

Interactive Digital Storytelling in the Sarajevo Survival Tools Virtual Environment

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Abstract

Virtual museums enable Internet users to explore museum collections online. The question is how to enhance the viewer's experience and learning in such environments. In the Sarajevo Survival Tools virtual museum we introduced a new concept of interactive digital storytelling that will enable the visitors to explore the virtual exhibits - objects from the siege of Sarajevo - guided by a digital story. This way the virtual museum visitors will learn about the context of the displayed objects and be motivated to explore all of them. In this paper we present the virtual environment we developed and our experience with it. The results from three empirical studies we conducted, indicate the positive influence of digital storytelling and sound effects on visitors' perceptual response, resulting in increased motivation and enjoyment, and more effective information conveyance.

CR Categories: Computer Graphics [Virtual Reality - I.3.8]: Applications—;

Keywords: Storytelling, Virtual Museums, User Study

1 Introduction

Nowadays people live at a fast pace, with no time for culture and education. In Bosnia and Herzegovina museums have fewer and fewer visitors, often only school children and occasional tourists. Virtual museums (VM) offer the possibility to explore museum collections online without leaving home. This could inspire potential visitors to visit the real museum, and in any case to learn about the collections and cultural heritage.

Our experience from previous virtual museum projects showed that visitors often do not explore all displayed objects, but only a small subset. Furthermore, if the objects are linked to a central virtual environment, such as in [BTP], the viewer has no perception of their context or common background. In order to motivate the visitor to explore the whole collection displayed in the VM, we introduced a new concept where a digital story guides him/her through the collection, presenting its common background and offering the oppor-

tunity to explore more objects after watching particular segments of the story.

This paper is organized with the following structure: Section 2 presents an overview of related work in the virtual museums area and existing concepts of VMs, Section 3 explains our concept of interactive digital storytelling and its potential in VM applications, Section 4 presents the Sarajevo Survival Tools project where the concept was implemented, Section 5 provides the results of visitors' evaluation to confirm the advantages and drawbacks of the concept, Section 6 presents further exploration using interview, and finally Section 7 offers our conclusions and some possible directions for future work.

2 Virtual museums and existing concepts

In recent years we have witnessed the introduction of different presentations of VMs, all seeking to create not just an informative, but also an engaging, vivid and enjoyable experience for visitors. VMs today are not just a catalogue of what they are exhibiting. The degree of technology used in their presentations varies greatly from simple multimedia presentations to a truly immersive 3D experience. Below are a few examples of relevant VM presentations.

The VR museum of Inuit culture [Ivory] contains 2D images, 3D artifacts to view at 360 in QTVR, video clips including archival film footage about how the exhibits were produced and used, video conversations with elders, narrations and transcriptions. The Virtual Hampson Museum offers a range of 3D presentations of artifacts available for download in VRML, 3D PDF and OBJ format in both high and low resolutions [Smallwood et al. 2006]. In the virtual world of Eternal Egypt [Tolva and Martin 2004], the visitors are offered different multimedia features for exploring, such as: a collection of high-resolution zoomable pictures, virtual recreations of famous Egyptian sites, 3D views of artifacts, 360 degree interactive panoramic views of locations in Egypt, animations helping to illustrate and explain artifacts, and web cameras providing up-to-date interactive views from certain locations in Egypt. The State Museum of Auschwitz-Birkenau offers a virtual tour of Auschwitz/Birkenau through either QTVR or Flash panoramas, with a textual explanation provided on the side. This website is referenced here as an example of darker tourism VMs, a growing phenomenon which allows virtual visits to sites of death, disaster and tragedy.[Kaelber 2007]

There are several more examples of how some VMs have expanded their presentations with virtual environments. In addition to digital archives of paintings and calligraphies, antiquities, books and documents, the National Palace Museum holds a virtual replica of the exhibition hall containing virtual map presentations of the museum, digital stories and panoramic images with hotspots where the visitor can get more information on particular objects (sometimes including an audio guide), as well as a suggested virtual tour for children [Lai and Lin 2006]. The Virtual Museum of Iraq presents eight virtual thematic halls, set up in chronological order. Each hall

