[POSTER] The Augmented Library: An Approach for Improving Users Awareness in a Campus Library

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ABSTRACT

Most existing libraries use floor plans and call numbers in order to locate books rather than providing truly user's awareness of the extensive collections and services for students in the library context. With a collection of more than 48,568 volumes at the Engineering and Exact Sciences library of the Universidad Autónoma de Yucatán (UADY), the task of looking for a book can be really a time-consuming and frustrating task, specially for newcomers. This paper proposes an Augmented Reality (AR) based application which aims to solve users spatial unawareness at library by providing an AR shelf searching system, and to assist students and newcomers by providing a mobile guide with library information services into library.

In this work, the results of a pilot study are presented demonstrating that user's experiences and performance at library were enhanced through the use of augmented reality technology.

Keywords: library, augmented reality, mobile guide, localization.

Index Terms: H.5.1 [Multimedia Information Systems]: Artificial, augmented and virtual realities; H.5.2 [User Interfaces]: Interaction Style;

1 INTRODUCTION

Many libraries make use of passive and fixed signs, such as floor plans and call numbers, in order to bring some guidance to the users. However, these indications are not fully functional since they do not provide personal aid for students that requires a specific material or service nor for newcomers that might be confused about their own location while looking for resources at the library.

In particular, the Engineering and Exact Sciences (EES) library of the Universidad Autónoma de Yucatán (UADY) is a science and technology specialized library which houses the documentary collections of the Engineering, Maths and Chemistry Engineering faculties. This venue serves as a multipurpose study place where students can find a vast majority of resources such as the printed collections and other digitalized works and services.

Every year, this library provide some internal tours and courses to new students about how to use and make effective searches for academic material, but despite this efforts, the library staff is not able to bring this courses to every newcomer.

Traditional earlier systems for book tracking in the library make use of static desktop computing with database systems that only had the classification call numbers of the books rather than providing any more guidance to users for services and spatial awareness. Owing to this fact, many constraints becomes more apparent, students might be confused about the location of the resources and their own location after querying in the library system until he/she ask to the librarian staff to look up the shelf numbers or by doing manually by searching each shelf by his own, of course this is time-consuming. But the fact is that not every user will ask about how to use and search for material; it was found that 75 to 85 percent of students using library with research purposes described in terms of fear and confusion their initial response to library research [7]. Three main concepts emerged from these descriptions: (1) in general, students feel that their own library-use skills are inadequate in comparison to others, (2) that inadequacy is shameful so must be hide, and (3) the inadequacy would be revealed when asking questions.

The actual collection of printed and electronic resources in EES library is in constant expansion, which makes books sections in shelfs change several times within a year; even more, this academic library does not provide any floor plans or guidance to the users other than having call numbers for books classification and an online database. This could guide to some drawbacks in the user's experience such as unknown services and spatial unawareness which at the same time leads to some major problems in students like library anxiety, in which according to Mellon in his 1986 work, the sense of being inadequate in comparison to others, conduct to a continuing incompetence since students do not ask questions because they are afraid of revealing their ignorance [7].

Over the past years, several advancements in miniaturization were made, allowing the use of information technology in an unprecedented scale, with a clear transition from stationary office and desktop computing to mobile and ubiquitous computing. In this sense, the use of smart mobile devices such as smart-phones, tablet PC's and wearables allows users to access a vast amount of information in real time almost everywhere. Thus, scientists, researchers and developers are finding more ways to explore the potential of scientific applications. However, this almost instant access to real-time information is still being excluded to the physical world, making electronic information unsuitable for certain tasks. Therefore, we need a practical link between the real world and the virtual information, and this is where augmented reality becomes apparent, merging our physical world with the electronic information in the promise of being in a mixed reality world.

Augmented reality (AR) is a Virtual Reality (VR) variation technology. Since VR places a user in a totally immersed computer-generated environment, the purpose of augmented reality is to fill those gaps between the physical world and electronic information while enhancing the real world with computer-generated augmentations that merges seamlessly in the users physical environment.

It is to mention that augmented reality is not limit to specific technologies such as projectors or head-mounted displays. According to Azuma in his 1997 survey paper [1], every augmented reality system must meet the following characteristics: (1) combines real and virtual, (2) interactive in real time, and (3) registered in 3D.

Thus, augmented reality is the collective result of many research disciplines, such as computer vision, image processing, mobile computing and so others, providing a simple and immediate user interface to an electronically enhanced physical world both spatially and cognitively.

