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VR Video Storytelling for Intangible Cultural Heritage Preservation

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Abstract

Interactive digital storytelling has become a popular method for virtual cultural heritage presentations. Combinations of stories and 3D virtual reconstructions are attractive for the audience and have high edutainment values. In this paper we investigate if 360° VR videos further contribute to user immersion in the preservation of intangible cultural heritage. It describes a case study of the Mostar bridge diving project, aimed to present and preserve the bridge diving tradition from the Old Bridge in Mostar, Bosnia and Herzegovina. It is a virtual reality application which enables the user to virtually jump off the bridge after watching 360° video stories about its history and the bridge diving tradition and upon successfully completing the quiz evaluation of the knowledge gained from the stories. The user experience evaluation study shows that our method was successful in preserving a form of intangible heritage and posits suggestions that can be used in developing an intangible heritage preservation framework.

CCS Concepts

•***Human-centered computing*** → *HCI design and evaluation methods;* •***Computing methodologies*** → *Virtual reality;* •***Applied computing*** → *Education;*

1. Introduction

Cultural heritage can be broadly separated into two categories: tangible culture and intangible culture [Vec10]. Tangible heritage focuses on buildings, monuments, artifacts, works of art, and other cultural property. Traditionally, the term cultural heritage typically referred to tangible heritage. However, in the last decades of the 20th century the meaning of the term was broadened to include intangible heritage. Intangible heritage as defined by UNESCO [UNE03] includes:

- "oral traditions and expressions, including language as a vehicle of the intangible cultural heritage;
- performing arts;
- social practices, rituals and festive events;
- knowledge and practices concerning nature and the universe;
- traditional craftsmanship."

Currently traditional methods aimed towards the digitisation of intangible heritage use basic storage media such as audio and video recordings which are good documenting tools. More recently, techniques have begun to explore more contemporary technologies [SAS*12, DWH*17] for documentation of intangible heritage. These efforts have been geared towards preserving intangible cultural heritage and permitting their use in an educational context. This could be communicating dance choreography or the immersivity of a particular environment but ultimately is better described as the documentation of the intangible heritage and there is a difference between purely *documentation* and *preservation* [MLJ16].

To *preserve* intangible heritage it is important to convey context and the experience of the community of people involved with the heritage. In this work, through a case study, we explore the usage of digital storytelling techniques to preserve the context of the intangible heritage and we make use of Virtual Reality (VR) to provide immersivity, presence and experience.

Virtual environments (VEs) can provide a means by which to explore and investigate intangible cultural heritage sites in a rigorous manner. This is a function of many elements, the most important of which is probably the reconstruction of a cultural heritage site. Realism can be misleading in that it implies a degree of certainty about the environment being presented [HBRW*12]. Addressing the uncertainty that surrounds a VE is important due to the interpretation that it provides through participant inference. This is to preserve the historical context that governs cultural heritage sites.

Standardised methods for preserving the past digitally are being developed [AG07, 3dC09, DH09, GB11]. Unfortunately, this area of work does not actively consider the following key concerns related to intangible heritage:

1. **Validity**: historical records can lead to subjectivism and misinterpretation of many functions of intangible heritage;
2. **Inclusivity**: expressions of intangible cultural heritage are those shared by other cultures, and can be evolutions of a common root or evolutions from distinct roots yet remain similar;
3. **Representativity**: scientific approaches of the modern era mitigate this factor, e.g. we can record dances or measure materials.

However, recreating the past requires intelligent extrapolation of data, yet it still requires the need to be representative of knowledge and tradition, skills and customs;
4. **Temporality**: to experience something through the lens of a different culture, even ignoring the hardware and software implications which are not non-invasive, is an entirely different precept. Intangible heritage doesn't only represent inheritance, but is also reflective of the contemporary;
5. **Sensitivity**: current themes influencing religious and political bias can affect the agenda of recreating intangible heritage, whether traditional or contemporary;
6. **Community**: intangible heritage is only such when recognised by the communities that create, maintain and transmit it.

To assess a cultural heritage reconstruction is not necessarily deterministic: it is neither quantitative, nor qualitative, but an ad-hoc process employing fuzzy logic to govern both techniques [NH04]. It is possible to assess the tangible quite readily. The availability of commodity hardware and techniques such as spectroradiometers, laser scanning, ground penetrating radar and reflectance transformation imaging allows for goniometric, radiometric and perceptual evaluation of numerical quantities. However, the intangible is more difficult to assess.

