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Service Oriented Architecture to Support Mexican Secondary Education through Mobile Augmented Reality

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Abstract

This paper proposes a mobile augmented reality system that allows Mexican secondary education students to access additional educational contents related to their textbooks. Our system recognizes the images printed in the book as part of regular taught topics and shows multimedia contents that complement the topics covered in the book. These contents are generated through a service-oriented architecture. Initial usability testing of our augmented reality system showed a user satisfaction of 97%.

Keywords: Augmented reality, Service-Oriented Architecture, Mexican Basic Education, Mobile computing;

1. Introduction

Teaching methods used worldwide are constantly evolving and involve new technologies in these changes. For example, at the beginning of 20th century, movies were adopted as an educational tool in American schools [1]. In the 1990s, with the worldwide adoption of the Web, content on the Internet and digital communications were well received in education. In the early twenty-first century, great advances in mobile technologies are enabling us to make use of technologies such as augmented reality (AR) in educational projects.

AR mixes virtual features with the real world. As its name suggests, it augments the real world with virtual information [2]. While the concept was created in the 60s, AR is a technology that allows to develop, distribute and use virtual augmented applications on a large scale. The boom of mobile devices with high processing capabilities and the presence of cameras in virtually all recent mobile devices make a

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great support for AR applications. Currently, there are several prototypes of AR systems applied to education. Some examples are [3], [4] and [5].

Our work aims to support basic education students to improve the understanding of the topics covered in their textbooks using only their own mobile phones. To understand the challenges and circumstances around the subject, we conducted interviews with a group of them in a public secondary school. Those interviews served to inform our design of a system that aims at improving the learning process of these students. The main concept behind the proposed solution is a mobile augmented reality system, through which students can enrich their experience with textbooks, using augmented contents, like videos, music or 3D models. We argue that this system will allow students to engage more with classroom activities, and will have a positive impact on their learning.

2. Background

Our field work was designed to know the characteristics of their cell phones. We focused on four main aspects: genre usage, time of use, brands and the camera component.

2.1. Methods

We interviewed 30 randomly-chosen students. There were three groups of 10 students each from different grades from Pablo Latapí School. This is a public school located at Manzanillo, Mexico.

2.2. Results

Fig. 1(a) shows that 100% of interviewed men and 78% of interviewed women had a cellphone, which comprises 86% of the whole group. Fig. 1(b) shows that of the 26 students that had a cell phone most of them got it within the last two years, which is the time most of them got into secondary school.

(a) (b)

Fig. 1. Statistics by genre and time of use.

Fig. 2(a) shows that of the 26 students interviewed that have a cell phone we found that the brand that most people use is LG, followed very close by Samsung and Sony Ericsson.

(a) (b)

Fig. 2. Cell phones brands and camera statistic.

Of the 26 interviewed students that had a cell phone we found that 96% of them had a cell phone with a built-in camera, as seen on Fig. 2(b). The camera is the most important element of an augmented reality system and this result indicates that currently it is very unlikely to find a recent cell phone without a built-in camera.

We found in our study that almost the same number of male and female students use cell phones at the Pablo Latapí school. 96% of the students used regularly the built-in camera of their cell phones. Most of the cell phone ran Android operating system. We have found in the literature that there are already many augmented reality applications for the Android OS. The latter motivated us to develop an educational augmented reality system for cell phones like the ones used by the students.

3. Related work

In this section we compare some alternative approaches that have been discussed within the context of supporting education through augmented reality.

Construct3D: This system uses augmented reality to support face to face collaboration between teachers and students. Its main advantage is that with AR students can see 3D projections of objects that otherwise they had to draw using pencil and paper. With Construct3D, students can work directly on three-dimensional spaces, complex spatial problems, and spatial relationships and arguably understand those topics better using AR than using traditional methods (such as pencil and paper) [6].

MagicBook: It is a printed book that shows how the AR can be used in schools for educational purposes as an interesting method of teaching. Allows students to read a book like any traditional book or can be used with a screen to watch 3D virtual images out of the pages [7].

ARSK: It is a mobile augmented reality system developed by researchers from the Technological University of the Mixteca in Mexico; this system uses Android cell phones to show skeleton 3D models over augmented tags [8].