The proposed approach introduced in this paper encourages the use of augmented reality technology as a solution to address problems new users might face at the library environment. Experimental tests on this study demonstrates that mobile guide as well as an AR

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shelf searching system (ARSSS) can alleviate the hard aspects of library anxiety by providing users with information about library services as direction based on the physical location of the users and the content of interest.

2 Related work

The use of AR technology in library context situations has been slightly touched; with most of the existing research focused in book searching approaches. This section is intended to present a brief overview of related works in the library field.

With corresponding increases in resolution, brightness and contrast ratios for projectors, Crasto et al. (2005), explored the capabilities that camera-projector systems can offer in a smart bookshelf application [4]. Their system utilizes two cameras and a projector to check the actual state of a library shelf, allowing users to query for the presence of a book through a user interface and highlighting book spines by transforming image pixels to the corresponding points in the projector. But, two main constraints arrives with this approach if is intended to be applied in a real library context: (1) the system assumes that one single change event occur over a fixed time interval, and (2) it is a cost-prohibited application since a set of two cameras and a projector is needed for each side of a shelf. Therefore, rather than being helpful for libraries and its users is unpractical.

Another example of an augmented reality application for libraries could be found in the Institute of Computer Graphics library, where Umlauf et al. (2002), developed ARLib, a location-based application which aims to assist the user in searching and returning tasks for books through AR technology by attaching fiducial markers in shelfs and walls for their recognition [6]. Despite it provides a navigation system, their work relies on a notebook computer and a head-mounted display fitted with a 320×240 resolution camera making it unsuitable for real appliances in libraries with final users.

In contrast, a hand-held focused application for books recognition was developed by Chen et al. (2011), providing information about books stored within a bookshelf by snapping pictures of the books spines through a smartphone camera [5]. Their system relies in two main components: the mobile device which is mainly used for images acquisition and a server computer which process those images. On the mobile device, the motion of objects seen by the camera is analyzed to detect low motions periods, when users are more likely to be interested in a book. When a new interval of low motion period is detected, a photo is taken by the onboard camera and transmitted through Internet connection into a server, initiating a query request. Once on the server, the spines are segmented from the query frame, and are matched with a spine images database, and that matching is sent back to the mobile device providing thus augmented information of the books in the scene.

In matter of book spine recognition, Brinkman and Brinkman (2013), proposed ShelvAR, a shelf-reading system which involves adding 3/8" wide tags in books spines for optical tracking. ShelvAR reads the tags on a row of books and using 2D augmentations indicates to the user whether the books are in correct order or not by marking book spines with check-marks. If books are out of order, their system calculates the best way to rearrange the books, and marks those books that are needed to be placed in order [2]. With this approach, ShelvAR is more intended to library workers rather than being for students that uses libraries with research purposes.

With the work of Chen and Tsai (2011), the use of augmented reality with library purposes overcomes in a different issue with ARLIS. Rather than providing a shelf-reading system, their work focuses in library instruction for elementary school students [3] by developing an AR educational game, based on a situated learning theory. Since the same content was presented in every test, users learned the same instructions demonstrating that the performance of ARLIS was equivalent to the performance of the library staff in library instruction teaching. But, despite of the results, the experimental users group had to receive a 1-hour training session in order to learn how to use the AR system and which is more, the game relies on a computer system and a web-cam for its execution. These conditions obstruct its use in a wider library scope since every user needs to carry a not-so-portable computing device and with the fact that the time consumed for training could be used for actual library instruction.

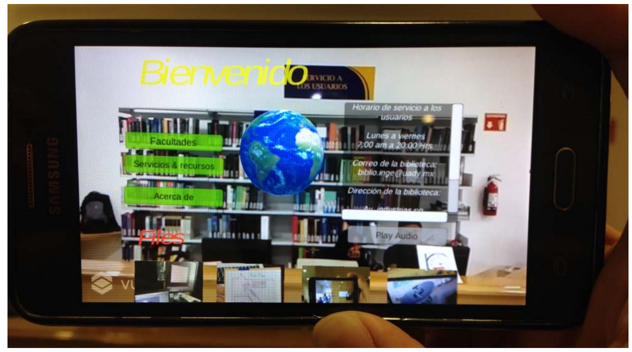

Figure 1: Overview of the user's interface in the main menu.

3 Designing an AR campus library system

Due to the technological advancements in miniaturization, and with the constant increase in power computing, mobile devices rate have growth in such a way in which hand-held devices could be thought for serious scientific applications. Bearing this in mind, for the development of a mobile AR system, the smart-phone market was chosen, since almost every EES library's user have at least one. The purpose of this AR campus library system is to assist students and newcomers, by improving their awareness in the library context, therefore, the main features of the application are: (1) deploy basic services information and main points of the EES library; (2) infer the users location utilizing an optical approach, relying on fiducial markers and natural feature tracking; (3) show the location of the main services and book shelfs of the library through the use of a 3D augmented reality indoor map; (4) inform about the campus faculties as well as main information of each one; (5) provide an AR shelf searching system (ARSSS) which enables users to navigate and search for material; and (6) show related information about the books stored in the shelfs, according to the call number range of each individual shelf.