The reality is that validation will take the form of opinion if it is required to evaluate outside of the context of the current generations. This is even true for quantitative information such as Geographic Information [Bra02]. Validation should occur considering the quantitative, supplemented with error metric; and qualitative, supplemented with error metric. In the context of intangible heritage and considering the Community element of the concerns, the validation should come from contemporary practitioners.

The main contribution of this work is suggesting up-to-date methods for *preserving* intangible cultural heritage. The methods introduced are tested in a case study of preserving the Mostar bridge diving tradition, and user experience evaluation is designed and conducted to identify strengths and weaknesses in order to inform upon a framework for intangible heritage and validate our approach.

2. Related Work

Athena Plus [Plu17] introduces recommendations for cultural institutions that highly encourage conveying cultural heritage information through digital storytelling. There are many challenges in the design and development of story worlds for Interactive Digital Storytelling (IDS) systems according to [SF15]. Among them is the Narrative Paradox challenge [Ayl00]. Henrik Schoenau-Fog [SF15] defines this challenge as a struggle between a user's freedom of choice and the control of the main storyline. Interactive virtual environments as parts of IDS encounter this problem when stories are linked to objects in these environments. Users could miss finding those triggers and consequently not perceive important information. Therefore, solutions for the narrative paradox are important contributions to an IDS methodology.

As possible solutions to this challenge, there are several works arguing in favour of emergent narratives [LA03, RA99, TSF12]. These are presented in the form of stories that emerge from the interaction between players and the systems that govern gameplay. As our case study has already predefined stories, this proposed solution could not be taken into consideration.

Argyriou et al. [AEB17] propose a conceptual gamification framework for VR applications based upon the use of game elements in a 360° video environment to enhance user interaction with a case study of the cultural heritage site, in Rethymno city, Greece. The work presented by Argyriou et al. introduces a similar case study to the work presented in this paper. It uses 360° video to convey information, it has a quiz with questions from videos, and it has a motivational factor. The main advantage of this approach is that the game presented has good replayability value, which is not the case with our case study. However, if the user plays the game only once, and chooses only a small subset of the many fountains in the game, the user is not presented with all of the information about this historical place.

Ivkovic et al. [IKS18] also use 360° videos for representation of cultural heritage in presenting the Bridges of Sarajevo. The user study that is presented with this work has shown that users like 360-degree videos and the freedom in choosing the order of the stories, in addition to the reward at the end. The main drawback of this paper is that there is no defined methodology to be able to check how much information the user has learned from the stories about the bridges. The advantage is a high level of immersion and the user study corroborates this as it is reported that a significant number of users felt like they were walking on the real bridge while watching the 360° videos.

Russia's Hermitage Museum [MV17], in partnership with Russian video production company Videofabrika, has created a novel VR experience for visitors, called The Hermitage VR Experience. This takes the form of a 19-minute movie in 360° format. As in the work by Ivkovic et al. [IKS18] there is no sure way of testing the user's knowledge after watching the video. Also, other drawbacks are that the user cannot choose the order of the stories, and there is no motivational factor for the user to watch all of the stories. However, this is a new format in historical pedagogy through an interactive and immersive experience.

2.1. Interface

VR allows users to experience a virtual world and, in most cases, to interact with it. The interaction techniques in VEs have been studied for many years. The interaction mode can been divided into several parts: locomotion - for navigation through the virtual environment; selection - scenario dependent mode, used for interaction with virtual objects; manipulation - for changing an object's position, orientation or shape; scaling - for exploring the object details (scaling up) or environment (scaling down); and menu interaction - for performing actions that are difficult to perform using direct interaction [Min95]. Our study is concerned mainly with the selection and menu interaction which are directly correlated and have to be considered holistically.

For selection, two elements are essential: identification, so the systems knows which object is to be selected; and a command to perform the selection of the identified object. The selection can be local, where the object is within reach, and at-a-distance, where

the user cannot reach the desired object. The latter can be achieved by using laser beams, spotlights, gaze selection or voice input. Mendes et al. [MMS*17] proposed a selection taxonomy, in which, besides the reach, they include cardinality - the number of objects that can be selected simultaneously, and progressive refinement - gradual subselection among multiple larger groups of initially selected objects. An extensive survey with another classification of selection techniques is proposed in work by Argelaguet and Andujar [AA13].

