Augmented Reality applied in Tourism Mobile Applications

Cintya de la Nube Aguirre Brito
School of Computing. Faculty of Technology
University of Portsmouth
Portsmouth, United Kingdom
cintya.aguirre@gmail.com

***Abstract*—Augmented reality (AR) has been used in the last years as a tool for enhancing collaboration between the real world and virtual environments. One of these fields where AR has been used is the touristic sector. The aim of this project is to identify the benefits of the use of AR in tourism mobile application through the development and evaluation of an AR tourist mobile application. The results of the implementation of this project show AR enhance tourist on-site experience in an innovative way in the real life. Moreover, AR could be applied in different industries as a method of improving the quality of service.**

Keywords—Augmented Reality, mobile applications, cloud computing, cultural tourism

I. INTRODUCTION

Augmented reality has been used in the last years as a tool for enhancing collaboration between the real world and virtual environments. There are many examples of application domains where these collaborative Augmented Reality Systems are being applied such as Education, Urban Planning, Automobile Design and Outdoor Entertainment [1].

In order to support the creation of collaborative augmented reality, it is necessary to have access to seamless interfaces that allow interacting with virtual and real objects at the same time [1]. The current generation of mobile phones offers an ideal platform for the application of collaborative Augmented Reality, due to the co-located characteristics that it provides, such as GPS and Wi-Fi support [1], and the massive penetration of these devices in the worldwide population.

Taking into account that tourism is part of Outdoor entertainment application domain, this field offers a desirable environment to apply the concept of the use of augmented reality using mobile phones as collaborative interfaces.

Although augmented reality and its practical applications have been a research topic for several years, a constant obstacle in its overcrowding was the lacking of powerful augmented reality interfaces. However, with the current mobile phone technology, this impediment is disappearing. As a consequence, this fact challenges the creation of augmented reality mobile application that satisfies a wider set of current industry needs.

A personal bias that conducted to put particular attention on the use of augmented reality in mobile application related to the tourism sector was the fact the results of this research could be applied worldwide. As a scholarship holder from the Republic of Ecuador, it is necessary to accomplish one of the desired aims of Ecuador, that is to use the knowledge obtained by its scholars during their abroad study time in developed countries in order to reach a better quality of life through the application of this knowledge to change the productivity matrix of the country [2]. One of the important points in this process is to strengthen the tourism sector, due to this is one of the main income sources of Ecuador. Therefore, the results of the proposed research topic may help to reach this objective.

II. RESEARH QUESTION

What are the main benefits of location-based Augmented Reality applied in tourism mobile applications?

III. AIMS AND OBJECTIVES

A. Aim

Identify the primary benefits of the use of mobile application based on location-based augmented reality in the field of tourism through the implementation and use of an Android native mobile application as a case study.

B. Objectives

- Review academic literature related to the impact of Augmented Reality in human behaviours and the implementation of location-based augmented reality using mobile technology.
- Develop an Android native application based augmented reality mobile application that enhances on site tourism through the use of User Centred Mobile Development Pattern.
- Evaluate and test developed mobile application in order to identify the main characteristics of the use of location-based augmented reality that could benefit on-site tourist satisfaction.

IV. Methodological Approach

Although developing software artefacts, such as software components or mobile applications, follows several standard software process models depending the nature and the aims of the artefact, however it is possible to generalise the inputs of all these processes into idea and resources, and the output of the software product [4]. Taking into account that, for answering the proposed research questions and reaching the aim of the study, it is desirable to develop an application using Human-Computer Interaction (HCI) approach as the software development process [5]; this means the idea and resources will come from people as input process, and in order to follow the Iterative design used in HCI, it is necessary to refine and improve these inputs in each iteration process. However, In order to discover what characteristics of the application change people behaviour, it is necessary a method that helps to identify cause-effect relationships related to the desired behaviour [3].