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contains a selection of artifacts that are representatives of the phase in question; each phase is presented through different formats: information sheets, three-dimensional models that can be rotated by the user, brief videos and films with animations and reconstructions [Cultraro et al. 2009]. The Inuit 3D virtual museum [Canada et al. 2002] is an interactive VRML exhibition of Inuit art and objects, containing three exhibition rooms to navigate through, and twelve interactive 3D models of objects in VRML format. Introductory videos are presented at the entrance to each room. Pop-up text panels provide additional information on the objects. The Virtual Smithsonian tour [G.Jones 2002] allows visitors with high bandwidth to take a virtual, audio guided, room-by-room walking tour of the whole museum. The visitor can navigate from room to room and explore hotspots which contain artifacts that rotate in 3D and morph into other artifacts, high resolution images, video and audio clips, and more. A few more examples are: the Smithsonian Latino Virtual Museum (LVM) [LVM] with an avatar-guided 3D virtual learning environment, the Van Gogh Virtual Museum [Galani 2003] with another unique opportunity of entering into a virtual conversation with other visitors, and the 3D environment of Anne Frank's house [AFH] guided by audio narration.

In order to extend and evolve their relationship with visitors, museums need to develop a holistic view of the audience journey across both the physical and virtual spheres [Barry 2006]. From that point of view, what distinguishes our VM's concept from those described is a story guide that helps visitors to learn about and explore exhibits in a carefully designed order and presentation style. We believe that this digital story guidance will increase their sense of presence in virtual space and encourage them to explore more objects. The foundation for this idea comes from a number of studies that showed how different forms of mediations (audio and visual) in virtual environments can increase the users' feeling of presence and make them more involved and interested in exploration [Murphy and Pitt 2001; Brown et al. 2002; Walker et al. 1999].

3 Interactive digital storytelling in virtual museums

Glassner defined interactive storytelling as a two-way experience [Glassner 2004], where "the audience member actually affects the story itself". In our concept the user does not change the plot of the story, but he/she expands his/her story experience by viewing the interactive presentations of the objects mentioned in the story.

"Digital storytelling is narrative entertainment that reaches the audience via digital technology and media" [Miller 2008]. Miller states that digital storytelling techniques can make a dry or difficult subject more alive and engaging to the viewers. This was exactly our aim when introducing digital storytelling in a VM application.

Museum collections are mainly organized in thematic sets connected either by the time period or some common background. There is always a story related to the collection and its history. In the real museum visitors often have no time or motivation to read through the text displayed in the windows behind the exhibits. Therefore their knowledge about the visited collection is very limited.

Digital storytelling offers a solution to this problem. If after entering a VM the visitor sees a story about the collection, he/she will be introduced to the context and the common background of the exhibits. After a story segment is finished, the viewer is given the opportunity to explore an object or group of objects mentioned in the story. After exploring the objects and learning the details about them, the story continues with the next segment of the collection.

This concept is an unusual way of navigating through the virtual environment which could be unfamiliar to the users. Furthermore, if the user visits the museum more than once, he/she will not want to watch the same story segments again and should be given the opportunity to skip them and navigate directly to particular groups of objects. We implemented this concept in the Sarajevo Survival Tools virtual museum [SRP] and asked the users to compare it with the museum of Bosnian Traditional Objects [BTP] in order to verify the advantages and drawbacks.

4 Sarajevo Survival Tools project

The "Sarajevo Survival Tools" project (Figure 1) is an outcome of the cooperation between the Faculty of Electrical Engineering Sarajevo (ETF) and the Historical Museum of Bosnia and Herzegovina in the field of cultural heritage digitization. In this project we created a virtual presentation of the exhibition "Sarajevo Under Siege" from the Historical Museum, which contains objects created and used by the citizens of Sarajevo during the 3.5 year period the city was under the siege (1992-1996). The digital content was created by 3rd year students of the Computer Science Department, as lab coursework in the Computer Graphics course.

The siege of Sarajevo started on 4th April 1992 and lasted for 1425 days. It was the longest siege in modern history. The water, power and supply was cut. The food supply was significantly reduced. Snipers located on the surrounding hills fired mercilessly at pedestrians crossing street intersections and the city was bombed all the time. In addition to horrific casualties, the city also suffered enormous damage in physical destruction and the devastation of numerous buildings and institutions. Still, nothing could destroy the spirit of resistance of the brave and proud citizens of Sarajevo.

This project enables Internet users to learn about life in Sarajevo under siege and the extraordinary creativity of its citizens, who managed to survive and defend their town in terrible conditions, with lack of food, water, electricity and heating, under permanent danger to their lives. All project team members are witnesses of the siege in Sarajevo.



Figure 1: Sarajevo Survival Tools home page with the "Sarajevo rose" pattern.

