Do you remember that building? Exploring old Zakynthos through an augmented reality mobile game

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Abstract—**This paper presents a mobile augmented reality application, that was designed with the objective of visitors, to experience the historical center of old Zakynthos, Greece, that was destroyed after an earthquake, and allow the users to re-live the atmosphere and life of the historic place. Special attention is given to the mental model of the landmarks developed by the users after interacting with the application, discussing some of the observed flaws of this model.**

Keywords—augmented realtity, location-based mobile game, cultural heritage

I. INTRODUCTION

In 1953 a devastating earthquake destroyed most buildings in the islands of Zakynthos and Kefallinia, in western Greece. The capital of Zakynthos used to be a charming town of Venetian architecture which was completely flattened after the earthquake. When the town was rebuilt later on, despite the fact that some effort was put in maintaining its old character, most of the old scenery, including the unique architecture of the old mansions, the beautiful churches and the narrow streets was lost forever. However, modern augmented reality technology can help the visitors of the place to re-live this old Zakynthos town atmosphere and learn about the social and economic life of its people through a playful activity. This was the objective of a collaborative project of the SoFar group and the University of Patras. The prototype that was built out of this collaboration is presented here and discussed, with particular focus on the mental model of the old town developed by the users after their interaction with the prototype. In particular, in the evaluation study presented here, users were asked to recall specific buildings and landmarks after game activity. The findings of the study can support development of similar applications that aim to enhance the experience of the visitor in places of historical significance.

II. MOBILE AUGMENTED REALITY APPLICATIONS FOR CULTURAL HERITAGE

In recent years we witnessed improvements in mobile devices in terms of built-in sensors, computational resources and power of connected information. This new technology has made Augmented Reality possible on mobile devices. We are able to blend information from our senses and mobile devices in many novel ways, despite the many limitations that still exist [1]. Mobile Augmented Reality is the overlay of real-time, real-world environments with digital information designed to enhance a person's perception of that view, facilitated by mobile media devices. In addition, during the last years, mobile devices (smartphones/tablets) include powerful Graphical Processing Units, that make possible the implementation of 3D virtual world/game applications. There have been various similar attempts, during the last years. Archeoguide [2] is a typical early example that used a wearable computer to guide the user through ancient Olympia, in Greece. On the other hand, iTACITUS [3] reality filtering enabled context sensitive overlays of original historic drawings of missing paintings or lost architecture. The Mobile Augmented Reality Tour (MART) system [4] also demonstrates a mobile outdoor augmented reality system tested in Gyeongbokgung in Korea. Using this system, 3D characters were superimposed in the environment. TimeWarp [5] was a mobile outdoor mixed reality game for exploring the history of a city in the spatial and the temporal dimension in the city of Cologne, Germany. ExCORA [6] is also an augmented reality pervasive game that aims to engage general public with the Urgull Mountain in San Sebastian, Spain in order to educate visitors on its hidden history. In the case of the MARA framework [7], image recognition was used for identifying the context of the augmented reality application in an archeological site in Italy. Other recent examples of such applications for cultural heritage sites is the game developed for the Acropolis Museum in the frame of the CHESS project [8] and UAR (Urban Augmented Reality) [9] that is an application that has been developed by the Netherlands Architecture Institute, to provide information about the build environment of the past, in various Dutch cities through texts, images, archives, by means of advanced 3D models. Finally CultureClic [10] is a mobile cultural application to discover geo-located works of arts in high definition, to access to French museums information, and to discover cultural events, through augmented reality.

III. THE VIRTUALZAKYNTHOS PROJECT

The *VirtualZakynthos* prototype is a case study of a project (VirtuallityCity) that experiments on the application of a virtual world as an overlay on top of a real world. In the

VirtualZakynthos project, a 3D model of the historical town center was created from old plans and photographs of the first half of 20th century, covering a great part of the town center. This 3D virtual world was then incorporated in the form of a mobile application that is able to geographically overlay this lost view of the town on today's world. The virtual world is accessible through this application where the user can explore it while moving in the real world.

