A Study on the Design of Augmented Reality User Interfaces for Mobile Learning Systems in Heritage Temples

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Abstract. In order to reduce switching attention and increase the performance and pleasure of mobile learning in heritage temples, the objective of this research was to employ the technology of Augmented Reality (AR) on the user interfaces of mobile devices. Based on field study and literature review, three user interface prototypes were constructed. They both offered two service modes but differed in the location of navigation bars and text display approaches. The results of experiment showed that users preferred animated and interactive virtual objects or characters with sound effects. In addition, transparent background of images and text message boxes were better. The superimposed information should not cover more than thirty percents of the screen so that users could still see the background clearly.

Keywords: Mobile Learning, User Interface Design, Augmented Reality.

1 Introduction

With the advent of wireless network technologies, some heritage temples had begun to provide mobile devices for navigation and mobile learning. However, when visitors used the mobile device, their attention was divided into three parts, i.e., the environment, the user interface and digital contents on the devices, and other participants. Divided and distracted attentions reduced the usability and pleasure in using such systems. In order to reduce switching attention and increase the performance and pleasure of mobile learning, the objective of this research was to employ the technology of Augmented Reality (AR) on the user interfaces of mobile devices. With such user interfaces, the image and information can be superimposed on the background. Visitors could experience the rebuilt 3D images while some cultural heritage was damaged in the temples as well.

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2 Literature Review

Recently, AR technology had been applied in mobile devices successfully. Henrysson et al. (2005) constructed a system in which 3D content could be manipulated using both the movement of a camera tracked mobile phone and a traditional button interface as input for transformations. Liarokapis et al. (2006) developed the augmented reality interface that uses computer vision techniques to capture patterns from the real environment and overlay additional way-finding information, aligned with real imagery, in real-time. Liu et al. (2007) integrated the 2D barcodes, the Internet, augmented reality, mobile computing and database technologies to construct a mobile English learning system. Tarumi et al. (2008) developed a virtual time machine for edutainment on commercially available mobile phones. Their system displayed graphical images of a past scene within a given area, viewing from the location given by GPS and with arbitrary viewing angles. Users could virtually explore the past world with it. Schmalstieg and Wagner (2007) implemented a client-server architecture for multi-user applications and a game engine for location based museum games. After reviewing a great deal of existing AR systems for cultural heritage and museum guides, Damala et al. (2007) concluded that trying to make abstraction of the technological constraints is of paramount importance for the development of Augmented Reality applications

3 Field Study

The authors first conducted a field study through observing the tourists' behaviors in a heritage temple, Lungshan Temple, located in Taipei. In addition, the authors interviewed some tourists and temple administrators to elicit the requirements of user interface design for mobile learning. This temple was founded in 1738 and dedicated

