The Implementation of Augmented Reality Applications in Education

Kalliopi Kanaki, and Nikolaos D. Katsalis

Abstract—In this paper, we present augmented reality applications implemented by students and teachers of the 5th Vocational High School of Heraklion in Crete, within the context of informatics courses. The applications aim to enhance the traveling experience of the visitors of Heraklion city, exploiting the global spread of smart mobile devices in contemporary societies and the facilities they provide. The whole project was accomplished in a collaborative manner and focused on the provision of information about museums and monuments of Heraklion city. The applications have to be installed on the smart mobile device of the user.

Index Terms—Applications for Tourism; Augmented Reality; Smart Mobile Devices.

I. INTRODUCTION

In the last two decades, smart mobile devices (tablets, cell phones) have become a constituent part of everyday life in contemporary societies. Their use has been spread to a broad spectrum of the population, regardless of age, due to their high availability, as well as to the wide range of their prices, which makes them accessible to people of all economic strata. The last decade, there has been a rapid increase in the use of smart mobile devices, particularly in countries of Europe and Asia, while in some of them the number of mobile phones used is higher than the population of the country [1].

The rapid evolution of smart mobile phones allows their users to utilize them not just as phones, but also as handy computers that can offer their services anytime, anywhere. Smart mobile devices allow the user to install and use applications of their choice, according to their needs and interests [2],[3]. One of the most popular categories of applications for smart mobile devices is that related to tourism [4].

In this article, we attempt to describe the innovative project we realized together with 16 students of the Informatics sector of the 5th Vocational High School of Heraklion in Crete, during the last winter semester, within the context of informatics courses. More precisely, we present the implementation of two augmented reality applications that aim to enhance the tourist experience of the visitors of Heraklion city, facilitating the obtaining of information for points of high tourist interest. The applications do not require Internet access and their scope is to help users plan their visits to museums and monuments of

the city. The innovative nature of our work lies on the fact that the novel technology of augmented reality was not only introduced in the classroom, but also led to the construction of pioneering tourism applications.

II. SMART MOBILE DEVICES

Smart cell phones and tablets facilitate communication, have remarkable computational power, and their user can easily hold them in their hand and keep them in their pockets. In addition to enabling users to call and send messages, they also offer a variety of upgraded services, such as web navigation, the technology of Global Positioning System (GPS), high quality cameras, recording capability. These features, combined with powerful processors, sophisticated operating systems, great memory and high-definition displays, have converted smart mobile devices into small computers that a user can carry throughout the day to enjoy anywhere their numerous services [2],[3].

Smart mobile devices provide access to hundreds of applications that offer services related to communication, social networking, health, education, entertainment, tourism etc [5]. Nowadays, among the most pioneering applications of smart mobile devices are those of augmented reality. In recent years, the technology of augmented reality has begun to become more and more popular, while it has already been integrated into many areas of everyday life [6].

III. AUGMENTED REALITY

A. A brief history of augmented reality

The term “augmented reality” was first introduced by the researcher Tom Caudell in 1992, within the context of his work at the Boeing Airline. In the same year, the US Air Force research team constructed the first internationally recognized augmented reality system. However, research on augmented reality had already begun to be carried out since the 1970s, even if the relative term had not yet been conceived [7].

In recent years, technologies associated with augmented reality have been undergoing rapid growth while also becoming more widely known to the public through mobile phones and digital games. Augmented reality technology has already been applied to education, industry, commerce, medicine, constructions and entertainment [8].

B. The functionality of contemporary augmented reality applications

Augmented reality applications combine the real and the virtual world, with the real world dominating [9]. Their functionality is based on the use of smart mobile devices

Published on February 2018

K. Kanaki is with the 5th Vocational High School of Heraklion, Greece (e-mail: pkanaki@hotmail.com).

N. Katsalis is with the 5th Vocational High School of Heraklion, Greece (e-mail: katsalis@sch.gr).

and aims to combine a real world image, object, or place with virtual objects. An augmented reality application activates the camera of the smart mobile device in order to display the real world on its screen. Then, virtual objects come to enrich the real world, as they are displayed on the screen, augmenting the ones already shown. Virtual elements are digital and may include one or more multimedia components such as text, image, animation, video, and sound [10].