In contrast with those systems, we aimed to create a system that provides augmented content directly embedded into the actual textbooks, and displaying on their own mobile phones getting the rich content from a service oriented architecture in the cloud.

4. Envisioned system

In order to achieve these issues, we envision that our system needs to address the following aspects:

Support heterogeneous devices. The system must be able to be used in as many Android devices as possible because there are a very large number of different devices. The idea is that the scope gets to be as broad as possible.

Interface easy to use. The system must have a very small learning curve and be as easy to use as possible. To achieve this, the AR interface must be properly designed and have gone through the necessary usability testing.

Content should be generated by teachers. To ensure validity of the information, the system should allow teachers to add contents on a particular topic.

5. System design

Based on our envisioned system we engaged in the design and development of a prototype of the system, which architecture is described next.

5.1. Architecture

As illustrated in Fig. 3, our prototype has a Service Oriented architecture technology in order to centralize the content generation and seamless deployment on the mobiles phones.

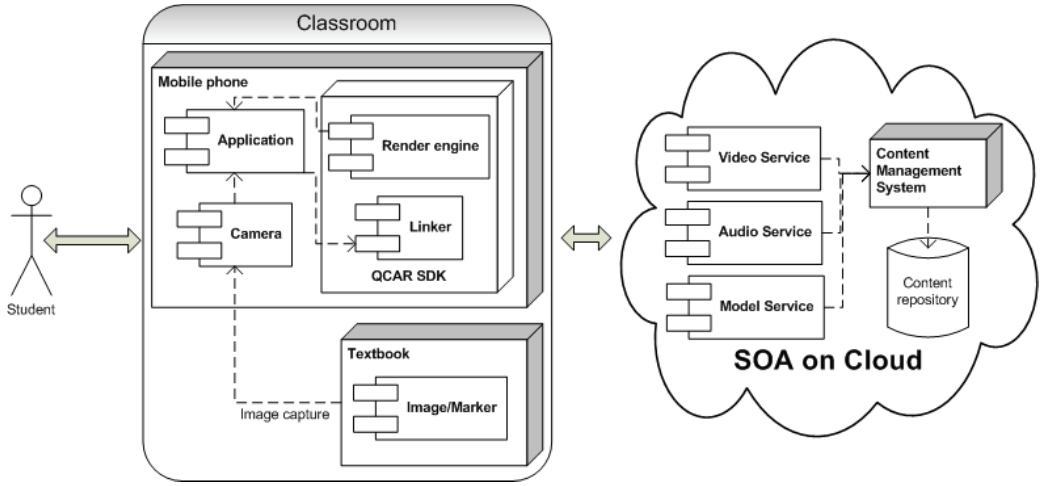

Fig. 3. System architecture.

5.2. Classroom

The classroom layer represents the teaching environment, where the following two components are present:

Mobile phone: On this component we can find the render engine which interprets the information from the mobile application through the linker; and by using some calculations it identifies what web service should be called in order to get the appropriate content. After doing that, the render engine receives the content from the web services and it sends the information that should be displayed to the application. This way the user can interact with it.

Textbook: This component represents the physical book, where the augmented tags or the image that is going to be tracked are located. They are linked to the application content. It is important to highlight that we have worked directly with the textbook when the image is big enough to be tracked by the camera, when it cannot be done, an augmented tag is used. The application gets the information from the image tracked using the device's camera and it sends it to the QCAR SDK to send the request into the cloud.

5.3. SOA on cloud

The Service Oriented Architecture layer enables us to implement a scalable and loosely-coupled system in which by means of web services we can add new contents to the system.

The main components of this layer are described next:

Content Management System (CMS): It is included in the prototype, where the teacher generates the content to be displayed on the mobile phones through the web services available.

Content Repository: In order to store the contents, we require a multimedia server component (MMS) to manage the documents used by the application, when the CMS requires retrieving a document, it will send the request to the MMS that will act as a gateway to the actual repository that keeps and maintains the files.

Video, Audio and Model services: These services receive the request of content from the mobile phone, and the CMS generates the appropriated one and send it to the phone in response.

6. Development

We developed a fully-functional system prototype. To create the 3D models we used Autodesk 3Ds Max. Also, we also used Creative Commons licensed 3D Models from [9].