4.1 Digital content

In order to hold the visitors' attention and to provide them with a truly immersive war experience, for our VM we created a very dark basement environment enriched with environmental sound effects

such as shelling, bombs, warning sirens, the sound of bullets fired from shotguns, etc. Our intent was to conjure up for the visitors, even partially, the fear of people hiding in the basements of their homes during the heavy shelling, with no water, food or light. The digital content created inside the Sarajevo Survival Tools project consists of a digital story which guides the user through the exhibition and virtual galleries of museum exhibits.

The digital story (Figure 2) is a movie about the context of the siege, created according to the rules of film language grammar [Rizvic and Sadzak 2008] from photos exhibited in the Historic Museum of Bosnia and Herzegovina, photos from the Internet, shots of real exhibits and authentic sounds from the period of the siege. The story consists of the following segments:

- **Introduction** - short historical overview of the city’s history, basic information about the siege, the exhibition and the VM
- **Water** - life without water
- **Light** -Life without electricity
- **Food** - Life with lack of sufficient food
- **Cookers** - Heating and cooking
- **Cigarettes** - The phenomenon of cigarettes
- **Medical instruments** - Massacres
- **Weapons** - Defending the city
- **Communication** - Information blockade
- **Energy** - Gas installations
- **Hygiene** - Spirit of resistance
- **Sport** - Cultural life
- **Closing story** - Consequences and the end of the siege

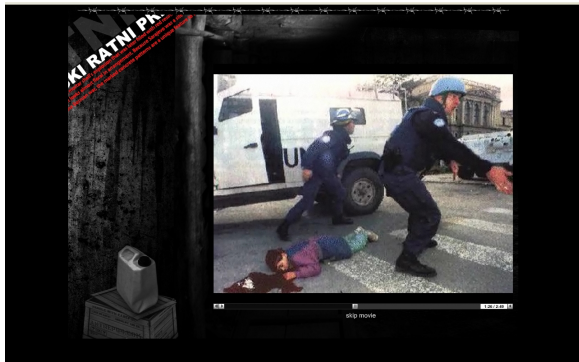


Figure 2: Digital story - introduction segment.

After each part is finished, the viewer is given the opportunity to browse a gallery of objects related to the content of that particular story segment. Every object is represented by text information, a gallery of photos, a movie and an interactive 3D model (Figure 3). Photos are displayed in order to enable the viewer to compare the real appearance of the object with its virtual model. The movies are digital stories about particular objects, their role in life under the siege and the process of their construction. They show the wonderful creativity of people in desperate conditions. 3D models are created in 3ds max and exported to VRML. They can be explored using VRML browser. Galleries of objects are created by students who, through the movies, showed their perception of the siege, which they remember from their childhood.

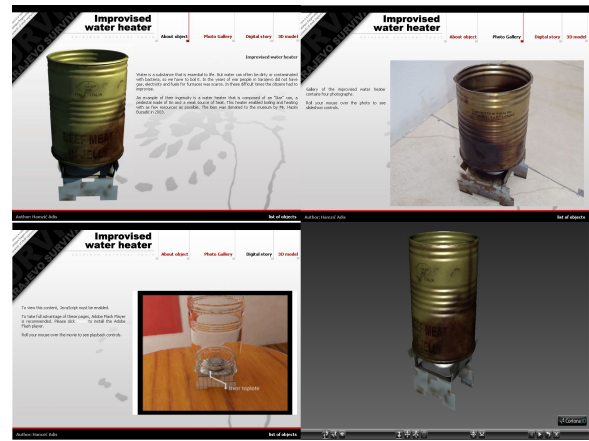


Figure 3: Exhibit “improvised water heater”: a) info; b) photos; c) digital story; d) interactive 3D model.

4.2 Navigation

Upon entering the VM, the visitor is provided with a link to the digital story, which is not only guidance through the museum’s collection, but also through the life story of Sarajevo citizens who were forced to live under the siege. The whole digital story is divided into a series of story segments organized in a logical sequence. The story segments are created in order to present the interrelation of the exhibit objects within a specific theme, all linked through a storyline.

Each segment of a story is linked to the gallery of exhibits corresponding to that story theme. After selecting a specific exhibit from the gallery, the visitor will arrive on a page which offers several multimedia features, allowing him to visually explore and interact with the exhibit: a textual description of the exhibit, an image gallery, a movie describing its use or how it was made, and an interactive 3D VRML model of the exhibit. After exploring the gallery the visitor is able to continue with the next segment of the story, or to see the previous one again. As our intent was to present the museum’s collection in a sequential storyline order, we did not make it possible for visitors to jump directly from one story to another - instead we made it possible to skip the story segments and to navigate through the galleries sequentially. For visitors who are not used to this kind of presentation we made a site navigation map, available both on the first page and as a link from all other pages, organized in a hierarchical tree structure. This map shows a graphic representation of the guided tour and helps visitors to step through the museum’s navigation. The navigation tree includes gallery nodes, directly linked to galleries of exhibits (Figure 4).

