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Mobile Campus Touring System based on AR and GPS: a Case Study of Campus Cultural Activity

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Abstract: Campus cultural activity is usually propagandized through the Internet, pamphlets and posters. Print media draws more attention in public, but is not environmentally-friendly and economical. Similarly, Internet media is known for its prompt and rich content, but is hardly expected to arouse the interest of learners since it separates information from real-life environment. Augmented reality (AR), a promising technology of bridging virtual and real worlds, has been considered as a better choice for realizing an interactive and boundary-less mobile learning environment, or an even more advanced ubiquitous learning environment based on context-aware technology. In this paper, a novel campus touring system for cultural activity is implemented based on AR technology and smart phones which contains the built-in GPS, camera, WiFi and digital compass. Wikitude, a mobile AR implementation tool, is used for system implementation. Furthermore, two groups of students have been selected for system testing and evaluation. Experimental datum are collected and summarized via an open-ended online questionnaire. Experimental result shows that propagandizing and learning campus cultural activity through this mobile campus touring system is a more satisfying and interactive approach for college and university students.

Keywords: Augmented reality, ubiquitous learning, campus touring system

1. Introduction

The rapid growth of wireless and mobile technologies has attracted attention of researchers in educational technology. Due to the advances in wireless technology and mobile devices, like smart phones and other handheld devices, students can start learning without any limitations of time and space. Numerous studies have investigated the effect of mobile learning (m-learning) as a complementary teaching technique in outdoor learning activities, and proofed its effectiveness in practice (Chin & Chen, 2013).

Recent progress on mobile hardware technology makes it possible to achieve the ubiquitous learning (u-learning) environment. Compared with m-learning, u-learning is a higher level of e-learning. This new kind of learning environment can provide an interoperable, pervasive, interactive, and seamless learning architecture to integrate, connect, and share learning resources among appropriate identities (Huang, Chiu, Liu, & Chen, 2011). Up to now, smart phone does appear to be a more maturing platform to support u-learning environment: the built-in GPS and digital compass sensor can guide students where they are and which directions they are heading to, the camera and multi-touch screen are well designed for observing real-life environment and manipulating digital information gained from the Internet. By means of augmented reality, all digital information will be integrated with the real-time image on the multi-touch screen, and users can operate them easily with a couple of finger-clicks.

Campus cultural activity is a common form of informal learning for college and university students. Nowadays, traditional print media and modern Internet media are two most frequently-used approaches for activity propagandism. Print media, like posters and pamphlets, can be put up and handed out anywhere on campus conveniently; the well-designed content can easily arouse students' attention and leave audience an indelible impression. However, the production cost of print media is high, and when the activity is over, outdated posters and pamphlets may also cause environment pollution. In contrast with print media, Internet media is environmentally-friendly and prompt, whereas it seems not that natural and convenient to search information by typing keywords. As a result of breaking down the connection between digital information and meaningful context, Internet media makes students cause confusion in a mass of information.

In this paper, we implement a mobile campus touring system based on Augmented Reality and GPS technology, which contributes to the application of innovative technologies in an informal learning situation to propagandize campus cultural activities.

2. Related Works

2.1 Situated Learning

According to situated learning theory(Lave & Wenger, 1991), knowledge acquired in the context of real life is more practically applicable to problem solving in reality, maximizing the effects than the one gained through direct teaching (Kim, Park, & Lee, 2011). In other words, meaningful learning is deeply rooted in relating real-life context; there is no sense in learning without practical situation. As can be seen, situated learning theory emphasizes two important learning principles: one is integrating learning with actual practicing in meaningful context; the other is learning collaboratively and socially by face-to-face communications or social network tools. At present, formal learning is commonly limited in classrooms; students cannot experience the pleasure of knowledge application, let alone apply knowledge flexibly to solve everyday problems.

Currently, the functions of smart phone can basically support situated learning in following ways: wireless network enables any learner to search and download any learning material anytime and anywhere; portable size and extensible storing space make it possible to carry and record individual learning progress in detail; abundant mobile apps afford different learning materials and methods to learners of different learning styles. However, most of the content in existing mobile learning software has no relationship with learner's real location and context. That is to say, a completely virtual learning environment implemented by flash or video is designed for learners, which doesn't fit the requirements of situated learning theory. Therefore, a different kind of mobile learning software based on the theory of situated learning is totally in need.