As a consequence, considering that experimentation have been used in the human-computer interaction field to manage user models and evaluate different kinds of design patterns [3] and that "Experimentation provides a systematic, disciplined, quantifiable and controlled way of evaluating human-based activities" [4], the chosen research method for this project is an empirical strategy based on a survey for requirements elicitation phase and Quasi-experiment for the evaluation of the whole software development process.

A. Research and Evaluation Method

Traditionally, empirical studies have been used widely in the social sciences, due mainly to the concern with human behaviour. Considering that, although Software Engineering belongs to a technical field, it is highly attached to human behaviour in all the development process [4]. Particularly, in Software Engineering, empirical studies are applied as quasi-experiments due to full randomisation (the difference between experiments and quasi-experiments) is difficult to perform [4]. Hence, for the study, it will be used empirical strategy focused on technology-oriented quasi-experiment. The Object of this study is the use of augmented reality in tourism mobile applications for enhancing on-site satisfaction.

1) Research Context

A quasi-experiment will be conducted in an off-line setting and executed in a controlled manner. The environment proposed is Cultural Places in Brno Czech Republic. A special developed AR application is used in a smartphone, and a traced route will be followed for the subject using the mobile application in order to test the functionality.

2) Hypotheses

- Existence of Benefits for using Augmented Reality mobile application
- Augmented Reality mobile application has a high score in terms of Usability

3) Variables

The independent variable is the use of AR mobile application. The dependent variables are the number of benefits found using the AR mobile application and the tourist on-site satisfaction for using AR application.

4) Measurements

In order to measure the dependent variables for the quasi-experiment, the project will use System Usability Scale SUS usability testing with two extra questions about the benefits found in the use of AR mobile application use.

5) Quasi- Experiment Design and Analysis

This quasi-experiment is a behaviour comparison between the use of an AR mobile application in cultural tourism and the absence of that use, and the design type is one factor two treatments. The factor is the on-site tourism experience, and the two treatments are the use of the AR mobile application and the absence of the use of AR mobile application. As part of the analysis of data, descriptive statistics will be used to show the data collected.

B. Requirements Elicitation Method

Pervasive and Context-Awareness Computing needs a method for requirements elicitation and development process. Usage Model schema is suggested as a choice for requirements definition due to allows describing the usage of the mobile interface, including all aspects of computing environment and links with the user requirements [6].

C. Implementation Method

For implementation process, this project is set to use of adapted interactive user-centred process because general interactive user-centred process are focusing mostly on GUI-driven approaches [6], but for pervasive computing environment it is necessary to consider the physical world surrounding the user and the context [6].

V. Design of the AR City! A Mobile Application for Cultural Tourism

A. Functional Application Design

Taking into account that the Usage Model schema was used for the definition of requirements due to allowing the description the usage of the mobile interface and links with the user requirements, it is necessary to define the behaviour of the application. Using the patterns of Unified Modelling Language [7], it was determined as a first step the General Requirements Model of the system, in order to know and manage the scope of the implementation. Also, it was required the identification of actors. In this case, the application has only tourist as a principal actor, due to the main target of the application are the tourists (See Figure 1).

B. Graphical User Interface Design

Designing Application User Interface was carried out with respect to UI design guidelines. Main source of information was Android Design website [8] since the application is targeted for Android powered devices.

