Remembering the City: Stumbling Stones, Memory Sites and Augmented Reality

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ABSTRACT

This paper describes the development of *Remembering the City*, a digital and public humanities project on an urban scale, which takes advantage of augmented reality techniques in order to bring memories of the Holocaust victims to the surface of the urban fabric. The project has been built in conjunction with the *Stolpersteine* (Stumbling Stones), the largest decentralized monument in Europe dedicated to the Holocaust, allowing for the first time a contextual access to information related to the stones. The paper describes the conceptual design of the project, the technical challenge of tracking bi-dimensional objects in the outdoors and the ethical concerns. The iterative development led to prototypical implementations that were tested with two evaluation studies, performed respectively with 10 volunteers aged between 30 and 50 and 22 students from a local high school. Both studies provided valuable feedback and directions for future development.

CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**; **Contextual design**; **Interface design prototyping**; **Empirical studies in interaction design**.

KEYWORDS

augmented reality, digital humanities, evaluation, prototyping, public history, stumbling stones

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1 INTRODUCTION

This paper describes *Remembering the City: Stumbling Stones, Memory Sites and Augmented Reality*, a project of digital and public humanities with a focus on public history, developed in conjunction with the public history project the *Stolpersteine* (Stumbling stones) by the German artist Gunter Demnig. The idea for the Stumbling stones was first conceived in Cologne in 1992, as part of an initiative to commemorate Roma and Sinti victims of the Holocaust [13]. Each stone commemorates a victim outside their last-known freely-chosen residence. Unlike the usual monuments to the Holocaust, the Stumbling stones are different. Just under 10 sq. cm, one might be easy to miss: a small brass stone, embedded directly underfoot, in the cobblestones of the street (see an example in Fig. 1). There are now more than 70,000 such memorial blocks laid in more than 1,200 cities and towns across Europe, Russia, and South America.

There are some publications related to the Stolpersteine initiative which offer the opportunity to have more information related to the stones that have been installed. The initiative features an official website [9] and there are also several complimentary websites related to different urban contexts, which sometimes also include maps with the stones' locations. Wikipedia offers a main page [29] translated into several languages and a number of related entries which give details about the project and the stones installed to date.

The AR project *Remembering the City* was developed in the context of the Master in Digital Humanities of the Ca' Foscari University of Venice and it has drawn the attention of the local authorities for its potential to engage new generations in events related to the Holocaust. While the various media cited offer different opportunities to access additional off-site information about the stones, to our knowledge this is the first project that takes advantage of AR technology to allow contextual access to these urban artifacts. AR technology was selected because of its capability to provide a perceivable connection between the real world, and the additional multimedia content associated with it. Moreover, the availability of the AR platform for common mobile devices, widely used in particular by younger generations, was an additional feature addressing one of the goals of the project: involving young people and heightening their awareness about this tragic past.

While AR technology has already been used in several urban projects that will be described in Section 2, this work possibly represents one of the first experiments of the urban landscape as

Figure 1: The Stumbling stone dedicated to Olga Blumenthal at different hours of the day.

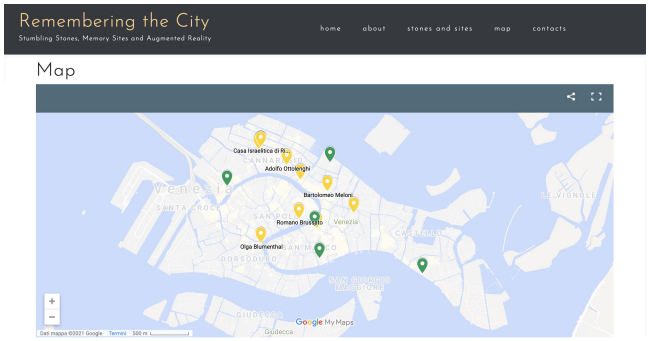

Figure 2: The urban scenario with the localization of the Stumbling stones and other memory sites in Venice.

public history implemented with AR technologies. The project is focused on a sensitive topic that requires special care when using AR technology, balancing cognitive and emotional involvement, deep respect for the people involved in the tragic events, and focus on raising citizens' awareness, while keeping them in control of the experience, in order to promote an active participation. Because the project is built in conjunction with the largest decentralized monument in Europe dedicated to the Holocaust, it has the potential to be implemented and delivered in many locations. Therefore, while this paper describes a first experiment limited to a single urban context (e.g., the city of Venice), could also be used to design a general model that experiments with technical solutions general enough to be exported to all the other contexts where Stumbling stones are part of the streetscape.