The basic requisites of an augmented reality application in terms of hardware are: a) a camera, to enable capturing the real world, b) enough storage capacity, to store digital objects, c) powerful processor and sufficient memory, to support the combination of the virtual objects with the real world images, d) a user interface, to provide a high quality experience of augmented reality [9], [11]. In addition to the basic requirements of an augmented reality application, there are also some other technologies that help improve its usability, such as: a) the Global Positioning System (GPS), b) image recognition software, c) loudspeakers and audio systems, d) access to the Internet, in the case of retrieving digital data stored on the Web [12].

IV. THE RESEARCH OBJECTIVES

The basic research question posed, is: "Could applications for smart mobile devices facilitate the visitors of Heraklion city to obtain information about its most important momentums and museums and, thus, enhance their traveling experience?" The research question arose after an educational visit of our research team at the Information Office of the Municipality of Heraklion. At this point, we should mention that the research team consisted of the 16 students of the 2nd grade of the Informatics Department of the 5th Vocational High School of Heraklion and the authors of this paper, who are informatics teachers at the pre-mentioned school. During our visit, we had the opportunity to use and study digital applications which are currently provided to the visitors of Heraklion city. The applications were interesting and pioneering. However, we noticed that there was a gap in the existence of augmented reality applications and, thus, we decided that it was worthwhile trying to fill this gap.

Based on the above, the research team implemented two augmented reality applications that serve the same purpose, are characterized by the same functionality, but satisfy different needs. The first application is deployed by the user during his tour in the city. The second application is used in conjunction with a map, without requiring the physical presence of the user at the point of tourist interest. The above-mentioned map is the one that is being distributed to the visitors of Heraklion city by the Information Office of the Municipality of Heraklion.

The first application aims to improve the user's visiting experience in Heraklion city. When they visit a monument or a museum, they focus on the subject of their interest, with their smart mobile device, and the image of the real world shown on the mobile device will be augmented with relevant digital elements, such as video, photos or text.

The second application, which is completely innovative, aims to support the user to organize their visits to monuments and museums. More specifically, when they rest

in their hotel, enjoy Cretan hospitality at a restaurant or at a leisure center, or when they relax on a beach, they can study the city map in order to decide the next place to visit. In this decision, information about that place could play an important role. With our application, the user does not need to carry tourist guides in printed form, except for a map. Moving one step forward, we could make the map available to the general public by uploading it on the Web. Thus, before the user even arrives in our country, they could print the map or display it on their computer screen and then use our application to get all the collected information and get a first experience of sightseeing of our land. It would not be an exaggeration to claim that the use of our application could create additional incentives for someone who is thinking to visit our place. Of course, one can search for information on the Internet or read a tourist guide to be informed about an area's attractions and points of interest. The advantage of our second applications is that it provides gathered information and therefore the user does not waste time searching for it. Furthermore, the user does not need Internet access to retrieve it.

V. METHODOLOGY

The development of our project followed the Waterfall Software Development Life Cycle Model [13], the main phases of which are: (a) the requirement gathering and analysis, (b) the design, (c) the implementation / coding, (d) the integration and system testing and (e) the maintenance of an application. Probably, the adoption of the Spiral Software Development Life Cycle Model [13] might positively contribute to the improvement of the quality of our applications. However, time limitations did not leave any room for choice.

A. The requirement gathering and analysis

Initially, the thematic content of our applications was determined. Therefore, we decided that our applications would provide information about four tourist sites of our city: the Morozini Fountain, the Koule Castle, the Heraklion Archaeological Museum and the Heraklion Historical Museum.

Research was also carried out on the existing digital applications that serve the tourist needs of Heraklion city in order to identify their positive elements and to highlight the gaps and further needs in this field. The research revealed that our idea, regarding the application that works together with the map of the city, is completely innovative and not yet recorded in the international literature. Finally, we identified the target group of our applications i.e., the visitors of our city, a work plan was developed and a time schedule was constructed.

B. The design

At this phase, we made decisions about the software we would use to implement our applications, and about the platforms on which they would run. Based on our beliefs against software piracy, we used free software. More specifically, we used the video editing software "MovieMaker" to create the videos of our applications, and the augmented reality platform "Aurasma" to create the augmented reality applications themselves. Aurasma is very

friendly and easy to use, and it does not require code writing. Therefore, it is suitable for people who have no computer programming skills. In particular, it gives the user the ability to create "auras", which are virtual digital elements that appear on the screen of a smart mobile device when the user focuses on an object, an image or a symbol. Both MovieMaker and Aurasma are offered free of charge for Windows and Android operating systems.