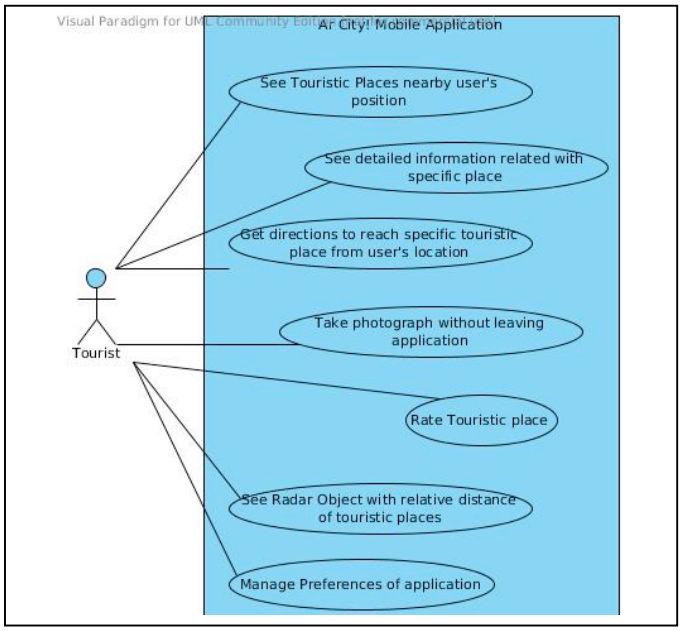

Fig. 1. Functional Model of AR City! Mobile Application.

Web site was evaluated as most relevant source of information, as it is up-to-date which is crucial in such rapidly evolving field as mobile applications are. Moreover, some AR applications were taken as examples in order to apply functional design patterns oriented to AR applications.

After the analysis of the example design for AR mobile applications, and applying the patterns of design given by Android Design website [8], Low and High-Fidelity Prototyping for AR City! Mobile application was designed and developed to provide guidelines to the developer about the final product appearance and functionality (See Figure 2 and Figure 3).

VI. Implementation of the AR City! A Mobile Application for Cultural Tourism

A. Architecture

The Architecture Model applied to this project contains two main blocks: Service Consumer and Service Provider. The Service Consumer includes the Android native application that provides Augmented Reality Framework and calls the front-end component of the application. Meanwhile the front-end part, based on web technologies (HTML, CSS and JavaScript), is bound to the service provider through the use of communication with JavaScript Open Notation (JSON) messages between Web Services. On the other side, the service provider, which contains the back end component of the application, responsible for including the business rules and processes of the application.

The components of the Service Provider are a MySQL Data Base Server, a Java EE Application, JBOSS Application Server and Google Services API. These components are encapsulated into a Red Hat's Platform-as-a-Service called OpenShift® that allows to host and scale applications in a cloud environment (See Figure 4).

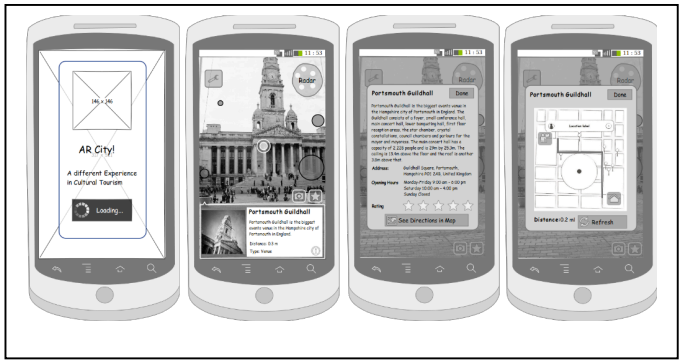

Fig. 2. AR City! Low Fidelity Prototyping.