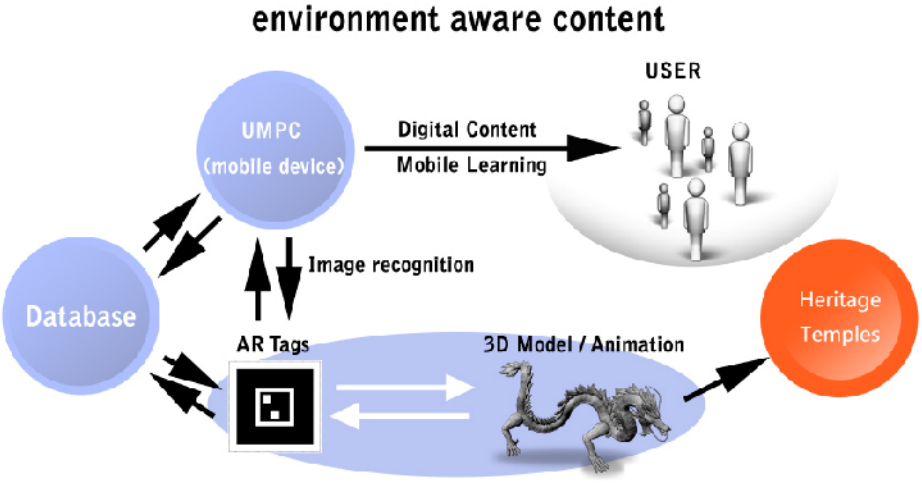

Fig. 1. System operating architecture

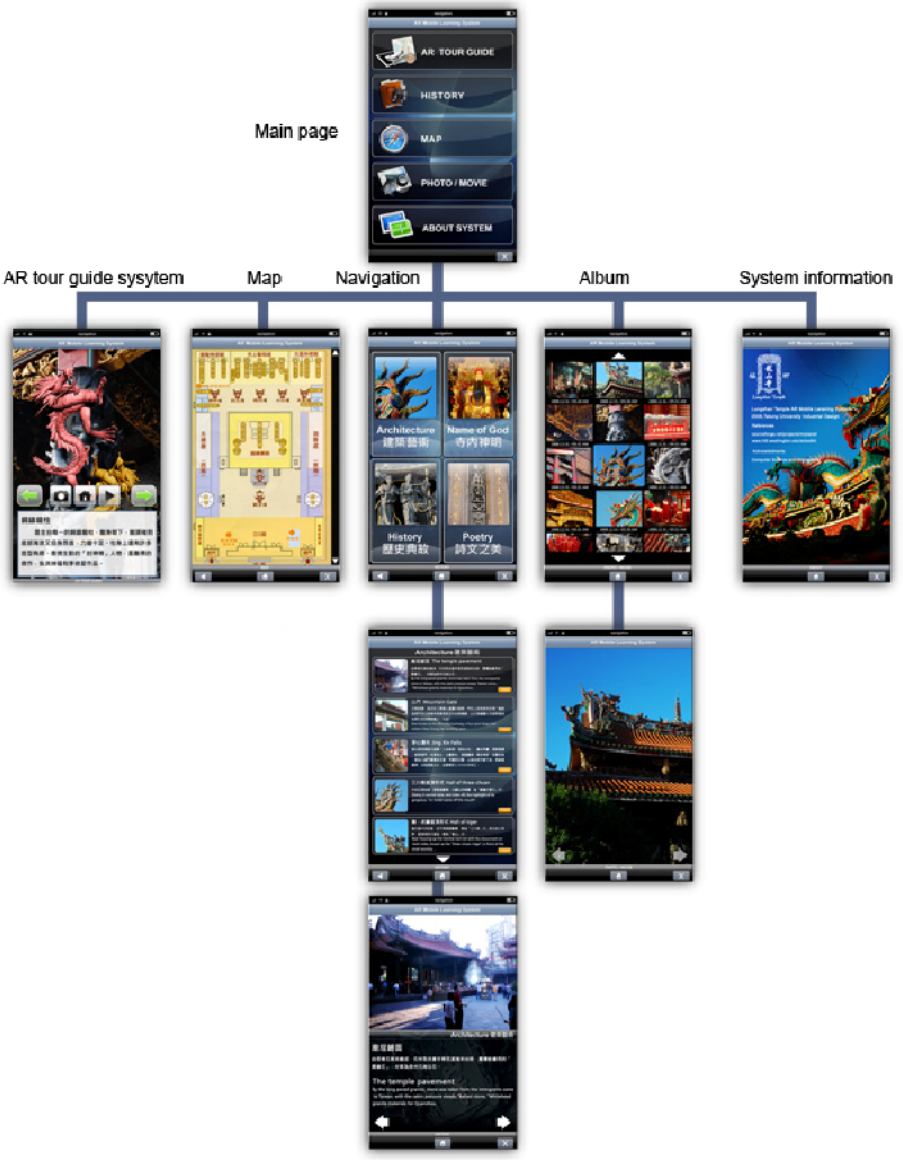

Fig. 2. The proposed mobile learning services

to the Buddhist Goddess of Mercy. It was famous for its magnificent architectural ornaments, such as Taiwan's only copper-cast dragon column. The temple's doors, beams and poles were beautifully decorated with auspicious animals (such as dragon, phoenix, and unicorn) and the sculpture of folktales.