In order to retrieve information of the real world, the application makes use of Unity3D engine with Qualcomm's Vuforia extension to process images of the environment in real-time. Vuforia is a free library for AR that allows to develop applications with cross-platform capabilities including both iOS and Android [8].

The system mainly depends on natural feature tracking for navigation and rendering of the virtual objects, however, artificial feature tracking is also used by adding fiducial markers onto the shelfs spines; the main purpose of adding this markers is to provide a users interface extension for the ARSSS. The use of a database stored in a server is not necessary since it could increase latency due to Internet connections, and users are most likely to need fast and accurate information; thus, the relatively small amount of data used is stored within the application. By doing this, processing of queries and augmentations results faster, leading to good users experiences.

When the onboard camera of the device is pointed to the EES library main entrance of the second floor, the main menu is deployed; here the services and faculties information could be found through different options in a user's friendly interface which allows interactivity as shown in Figure 1.

With this interface, "faculties", "resources and services" and

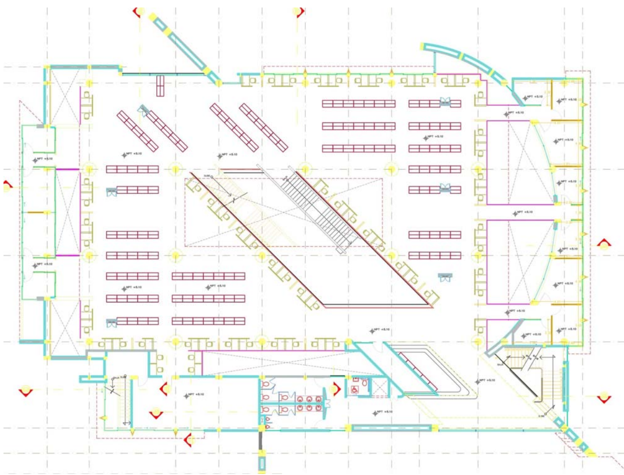

Figure 2: Floor plans of the library second floor.

an "about" options could be found in the main section as well as related library information like email, phone number, address, etc. In addition, the option "Play Audio" is deployed in which if selected, an audio file is played giving history and services facts of the EES library. On the other hand, if the "faculties" option is selected, the user is taken to another menu showing three main options, with each one corresponding to the faculties of the campus. Once an option is chosen, the interface allows users to see main information of the selected faculty such as careers, main authorities, emails, phone numbers, etc. And as an added option, an image gallery could be found showing augmented panoramic views of each faculty in the campus. But, in matter of actual awareness of the services and resources, its corresponding option allows users to retrieve useful information since a list of each service with its related information is given to more added detail.

3.1 The shelf searching system

To maximize performance while enhancing users experiences, the AR shelf searching system has two main purposes: to work as a mobile guide inside the library, and to assist users in books searching tasks. Therefore, ARSSS was designed to optimize both awareness and portability by dividing its core functionality in three main components: (1) a three-dimensional AR indoor map that highlights shelfs and regions of interest, (2) a navigation system that automatically identifies shelfs and main zones of the EES library in real-time, and (3) a searching engine that allows users to find their library items.

3.1.1 The 3D augmented reality indoor map

Through the use of AutoCAD software in conjunction with the Unity3D engine, it was possible to design and develop the virtual installations of the EES library second floor. In order to provide accuracy in showing the locations of shelfs and main points of the library, it was required a level of precision that only architectural floor plans could provide. Therefore, the modeling process begins with the virtual edification of the second floor in AutoCAD by using the original architectural floor plans and local real images for references of the installations. Figure 2 shows the installation floor plans of the library while Figure 3 presents an actual image of the real environment.

Once the virtual edification stage was completed, Unity3D engine was used for setting color materials and lighting application as well as the important task of programming users interaction. A sample of this process stage could be found in Figure 4, which shows a virtual

Figure 3: A reference photo used when modeling the 3D indoor map.