Decisions were also made about the type and the origin of multimedia elements to be used. During the development of our work, we have been particularly careful about digital piracy, as it is not only unethical, but also illegal to use something that someone else has created and then claim that it is your own creation [14]. Thus, we did not download any pictures from the web. We personally took all the photos that would be included in our applications, during our educational visits to the four sites of our city. Additionally, the map we use in conjunction with our second application has been provided to us by the Information Office of the Municipality of Heraklion, together with permission to use it itself, or part of it.

C. The implementation

At this phase, the students of the research team created four sub-groups, each of which undertook to create videos that will provide information on the four tourist points of interest that we have decided to deal with. When the construction of the videos was completed, we implemented the augmented reality applications themselves. It is noteworthy, that we paid great attention to the accessibility of the applications by people with hearing and vision problems. We, thus, put subtitles on the videos, in order to make the information accessible to hearing-impaired people. We also added a recorded version of these subtitles to make our applications friendly to visually-impaired people.

D. The integration and system testing

In order to identify the potential shortcomings and drawbacks of our applications we disseminated them to a sample of fifty-six (56) users. Then, we interviewed each one of them regarding their experience of using our applications. The interview questions were focused on the quality and the quantity of the content, and the features and the functionality of the applications. We also have to mention that the sample consisted by friends, classmates, teachers and relatives. After collecting the users' comments, we went ahead with the resulting revisions and conducted the necessary modifications on the applications.

The greatest advantages of the applications reported were: (a) the fact that they are available to the user anywhere and anytime, as the smart mobile phone is an integral part of today's everyday life and (b) easy and quick access to information about tourist points of interest, with no need to use the Internet or tourist guides in printed form. Users have also found our applications attractive, impressive and entertaining, because of their feature of augmented reality i.e., adding digital data to the image captured by their smart portable camera at a given point in time. These comments led us to the conclusion that we achieved the goals we had set, regarding the facilitation of the visitors of Heraklion city to obtain information about popular tourist attractions of the city and, thus, to improve their tourist experience.

E. The maintenance

Due to the short life cycle of our applications, no issues of maintenance have yet arisen.

VI. PEDAGOGICAL APPROACH

During the implementation of the project, the teachers were constantly encouraging and supporting the students to tackle potential difficulties. The whole attempt was based on the principles of active learning and collaborative learning [15]. The main objectives were to transform our students into active creators and to engage them in the learning process. Both of them were successfully accomplished.

VII. DRAWBACKS AND FUTURE WORK

The augmented reality applications we have implemented, have great potential for improvement if they are enriched with information about more sites of tourist interest of our city. Our plans also include the advancement of our applications with the creation of versions in several foreign languages. Additionally, the need emerges for further evaluation of the effectiveness of our applications in terms of improving the tourist services of our city. So far, the evaluation of our applications has been limited to a qualitative analysis, which did not take long enough to produce safe results. Furthermore, obvious social, family and emotional links with the users may have reduced the breadth and the amount of the feedback about the quality of our work. We plan to conduct a quantity analysis too, while enlarging the research sample.

VIII. CONCLUSIONS

Augmented reality is a modern technology breakthrough, which can, in real time, create environments in which digital elements augment the image of the real world displayed on the users' smart mobile devices' screens. In this article, we present the implementation of two augmented reality applications that serve the tourism sector. The progress beyond the state-of-the-art that our work entails is the incorporation of the latest technology of augmented reality in the classroom in order to construct innovative applications. Especially our application that involves the use of a map is pioneering not only in the field of education, but in the field of tourism too.

REFERENCES

- [1] J. Billieux, P. Maurage, O. Lopez-Fernandez, D. J. Kuss, and M. D. Griffiths, "Can Disordered Mobile Phone Use Be Considered a Behavioral Addiction? An Update on Current Evidence and a Comprehensive Model for Future Research," *Curr. Addict. Reports*, vol. 2, no. 2, pp. 156–162, Jun. 2015.
- [2] C. L. Ventola, "Mobile devices and apps for health care professionals: uses and benefits," *Pharm. Ther.*, vol. 39, no. 5, pp. 356–364, 2014.
- [3] H. Verkasalo, C. López-Nicolás, F. J. Molina-Castillo, and H. Bouwman, "Analysis of users and non-users of smartphone applications," *Telemat. Informatics*, vol. 27, no. 3, pp. 242–255, 2010.
- [4] H. Kennedy-Eden and U. Gretzel, "A taxonomy of mobile applications in tourism," 2012.
- [5] D. Wang, S. Park, and D. Fesenmaier, "An examination of information services and smartphone applications," 2011.
- [6] D. Fonseca, N. Martí, E. Redondo, I. Navarro, and A. Sánchez, "Relationship between student profile, tool use, participation, and academic performance with the use of Augmented Reality technology for visualized architecture models," *Comput. Human Behav.*, vol. 31, pp. 434–445, Feb. 2014.