5 User evaluation

To evaluate the proposed environment we conducted three studies with 63 participants in total (11 in the pilot study, 46 in the main study, while six participants were interviewed). In the first two studies (Sections 5.1 and 5.2) the participants were asked to visit and explore two virtual environments and fill in online questionnaires. In the third study the participants were interviewed after visiting the virtual environments.

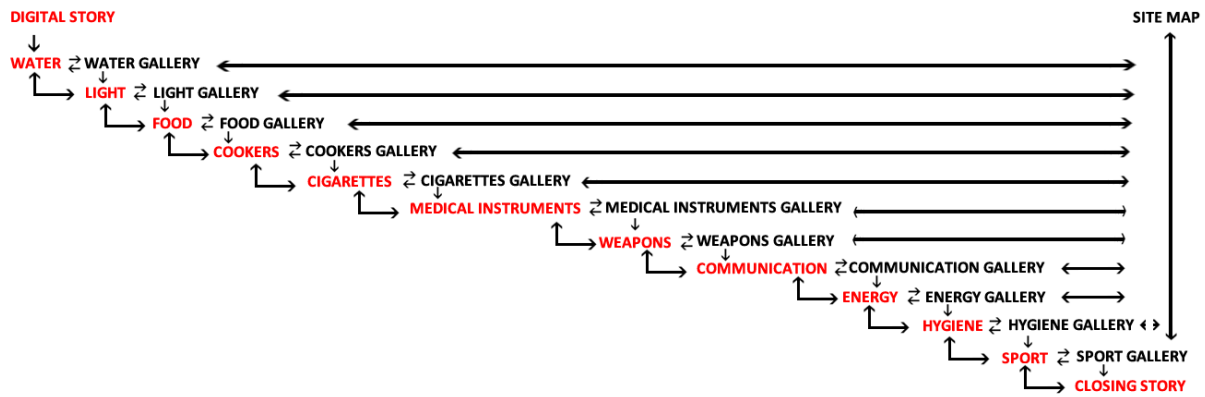


Figure 4: Virtual museum's navigation tree; digital story segments are highlighted in red color

5.1 Pilot study

As a pilot study, an evaluation of the effectiveness of digital storytelling on the user's engagement and feeling of presence in VM environment was conducted. We collected user comments and feedback from two questionnaires created to compare their involvement and interest in the exploration of exhibits in Sarajevo Survival Tools (SRP) VM and Bosnian Traditional Objects (BTP) VM. In the BTP museum all exhibits were linked to a single, central VRML environment without any introductory story or explanation about how they are interrelated to each other, while for the SRP museum, a digital storytelling was used for introducing the VM and each section of the museum. Additionally, sound effects were used in SRP museum.

The evaluation was performed on eleven visitors, both local and international, who were asked to visit both VMs, fill out the questionnaires and submit them online. The two questionnaires contained the same questions, including few additional questions in the questionnaire about SRP for analyzing how visitors respond to the use of the environmental sound effects and digital story guidance in the virtual environment. Results were measured by comparing the scores for questions focusing on ease of use, navigation, enjoyment and entertainment related to the virtual environment experience, ratings on how natural the displayed environment seems and on visitor's sense of presence in the scenes displayed. In order to measure the effectiveness of the digital story guidance, the degree of visitors' engagement in the two VMs was compared. Two key parameters were used: the number of exhibits they visited and the amount of information they learned about them. Other factors related to the use of environmental sound effects, and digital story in virtual environments were also measured.

All visitors reported that both virtual environments were easy to use. In the case of the BTP virtual environment 20% of visitors experienced problems with navigation, mainly due to the slow moving speed, and in the case of SRP 27% of visitors reported complaints about not being able to jump from one story to another. The question "Is the virtual environment entertaining" was positively answered by 100% of SRP and 60% of BTP visitors.

From observing the answers to three rating scale questions (Figure 5) dealing with visitors' perception of VE, one can notice that the SRP virtual environment gives visitors a slightly more immersive and natural experience than the BTP virtual environment.

The summarized answer results to the series of questions considering the communicative effectiveness of the virtual environment show that the environmental sound effects and the digital story add

to the enjoyment and to the content of the page, without distracting visitors from their perception of the environment (Figure 6). What is particularly interesting to us is that 100% of visitors reported that the digital story was useful in conveying information and motivated them to explore more exhibits.