From a technical point of view, the project faced peculiar challenges related to the focus on bi-dimensional urban objects (mainly small stones inserted in the urban soil or plaques attached to buildings) and the use of AR technology based on the recognition of target images, in a context characterized by wide changes of light and weather conditions. This led, after many trials, to a solution that not only provides alternative access to information during bad weather conditions, but that enables access during very low-light conditions (night-time) and to users affected by physical limitations (e.g. users affected by motor problems which could present problems in pointing at the urban artifacts).

The rest of the paper is organized as follows: Section 2 summarizes related work; Section 3 presents the conceptual design of the AR project, with an additional focus on the technical challenges and the ethical concerns; Sections 4 and 5 present the iterative prototyping and the related evaluations studies: respectively a preliminary pilot study with citizens encountered in the urban center and a more structured evaluation with two classes of a local high-school; Section 6 draws the conclusions.

2 RELATED WORK

AR technology has been with us for a while, starting with the early experiments by Steve Feiner [11], which required special equipment for superimposing multimedia elements to the real world scene as seen through the users' eyes, to the recent and massive use of smartphones which augment the real world, as seen through the cameras of personal mobile devices. Comprehensive surveys of the different technologies are available in [4, 7].

AR experiences have been designed for different domains, ranging from scientific applications, industry [8], medicine [22], navigation [3], cultural heritage [2], gaming and education [23]. The goal of these experiences has been twofold: augmenting the knowledge related to the set of objects used in the experience; augmenting the emotional potential of the object themselves. Some projects, like *Augmenting Modus* [24], an AR experience designed for an affiliated event of *La Biennale Arte* held in Venice in 2017, pursue both informational and emotional engagement. Another recent project, developed as a Senior Independent Study Thesis, is about remembrance in Ho Chi Minh City (Vietnam). This project, which uses AR in order to visualize sites of memory in Ho Chi Minh City, and explores the context and subtext of urban memories and their formation [10]. In terms of preserving and exploring cultural heritage, the study [28], confirms how AR can improve user experience and, in this particular case, increase the enjoyment in learning about cultural heritage.

The role of AR as an enabling technology for the creation of a new type of narrative media has been underlined by Azuma [1]. Concerning history, different studies show the positive impact of AR for augmenting the cognitive and emotional involvement of users visiting sites affected by relevant historical events [14, 15, 25]. On this point, a critical reflection on how AR can create a positive collaboration between historians and developers to improve and innovate storytelling as a new expression of historical events has been the topic of Roth and Fisher [26].

As Challenor and Ma [5] point out, AR applying to Holocaust Education is not a new concept. Two studies on AR applied to the Holocaust are presented in their research paper. One by Stapleton and Davies [27] in collaboration with the Maitland Holocaust Museum and, another by Ma et al. [17] in collaboration with the UK National Holocaust Centre and Museum. Nevertheless, as shown in [5], little research has been undertaken on how AR can be used to enhance the delivery or impact of Holocaust Education. In addition

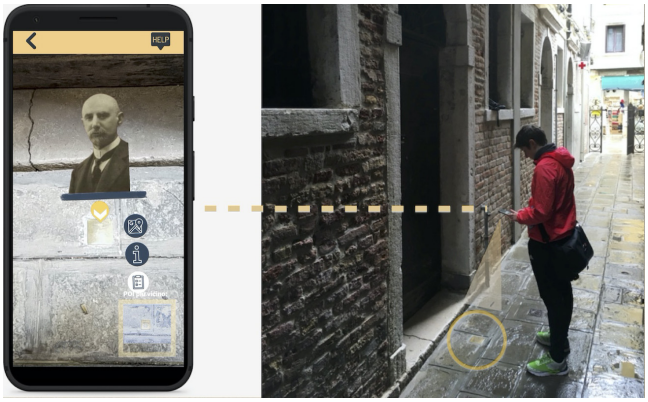

Figure 3: The augmentation activated by the Stumbling stone dedicated to Giuseppe Jona, in front of his house in Venice.