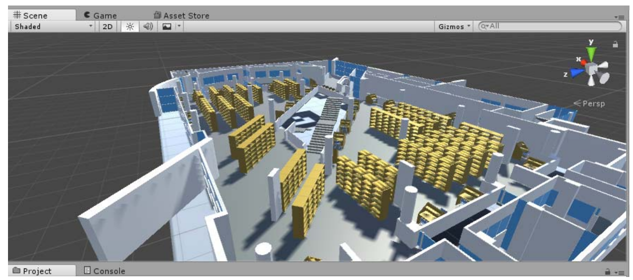

Figure 4: Unity3D engine allows the final steps of the augmented indoor map.

view of the EES library. For its deploying, a fiducial marker was placed near the main entrance.

3.1.2 The navigation system

The navigation system through the use of the onboard camera of the device, mainly depends on a natural feature tracking approach in order to automatically identify shelfs and main zones of the library. Since the indoor illumination of the library may be completely different from one hour to other (due to natural light from windows, or artificial light from lamps), the scene observed by the camera may vary, thus, for development of the navigation system, it was necessary to take 183 pictures under different light conditions of the library in order to create a reliable training database. Then, Vuforia was used to process images from the onboard camera in real-time allowing its detection through the training database previously created. With this approach, the system is capable of detecting the main zones and shelfs of the EES library without necessity of being closer, just by pointing the device camera to a zone in order to identify it, as shown in Figures 5 and 6.

3.1.3 The searching engine

Nothing of this work is useful if the users still having to search material by their own, allowing space for library anxiety since the EES library collection is in constant expansion. Therefore, ARSSS relies on a searching engine that aids users to find content of their interest. For its development, an AR keyboard was designed to meet users requests by handling the classification ranges of the shelfs. When the user types the call number of a book, the system actively searches for shelfs matches. If the book is in the scope of a shelf, then the system, in combination with the 3D augmented indoor map, presents information about where the shelf is located, as shown in Figure 7.

Since this searching engine was created to aid users in actual

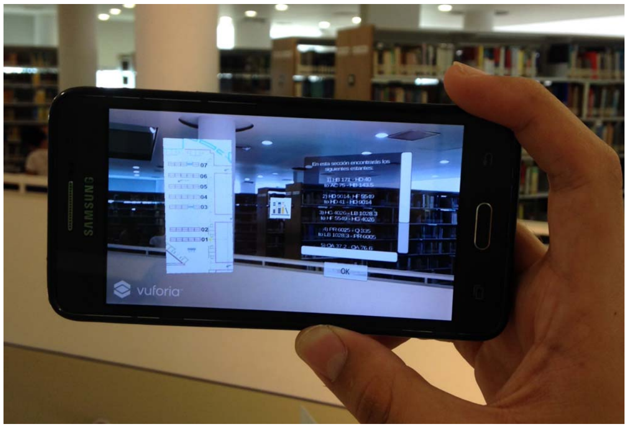

Figure 5: ARSSS detecting a shelf section and showing related information.

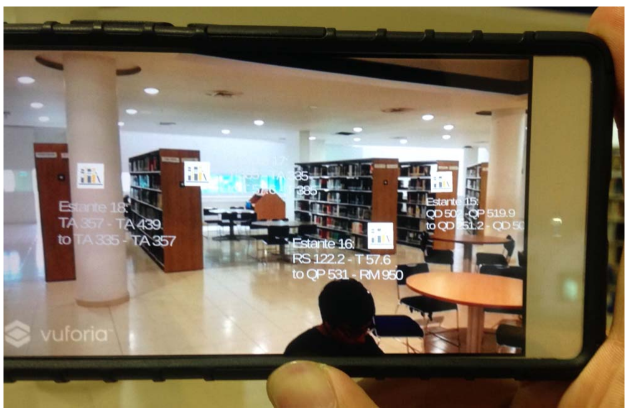

Figure 6: Some shelfs are in the camera's field of view, thus, ARSSS deployed its books call number ranges.

searching tasks, will be a drown in mobility if users needs to go each time to the main entrance for initiate a query in the augmented map; thus, in every shelf spine, a fiducial marker was placed in order to serves as an extension of ARSSS. By doing this, users could point the camera device to a marker, and find the searching engine as well as an option to see the related content of the books stored within the shelfs according to their classification.