Menu interaction in virtual environments allows for adding additional functionality to a VR application. While this is a very common interaction style in conventional 2D interfaces, there is a plethora of work on menu selection in 3D VEs. Since the emergence of VR applications, different techniques have been explored and taxonomies proposed [DH07]. One approach is to use common 2D menu types in 3D VR environments, such as pop-up and pull-down menus [JE92], that could be fixed to the camera view-port, used as a heads-up display (HUD), or floating in 3D space, with a predefined position and orientation [CVRF97, BW01]. The other approach is to use more natural paradigms with "physical" 3D menus in 3D space, e.g. spin/ring menus [GB05]. However, the selection of an appropriate VR menu type should be based on interaction style and purpose, application domain, and possibly other factors. For a comprehensive overview of 3D menu paradigms and taxonomies refer to [LVT03, DH07].

2.2. Evaluation

Qualitative studies are essential in understanding user behaviours and evaluating the situational use of technology, especially to address interaction design when delivering novel designs and understanding user needs for future designs [Bla13]. In designing our evaluation study, we followed guidelines and established criteria [Cre08, Fli09], but also had to balance attainment of the study objectives with the challenge of the available resources [Bla13]. In our study we combined semi-structured interviews and contextual observations for data gathering, and basic content analysis, as suggested for the research question related to understanding the phenomenon [Sn09].

The literature addressing the evaluation of user experience in intangible cultural heritage applications is scarce, however a valuable and detailed example is presented within [VMH*18]. The authors proposed the operational model for evaluating the influence of a user's emotional state, the quality of gesture interaction, and user skills on overall perceived performance. This was done with respect to effectiveness, efficiency, and satisfaction.

3. Mostar Bridge Diving

Mostar is a city in Bosnia and Herzegovina famous for its Old Bridge. It is a 16th-century Ottoman bridge over the river Neretva, designed by Mimar Hayruddin, a student and apprentice of the famous architect Mimar Sinan. The Bridge was destroyed on 9th November 1993 by Croat military forces during the aggression on Bosnia and Herzegovina and rebuilt in 2004. Diving from this bridge is a tradition which started in 1664 and is preserved today as a part of B&H intangible cultural heritage. The aim of the project is to present the history of the Bridge and cliff diving to the users through VR videos and, if they learn enough from the stories, to offer them an opportunity to perform a virtual jump via a VR computer simulation.

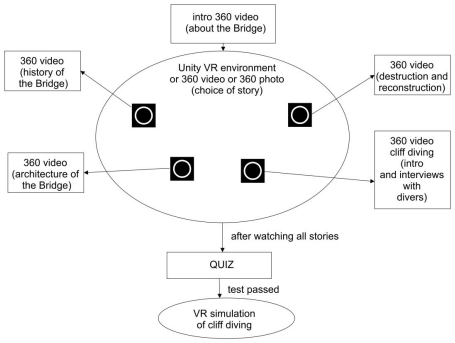

Figure 1: *The structure of the Mostar bridge diving application*

3.1. VR Storytelling

The structure of the project is presented in Figure 1. As the application is designed for a Head Mounted Display, everything is in 360°: the stories, the user interface, the quiz and the bridge diving simulation. The link to download executable application is provided online [Sar18b].

Digital storytelling follows the rules of telling stories implemented in other media, such as the theatre and film. However, VR video brings with it new challenges, as those rules do not apply anymore. For example, there is no staging or directing the story as defined in film language grammar, as our viewer can now turn around and watch the content in a 360° field of view. VR stories need to convey the information to the user while using the immersive potential of its virtual surroundings.

For this project, we have structured the storytelling into five stories. The introduction story offers an overview of the Old Bridge cultural monument, cliff diving tradition and what the users can

Figure 2: *Story about bridge diving - the interview with Lorens Listo, the cliff diving champion*

expect from the application. It is a combination of voice-over narration and 360° videos of the Bridge. The stories about the history of the Bridge, its architecture, destruction, and reconstruction are implemented in the same way with 360° videos recorded in different positions on the Bridge and around it. The story about cliff diving is done as an interview with Lorens Listo (Figure 2), the famous cliff diving champion and a legend of the city. He is describing the cliff diving tradition, competitions, the types of jumps performed in competition, as well as his emotions towards this sport and motivation to dedicate his life to it.