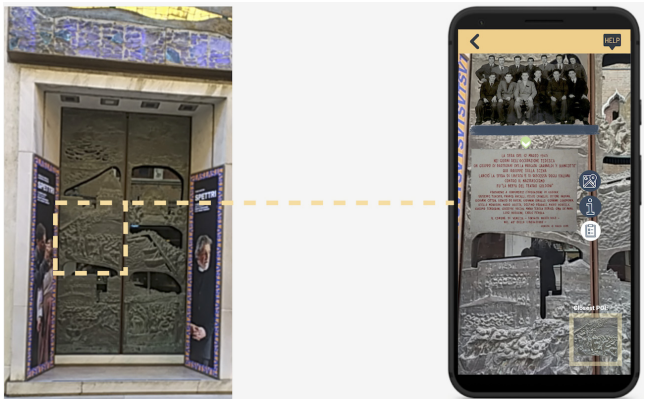

Figure 4: The augmentation activated by the artistic doorway of the Goldoni Theatre.

to the project mentioned above, it is important to refer to a non-academic project launched in 2018 by the United States Holocaust Memorial Museum in Washington D.C. Using a smartphone app the visitors are allowed to view a part of the museum exhibit in AR. Targeted at young students, this pilot program involved about 80 students learning about the lives of Lithuanian villagers before their executions, who are featured in the Tower of Faces display, located in a three-floor-high segment of the permanent exhibition [18].

Concerning the digital humanities domain, there are several innovative projects where information, engagement, and storytelling are brought together with the goal of creating a unique experience, such as the Svevo Tour [12], one of the first AR experiences designed for a literary museum. A study based on a digital historical narrative approach using Augmented Reality sees the development of an AR mobile guidance system to increase the sense of belonging for Heritage Places in Tamsui cultural and historical sites (Taiwan) [6].

Regarding the projects outlined above, it is significant to note that they were designed and executed almost exclusively for museums. The AR experience described in this paper pursues the same goals but in an urban context.

3 CONCEPTUAL DESIGN

Remembering the city is a multidisciplinary project comprised of different phases, including historical research, content creation and adaptation, design, and the implementation of the AR experience. Collaboration with institutions was of paramount importance to ensure the historical accuracy of the content delivered through the experience. While the project is focused mainly on the augmentation of the Stumbling stones' sites, it extends its scope to additional memory sites connected to the dramatic events of the of Italian Resistance movement and the fight against Nazi-Fascists.

The historical research and the production of multimedia content were initially focused on a representative subset of the Stumbling stones located in the historical center of Venice (17 stones) and on an additional set of 5 historical memory sites, ranging from the train station to the Goldoni Theatre. Each location was fully investigated in order to capture suitable target images and to identify possible technical problems. The snapshot in Fig. 2 displays the map with all the locations that were selected for the initial development of the application.

Remembering the city is a project designed for mobile users moving in an urban scenario, and this influenced, for the AR views, the design of a simple yet informative and engaging interface, based on an initial audio narration, enacted by a professional actress, accompanied by a smooth audio background, triggered by the initial recognition of the target image (see Fig. 3). The interface features also different visual widgets and interaction opportunities that are described below. We intentionally avoided any special effects that could have been obtained with AR technology, instead the focus was on the emotional impact of the audio track heard in the physical context where the events happened. In the case of public memory sites which did not include stumbling stones, other urban objects were used to activate the augmentations, like the artistic doorway of the Goldoni Theatre (see Fig. 4).

A selection of screenshots taken from the final version of the mobile app is displayed in Fig. 5. The dashboard (Fig. 5-1) permits access the main app functionalities: an introduction to the app theme, an initial help, a map with the localization of all the memory sites, access to the AR view, and a survey for sending feedback to the app authors. Finally, the dashboard also offers the possibility to change the language, with the application currently available in English and Italian. The map view (Fig. 5-2) displays all the memory sites mapped by the application and takes advantage of Google Maps functionalities in order to guide the user to the selected location.

The AR view (Fig. 5-3) is the most important interface and activates the augmentation of the urban objects (stumbling stones and other artifacts) framed by the smartphone camera. Aside from the audio narration being automatically triggered by the initial recognition of the target image, the interface is characterized by different types of visual augmentations: a historical image representing the persons recalled by the stumbling stones or other related subjects, a menu which permits access different contextual functionalities, a set of colored markers pointing at the different stones and suggesting the possibility to tap them. The menu buttons permit the user to access: a map showing their current location and the other memory sites available nearby; a hypermedia version (Fig. 5-4) of the audio narration complemented by bibliographic references, used

Figure 5: The user interface: (1) dashboard, (2) map, (3) AR view, (4) hypermedia info, (5) additional hypermedia, (6) alt. view

as an accessible alternative for people audio impaired which can not access the audio stream; the survey for sending feedback about the user experience. The colored markers pointing at the stumbling stones and the other urban artifacts had different colors which helped to distinguish between single persons, groups of people, or the different roles of the artifact, like in the case of the augmentation at the Goldoni Theatre. As anticipated, the different stumbling stones and the other urban objects pointed by the markers can be tapped for accessing more information about each victim (Fig. 5-5) or additional details about the historical facts narrated.