Fig. 3. A scenario with an augmented 3D dragon

Fig. 4. The screen shots of UI soncept 1

4 System Implementation

Based on the results of observation and interview, a user interface prototype was built on a Ultra Mobile PC (UMPC) with a 5.6 inch touch-screen and physical keyboards. Since the prototype weighed 600g, it should be held using both hands or carried by a dispatch bag. With this ergonomically designed bag, the tourists were able to enjoy the journey without worrying about how to carry it while walking in the crowded temple. Tourists could use the camera to capture the image of marks located near the spots with heritage features. The media introducing the heritage features would show up to provide augmented information superimposed on the corresponding background. In the media, animated characters or creatures in the folktales were re-built to deliver the story of the ancient. These contents help tourists understand the history and traditional culture of Taiwan. The user interface of Augmented Reality system was constructed based on ARToolKit and user interface widgets. The 3D digital skeleton models of characters and animals were created using Maya 8.5. Real-time rendering of these models were executed and displayed using graphic modules. In addition to the story contents, virtual direction arrows and landmarks were provided at each spot to help visitors navigate in the temple. Figure 1 demonstrated the system operating architecture. Figure 2 displayed the proposed services of a mobile learning system. The scenario with an augmented 3D dragon was presented in Figure 3.

Based on this architecture, three prototypes of user interfaces were constructed. They both offered two service modes but differed in the location of navigation bars and text display approaches. The first prototype superimposed digital images on the background and contained a navigation bar at the middle of the screen and a semi-transparent text message box at the bottom of the screen (Figure 4). Visitors could

Fig. 5. The screen shots of UI concept 2

Fig. 6. The screen shots of UI concept 3

switch between two services that had contents either relevant to the components of physical objects in the temple (left) or virtual characters that are cute versions of representative gods in the temple (right). Compared to the first prototype, the second prototype increased the percentage of transparency for the text box and displayed text in white color. In addition, the navigation bar was placed at the bottom of the page (Figure 5). In the third UI prototypes (Figure 6), the screen was divided into two windows. Furthermore, the background of the text message box was not transparent.

5 System Evaluation and Results

In order to test the advantages and disadvantages of proposed systems, ten students were invited to participate in the experiment of prototypes. During the experiments, video recording and audio recording were used to record the behaviors of participants. Interviews and post-test questionnaire surveys were used to obtain the opinions of participants after performing typical tasks. These tasks included locating some historical spots and reading the information through augmented contents. The results of experiments showed that, in general, the participants appreciated the new paradigm of interaction. Some participants indicated that locating marks and retrieving information through camera was intuitive. In addition, the connections between physical objects of the temple architecture and their detailed information were increased due to co-presence within a single screen at the same time. Furthermore, they could use the function of print screen to capture the image of superimposition. Some participants even creatively extended this function by asking their friends to stand aside the mark so that the background, the people, and the augmented contents appeared in the same picture, thus increasing the pleasure of visiting.

Table 1. Comments of two service contents

Comments	Virtual Objects	Virtual Characters
Advantages	Increase the immersion of visiting; Vivid and attractiveness; It's like a magic for kids	Cute and user friendly; The god characters had strong connectivity to the temple and the culture
Disadvantages	Large objects interfered the background; Difficult to distinguish physical and virtual objects; Serious and not user friendly	Proportion of virtual characters were too big; The form is too complicated; Lack of dynamic actions
Recommendation in Content Design	Cartoon version is more accessible; Decrease the proportion of objects; Increase the dynamic actions of objects; Enhance the connection between objects and text descriptions; Simple the form of objects	Add some dynamic actions to the characters; Two characters interact to each other; Make character interactive with users; Add sounds to enhance impression

Table 2. Comments of three UI concepts

Comments	Concept 1	Concept 2	Concept 3
Advantages	Icons are easy to be recognized; Color of text is legible	Text is clear and legible; Information is transparent; High quality	Color contrast of text is good; Option is clear
Disadvantages	Font is too small; Too many blocks; Big icons may cover background	Font is too small; The proportion of the text box is too big; Icons are too small to be overlooked	Font is too small; Too many menu icons; The proportion of the text box is too big;
Recommendation in UI Design	Place icons into the text box; Increase the font of text	Change the location of icons; Increase the size of icons	Make text box smaller and transparent; Reduce the number of icons