2.2 Mobile Augmented Reality

Augmented Reality technology helps us combine physical world with the virtual world seamlessly. Without replacing the real world, this technology augments virtual information on top of the real world with continuous and implicit user control of the point of view and interactivity (Kesim & Ozarslan, 2012). The coexistence of virtual objects and the physical environment allows learners to visualize abstract concepts and experience phenomena that are impossible or dangerous in the real world (Arvanitis et al., 2009; Klopfer & Squire, 2008).

Two main devices for displaying Augmented Reality are recorded in the history of development. Head-mounted display (HMD) is the first display device utilized for creating an AR environment. Users should wear a special helmet on their head, and then HMD displays images of both the physical world and virtual objects over the user's field of vision. With the rapid development of handheld computing, mobile Augmented Reality (mobile AR) technology begins to emerge. The mobility offered by handheld devices would leverage the authenticity of a learning environment and increase learner's interaction with others (Klopfer & Sheldon, 2010). In addition, mobile devices with built-in location sensor (e.g., Global Positioning System [GPS]), having the ability of obtaining learner's accurate location and environment information in real time, could assist mobile learning softwares in estimating and sending the most suitable resources automatically and adaptively.

Mobile Augmented Reality provides unique user experience in information accessing. Searching through smart phone's built-in camera instead of typing keywords in the input box has totally reformed the customary way of human-computer interaction. Researchers and developers focused on mobile education have already paid close attention to these amazing features of mobile AR technology. Therefore, a growing number of studies and applications on mobile AR have come out, and numerous open-source software development kits on mobile AR are available on the Internet.

In order to validate the real effect of mobile AR-based learning, Parhizkar et al.(2012) in LIMKOKWING University design and develop a mobile phone augmented reality application and multimedia application on Android OS platform for general science studies of primary school syllabus. Santana-Mancilla et al. (2012) at the University of Colima propose a mobile augmented reality system that allows Mexican secondary education students to access additional informative contents related to their textbook. Chou and ChanLin (2012) implement a prototype campus touring system for Fu-Jen Catholic University, which provides hidden information to help freshmen get acquainted with campus through mobile AR on smart phones. Liu and Tsai (2013) in Kainan University develop AR-based mobile learning material installed on mobile phones, which enable students to access information about scenic spots nearby, so that they can learn about buildings/places/views of interest in English. It is encouraging that all the studies above verified the effectiveness of mobile AR technology in educational practices.

All in all, mobile AR technology certainly creates a promising opportunity in situated learning, and applications in most of related studies get satisfying results. However, there is more research paying attention to the mobile AR-based applications in indoor learning, only a few studies focus on outdoor learning, for instance, AR-based campus touring system for freshmen. Therefore, more case studies on outdoor learning could be performed and beneficiaries of mobile AR-based learning system could be enlarged, not just focused on freshmen. In consequence, this study has been conducted to explore the effectiveness of mobile AR technology on outdoor learning applications for students except for freshmen.

3. System Implementation

3.1 Overview

The aim of our research is to design and implement a mobile AR-based campus touring system for cultural activity in Beijing Normal University. In addition, system evaluation was carried out among 17 student participants, and user feedback was collected by using an online questionnaire.

3.1.1 System Architecture

The whole system contains two parts: a mobile client app on Android OS platform and a remote data server. Wireless Network is the only connection between client and server. After submitting a request from a client, the server will receive and respond this request and return the processing results to client. The system architecture is shown as follows (Figure 1).