The AR screen also features, on the right bottom of the screen, a carousel with a preview of the urban objects available nearby, useful in the case where the user has some difficulties in identifying them. This widget also permits access an alternate presentation of information (Fig. 5-6) in the case of problems in the activation of the augmented view. More details will be provided in Section 3.1.

A video recording of interaction with the app interface, displaying the standard access to information through the augmentation and the alternative access through the carousel, is included as supplementary material to this paper.

This final interface solution was achieved after several design efforts, with the aid of iterative prototyping and associated evaluation. Before focusing on the prototyping phase, the next subsections will illustrate the main technical challenge that was faced and the ethical concerns which guided the development of the final solution.

3.1 Technical Challenges and Design Solutions

The main technical challenge faced during the development of the application was related to the use of augmentations based on the recognition of bi-dimensional target images corresponding to flat surfaces belonging to real objects. This was a necessary choice because of the bi-dimensional nature of the stumbling stones, which display only one surface to the citizens' gaze.

The ever-changing outdoor light conditions, coupled with varying weather, make it difficult to activate the augmentations for all the hours of the days and different additional contextual conditions. Fig. 1 shows how the appearance of Olga Blumenthal's Stumbling stone, located at the gate of one of the Universities of Venice, changes radically because of the shadows cast by the gate. Rain can make things problematic as well, and low-light conditions prevent access to the augmented view after sunset.

In order to cope with this situation and the frustration of the volunteers who tested the first version of the prototype, we designed and implemented a complementary access to the information associated with the memory sites, based on the use of GPS localization. Starting from constant monitoring of the GPS position, we decided to introduce, in the case of failures of the AR matching, the possibility to activate an alternative presentation of information. Therefore, when the smartphone camera is activated, but the recognition mechanism fails and there is no augmentation of the real objects (like in Fig. 5-3), the user can still access information from a widget located on the bottom right of the screen. The widget shows a carousel of miniatures of the nearby urban objects (eg the stumbling stones) and, when tapped, permits access to the same information that can be accessed through the augmentations, including the audio track and the hyper-textual resources.

We came up with the solution of providing a carousel of miniatures instead of a single miniature because of the limits of the GPS signal, which are particularly noticeable in the case of narrow streets, like the ones which characterize the urban environment the application was designed for. The experimentation made with a preliminary implementation showed that in some situations there was a mismatch between the memory site near to the real user location and that one displayed on the widget. It happened in particular in the case of memory sites which were located very near to each other. Therefore, in order to avoid the risk of presenting a wrong miniature, we matched the uncertainty area of the GPS signal with a carousel of miniatures corresponding to the subset of memory sites located in that area. This mechanism, combined with the user's visual exploration of the natural environment, allows a more consistent correspondence of the miniatures with the real scene and a more consistent identification of the sought object.

Overall, the design solution described above permitted not the extension of the contextual access to information in adverse environmental situations but also augmented the accessibility for

persons with physical disabilities, who might encounter difficulty in pointing the device towards the urban artifacts.

3.2 Ethical Issues and Design Solutions

A second significant concern stemmed from the peculiar nature of the project which focused on a highly sensitive theme that deserved deep respect and that, at the same time, appealed to the younger generations, encouraging them to improve their awareness.

For this reason, we discussed the type of augmentations used to associate with the memory sites and the type of media to associate with each AR view, seeking an equilibrium betweeen emotional and cognitive involvement. The use itself of modern AR technologies seemed an opportunity, but at the same time, we were aware of the risk of the unethical use of this potential [21], leading to situations where the application, rather than the user, was in control of the experience. The intention was to engage users without overwhelming them, on the contrary, allowing them to build their awareness at their own pace, by using a solid but engaging narrative anchored in historical research.

For all these reasons, after the implementation of the prototype, we dedicated a consistent part of the evaluation questionnaire to investigate these issues: to receive feedback and direct the following development. The results of this evaluation, available in Section 5, suggest that we were successful in maintaining a proper balance.

4 FIRST PROTOTYPING PHASE

The technical implementation was based on the well-known Wikitude [30] AR platform. This platform is characterized by the availability of an authoring environment accessible to content experts and a prototyping environment that permits implementing different technical solutions before the final app deployment.

The first prototype was based on the implementation of a set of AR views, corresponding to the memory sites mapped by the project. Each view included most of the audio and visual components described in Section 3. The different widgets available in the AR views (the menu and the transparent buttons associated with the stumbling stones and other artifacts available in the real scene) were organically mapped to the pages of a hierarchically structured website that complemented the augmentations with hypermedia information. It allowed a good balance, already experimented with other projects [12], between the emotional approach given by the augmentations and a structured approach compliant with the educational goals of the project.