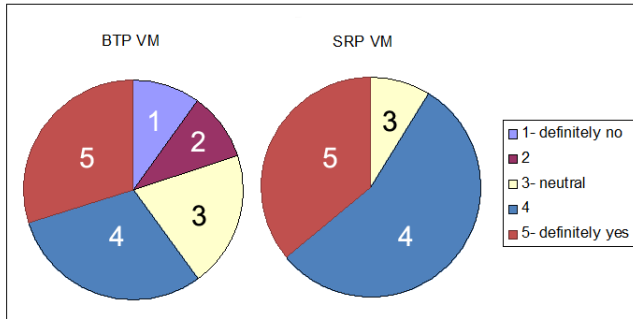
The results of the pilot study indicated that interactive digital storytelling enhances the users' experience and motivates them to visit and explore more artefacts in the VM. However, there were a few shortcomings in this study that might have affected the results. Firstly, a direct comparison of the two VMs might not have been appropriate, as the presentation styles are different, making it difficult to generalize and apply to other VMs. Secondly, there were not enough participants to make the solid conclusion of significance of the effect. Furthermore, both Bosnian and international participants were involved in the study. Some of the Bosnians had had survived the siege of Sarajevo and therefore might have been subjective, due to the emotions evoked by the presentations.

5.2 Main study

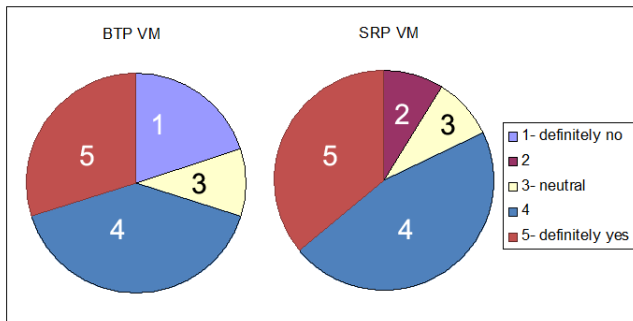
In the main study, we addressed the main limitations of the pilot study. 46 people volunteered for the experiment. The participants were aged between 22 to 65 with an average age of 33. Five participants reported seeing impairment and were excluded from the analysis. Two additional participants were discarded as they reported being Bosnian citizens. The reason for this was to avoid the emotional effect and attachment of the participants who have survived the siege of Sarajevo. After those exclusions, there were 22 participants left for the BTP VM and 17 for the SRP VM. The perceptual response of the participants to the presence of the interactive digital storytelling was studied. The same two VMs as in the pilot study were compared. The main difference between them, apart from the content, was the presence of the digital story and sound effects in the SRP VM. All the questions were carefully designed and phrased, trying to address only one issue per question and maintain consistency across response options by using a 1-5 Likert scale from "Strongly disagree" to "Strongly agree" [Lessiter and Freeman 2001].

In the main study, each participant evaluated only one VM. In this case, the objective scores for both VMs were gained, allowing for further comparisons with other museums. Each participant was given a set of instructions and links to the VM and to the corresponding online questionnaire. In the instructions they were told how to install the VRML browser required for exploring the content and a short summary of what they are about to see in the museums.

Did the displayed environment seem natural



Did you have a sense of being in the scenes displayed



Did you feel disoriented

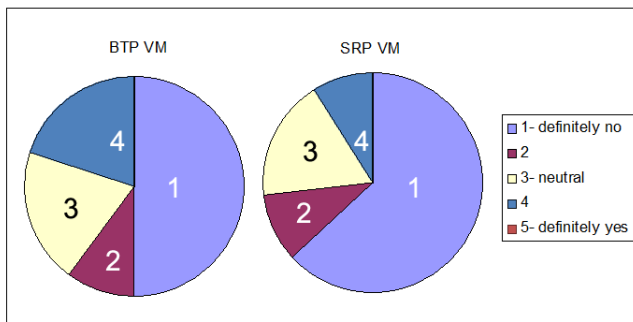


Figure 5: Obtained results for the presence elements of the two virtual environments

They could explore the museums as long as they liked and visit as many exhibits as they wanted.

5.3 Results

In order to evaluate the users' response and see how interactive digital storytelling affects perception, motivation and immersion of a user, we analysed both, responses to the questions directly related to only SRP museum and to mutual questions asked in both questionnaires. One of the indicators of the efficiency of storytelling and users' engagement is given by the number of virtual objects visited in the VMs. Figure 7 shows that the users that were given the SRP VM, containing a digital story, visited more objects than the users who visited the BRP VM without a story. This indicates that storytelling, used for guiding a user through a VM, motivates visitors to stay longer and see more exhibits.

