

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

**Abstract**—This paper presents a mobile augmented reality application, that was designed with the objective for visitors to experience the historical center of old Zakynthos, in 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, and also the reasons for its flaws.

**Keywords**—*augmented reality, 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 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 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 ways that were not possible before, 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 (smart phones/tablets) include powerful Graphical Processing Units, that makes 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. iTACITUS [3] reality filtering on the other hand, 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 correctly 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 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 geolocated 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 is a case study of a bigger project (VirtualityCity) 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 20<sup>th</sup> 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 application the 3D representation

of the town augments the presented information creating a direct link with the present physical environment in an intuitive way. With respect to this principal, 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

The application of VirtualZakynthos is a location based game. The application implements a 3D virtual world where user's context is used as a mean of interacting with the virtual world. At the same time the virtual world becomes an augmentative tool of the real world. The context properties of the user used in this project is the location, orientation and 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 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 our 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 is allowed to tap on an old building to get more specific information about it (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 which 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 massive majority of the users commented the use of the application as an astonishing experience, justifying that the application is usable. 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 story of the game unfolds in the 17<sup>th</sup> century during the revolution of independence in Greece. 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) that is formed to support the revolution. In order to find Romas players must search for him in places he used to hang out like the theater, a coffee shop etc. They must start from the coffee shop which is the first hint; there the second hint will appear that will lead them into the next phases of the game. The game finishes when the player visits all the sites included in the game and finally finds Senior 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 the players have developed of the old town. This issue has been the focus of the evaluation study that is described next, part of an ongoing evaluation of this innovative application.

#### 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. Students came from different parts of Greece and with the exception of one who had studied the story of old Zakynthos, the rest of the participants were not familiar with the story and the buildings existing in the city before 1953. The implementation took place in two consecutive sessions within one week. In the first session 20 students played in dyads and thus formulated 10 groups. The second session was implemented 2 days later. 10 more groups played in this second session. Game play lasted 30 minutes approximately for each group. In each session 3 groups could play simultaneously after the end of game play players completed individually the questionnaire (i.e. two questionnaires per group). At the end of each session we had a short discussion on the game experience with the students who volunteered to stay after the end of the session (which lasted for approximately two hours). Two researchers participated in the first session and three in the second. One of the researchers remained in the starting point of the game and was responsible to collect the mobile devices from the groups, and give instructions to the next group that was going to play. The other researcher(s) followed one or two groups so as to record student behavior during game play (field notes), offer technical support if needed and ask clarification questions triggered by participant dialogues or actions. Apart from the questionnaires and researcher field notes the data we collected also consist of voice recording of players' discussions during

game play and path tracking. In this paper 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 exists 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 of the old town.

**C. The Game Tasks**

The game was designed to fit the purposes of the evaluation followed a classic scenario of a treasure hunt game. The subjects where following some hints as presented to them during 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 to follow descriptive guidelines regarding navigation information. As soon as the player reached the correct location a dialog was engaged to bring more hints for the next task.

**VI. EVALUATION RESULTS**

The main focus of this study was to measure the effectiveness of the VirtualZakynthos game in supporting the subjects in building a mental map of the architecture and the town plan of the historical virtual world and how the current scenery affects this process.

In order to be able 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 activity involved the navigation through an area with more than 30 buildings and the interaction was related mainly with 5 specific historical buildings.

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. Farther more it became evidenced that a few buildings where easier to recall than others.

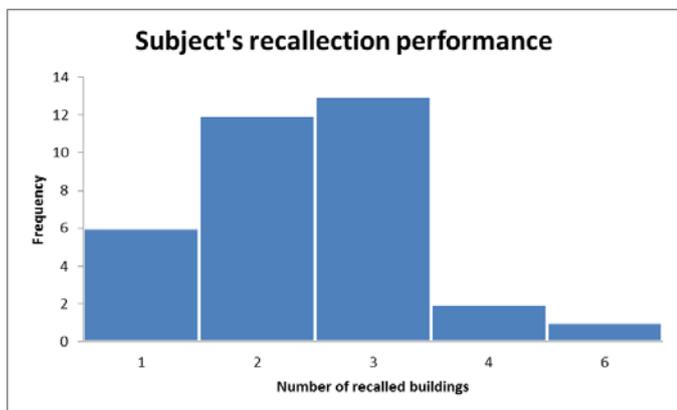


Fig. 2. Subject's recollection performance

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 where the ones that where 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 encountered difficulties on using the mobile devices were proved 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 on understanding the game interface. Looking also at the time that the subjects spent on completing different game tasks it is also evident that the good performers were the ones that spent more time in the task.



Fig. 3. 3 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 followed at the end of the game with a focus group, it became apparent that the best performers where the ones that liked the virtual world. They took more time to finish the tasks, not because they had any particular problems, but because they just enjoyed walking around the virtual and real world. Having problems with the application interface did not stop them having a good recollection performance. Probably to some extent, while they were trying to figure out how to use the

interface the level of engagement with the game raised and therefore affect positive 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 levels of similarity between the real and the virtual world have 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 displays a scene from the main square.

Fig. 4 presents the correlation between similarity level and frequency of recollection.

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 today's scenery generate more mental processing and thus are easier to recall.

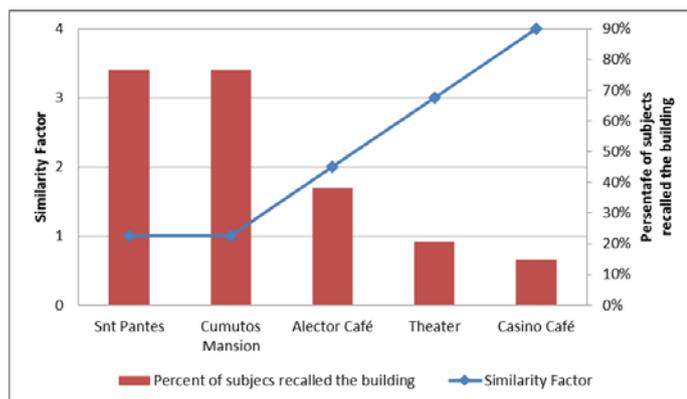


Fig. 4. Correlation between memory performance and building similarity between virtual and real world

## VII. CONCLUSIONS

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

Also 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 focused groups. All of the subjects stated that were more interested and impressed with the differences between the today (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 ease of use of the application seems to be negatively correlated to performance. Interface should be simple but also should introduce a level of effort. Raising the engagement with the application seems to affect user engagement and thus contributing towards building of a more accurate mental map of the virtual world.

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