Following the authoring phase, the general-purpose Wikitude mobile app permitted testing the AR project and the connected web resources in a single mobile environment. Despite the app limits (e.g. no possibility to complement the AR views with external menus in the same screen or to add complementary functionalities like an initial dashboard or alternative views based on GPS positioning, as described in Section 3.1), the test was useful to test internally the core interface of the application, and refining it and then extending the evaluation to citizens encountered along the streets where the stumbling stones were located.

4.1 Prototype Evaluation

Despite the difficulties related to the COVID pandemic, we were able to organize a first pilot study on the field which involved 10 volunteers (six men and four women, between 30 and 50 years old). Of these, eight were tourists and two were students living in Venice. They were intercepted in different parts of the city, while they were passing by the locations of memory sites. The volunteers were asked to try the prototype and then to answer a short questionnaire. The test adopted proper safety precautions and social distancing measures.

Because of the pandemic constraints, we limited this preliminary investigation to four main aspects of the experience related to some usability and engagement dimensions: ease of use, intuitiveness of the interface, usefulness and decision to use it again. The volunteers were asked to give a score using a 5-points Likert scale. We obtained good mean scores (4 or higher) for all the parameters taken into consideration.

Furthermore, we gave the volunteers the possibility to provide extra comments and feedback. Some users emphasized their commitment and the novelty of the experience for contextual access to Holocaust-related events. Given the international nature of tourism in Venice, foreign tourists stressed the importance of having this app translated into different languages. Other users reported that, in some locations, it was difficult to identify the target image in order to activate the augmentation. This was the case at the Goldoni Theatre where, in the absence of any plate, we had used a section of the doorway as a target image (see Fig. 4).

5 SECOND PROTOTYPING PHASE

The results of the first pilot study, together with the difficulties experienced in activating the AR views under specific environmental circumstances, led to the revision of the prototype, especially in guiding the citizens to the memory sites, and helping them to identify the artifacts that activated the AR views and providing them with alternative access in the case of problems with the activation of augmentations. Overall this required implementing a custom Android app, embedding all the features of the previous prototype and the support for all the issues evidenced in the first prototype. The implementation also included an initial dashboard and complementary features, as described in Section 3, for permitting an independent and informed use of the application. This prototype still lacked the final graphic fine tuning visible in Fig. 5.

Despite the shift to a stand-alone app, the content production flow still included the possibility, for the digital humanists involved in the project, of using the Wikitude authoring environment for composing the AR views and a Web CMS (e.g., WordPress) for composing the web pages connected to the augmentations. Wordpress was of paramount importance for maintaining the content production flow under control of the content experts. The Web CMS was designed with a double role for the project: complementing the emotional approach of the AR view with hypermedia information, and also providing a stable presence on the web, informing perspective users about the project, providing directions for downloading the app and also permitting users to retrieve the memory sites mapped by the project and to navigate all the information with a desktop interface.

5.1 Prototype Evaluation

This second prototype experimented with two classes of a local high school, which represented a good sample of one of the main targets for which the application was conceived. 22 students (six males and 16 females) aged 16-18 took part in the evaluation.

The evaluation was preceded by an introductory meeting in which the students were informed about the project and were given a brief demonstration of the prototype, focused on stumbling stones and other places of memory located near the high school. Then each student was invited to experiment with the app by herself, selecting at least six memory sites, locating them and interacting with content. The students were given a full week to complete their task, out of school hours, and to fill in the questionnaire.

5.2 Questionnaire Structure

The questionnaire implied exploring different facets of user experience after the trial of the mobile app. It was designed to collect the user feedback about some general UX parameters, such as the user engagement, and about additional facets related to the specific theme of the project.

In particular, we were interested in understanding how the users would have perceived the use of modern AR technology and the specific design choices for augmenting the awareness of the tragic events connected to the Holocaust. It meant on one side to focus on the respectfulness of the approach and the appropriateness of the AR to increase the awareness of young generations for the historical events, and on the other side to focus on the ethical use of AR. As a matter of fact, according to Pase [21], AR is a persuasive technology and, therefore there are unique ethical implications that should be kept in mind when designing an experience based on this paradigm. Pase lists several issues we took inspiration from for defining a set of questions for assessing the ethical use of AR, as perceived by the users. In particular, the questions were targeted to understand if:

- the novelty of AR had distracted the user from content;
- the user felt overly stimulated to interact and pay attention to the content of the experience;
- the user felt in control of the experience;
- the emotional involvement had caused discomfort to the user;
- the content appeared credible;
- the user was aware of the project's authorship.