All VR videos have been recorded by a Garmin VIRB 360 Action Camera. The sound for the interview was recorded separately with two microphones (Sennheiser ew 100 ENG G3 Wireless Microphone Combo System) and an audio recording device (Tascam DR40). We elected not to perform any spatialization of the sound and chose to present sounds in a binaural fashion. However, this does interfere with the user immersion [HHD*12], and this is corroborated in the user experience evaluation results. We follow, as much as possible, the guidelines for interactive digital storytelling [RDA*17]. In this case, we have not been using actors, but the stories still have a unique visual identity. Professionals have been engaged for all content creation fields, the content has been divided into sub-stories which can be watched independently, and the stories are short, dynamic and informative. As emphasized in [RDA*17] and [RBOS17] the motivation factor has been introduced to inspire the users to watch all of the stories and to solve the narrative paradox. In this project, the motivation is to be able to experience bridge diving through VR simulation, and it is permitted if the user passes the quiz with sufficient correct answers (60% threshold) to the questions framed around information from the stories.

3.2. User Interface and Navigation

In our virtual environment we used both local and at-a-distance interaction. The former has been used for climbing the ladders in the diving simulation. The latter has been used elsewhere, e.g. to navigate the digital stories and to provide answers in the quiz. Within the diving simulation stage, natural interaction has been used for locomotion, both for walking/swimming and for climbing the ladder before the VR dive into the Neretva.

The story selection was implemented using a main menu, where a user could select one of the four stories - the introduction story was played automatically on starting the application. The menu has been implemented using the Unity Canvas UI component and Button UI elements. The button consisted of two elements: the camera icon and the label, Figure 3 (left). All the buttons were positioned so that it appears as if they were floating in the river, with the label reflection on the water surface. Once watched, the camera icon above the story title would turn its colour from white to green. Upon watching all the stories, a new menu item to take the quiz appeared in a yellow colour with a red hover colour, Figure 3 (right). This button triggered loading a new scene for the quiz. In addition, while watching all the stories, a floating 2D menu with two buttons was visible. One button was the Play/Pause button, and the other was the Fast Forward, used to skip the story and go back to the main menu, Figure 4 .

The quiz scene was a room with a few windows, a door and some traditional Bosnian objects: a Bosnian rug and “Peškun” - a traditional carved table or chair with six, eight or nine sides, Figure 5. Through the windows, the user could see the Old Bridge, giving the impression he or she is in one of the towers next to the bridge.

In terms of the quiz interface, the intention was to blend the quiz questions and answers with the 3D environment, so it looks as if they were written on the walls, Figure 5 (middle). This was achieved by using three canvas elements: panel, text and button. The canvas elements were aligned to three walls on which the questions were displayed, and multiple panels were used where more than one question was displayed on the same wall, i.e. in the same canvas. Their appearance was controlled using the MenuController script. If the next question was to appear on a different wall, an arrow indicator was used to display the direction in which the user had to turn. As in the main menu, a laser pointer was used for interaction with the quiz menu and to be able to select the answers. The score is kept in the background as the user progresses, and if at the end he/she answered correctly on 60%+ questions, the door of the room opened with a subtle creak sound, and an animated water stream was visible outside. The button, in form of 2D text, to go to the diving simulation is displayed within the doorframe, Figure 5 (right). Once clicked the simulation scene is loaded and the user appears at the bridge, Figure 6.

3.3. Simulation

The simulation uses the Virtual Reality Toolkit (VRTK) [Vrt18] which helped solve locomotion problems. The movement of the user is handled using arm-swinger system technology, where the user moves by pressing a button on each controller and swinging his/her arms. The feature of climbing up a diving platform is implemented using VRTK’s grab attach mechanics system. This simulation uses a polygonal model of the Old Bridge in Mostar, which is created accurately to real-world scale. Modeling and texturing was done using Blender and SketchUp tools.