Another significant effect of storytelling technique, employed for

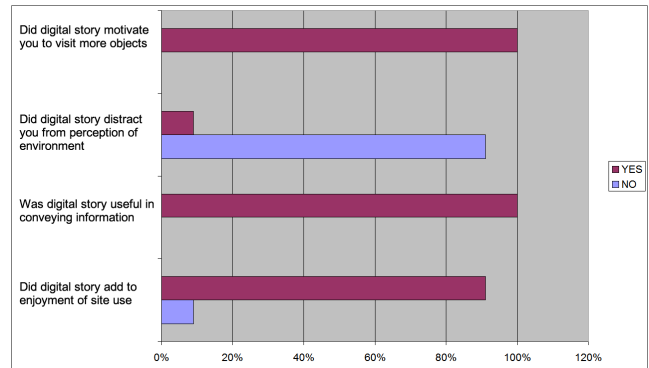
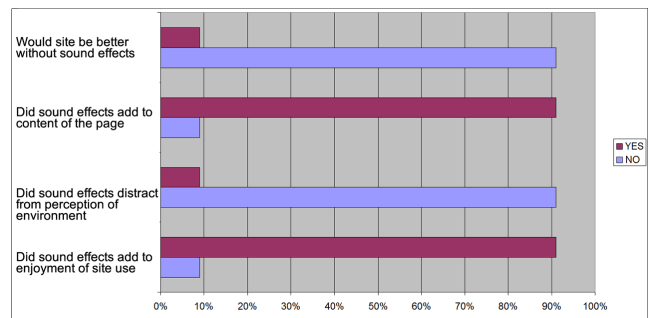


Figure 6: Obtained results for the questions about incorporating sound effects and digital story guidance in the SRP VE

VMs, is that it provides visitors with additional information about an object, a group of object or the exhibition as a whole. In order to verify this effect, the participants were asked if they learned new things by visiting the VMs. The comparison between the answers gained for both VMs are given in Figure 8. The results show that participants felt they learned more when visiting the SRP museum.

The same Figure shows the comparison of the user responses when asked if they felt as if they were in the scene displayed. The graph shows that, when storytelling and sound effects were present, mean value of the given answers is 3.41, compared to the mean of 3.0 for the visitors of the BTP VM.

It is not only the immersion or presence that keep the motivation of the visitor to visit more objects and learn more from in the VM. The visitor needs to enjoy the virtual environment so that the motivation

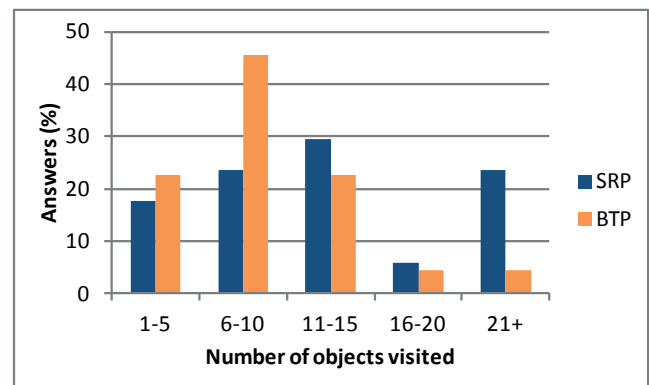


Figure 7: Number of objects visited in both Sarajevo Survival Tools (SRP) and Bosnian Traditional Objects (BTP) virtual museums

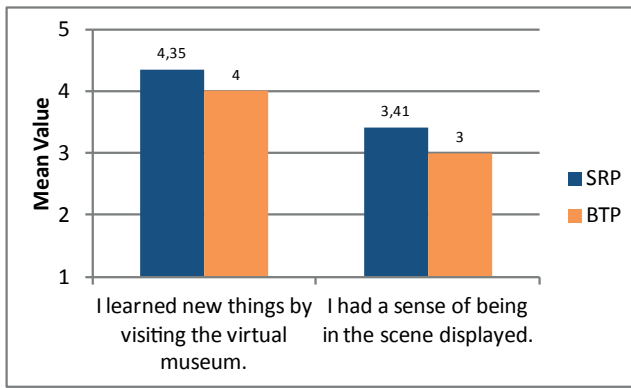


Figure 8: A comparison of the mean values of the responses for both virtual museums

persists. One of the questions asked in the questionnaire for the evaluation of the SRP VM was if the visitors enjoyed the VM better because of the digital story. The user response for this question is given in Figure 9. The chart in the figure shows that around 71% of the visitors enjoyed the VM better due to storytelling.