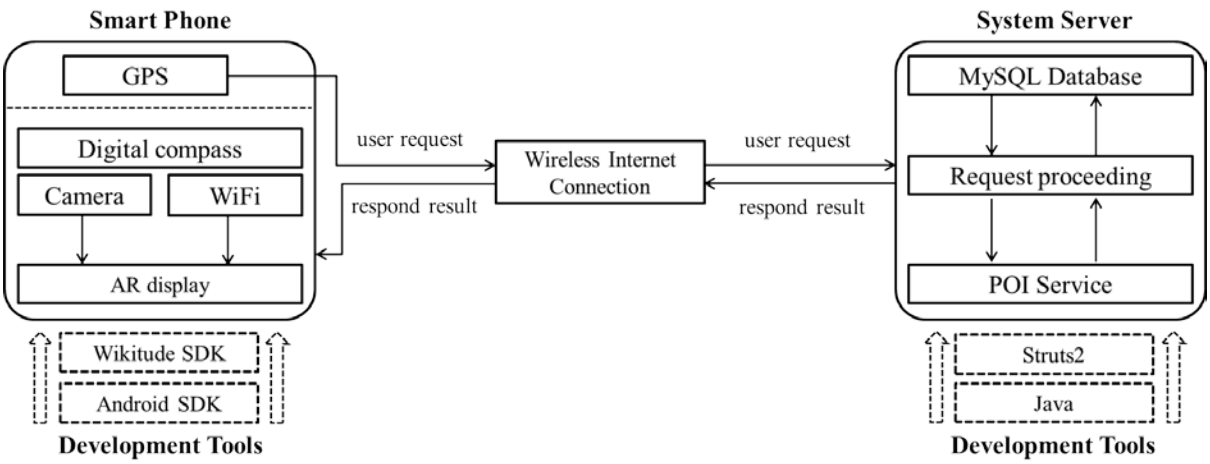

Figure 29. System Architecture.

3.1.2 Available Functions

The mobile client app mainly consists of two systems: mobile AR Displaying system and auxiliary collaboration system.

As for AR Displaying system, location-based virtual learning information combined with real-time images will display on the muti-touch screen, users could click the information they are interested in and start to learn in detail immediately.

While AR Displaying system makes up the primary function of a mobile client app, the functions in auxiliary collaboration system, such as making comments, following activities of interest and rating activities, help make this app a collaborative learning environment instead of noncooperative one. Users can not only learn outdoors by themselves, but they can also exchange ideas on some cultural activity with other students who have the same interest.

The functions of this mobile client app are shown as follows (Figure 2).

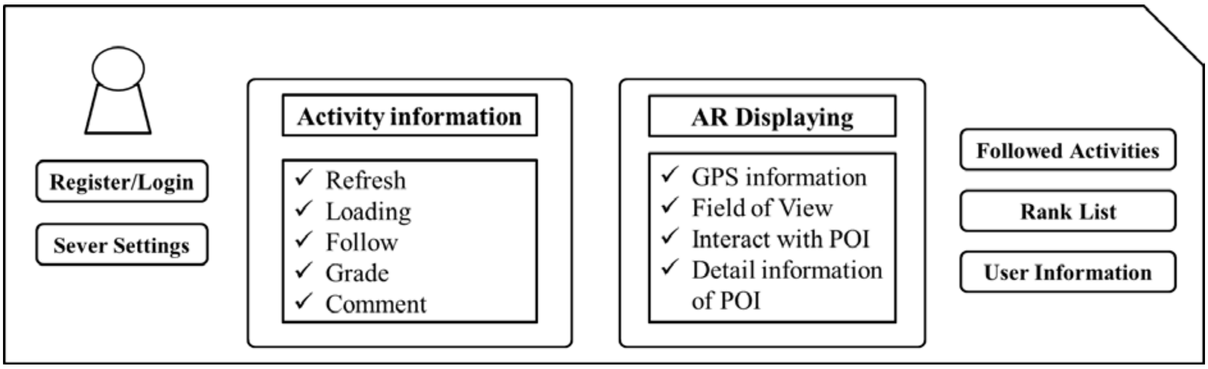

Figure 30. The Functions of Mobile Client App.

3.2 Implementation

3.2.1 Technologies and Tools

Different parts of this system are implemented with different technologies. Mobile client app was developed using the Eclipse platform based on Java JDK, Android SDK and Wikitude SDK. Wikitude SDK is a freeware tool which assists developers in creating mobile AR environment or applications in an easy way. Founded in the fall of 2008, Wikitude is widely used on various mobile OS platforms, such as iOS, Android, BlackBerry and Windows Phone; lots of development examples and discussions can be found through the official website (http://www.wikitude.com). The AR Displaying system follows the Wikitude's architecture, providing virtual objects based on GPS and multiple interactions with the virtual-real learning environment.

Apache Struts2 development framework is used for the remote data server, and MySQL database server was chosen for its free and easy-to-use features. HTTP protocol and JSON transmission format are the common data communication pattern between client and server. Table 1 shows the overall requirements needed to develop this mobile AR-based campus touring system on cultural activity.

Table 15: Requirements for System Implementation.

Client OS	Android 2.3+
Client Language	Java JDK, Android SDK, Wikitude SDK
Mobile Device	Android Smart Phone
Server Database	MySQL
Server Structure	Struts2
Data Communication	HTTP protocol and JSON transmission format

3.2.2 User Interfaces

Beside the development tools mentioned above, Adobe Photoshop is used to design user interfaces of the mobile client app, and Google Earth is selected to construct Point of Interest (POI) information in Beijing Normal University (BNU).