In order to improve immersion, the simulation allows the user to actually dive into the Neretva river and come out of it. This is implemented using a Buoyancy force. This force is put into effect onto the player object as soon as the player enters the water. This has the influence of modifying the player velocity upon entering the water by a controllable value relative the normal of the water surface: $p_v = p_v + s\hat{N}$, where p_v is the vector component of the player velocity, s is a scalar and $\hat{N}$ is the unit vector normal to the water surface. This is evaluated until the player reaches the surface of the water. Once the player reaches the surface, after several seconds of movement and possible swimming with the arm-swinger technology, the simulation takes the player back to the start of the dive simulation and allows them to dive again if they wish, permitting replayability of this component of the VR application.

4. User Experience Evaluation

This section describes the evaluation of the user experience in the case study of preserving the Mostar bridge diving tradition.

Our primary objective was not limited to the assessment of the

Figure 3: *Screenshots of the main menu: the story selection (left) - the green camera button indicates the story has been watched; the quiz button (right) - displayed only once all the stories have been watched.*

Figure 4: *Story controls - left button for skipping the current story and moving to the main menu, and right button to play/pause the story.*

Questions	Responses	Number	Percent
Gender	Female	15	47%
	Male	17	53%
Age	18-24	5	16%
	25-34	14	44%
	35-50	4	13%
	>50	9	28%
Fear of Heights	Yes	14	44%
	A bit	3	9%
	No	15	47%
Visited Mostar Old Bridge	Yes	21	66%
	No	11	34%
Heard of Old Bridge Diving	Yes	24	75%
	No	8	25%

Table 1: *Question summary statistics for the demographic breakdown of the participants.*

VR application. It is desirable to consider routes to improve interaction and subsequent quality attributes such as immersion and edutainment. However, the main purpose of the study was to explore user needs and behaviours, compare their experience and performance (with respect to different levels of preconditioning), and identify strengths and limitations of the approach proposed in the paper.

4.1. Experiment Setup

The experiment was conducted at the University of Sarajevo (21 participants), Birmingham City University (6 participants) and the University of Bournemouth (5 participants) and involved four interviewers. Participants were recruited by invitation. Evaluation sessions were conducted individually, lasting for around 35 minutes on average.

Since presentations of digital heritage is intended for a broad audience, we have invited users representing different groups including students and professionals, and balanced different user types with respect to their professional background and gaming experience. In order to ensure that the responses represent a diverse, cross-section of respondents and to establish the validity of study [LFH10] we asked participants to provide relevant demographic data: age, education, familiarity with VR and the Mostar Old Bridge diving tradition. Demographic data is summarised in Table 1.

Users were invited to engage with the VR interactive digital stories and dive from the virtual model of Mostar Old Bridge, shown in Figure 7. Throughout the course of the experiment, the users were expected to remain standing. Precautionary measures were taken to ensure participants safety. Prior to conducting the experiment participants were acquainted with the experiment procedure and tasks.

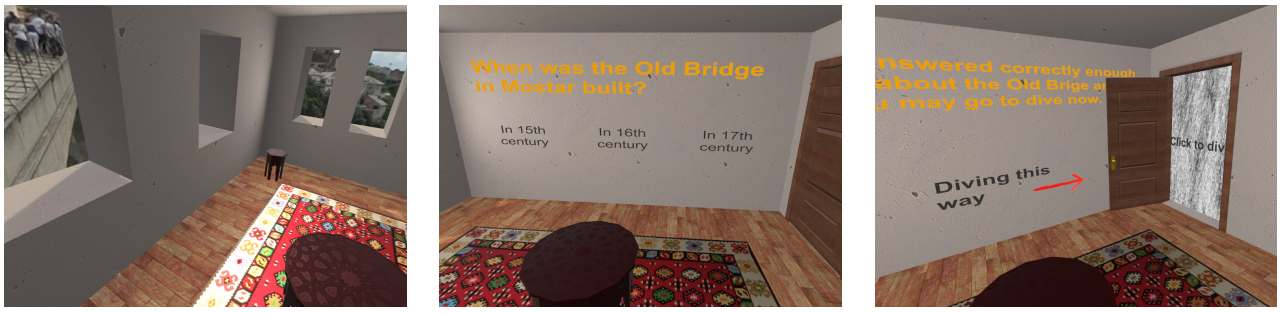

Figure 5: *Screenshots of the room where the quiz was taking place. The user could see some traditional Bosnian furniture in the room and the Old Bridge through the windows (left). The first question (middle) - each question was displayed on the left, front or right wall. The direction for progression to the diving component once the quiz participation was successful (right).*

Figure 6: *Screenshots from the simulation of the Old Bridge dive. The user starts the simulation at the start of the Old Bridge (left). View of the river from the top of the diving platform (middle). The view looking back up at the bridge after completing a successful dive from the Old Bridge in VR (right).*

Participants were advised to freely express their satisfaction or dissatisfaction, and to elaborate upon their experience when answering the questions.