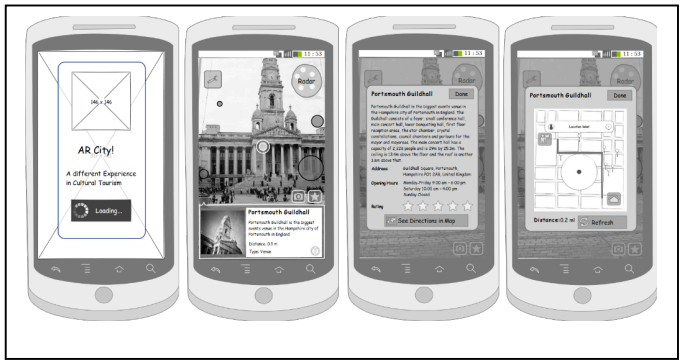

Fig. 3. AR City! High-Fidelity Prototyping

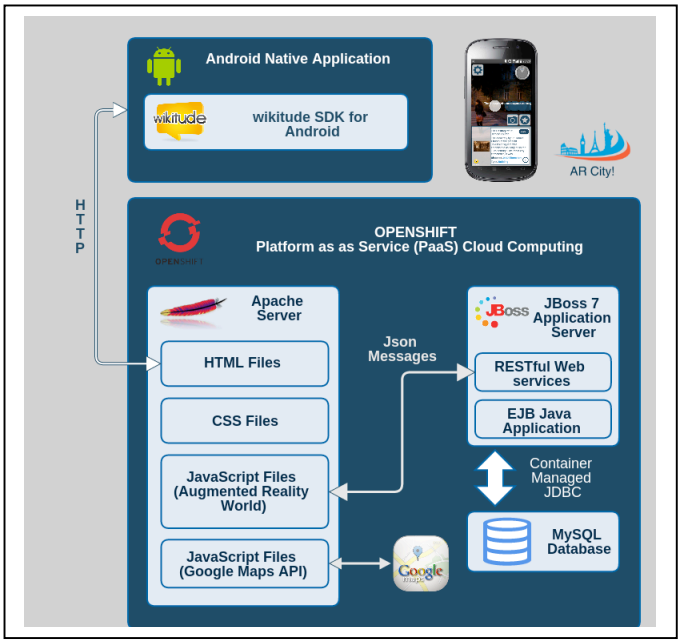

Fig. 4. Architecture Diagram for AR City! Mobile Application

B. Back and Front End Component

Back End component is a Java EE Application Web Service that exposes a method by the use of a JBOSS Application Server, following the chosen architecture pattern. This component was developed using NetBeans 7.1. Front End element is an Android native application client and a Web Site that consumes web services methods exposed by the back-end component. Frontend component was developed using Eclipse Java EE IDE for Web Developers Kepler Service Release 2 for native Android component and Sublime Text for the Web Site.

C. Integration

In terms related with Cloud Computing, Infrastructure as a Service (IaaS) provides on demand certain predefined virtual hardware configurations. Meanwhile, Software as a Service (SaaS) requires the least amount of maintenance and administration on developer's part. With SaaS is only necessary to sign up for the service and start to develop [9].

Platform as a Service (PaaS) is the middle ground between IaaS and SaaS [9]. With PaaS, using few commands (that could be in a web console) the developer could start the whole "virtual environment" along with all the "server" pieces required to run the application. Then, if the development team likes the new technology, they can demonstrate the application to the decision makers and sys admins to show the value of the novel technology.

Taking advantage of these features, the database engine, back-end component service and Web-based Front End component are hosted in this PaaS Service (See Figure 5)

D. Final Product

After the verification and validation process, the executable application ARCITY was released for the evaluation process. The application was developed following hybrid-platform pattern.

ARCity! Application is a native Android application, but web technologies give some functionality. Figure 5 and Figure 6 visualise this final product.

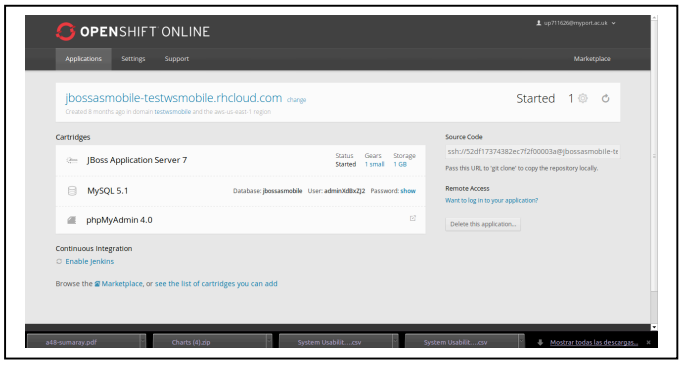

Fig. 5. Openshift JBoss Cloud Server

VII. Evaluation

In order to evaluate AR City! Cultural tourism application, the Android native application was tested in the city centre of Brno Czech Republic. Seven international students was selected as subjects from Masaryk University. Masaryk University has a strong cooperation with international with foreign institutions worldwide, and, as a result, there is a high rate of foreign students attending this university. With this employed sample, it is assured the subjects meet the characteristics of the target of the application. One criterion applied in the selection was chosen subjects needed to speak English in order to have a full comprehension of the application and the questionnaire.