Overall, the questionnaire was designed as a set of closed and open questions organized in thematic subsets. The closed questions were measured with a 5-points Likert scale, aimed at understanding:

- the initial level of knowledge related to AR mobile applications and the theme of the Stumbling stones;
- the user engagement, according to the definition of O'Brien [19] and explored through the UES short form described in [20], aimed at assessing focused attention, perceived usability, aesthetic appeal and reward;
- the perceived value, from the point of view of knowledge acquisition, associated to different facets of the user experience (the access to the narrative audio track, the augmentation of the scene with images, the access to hypermedia insights, the possibility to interact with physical objects through the AR interface, the access to information in the locations where tragic facts happened); the goal of this investigation was to assess if some media was perceived as more effective (audio, images, hypertext) and the effect of the contextual information (direct link to stones and presence in the location) for conveying knowledge;
- the perceived value, from an emotional point of view, of the same facets of the user experience listed above;
- the capability of the platform to augment the awareness of the new generations for the facts connected to the Holocaust and the respectfulness of the approach;
- the ethical implications related to the use of AR

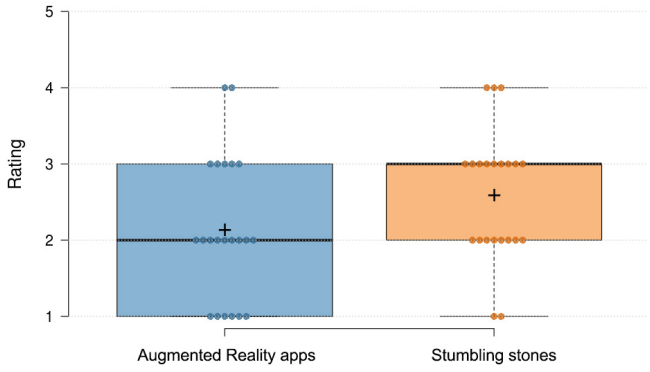

Figure 6: Prior knowledge.

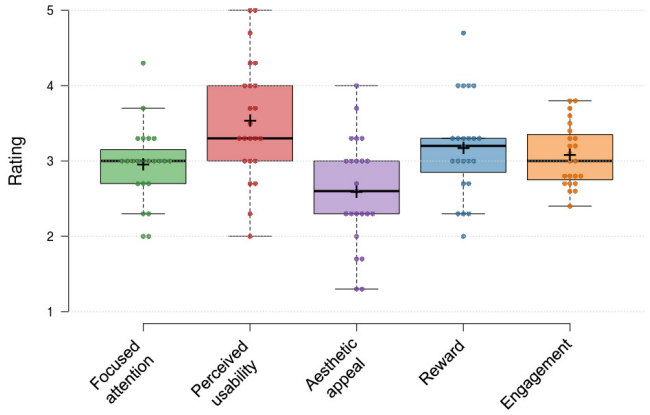

Figure 7: Focused attention, Perceived Usability, Aesthetic Appeal, Reward, Overall Engagement.

The questionnaire was complemented with a small set of open questions intended to understand which were the main points of strength and weakness perceived by the users and to collect suggestions about possible improvements of the application (e.g., an additional type of media, images and features).

5.3 Results

Fig. 6 shows the results related to the prior knowledge of the users. Despite the young age, many users did not have a high level of acquaintance with AR applications for mobile phones. Higher scores

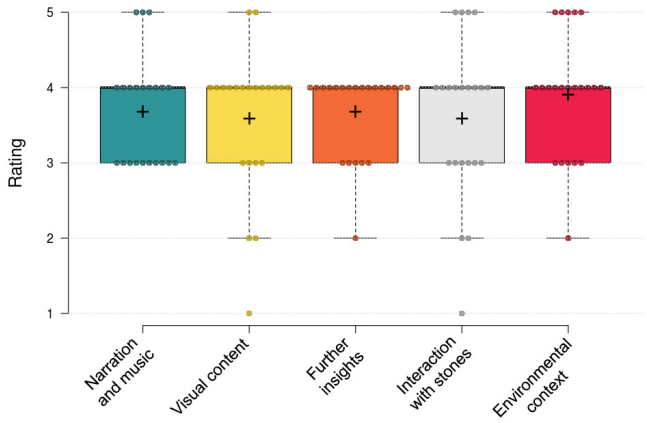

Figure 8: Facets of the UX and emotional impact.