In Figure 3, after launching AR Displaying system, GPS information will be accessed immediately and then POI information will be loaded relative to user's location. At this time, when a user points the smart phone to the library, a virtual object which represents the library will be supplemented on the screen. After that, the user could click this virtual object and get more detailed activity information of library for learning.

Figure 4 shows the captured images of the auxiliary collaboration system, including login, activity information list, submitting a comment and user's followed activities on the smart phone screen.

(a) Get GPS Information (b) Load Virtual POI Objects (c) Show Activity List Panel (d) Detailed Activity Information

Figure 31. AR and GPS based activity information module.

(a) Login (b) Activity Information List (c) Submit a Comment (d) User's Followed Activities

Figure 32. Captured images on the smartphone screen.

The mobile AR Displaying system and auxiliary collaboration system work together to produce a better user experience. AR Displaying system aims at supporting outdoor learning, while auxiliary collaboration system is necessarily designed to record the learner's individual data and learning history, which plays an important role in social collaborating.

4. Evaluation & Feedbacks

To measure the effectiveness of this proposed system, a small sample of students in BNU was chosen for a system evaluation. The purpose of this survey is to determine whether this system could facilitate the effectiveness and usability of cultural activity propagandism and learning on campus, compared with traditional medias, such as print or Internet media. Online open-ended questionnaire is utilized for data collection.

4.1 Test Design

4.1.1 Participants

17 random-chosen participants from School of Educational Technology in BNU are invited for this system evaluation.

4.1.2 Methodogies

Participants are divided into two groups, named Group 1 and Group 2. The former consists of 8 students, while the latter consists of 9 students. In particular, none of these participants is freshman. Two different preprocessors were applied in Group 1 and Group 2 respectively. As for Group 1, the participants were told with the background of system development and were trained to interact with the mobile client app. On the contrary, participants in Group 2 haven't received any related operation instructions or supplementary material on this system at all.

Table 16: The Differences between Group 1 and Group 2.

	Group 1	Group 2
Participant	9 students	8 students
Preprocessor	1. told the background of system development 2. trained in operation instructions	none

The evaluation session followed the preprocessing, and lasted one day. At the end of evaluation, all participants in both Group 1 and Group 2 completed the open-end questionnaire online.

The survey includes questions about essential personal information, objective questions on system effectiveness and usability, and subjective questions. Essential personal information gets us to know the general experience and habits of current students. Objective questions allow users to compare this system with traditional medias they used before and thus to validate the actual effect and usability. As for subjective questions, participants are encouraged to give their own suggestions, benefits and limitations, regarding this system.

Validations for effectiveness and usability are executed separately in this test. As for the effectiveness, we analyze the objective questions statistics on effectiveness part respectively in two groups; if there are more participants in both groups agree that this system is more effective than traditional medias, it will prove the effectiveness of this system by default. For the usability, we compare the objective questions statistics on usability part between two groups; if there is no significant difference there, it will verify the usability of this system, vice versa.

4.2 Results and Analysis

4.2.1 General Background of Participants

Four prominent trends among current college and university students are concluded as follows:

- With the construction of the campus wireless network, accessing Internet resources through smart phone is generally accepted by more and more students.
- An overwhelming majority of participants in both Group 1 and Group 2 consider it necessary to get informed of campus cultural activity information.
- Most of them regard both print media and Internet media as the most effective and efficient approach in cultural activity propagandism and learning.
- Few participants know augmented reality, let alone mobile AR technology.

4.2.2 Differences in Two groups

For the purpose of determining the differences between the proposed mobile AR-based system and conventional media, Likert rating scale (strongly disagree, disagree, neutral, agree and strongly agree) is applied to each assessment question.