Interviewers were observing the users during the experiment and noted any significant interaction issues, user specific path through the digital narrative, and knowledge quiz success (for example it may have been necessary for a user to revisit a question). Immediately after experiencing the VR application the users were asked a list of semi-structured questions, beginning with a direct question on user experience and followed by a request to provide a rationale. The questions posed to the participants were:

- Q1 What do you think of the Old Bridge application?
- Q2 What was your experience of navigation through digital stories?
- Q3 What was the most impressive part of the digital stories?
- Q4 How would you describe your navigation through quiz questions?
- Q5 Can you describe your actions and feelings while exploring the VR Old Bridge?
- Q6 How would you grade your ability to move on the Old Bridge?
- Q7 Describe how did you feel looking over the diving board?

Questions were aimed to assess gestural interaction accomplishments (Q2, Q4, Q6) and to summarise experience (Q1, Q3, Q5, Q7) as perceived by the users.

In order to obtain quantitative assessment on how appropriate a 3D approach is for documenting intangible cultural heritage, we have designed an additional web-based questionnaire. The questionnaire contained 11 questions using a 5-point Likert scale. The questions were organised into two themes, one addressing the sensation of presence and the other, 3D experience.

4.2. Analysis and Results

This section describes the observations and analysis of the findings from Section 4.

4.2.1. Navigation

In case of user-reported sight problems, the size of active objects becomes important in dictating an interactive and seamless navigation strategy. Participants wearing glasses had difficulties and needed assistance and guidance, this was not solely limited to visual acuity but also hardware synergy. There are several improvements needed to assist them in navigation: dynamic scaling of control buttons to encompass whole floating menu items and zooming in menu items, especially quiz questions and answers when these are the focus of interaction.

Regarding the attitude of the gaming cohort, and younger participants generally, their navigation strategy is markedly different to other age ranges. They have a readiness to explore, to point and try at-a-distance interaction, without fear of making mistakes. This type of user behavior is welcomed, but demands additional interaction improvements: not allowing for accidental selections, which happened in several cases. Several participants inadvertently answered

Figure 7: *User during the evaluation experiment. A full video highlighting key elements of this experimental process is available online [Sar18a].*

Group	Average rating	Number in group
Assistance Needed	3.83	6
Independent	3.60	10
Instructed	3.80	5

Table 2: *Average user rating of navigation within the VR simulation. Ratings were provided via a 5-point Likert scale, with 1-low and 5-high. Users are grouped by the level of their navigational success, as observed by the interviewers. Instructed implies verbal direction to a user was necessary, Assistance Needed covers users who required hardware intervention from the interviewer and the group Independent implies that no verbal or physical intervention was required from the observer.*

one or even two questions (wrongly) without noticing the incorrect selection. Contrary to this, more senior participants expressed reluctance to explore this interaction paradigm freely, with some of them waiting for narrative prompting. Few participants were assuming a passive role and only after being instructed, expressed a more active attitude. Obviously some monitoring of user behaviour would be beneficial and should trigger written or narrative guidelines and instructions, when needed.

There were several reports of navigational difficulty within the VR simulation where some of the users needed either additional instructions or assistance from the interviewer in order to climb the ladder. One user, due to feeling dizzy, was sitting during the experiment, with no impediment to his 3D diving experience. We have observed that it is important to provide control of the application by natural gestures and movements, but also it is good to enable controller based interaction as well. The latter is important to accommodate different user types and also to compensate for space and equipment restrictions, such as HMD cable length.

It is important to note that for all user types the overall perceived performance and user satisfaction is linked to their emotional state. This emotional state is influenced by the quality of their gesture interaction and user skill, but mostly by the unique experience of 360° digital stories and the VR diving simulation. During the interviews participants were asked to rate the navigation within the VR diving simulation. The perceived user satisfaction with navigation is not correlated to the level of assistance participants needed, what is illustrated in Table 2.