- [7] D. Van Krevelen and R. P. Amsterdam, "Augmented reality: Technologies, applications, and limitations," *Vrije Univ. Amsterdam, Dep. Comput. Sci.*, 2007.
- [8] H.-L. Chi, "Research trends and opportunities of augmented reality applications in architecture, engineering, and construction," *Autom. Constr.*, vol. 33, pp. 116–122, Aug. 2013.
- [9] R. T. Azuma, "A Survey of Augmented Reality," *Presence Teleoperators Virtual Environ.*, vol. 6, no. 4, pp. 355–385, Aug. 1997.
- [10] M. Bower, C. Howe, N. McCredie, A. Robinson, and D. Grover, "Augmented Reality in education – cases, places and potentials," *EMI Educ. Media Int.*, vol. 51, no. 1, pp. 1–15, Jan. 2014.
- [11] M. Billinghurst, H. Kato, and I. P. Graphics, "The magicbook-moving seamlessly between reality and virtuality," *IEEE Comput. Graph. Appl.*, vol. 21, no. 3, pp. 6–8, 2001.
- [12] S. Johnson, L.; Levine, A.; Smith, R.; Stone, *The horizon report*. 2010.
- [13] N. Ruparelia, "Software development lifecycle models," *ACM SIGSOFT Softw. Eng. Notes*, vol. 35, no. 3, pp. 8–13, 2010.
- [14] C. Ullrich, K. Borau, H. Luo, X. Tan, and ... L. S., "Why web 2.0 is good for learning and for research: principles and prototypes," in *In Proceedings of the 17th international conference on World Wide Web . ACM.*, 2008, pp. 705–714.
- [15] M. Prince, "Does Active Learning Work? A Review of the Research," *J. Eng. Educ.*, vol. 93, no. 3, pp. 223–231, Jul. 2004.

Kalliopi Kanaki was born in Athens, Greece, in 1970. She is a Ph.D. candidate in the department of Early Childhood Education at the University of Crete, Greece. She received a bachelor's degree in Physics from the University Of Heraklion, Greece, in 1994 and a bachelor's degree in Computer Science from the University Of Heraklion, Greece, in 1999. She also received a master's degree in Leadership and Management in Education from the Roma Tre University of Rome, Italy, in 2014 and a master's degree in Informatics and Multimedia from the Technological Educational Institute of Crete, Greece, in 2015.

She worked as a SOFTWARE ENGINEER for CMI/HTA (Center for Medical Informatics and Health Telematics Applications) at ICS/FORTH (Institute of Computer Science, Foundation of Research and Technology), in Heraklion, Greece (1999 - 2005). She has been working as a COMPUTER SCIENCE TEACHER in secondary schools in Heraklion, Greece, since 2001.

Mrs Kanaki is a member of the Federation of Secondary School Teachers of Greece and of the Hellenic Informatics Union. .

Nikolaos D. Katsalis was born in Athens, Greece in 1973. He received a Bachelor degree in Computer Science in 1996 and a M.Sc. degree in computer networks and distributed systems in 1999, from Department of Computer Science, University of Crete, Greece. He also received a Bachelor degree in Mathematics in 2015 and a M.Sc. degree in Mathematics in Education in 2017 from Department of Mathematics, University of Crete, Greece.

He worked as an IT TRAINEE during his undergraduate studies in Network Operation Center of University of Crete in 1994-1995 and during his postgraduate studies in Computer Networks and Telecommunications group in the Institute of Computer Science of the Foundation of Research and Technology – Hellas (FORTH) in 1996-1999. He was a cofounder of Kernel IT Applications General Partnership, Heraklion - Crete, Greece, and worked as an IT MANAGER for 3 years (1999-2002). Since 1998 he is working as an INFORMATICS PROFESSOR in secondary schools and in adult educational and training institutes. Since 2002 he is an INFORMATICS PROFESSOR in Hellenic secondary schools and since 2005 is teaching in the 5th Vocational High School of Heraklion in Crete, Greece. His current research interests include informatics and mathematics in education.

Mr Katsalis is a member of the Federation of Secondary School Teachers of Greece since 2002 and of Hellenic Informatics Union since 2008.