The comments about two services provided by participants were presented in Tables 1. Their recommendations were summarized as follows:

1. The size of virtual objects should be limited to prevent coverage of background
2. Cute style and simple characters were more user-friendly
3. Animated objects were better
4. Sound effects and interactive virtual characters could increase the impression

The comments about two services provided by participants were presented in Tables 2. Their recommendations were summarized as follows:

1. Transparent background of virtual objects and text message boxes were better
2. Increase the size of font
3. Increase the size of menu
4. The proportion of text message boxes should be less than one-third of the screen

The ratings of performances among three UI concepts were showed in Table 3. Concepts 1 and 2 had higher ratings than concept 3. Separated screens and solid background color hampered the navigation and increase the perceived workload of participants.

Table 3. The mean and standard deviation of performance ratings for different UI concepts

Performance Measures	Concept 1	Concept 2	Concept 3
Navigation Aids	5.67(1.12)	5.78(0.83)	3.67(0.87)
Perceived Workload	2.22(0.67)	3.00(1.12)	4.44(0.73)

6 Discussion

Although the first attempt was successful, the participants still encounter some problems of carrying such a big device. For example, tourists always had their backpack or carried cameras. The dispatch bag of the device sometimes interfered with their personal equipment. In addition, even though the augmented contents were able to deliver virtual objects superimposed on the background, the shape and texture of these objects were still rough compared to the beauty of the temple architecture. The mark recognition process was too sensitive so that some users had difficulties in finding the right angle between the camera and the mark. Furthermore, the color contrast of the virtual foreground and the physical background were influenced significantly by the glare of light.

7 Conclusion and Future Work

The results of experiment showed that user prefer animated virtual objects or characters with sound effects. In addition, transparent background of images and text

message boxes were better. The superimposed information should not cover more than fifty percents of the screen so that users could still see the background clearly.

Based on these findings, the research team had identified specific fields for further research to leverage between limited resources on current mobile devices and the design of user interfaces based on AR. First, the location and setup of marks deserve further experiments to avoid the influence of peripheral lighting. Second, the devices and algorithms for mark recognition need to be improved. Third, specific algorithms for real-time rendering of 3D models for AR should be developed. Fourth, the mapping of touch gestures and dynamics of content display should be addressed.

Acknowledgments

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References

1. Damala, A., Marchal, I., Houlier, M.: Merging Augmented Reality Based Features in Mobile Multimedia Museum Guides. In: Proceedings of the XXI International CIPA Symposium, Athens, Greece, October 1-6 (2007)
2. Henrysson, A., Ollila, M., Billinghurst, M.: Mobile phone based AR scene assembly. In: Proceedings of the 4th international conference on Mobile and ubiquitous multimedia, Christchurch, New Zealand, pp. 95–102 (2005)
3. Liarokapis, F., Brujic-Okretic, V., Papakonstantinou, S.: Exploring Urban Environments using Virtual and Augmented Reality. Journal of Virtual Reality and Broadcasting, GRAPP 2006 Special Issue 3(5), 1–13 (2006)
4. Liu, T.Y., Tan, T.H., Chu, Y.L.: 2D Barcode and Augmented Reality Supported English Learning System. In: Proceedings of the 6th IEEE/ACIS International Conference on Computer and Information Science, Melbourne, Australia, July 2007, pp. 5–10 (2007)
5. Schmalstieg, D., Wagner, D.: Experiences with Handheld Augmented Reality. In: Proceedings of the 6th IEEE and ACM International Symposium on Mixed and Augmented Reality, ISMAR 2007, November 13-16, 2007, pp. 3–18 (2007)
6. Tarumi, H., Yamada, K., Daikoku, T., Kusunoki, F., Inagaki, S., Takenaka, M., Hayashi, T., Yano, M.: Design and Evaluation of a Virtual Mobile Time Machine in Education. In: Proceedings of the International Conference on Advances in Computer Entertainment Technology, pp. 334–337. ACM, Japan (2008)