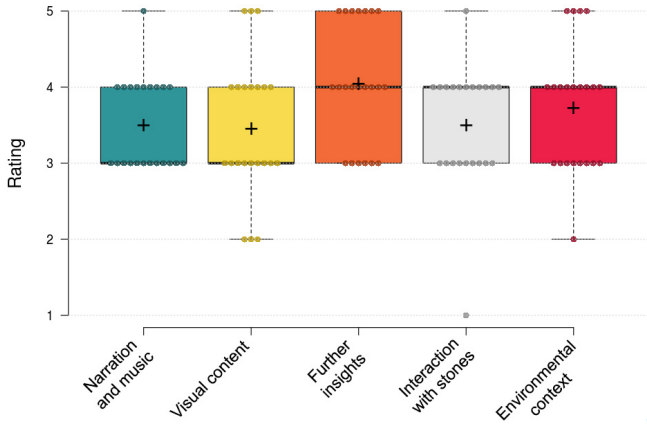

Figure 9: Facets of the UX and knowledge acquisition.

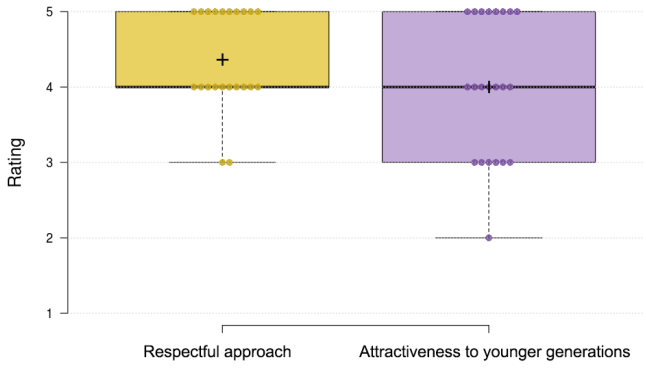

Figure 10: Respect and attractiveness.

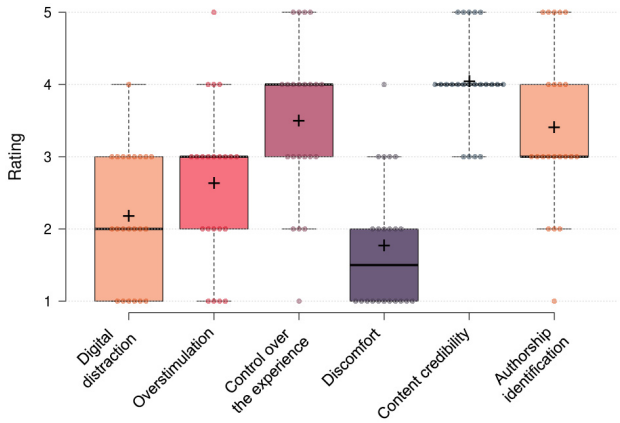

Figure 11: Ethical use of AR technology.

were obtained concerning the prior knowledge of the Stumbling Stones because of previous initiatives of the high-school. Fig. 7 summarizes the results for the four parameters that define the engagement: focused attention, perceived usability, aesthetic appeal and reward. The last parameter is the more complex and takes into account felt involvement, novelty and endurability. Higher scores were obtained for perceived usability, while a mean value slightly below 3 was registered for aesthetic appeal. The mean value for overall engagement scored 3. Fig. 8 and Fig. 9 display, respectively, the emotional value and the perceived impact in terms of knowledge acquisition of different facets of the user experience. Fig. 8, related to the emotional impact, shows high mean scores, with three out of four quartiles located above 3 points, for all the facets considered. Similar results stem from the perceived impact related to knowledge acquisition (see Fig. 9), with slightly higher values for the hypertextual resources associated with the stumbling stones and the other urban artifacts associated with the memory. Fig. 10 shows the answers to the questions related to the respectfulness and attractiveness of the application. All the students perceived the approach to the theme of the Holocaust as respectful (all the quartiles above 3 points) and at the same time capable of attracting younger generations (only one quartile below 3 points). Finally, Fig. 11 shows the answers to the questions related to the ethical use of AR. Concerning the risks of unethical use, we obtained levels of perceived distraction from content lower than 3 points for 3 out of 4 quartiles and perceived over stimulation equal or lower than 3 points for 3 out of 4 quartiles. Most users felt in control of the experience (only 1 quartile below 3 points) and declared low levels of discomfort (only 1 quartile above 2 points). Finally, they perceived the content as credible (all the scores above 3 points), having at the same time a good perception of the authorship (only one quartile below 3 points). The answers to the open questions added insights into the AR experience. Concerning the positive features of the experience, many students appreciated the possibility to have a tool that permitted them to discover and be guided to the memory sites distributed in the urban center. They appreciated the ability to interact with audio, images, and additional information in the places where the victims of the persecutions lived and to walk their same steps. Complaints were mainly concerned with the fact that the app was available only for Android and that the weather conditions sometimes prevented the use of the AR view. Concerning possible improvements, most students were happy with the current features. However, some of them suggested the fine-tuning of localization features and associating additional materials to the stones.