Many of the augmented reality applications discussed in the previous section were considered of high educational value. It is often this added information on the real environment that informs and generates new knowledge. In the case of *VirtualZakynthos,* the 3D representation of the town augments the presented information and creates a direct link with the present physical environment in an intuitive way. With respect to this principle, this paper presents a user study that explores the potential of this virtual world, overlaid on top of the real world, as a learning tool for history associated to architectural knowledge.
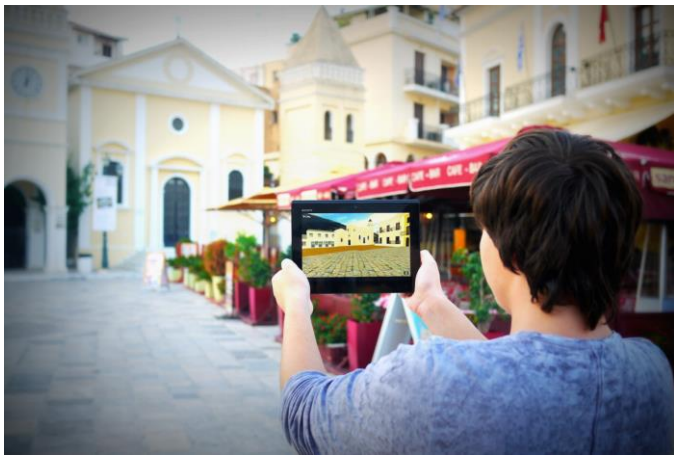

Fig. 1. Revisiting old Zakynthos St Marcus square.

VirtualZakynthos takes the form of a location based game. The application implements a 3D virtual world where the user's context is used as a means of interacting with the virtual world. At the same time the virtual world becomes an augmentative tool of the real world. The properties of the user's context that are used in this project are the location, the orientation and the time. The model of the 3D world has been realized as a virtual world fixed with respect to the real world. The main concept of the application is to map a virtual 3D representation of a town on top of a real town. The application takes into account device GPS location and orientation as properties for the camera that projects the 2D "window" of the virtual world on the screen device.

The result is an illusion of a window that points to another parallel world, which in this case is the historical town of Zakynthos. The users can move around the real town while viewing the old town through the mobile device. In addition, the user can tap on buildings on the screen to get more specific information about them, such as old pictures and descriptive text.

In this paper we present preliminary results of an evaluation study that investigates user's interaction and navigation experience with the game. Initially a small evaluation experiment was performed with two groups of volunteers who used the application during a guided tour through the center of the town as a means to view the old pre-earthquake town. All users were able to navigate through the virtual world, while walking around the real one without having any particular difficulties. The majority of the users described it as an "astonishing experience", confirming the perceived value of the application. Next we provide a short description of the *VirtualZakynthos* game and the results of the main evaluation study.

IV. GAME DESCRIPTION

The game is situated in the town centre of Zakynthos. The back-story of the game unfolds in the 19th century during the Greek war of independence. The player undertakes the role of a Greek fighter who has to deliver a message to a specific member (Romas) of a secret society (Filiki Etairia or Society of Friends) that was formed to support the revolution. In order to find Romas, the players must search for him in places he used to hang out like the theater, the coffee shop etc. The first hint points to the coffee shop which is the first location they visit; there the second hint will appear that will lead them to the next phases of the game. The game finishes when the player visits all the sites included in the game and finally finds Sunior Romas. With respect to the sites selected, some of those that exist in the real world are very similar with those in the virtual world (same building – different use) some others have been demolished and replaced (e.g. the church of All Saints does not exist anymore and in the area it used to stand a complex of shops is built, with no indication of the old church.) It is an interesting issue to investigate the effect of the relation between the current and old scenery, with respect to these landmarks, and how this has affected the mental map that the players have developed of the old town. This issue has been at the focus of the evaluation study that is described next, part of an ongoing evaluation of *VirtualZakynthos*.