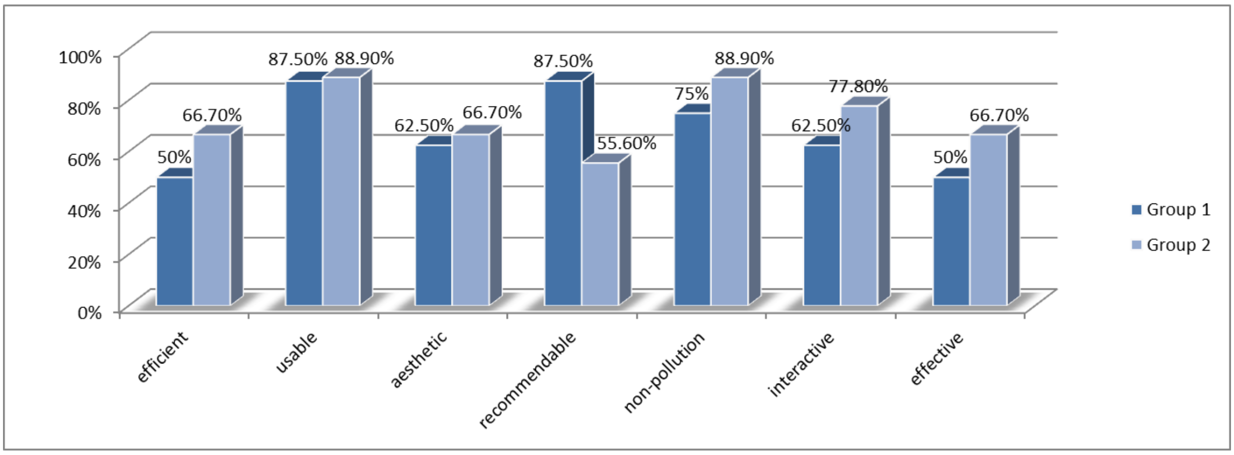

Figure 33. The Agreement rate of User Experience between Two groups.

As showed in Figure 6, we can draw three conclusions as follows:

- It is encouraging that more than half of participants in each group agreed that the proposed system was better than conventional media in all seven aspects.
- The attitudes towards usable, aesthetic and non-pollution questions were close in both groups.
- Significant differences on efficient, recommendable, interactive and effective questions reflected some imperfection in this system.

4.2.3 Causes Analysis

Different preprocessors could be the primary cause of different results in Group 1 and Group 2. Lacking of fundamental operation instructions on the mobile client app, participants in Group 2 have to spend more time than Group 1 in learning basic operations on their own, which could make the participants with little patience feel awkward after several trying-outs. Therefore, more participants in Group 2 consider that the app is not that recommendable. As for Group 1, thorough training before evaluation may weaken their curiosity of this system, so the attitude towards efficient, interactive and effective questions would decrease a little, correspondingly.

4.3 Feedback and Suggestions

4.3.1 Feedback

Mobile AR-based context-aware outdoor learning is strongly welcomed by most of participants. With virtual objects added on top of the physical environment, real-life context is beyond what we can see and touch. Hidden virtual contextual information arouses learner’s interests to explore the mysteries in the campus environment. It brings students an amazing experience in learning more about cultural activities outdoors.

Natural interaction with AR Displaying interface gives students a more convenient and timely assistance. Participants surely confirm that searching by pointing smart phone's camera to real destination is more user-friendly than typing keywords in the search menu which requires higher logical thinking to abstract the correct descriptive keywords from specific entities such as buildings and places. What's more, a quick and visualized information retrieving process makes assistances timely and easy to understand.

Social collaboration tools play an important role in supporting the context-aware outdoor learning. Participants complain about loneliness in previous outdoor learning experience, and appreciate that it definitely facilitates the effect of contextual learning by sharing and communicating cultural activity information online.

4.3.2 Suggestions

- Social collaboration capabilities should be further enhanced. Participants recommend that inheriting some frequently-used collaboration tools in existing apps could be a fast way to improve user experience of cooperating.
- Limited hot spot coverage and weak GPS signal make participants feel frustrated. Free WiFi and GPS signal are two crucial issues in the use of this campus touring system. Either inaccurate location information or inaccessible Internet connection could decrease the effect of utilizing.

5. Conclusion

In this study, a novel campus touring system for cultural activity propagandism and learning has been designed and implemented. Using advanced mobile AR technology and modern situated learning theory, the proposed system can support context-aware outdoor informal learning in some degree. With the help of smart phones' built-in camera and GPS, visualized interactions with virtual objects in the physical environment ensure the effectiveness and efficiency of context-aware outdoor learning, which was concluded from positive feedback in the system evaluation.

In order to improve the evaluation effect, three suggestions need to be conducted in the subsequent studies. First, in order to ensure the convenience and timeliness of user experience, alternative access should be taken into account in broken WiFi and GPS signal situations. Second, the effect of mobile AR-based situated learning could be optimized by better social collaborating designs. Third, participants should not be limited to only freshmen students, and more case studies should be performed by students with the experience of AR.

Acknowledgements

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