4 Experiment design and results

In this study, an empirical evaluation was made on a sample of final users for whom the application was created. Therefore, the user profile for the experiment mainly consists on students and newcomers of the EES library. In order to test the system, 30 participants were recruited and asked to look for three specific books in the library with the augmented reality system, and to barely describe some library services that they did not know before the experiment. Figure 8 shows a student using ARSSS on a shelf while doing the experiment. After each participant has completed the test, a questionnaire was applied to assess the AR system. The questionnaire was designed with seven propositions in a five-points Likert scale, organized to evaluate the effectiveness of the user, functionality of the application and users preferences. In order to evaluate the results, Likert items such as Totally Agree (TA), Agree (A), Neutral (N), Disagree (DS) and Totally Disagree (TDS) were used with a score that ranges from 5 (for TA) to 1 (for TDS). The

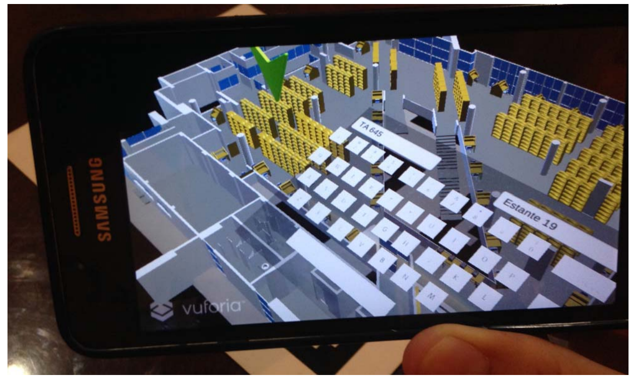

Figure 7: The AR keyboard deployed with the 3D indoor map; in green, an arrow shows the location of the shelf that matched the search.

propositions used were the following:

(1) *It is easy to use.*

(2) *I would surely use again the system for books searchings.*

(3) *I would recommend the program to other users.*

(4) *The AR content presented in the application was useful.*

(5) *Level of satisfaction.*

(6) *Awakes on me the interest in AR technology.*

(7) *The system eased information for expedite books searchings.*

From the 30 participants, a summarization of the provided answers with its corresponding distributions for each proposition is shown in Table 1; where ”Prop.” stands for proposition and ”SD” stands for standard deviation.

Prop.	TA	A	N	DS	TDS	Mean	SD
1	11	13	5	1	0	4.1	0.8
2	19	10	1	0	0	4.6	0.5
3	21	9	0	0	0	4.7	0.4
4	13	17	0	0	0	4.4	0.5
5	12	17	1	0	0	4.3	0.5
6	22	6	2	0	0	4.7	0.6
7	15	15	0	0	0	4.5	0.5

Table 1. The responses distributions of the five-points Likert data acquired from the 30 participants in the pilot study.

A further analysis on the data of the experiment, suggests the main following results: (1) Most of the users (97%) declared that they surely would use the system again for books searchings; (2) 80% of the participants finds the application easy to use; and (3), all the participants (100%) agree that the augmented content of the application was useful for their library awareness.

5 Conclusions and future work

The AR application developed in this study, brings back the opportunity to solve problems related with library anxiety by combining augmented reality technology and ubiquitous computing in a system that remains useful and portable. This seamless integration is truly unique, since it encourages the use of AR to improve awareness to the users in a library context. After the evaluation of the system was done, it was concluded that it successfully faces problems, such as spatial unawareness and unknown library services, that most newcomers and regular users could have when using the library with research purposes.

As future work, the author wants to implement the online database system of the EES library in order to determine whether the books are available or not; as well as to develop a recommendation system for users according to their careers, this with the belief that if the

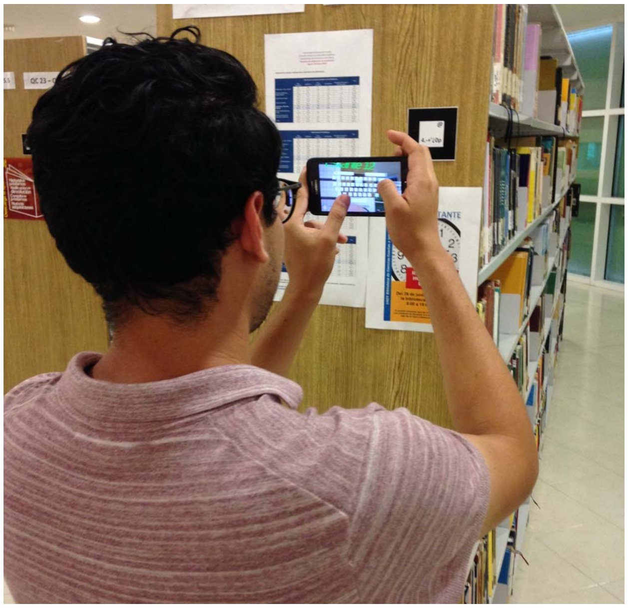

Figure 8: A participant during the experiment. In front of him, a shelf with a fiducial marker is used as an extension of ARSSS.

promise of a mixed reality world is made with aim to enhanced library user experiences, then this could lead to major advancements in the way we use libraries, allowing to create a more powerful and efficiently library environment than ever.

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