The evaluation instrument employed in this evaluation was DroidSurvey Android application with System Usability Test loaded in the application. DroidSurvey is part of ISurvey project that allows capturing date directly in smart-phones. This application was chosen due to allowing applying survey in a convenient way through a mobile application and the facilities for download results to analyse data.

Fig. 6. Real Screens of AR City! Mobile Application

Fig. 7. Start Screen of AR City! and QR Code for access to download.

VIII. RESULTS

The results obtained from the quasi-experiment execution as part of the evaluation are grouped by the hypothesis and described as follows:

a) Benefits of using Augmented Reality mobile application

The beliefs of the users about AR City! Application in terms of benefits given to cultural Tourism is showed in Figure 8. The vast majority of the subjects agrees that the application benefit the cultural tourism at least in some way. Moreover, Table 1 states the feedback provided for the subjects about the way the application could help the cultural tourism, taking into account the features of the system. It is noticeable that AR City! Application has had a good impact on the subjects, due to the high percentage (86%) of acceptability visualised in the figure.

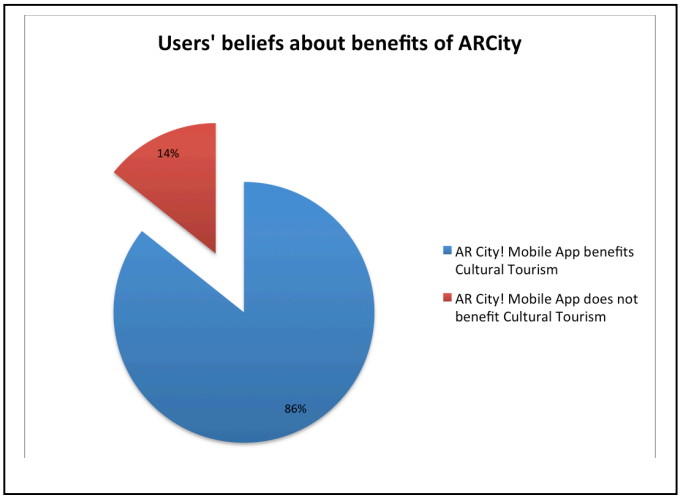

Fig. 8. Pie Chart about User's beliefs about benefits of AR City! Application

TABLE I. FEEDBACK PROVIDED BY SUBJECTS ABOUT AR CITY! BENEFITS

Subject	Feedback
1	"The tourist does not need any additional map to get the cultural places."
2	"The people can find cultural places without spending a lot of time."
3	"The maps inside the application help a lot to the tourists."
4	"People can see the maps without leaving the application."
5	"I found that it would help to go to unknown cities and discover cultural places easier than with only maps."
6	"With this application we could learn about the places visited in cities."

b) Score in terms of Usability for Augmented Reality mobile application

The mean value obtained by SUS test to the application was 71.79. However, in order to analyse the tendency of the data, it was necessary to calculate another tendency values like median (75) and mode (75) of the information obtained. These measurements clarify the slight tendency of the information to high scores (See Figure 9 and Figure 10).

In order to answer the stated research question, it is necessary to discuss the demonstration of each given hypotheses and then, based on those results, stating the answer to the research question.

