - Locally and Globally Interesting Stories for Virtual Museums*. In Proceedings of the Digital Heritage International Congress, 2013.
- [21] W. Kamakura V. Mittal. ”Satisfaction, Repurchase Intent, and Repurchase Behavior: Investigating the Moderating Effect of Customer Characteristics”. *Journal of Marketing Research*, 2001.
- [22] C.B. Seaman. Qualitative methods in empirical studies of software engineering. 25(4), 1999.

- [23] Feng J.H. Hochheiser-H. Lazar J. *Research Methods In Human-Computer Interaction*. Wiley, 2010.