4.2.2. Digital stories

When participants were asked about some key information that was presented aurally in the digital stories, such as years and nouns, they were unable to recall the specifics of this information. Hence, we suggest that the educational dimension should be enhanced with additional elements: such as synchronous visual presentation of critical information. When analysing the collected data it was discovered that it would be helpful to have more context to the quiz performance. This is because a score of 60% was deemed to be a success, but a more contextual measure could be obtained as a function of digital story review, story review pathway and indeed answer elimination upon quiz repetition. Also, the methodology of measuring performance should be improved upon to give greater insight into the efficacy of the VR medium in pedagogy compared to traditional forms of media communication.

Old Bridge divers represent the community of the intangible heritage in question, and the digital stories dedicated to diving from the Mostar Old Bridge is personalised by interviewing one from this diving community. It is interesting to note that the interview with the diver is selected as the most impressive part of the digital stories by 52% of the users familiar with the Old Bridge tradition, compared to 9% of the users not familiar with the tradition. This is indicative of the influence and effect *a priori* knowledge can have on the outcomes of preservation efforts. It also belies the need for the consideration of community when preserving intangible heritage.

4.2.3. Quiz

The majority of users liked the room with the quiz questions, and found the environment interesting and worth exploring. However, users reported ambiguity linked to interacting with the spatial UI which was integrated into the quiz room. Guidance was provided spatially to direct users to the next question by using the instruction "Next"and an arrow as a visual indicator. However, instead of turning in the direction of guidance to look for another question, users attempted to interact with the "Nextčue. Such an issue can be very frustrating and it is a typical example of miss-communication between developer/designer and a user. Standard interface types provide other means to help users to distinguish active and passive interaction objects, but in 3D environments, designers need to be more careful when communicating interaction instructions. In this case straightforward information to move would be more appropriate, as: "Turn around"or simply "Right"or "Left", what should be incorporated in the next version of the application.

4.2.4. VR Dive Simulation

The bridge diving simulation is the motivation offered to users who complete navigation through the digital stories and complete

the quiz by demonstrating successful learning outcomes from exposure to the storytelling.

Statement	Mean	Percent Agree
Q1.1 - I had a realistic feeling of looking down from height	4.33	94%
Q1.2 - I had a realistic feeling of falling from a height	4.22	83%
Q1.3 - I was uncomfortable with wearing the headset	2.72	22%
Q1.4 - I was feeling detached from the real surrounding	3.78	72%
Q2.1 - I was amazed with the experience offered by 3D application	4.22	78%
Q2.2 - The experience could not be achieved with a standard application	4.61	94%
Q2.3 - I would like another opportunity to use the application	4.33	83%
Q2.4 - I would like to try different 3D VR applications	4.78	100%
Q2.5 - I would prefer diving using 2D VR application instead of this type	2.00	0%
Q2.6 - The experience of looking from the bridge in 3D application can not be matched with seeing the photo	4.33	89%
Q2.7 - I would recommend the 3D diving application to my friends.	4.67	89%

Table 3: *Questions are split by sub-scale, with Q1.x directed towards presence and Q2.x addressing 3D experience. Responses were delivered on a 5-point Likert scale, with 1-strongly disagree and 5-strongly agree. Respective summary statistics measures are shown: Mean and Percent Agree. Percent Agree corresponds to the proportion of users who responded with a view greater than neutral, towards agree.*

In order to compare our approach with a more traditional one we have conducted an additional survey which addresses the benefits of VR on presence and 3D experience. During the survey, the users were shown a traditional form of presenting this intangible heritage via an image on a webpage. The image was of the view from the top of the diving board. Analysis of this comparison is governed by Q2.2, 2.5 and 2.6 shown in Table 3. The additional survey was offered only to participants at the University of Sarajevo, and 18 participants out of the original 21 responded to our invitation. All the questions and descriptive statistics are presented in Table 3.

Distribution of responses for each specific Likert item is presented in Figure 8; shown with a stacked bar chart [HR14]. It is important to note that answers for two negative statements: Q1.3 and Q2.5 were complemented prior to visualisation.