The content was designed based on Unit 5 from the book “Historia 1 Segundo Grado” Spanish for “History I Second Grade”, written by Gamboa Ramirez [10], which is used in second grade of the secondary school previously mentioned. This unit covers topics of recent decades such as recent wars, contemporary conflicts, economic and social inequalities in the world, and the technological and scientific advances in recent years.

The application was developed using the Android SDK. The device used for development was a HTC Droid Incredible smartphone running Android 2.3.3 and the Qualcomm Augmented Reality SDK (QCAR SDK).

The development environment used was Unity 3D with the official extension to develop using QCAR SDK.

The following paragraphs discuss the results achieved with the mobile application development.

(a) (b) (c)

Fig. 4. Augmented contents.

The Fig. 4(a) show the design of the application when it displays a 3D model.

In the lower area is shown the zoom controls of the camera. Most of the screen is occupied by the image obtained by the camera in real time. The book has a marker that the system identifies and, based on a comparison with the database, it displays a 3D model that is found on the cloud and can be obtained through a web service.

The model can be viewed from any angle as long as the marker is not completely out of sight of the camera.

Fig. 4(b) shows the video playback. The system searches the marker in the content repository and gets the video file related to it.

The video player is shown in the foreground and the user can interact with its controls (volume, pause and full screen). When the user wants to terminate the action he uses the back button included in all Android devices.

Fig. 4(c) shows the playback of an audio file recovered from the cloud. Just as with the video, the player will remain at the forefront regardless of whether the marker leaves the field of view of the camera and regardless of what it captures. The user can interact with audio controls and the timeline of the playback. When the user wants to stop using the application he uses the navigation buttons provided on all Android devices.

7. Evaluation

We applied a number of usability tests to see if our AR application can be used as an educational tool and to assess its application and validate how easy is it to use. The tests were carried out at the Human-Computer Interaction lab (IHCLab) from the University of Colima, Mexico.

7.1. Evaluation protocol

According to [11] the usability evaluation included 5 participants with an age average of 12 years old (two females and three males). They previously had studied unit 5 of the textbook "Universal History I". The five participants had previous experience using smartphones.

The evaluation session lasted about one hour. The first step of the test consisted of completing a pre-questionnaire to measure previous knowledge on the subject (universal history), which included topics such as Second World War, the Eiffel Tower, and the life and work of Martin Luther King. The second step of the test was to show and explain the participants how our AR worked. The next step was to ask participants to open the book and point the cell phone's camera to one of the markers to get more information on the topic being read in the book. After that, participants completed a post-questionnaire to measure the knowledge after the usability test (on the same topics of the pre-questionnaire) and an evaluation questionnaire assigning a usability score ranking from 1(very poor usability) to 10 (excellent usability).

7.2. Usability Test Results

Data collected from the first questionnaire gave an average of 7.9/10. At the time of the usability testing, the students were surprised with the augmented contents of their textbooks and remained focused until all the content was played. Of the five participants, the student who took longer to find the augmented content was the related to the second world war (4 minutes and 2 seconds), because this content, instead of using an augmented tag, it is played by directing the camera to an image of the same book, this finding indicates that we are not yet accustomed to the mixture of physical reality and virtual reality without special markers. After the usability test, students answered the questionnaire again, this time the obtained average was 9.4/10. Finally the children evaluated the degree of satisfaction with the application using a scale of 1 to 10 achieved a 97% satisfaction (10, 10, 9.5, 10, 9).

8. Conclusions

In this paper we described the development of a mobile augmented reality (AR) application with a Service Oriented Architecture and a usability test done on our AR system. Results of the test suggest that AR technology can strongly support secondary education in Mexico.

We found in the usability evaluation that our educational AR system was well received by secondary school students. The system would provide a richer mechanism to complement lecture contents.

Although nowadays not all students in middle school are able to access smartphones, these conditions are likely to change as the background study indicates and the prices of the smartphones continue dropping.

As a general conclusion we can say that the use of mobile phones as a platform to deploy augmented reality applications for education is adequate, and the use of a Service Oriented Architecture and AR ensures the delivery of up-to-date educational content for all the students.

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