5.4 Discussion

The initial answers to the questionnaire show a relative level of acquaintance with mobile AR technology and an average level of knowledge for the stumbling stones initiative, probably due to the commitment of the high school for this theme. The results achieved for the different parameters of the engagement represent a good start, given that the students could interact with a prototypical version of the app which lacked a final polishing. While perceived usability scored well, aesthetic appeal gained lower scores. It was not unexpected, because the main focus of the prototype was on the AR view. Minor attention was devoted to aesthetic issues, therefore the app was characterized by the lack of a splash screen, the availability of a dashboard with basic icons, and some slight unexpected scrolling of the screen content and menus). The new version following this experimentation has taken care of all these issues and has also added an initial graphic tutorial explaining the main features of the application. Scores obtained for reward, which also include the will to try the experience again, seem to be encouraging for the future development of the application.

The results obtained for the facets of the user experience show high scores both in terms of emotional impact and perceived knowledge acquisition. The scores obtained for the different types of media associated with the AR view (audio narration, images, and hypertext) suggest that the designed solution was perceived as a good balance between the different opportunities. In line with the expectations, hypertextual information scored higher (2 quartiles above 4 points) for what concerned knowledge acquisition. Also, access to information in the places where the historical facts happened and the direct link with the real artifacts obtained through the AR view scored well, confirming the value of contextual access in terms of knowledge acquisition and emotional impact. As stated in the initial part of this paper, one of our primary concerns was about designing an experience attractive for young generations but at the same time characterized by a respectful approach. For this reason, we avoided easy spectacular visual approaches, focusing instead on the value of narration, the power of images, and the potential of hypertext for in-depth information. The results displayed in Fig. 10 confirm the effectiveness of the design choice, leading to high scores both for the respectfulness of the approach and the perceived attractiveness for young generations.

Finally, the results related to the ethical use of AR, a persuasive technology, show that most students felt in control of the experience and they did not feel overstimulated. Besides, most of them did not perceive a high level of emotional discomfort and the novelty of using AR didn't result in a high level of distraction from the content. Finally, the students had a good understanding of the authorship and this probably had an impact on the perceived content credibility that gained a high score also because of the former initiatives of the high-school related to the theme of the stumbling stones. Overall we can conclude that the experience was perceived as characterized by appropriate use of AR technology, which resulted in the use of an acceptable level of emotional and cognitive involvement, maintaining the young citizens in control and aware of the projects' themes without overwhelming them. Therefore it was an experience compliant with the initial goals of the project.

6 CONCLUSION

The idea of viewing history through an urban context is extremely important to keep its memory alive and to make it more deeply felt. This idea has been the driving force behind this project and its use of the Stumbling stones and memory sites. Technologies like those used in this project hold incredible potential for improving historical engagement through the urban streetscape. Furthermore, these technologies can also be applied to education strategies, facilitating new modes of teaching that are engaging and effective for students [16]. The project allowed focusing on several relevant conceptual and technical issues and, despite the special focus on the city of Venice, it provided solutions valid also for other urban contexts. The evaluation of the mobile platform, following a development based on iterative prototyping, confirmed the quality of the design choices for some relevant parameters, including the effectiveness of user engagement. The focus on a sensitive topic led us to organize a further investigation in understanding if we had been able to obtain the right balance between respectfulness and attractiveness for young generations, obtaining positive feedback in this respect. The evaluation suggests also an ethical use of AR technology, which represents an opportunity but also risks that need to be investigated. We underline that while AR technology was selected to engage new generations, the first pilot study also showed a high degree of interest by older generations. The result is compliant with the findings of the Svevo Tour project [12], targeted at seniors, and deserves further attention in the future developments. The project also represented a technical challenge for the difficulty of using image target-based AR techniques in an urban context. The alternative view based on GPS positioning, designed through several iterations, represents a solution that copes with the initial problem and enhances the accessibility of the information in bad environmental conditions, like very low light conditions. In this sense, it also represents an initial step for leading to solutions that permit access to information by low-sighted users. Overall the solutions implemented so far represent a good starting point for the future development of the project. While the platform is already ready for adding content from all the European cities characterized by the presence of the Stumbling stones, the extension brings interesting challenges in terms of conceptual, technical, and human scalability that will be faced in the future development of the project.

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