By extrapolating from the participant interview transcripts, the key themes linked to the experience of virtual diving are: height, fear, jump, excitement, nauseous, and realistic. These are the themes mentioned in texts covering real diving competitions and correlate with what was said in the interview:

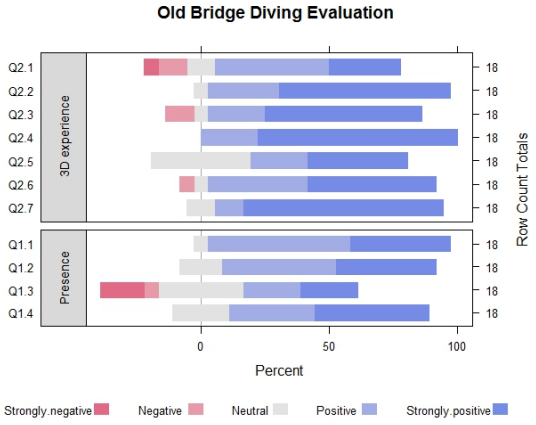

Figure 8: *Distribution of responses. (Note: Answers for statements Q1.3 and Q2.5 were complemented to preserve positive logic of the diagram.)*

> I always tried to dive "swallow" [a diving style] as it is much more attractive, and more dangerous, and by that I am more drawn to that adrenalin, and it means a lot to me.

This suggests that current technologies such as VR can facilitate an empathetic connection with the community and preservation of intangible heritage. The identified themes are relevant for designing a novel evaluation instrument to measure immersion and edutainment. An example of such an instrument is the thematic analysis of answers to the interview Q7. The most frequent themes have been identified as: fear, jump, height, and real. These themes were observed with frequencies from the interview transcripts of 9, 8, 7 and 6, respectively. This is visualised in Figure 9 (right).

Figure 9: *Word cloud illustrating the frequency of words used to describe feelings of being on the top of the diving board.*

5. Conclusions

In this work we explored an approach for preserving intangible cultural heritage. The tradition of Old bridge diving in Mostar was

used as a case study for this exploration. Applications of current VR technologies are used to enhance user immersion and improve upon preservation and pedagogy for this intangible heritage. The medium of interactive digital story telling was used, and special attention was paid when designing interface for 360 environment by integrating both local and at-a-distance interaction mechanisms where appropriate within the simulation. Simulation was used as an important mechanism of preserving Old Bridge Diving heritage as it enabled empathy of the participant in the virtual world with the diver in the real world. This created a close and personal connection with the tradition. The user study highlighted several recommendations due to the observed shortcomings in some components of the aggregated system. The study also demonstrated the correlation between the virtual and the real world environments and the emotions that are conveyed through either. This indicates transfer of context and the experience of the community involved with the intangible heritage, one of the key elements of *preservation*.

For preservation, it is not only important to document the heritage, but to transfer the intangible part which can include feelings, perception, drive and motives. On the continuum of reality, from functional- through photo- to physical-reality, it is clear that the divers and wider heritage community are afforded many feelings and emotions testament to being there in the moment. Traditional media does not excite the same level of feelings from participants which would indicate this being somewhere low on the continuum of reality whereas VR yields feelings of immersion and presence more closely aligned to that of physical-reality and being there in the moment. 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.

5.1. Limitations

The limitations of this study are discussed within. For the most part the technology considered 360 field-of-view, which correlated with the visual domain. However the experience in the digital stories could be improved by integrating 360 acoustic cues into the VE. Additionally it is possible to separate, rather than collapse, across the groups identified in the demographic capture. With this it is possible, through inductive analysis, to garner some additional insight into the nature of preconditioning and the opinion of these different groups when considering this form of preservation. For example, the group that knew of the heritage rated elements of the stories more favourably than the other group. Insight into these elements is important when considering the design of future preservation systems.

6. Future Work

Future work will look to build upon the suggestions and observations made within this case study and attempt to synergise a framework for preservation of intangible heritage such that it makes recommendations to address the challenges for intangible heritage: validity, inclusivity, representativity, temporality, sensitivity and community.

In regards to technical improvements for this simulation it would be good to investigate the influence of more physically based elements of the recreation. For example an environment map of the site, perhaps temporal. More accurate materials and textures would possibly increase immersion, it would be nice to identify the level of fidelity required in this example to elucidate the emotional responses expected from intangible heritage.

Additionally, during the interviews it was identified that there are many diving styles and the techniques may have adapted and evolved over time throughout the development of the diving heritage. Some of these may not even be practiced anymore. A motion capture database of these dives, with the provision to explore and experience these types of dives, from the frame of reference of a diver, should be created to further expand upon the preservation of the heritage.

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