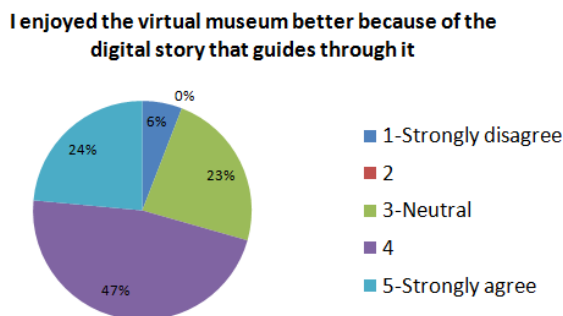


Figure 9: The effect of digital storytelling on user enjoyment

To investigate the other effects of digital storytelling in VMs, additional questions were asked. Figure 10 shows that digital stories are a good way of conveying information to a user. Additionally, it allows the content creator to choose what exactly is important and needed to be conveyed to a VM visitor. Furthermore, the digital story directly increases user motivation to visit more objects at the exhibition. This results in learning more about particular objects and the exhibition. None of the visitors reported that they were distracted by the digital story, while majority disagreed and few were neutral.

Finally, the impact of the sound effects was investigated. It has been shown that stimulation of additional senses, such as audition, in virtual environments increases a sense of “presence” [Slater et al. 1994; Witmer and Singer 1998]. To validate the influence of the sound effects in the SRP VM, a few questions were included in the questionnaire, Figure 11. The answers demonstrate the positive effect of sound on user experience when visiting virtual museums. The graph shows that the sound effects increased the sense of presence in the virtual scene. Furthermore, very few participants claimed that they were distracted by the sound effects or that the VM would be better without sound.

6 Interviews

To explore further user experience we introduced the qualitative analysis methodology and conducted interviews with six additional participants. The participants were four women and two men between 25 and 65 years old (median 32 years; five participants between 25 and 38 years and one 65 years old participant). Three of them were wearing glasses and none of them had problems with hearing. Three of them had visited virtual museums. All of them were in Sarajevo or in Bosnia and Herzegovina during the war and had relatively good knowledge of Bosnian history. All of them were experienced computer users. They first visited both SRP and BTP virtual museums. Participants were asked to visit two virtual museums before the interview, so that their visits would not be time limited. An average visit lasted for 41,6 minutes in the case of SRP virtual museum, and for 27,6 minutes in the case of BTP virtual museum. Half of participants first saw BTP and then SRP virtual museum. The other half of participants visited museums in reverse order. After the visit, we asked each of them several open-ended questions on their experience. The interviews lasted between 12 and 36 minutes, with an average of 20 minutes. The interviews were conducted, transcribed and analysed by one person. The quotations given here are translated from Bosnian to English by the paper authors.

The results from the interviews confirmed and complemented our findings from the previous two studies. Our participants highly appreciated having a digital story to lead them while exploring the museum. One participant put it this way: “I could not understand how the objects are connected, I could not find the common line, what is connected to what without the story.” Another said: “The story make it feel complete. In another [BTP] you have to guess...”. The SRP environment was also more realistic and interesting due to the digital story: “The other museum [SRP] was much more interesting, realistic and engaging although the other one [BTP] was looking more like a real museum”.

However, it is important how the story was presented. One participant gave the following advice to the researchers: “It [the story] is great, but you should avoid too much text as ...nobody wants to read when he is in the museum... you could read from the book at home instead”. It is also important that the story can be adapted to the visitors. Another participant said: “The story was very interesting, but if you know some of the objects, you should be able to skip some parts of the story”.

The emotions related to the visit of SRP were much stronger. One participant explained it this way: “I remembered the war and everything we experienced. The sound of alarm horrified me. ...I felt bad ...it was unpleasant to remember and come back to that period, but I am happy that this exists and witnesses about us”. It might of course be due to the personal experience of our participants (they all experienced the war), but the story itself also contributed to this: “The story engaged me and I wanted to hear the whole story so ..I explored all the objects... There are a lot of objects and I would not explore without the story.” Another participant said “It [BTP] made me feel proud and interested in history, but the other museum [SRP] was much easier to navigate in”.

All the participants agreed that the sound contributed to both presence and engagement of the visitors. “It [SRP] was very realistic, particularly music and background sound, shooting, shells, and ...made it realistic”. “Feeling, sound, everything was really fantastic”.