V. EVALUATION STUDY

A. Participants and study design

40 students of the local Technological Educational Institute (TEI of Ionian Islands) who attended a multimedia class volunteered to participate in the study. The students came from different parts of Greece and with the exception of one who had studied the history of old Zakynthos, the rest of the participants were not familiar with the island's history and the buildings that existing in the town before 1953. The evaluation took place in two consecutive sessions within one week. In the first session 20 students played the game in pairs and thus formulated 10 groups. The second session was implemented 2 days later. 10 more groups played in this second session. The game play lasted about 30 minutes for each group. In each session 3 groups could play simultaneously. After the game, the players completed individual questionnaires. At the end of each session, a group discussion on the game experience took place,

with the students who volunteered to stay after the end of the two-hour session. Two researchers participated in the first session and three in the second. One of the researchers remained at the starting point of the game and was responsible for handing out and collecting the mobile devices to the groups, and for instructing the next group on the rules of the game. The other researcher(s) followed one or two groups and recorded student behavior during game play, taking field notes. They also asked clarification questions that were triggered by participant dialogues or actions. Apart from the questionnaires and researcher field notes, the data we collected also consists of voice recordings of the players' discussions during the game and GPS logs of their paths. Next we present results of a preliminary analysis of the questionnaires.

B. Goal of the study

One of the goals of the evaluation experiment was to determine the ability of the subjects to recall landmarks (mainly buildings) that exist in the virtual world. Taking into account evaluation data collected through questioners and other observation measurements, this study tries to detect variables associated to the mental map created to support the learning about the old town.

C. Game tasks

The game was designed to fit the purposes of the evaluation; it followed a classic scenario of a treasure hunt game. The subjects were following some hints as presented to them through the background story in order to find places related to the narrative. In order to discover the right place, they had either to tap on buildings to get more information or they had to follow descriptive guidelines regarding navigation information. As soon as the player reached the correct location a dialog was engaged to reveal more hints related to the next task.

VI. EVALUATION RESULTS

In order to study the performance of the subjects, at the end of the game they were asked to recall places of the old town that do not exist anymore. The game acitivity involved the navigation through an area with more than 30 buildings and the interaction was related mainly with 5 specific buildings.
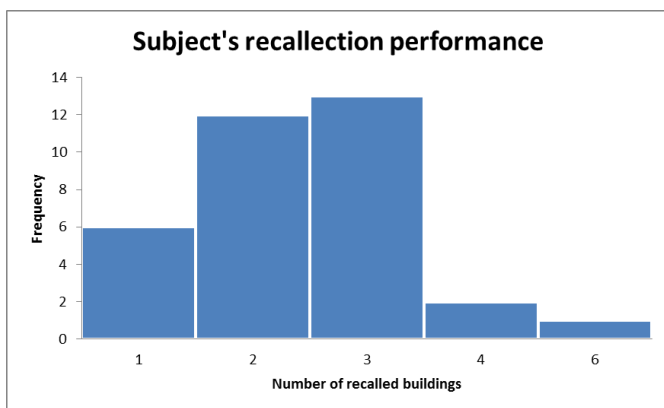
Fig. 2. Subjects' recollection performance.

In Fig. 2 the histogram of the subjects' performance with respect to this task is shown. The majority of the subjects recalled 3 out of 5 buildings, while some subjects recalled a few buildings that were not directly related to the game play. Furthermore, it became evident that a few buildings were easier to recall than others.

The analysis of the experiment data focused on investigating factors that influenced:

a. What drove the majority of the subjects to remember some buildings more than others

b. The overall performance of the subjects' memory towards the recollection of the buildings.

Looking at the town plan of the virtual world in contrast with the real world, it is evident that the buildings that do not exist anymore were remembered more than others. In fact, a deeper investigation on the characteristics of the buildings that were recalled by the subjects revealed that the rate of recall is proportional to the factor of similarity between the virtual and real world.