For demonstrating the first hypothesis, it is necessary to reject the null hypothesis shown below:

Benefits (AR Mobile Application) - Benefits (not AR Mobile Application) = 0;

From the obtained statistics, it is possible to infer that tested persons could find at least one benefit from the use of AR Mobile Application in cultural tourism than the absence of this use. Then, the null hypothesis is rejected. In order to demonstrate the second hypothesis, and considering the values presented above as a reference, the value of k (high rate usability score) is set to 68. Then, the null hypothesis:

H0: Usability (AR Mobile Application) < highRateUsabilityScore

Could be rejected, due to Mean Usability Score (AR Mobile Application) = 71

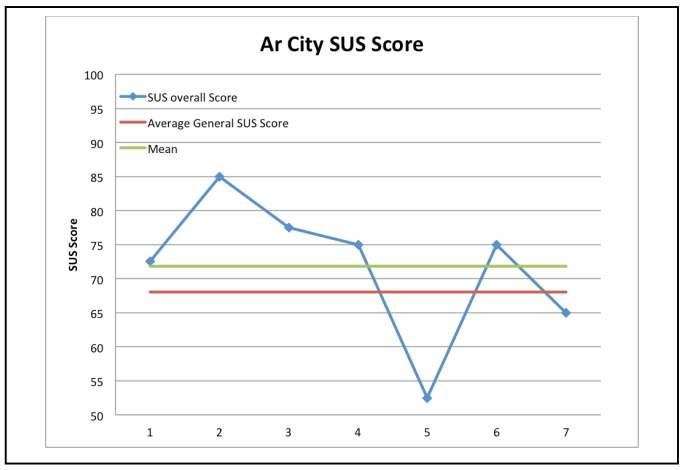

Fig. 9. Graphics with the results of AR City evaluation using SUS Survey to measure usability

Considering that two hypotheses presented in this project were demonstrated, and with the results obtained from the evaluation of the application, it is possible to give and answer to the research question "What are the main benefits of location-based augmented reality applied in tourism mobile applications?." The use of Location- Based Augmented Reality in tourist mobile application benefits the tourist user experience in, at least, two ways:

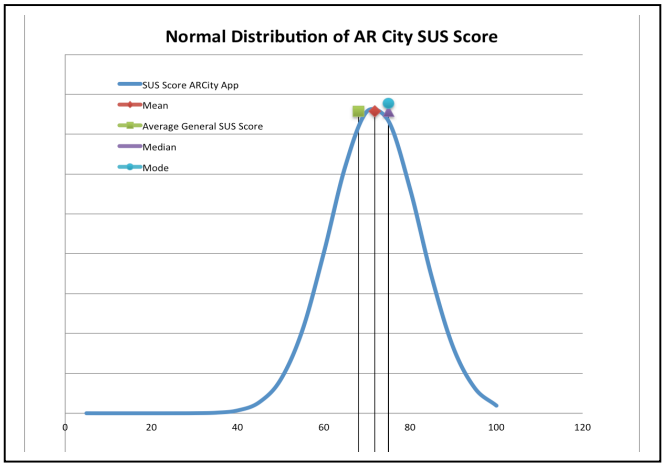

Fig. 10. Normal Distribution of results of AR City! Evaluation with SUS survey applied.

- Allowing Tourists to discover cultural places in cities by themselves
- Enhancing the on-site tourism experience because the application helps tourists in everyday activities such as getting directions to places and finding information about opening hours and entrance fees.

IX. Conclusions and Future Work

The purpose of this project has been to identify the benefits of using Augmented Reality in tourism mobile applications. In order to carry out this aim, AR City! Augmented Reality mobile application has been developed and tested based on User Centre Development Pattern. Due the use of a hybrid platform approach of implementation of the system (Native plus Web Technologies), the iterative process of developing was carried out without any problem. The obtained results have demonstrated that potential users of this type of application would accept and use in their touristic experiences. Moreover, this kind of systems would encourage people to visit unusual touristic places by themselves because, with the Use of Augmented reality and Location-Based systems, it is possible to get in touch with the environment and at the same time enhance the on-site tourist experience. However, Future work could use Augmented Reality in mobile application to implement smart cities concept over the world. However, one identified limitation of the developed application is the use of internet as requisite; hence, it is important to implement further functionality that allows the use of Augmented Reality in Off-line environments.

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