The main limitation of this study is that all of the participants were in Sarajevo during the war and might therefore be biased. The participants themselves reflected on possibility that some parts of the

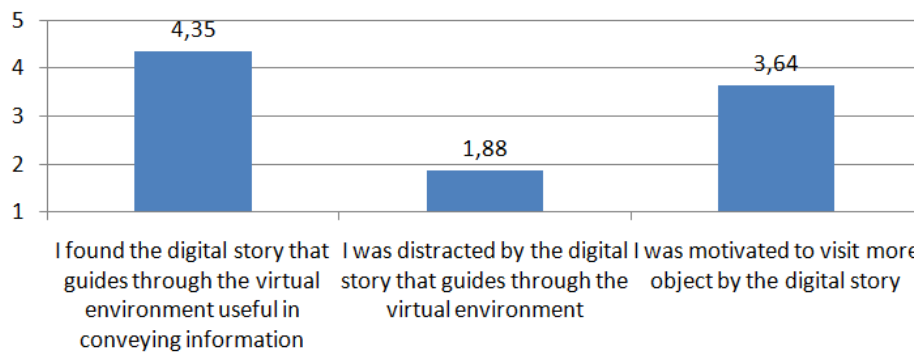


Figure 10: The other effects of the digital story on the user experience when visiting virtual museums

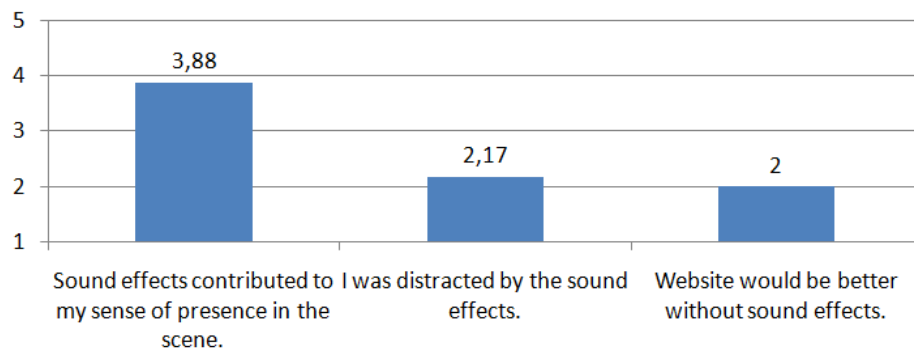


Figure 11: The influence of the sound effects on the user experience when visiting virtual museums

story might be boring because they know it or that some objects looks less realistic if you have been using them.

7 Conclusions and Future Work

The initial feedback we obtained in the pilot study shows that the introduction of interactive digital storytelling enhances the users' experience of the presented exhibition and motivates them to explore a larger number of objects. Although the results were highly indicative, a few drawbacks in the experimental design were discovered. Therefore, a new study was carefully designed and conducted, focusing on the effect of the digital storytelling on visitors' perceptual response.

The results of the main study showed that using digital storytelling increases users' motivation for visiting more objects. Furthermore, the visitors reported that they enjoyed the VM more because of the digital story. In addition, digital storytelling enhances information conveyance which is significantly important in such virtual environments. Finally, both digital storytelling and sound effects increased the sense of presence in the virtual scene.

The conducted open-ended interviews confirmed and enhanced these findings. The participants appreciated having the digital story to lead them through the museum but also advised the researchers to limit the amount of information and allow the user to easily "move" through the parts of the story. One participant also mentioned that it would be good to always know where one is, in case he/she comes back and wants to continue with the story at the same place he/she had left.

The concept of digital storytelling, used in the Sarajevo Survival Tools VM, had a slight drawback in navigation which was overcome by introducing a site map option, where the user can choose a particular story segment or gallery of exhibits.

We believe that using this concept the user gains more knowledge about the museum collection and its common background. This concept can be expanded to different kinds of multimedia cultural heritage presentations, such as digital stories about certain archaeological sites where interactive models of objects are incorporated in the story, offering the user the possibility to walk around the object mentioned in the story. This will enhance the immersion of the user and enrich his/her experience of cultural heritage. In addition, future work could include further evaluation of the digital storytelling such as comparison of the same museum with and without the digital storytelling.

8 Acknowledgments

We would like to thank Gina Landor, Professor of English language, for proofreading the paper. Thanks to all the participants who volunteered in our studies. The work of the last author is partly funded by the VERDIKT program of the Research Council of Norway 2009-2012 (R2D2 Networks project; contract nr. 193018). Virtual museum "Sarajevo Survival Tools" is included in FP7 Network of Excellence "Virtual Museum Transnational Network V-MusT.net" [VMUST].

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