In order to explore factors that affect the overall performance of the subjects, in the task of landmark recollection, the players were classified into two groups: the good performers and the bad performers.

Analyzing the questioners with a U-test, a few very interesting observations were made. Subjects that stated that they encountered difficulties with the mobile devices, were proven to be the good performers (at a level of 5% significance one tail U-Test). At the same time the good performers were also the ones that had trouble with understanding the game interface. Looking also at the time that the subjects spent on completing different game tasks it is evident that the good performers were the ones who spent more time on the task.

Fig. 3. Three cases of similarity in landmarks between physical and virtual world: (1) no building, (2) different building, (3) similar building.

Taking into account the video observations and the discussion that followed at the end of the game with a focus group, it became apparent that the best performers where the ones who liked the virtual world. They took more time to finish the tasks, not because they had any particular problem, but

because they enjoyed walking around the virtual and real world. Having problems with the application interface did not stop them having a good recollection performance. A hypothesis that could account for this observation, at least to some extent, is that while they were trying to figure out how to use the interface, their level of engagement with the game was raised and it positively affected their recollection performance.

Next an analysis of the effect of similarity between real and virtual world on the subjects' landmark recollection performance was made. For this purpose, a classification scheme was developed to describe the degree of similarity between the real and virtual world.

The level of similarity between the real and the virtual world has been classified as:

- Level 1 indicates no similarity at all but also the absence of a building that could create some kind of association.

- Level 2 indicates that there are buildings at the same position but almost no similarities between them.

- Level 3 indicates high degree of similarity in terms of architectural design and volume.

- Level 4 indicates that the buildings are almost identical.

As an example, Fig. 3 shows a scene from the main square. Fig. 4 presents the correlation between similarity level and frequency of recollection of the subjects of the study.

It is evident from this graph that the higher the similarity level, the lower the performance of the subjects. In other words, it was more difficult to recall landmarks of the old town that are similar to current buildings. This may be attributed to the level of processing effect [11] that describes memory recall of stimuli as a function of the depth of mental processing. The most striking differences between old and current scenery generate more mental processing and thus are easier to recall.
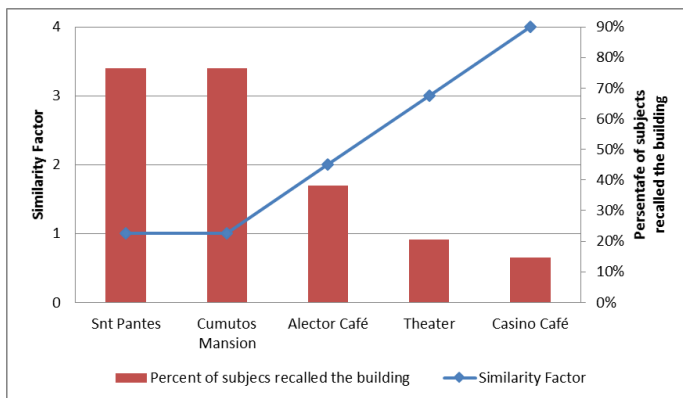
Fig. 4. Correlation between memory performance and building similarity between virtual and real world

VII. CONCLUSIONS

The evaluation experiment showed that using a virtual world as an overlay layer of information attracts users' interest in a great extent. It is evident that users get so focused on exploring the virtual world that in some cases, they get distracted from the game tasks.

Also, the subjects' performances on remembering buildings that have no or little resemblance with the real world was higher. This evidence is also supported by the discussions with the focus groups. All of the subjects stated that they were more interested and impressed with the differences between the current (real) world and the historical (virtual) world. It seems like big "gaps" between the virtual and the real world function as memory links to information.

Also the engagement with the task seems to be negatively correlated to performance. The game should be simple but also should introduce a level of effort. Raising the engagement with the application seems to affect user involvement and thus contributing towards building of a more accurate mental map of the virtual world.

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