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Mobile Commerce System Integrated with Augmented Reality and Interactive Multimedia

Abstract. *This study takes mobile devices as platforms, developing a mobile commerce display system of integrated augmented reality (AR) and interactive multimedia. Through AR technology, virtual products are added to real life of users. The experiment constructed two operation procedures of mobile commerce systems, General type and AR type respectively, as experiment samples which is only different in AR application. After operating the systems, a questionnaire is given to participants.*

Streszczenie. *Przedstawiono eksperyment dwóch mobilnych sieci sprzedaży wykorzystujących technologię AR (augmented reality).* (***Mobilny system sprzedaży zintegrowany z technologią AR (augmented reality) i interakcyjnymi multimediami***)

Keywords: E-Commerce, Augmented Reality (AR), Usability, Human-Computer Interaction (HCI).
Słowa kluczowe: sprzedaż Internetowa, AR – rzeczywistość rozszerzona o świat generowany komputerowo

Introduction

Due to limitation of computing ability to present mobile devices, though some products in mobile commerce have been displayed via 3D virtual reality (VR), most of them are still displayed via 2D images.Though some studies reported that utilizing VR in e-commerce can provide more product information [1, 2], it is insufficient to display products in consumers' real life. Consumers can only imagine real size of product and its compatibility with environment. This not only causes consumers to get the wrong idea about real products but also affects their purchase decision.

Users can use AR technology to display 3D virtual object in a real environment. It can present 3D image of virtual objects in real life space and create a virtual-and-physical space. In study of Zhu et al. [3], though he took tablet PC to construct AR shopping auxiliary equipments, he applied these equipments in real shops, not online shopping.

In study of Swan et al. [4], he thought it is still lack of formal user-based experiments in AR research. In Augmented Reality E-Commerce System: A Case Study reported by Yuzhu Lu and Smith [5], it constructed an AR e-commerce system, tested its usability and conducted the subjective assessment questionnaires. Though our study is similar to the above-mentioned study, we are different in goals of the entire system architecture. Furthermore, our study also mentioned the vision of applying AR in mobile devices in the future. The proposed system has improved the unsolved problems addressed in previous studies, creating an interface combining AR with interactive multimedia interface, not using AR alone. It also designs a simplified operation procedure, exploring usability of innovative integrated media. AR technology now has come out of the laboratory and has been applied in everyday life. If display equipments can be applied in a variety of environments and easy to obtain, it will be easier and more convenient for users to use AR.

System description

(a) System architecture

In traditional AR system, users need to install software, connect to webcam and print multiple visual tags to preview AR image. Similarly, when information is updated, the above procedure needs to be repeated and thus causes inconvenience. Different from the traditional architecture, the proposed system only requires a mobile device with camera. Users are allowed to browse all displayed virtual products through one single visual tag. The system architecture is shown as Fig. 1.

Users can connect to mobile display interface integrated with AR application via their mobile devices and obtain diverse information provided by Web Server of the system through network. Users need to print visual tag via the interface first when using AR application. Via 3D model displayed on visual tag, users can visually know the real size and ratio of products and preview the compatibility between products and real environment.

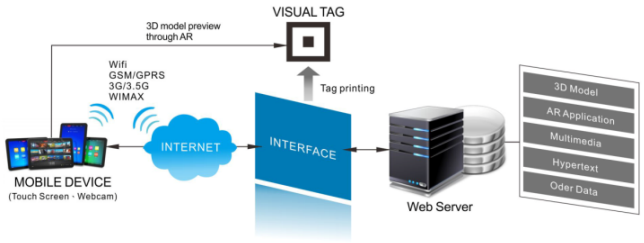

Fig.1. System architecture

This study takes construction of a digital shopping catalogues. Through touch screen of mobile devices, we can browse product information via page flipping for virtual books. Also, through touch graphical interface design, product multimedia information, product preview and AR preview are integrated with this system.

(b) Development tool

In this study, the development environment is Microsoft Windows XP. Action Scrip 3.0 of Adobe flash is adopted to develop the touch graphical interface and AR application. Development of AR application needs another three External code library, they are: Flex SDK code library: Processes the Embed metatag, FLARToolkit which handles tag graphic detection and Papervision3D code library (PV3D) which handles the importing, positioning and rendering of the 3D model. Flash Action Scrip and html can detect screen resolution of end user and automatically adjust to optimize the display.

As to database system, it adopts MySQL. Owing to graphical interface design in this study bases on flash, it requires Hypertext Preprocessor (PHP) to achieve the communication between flash and MySQL database.

(c) The function construction

The whole functions can be divided into two categories. One is assistant function, including catalogue index, instruction and card printing. The other is display function, including product choice, product information, and product preview.

Assistant function category:

• Catalogue index: the page layout is like magazines, and the product list is on the cover. Consumers can find the target product from the cover and preview products effectively.

• Instruction: it explains the purpose of constructing this digital shopping catalogue. Users can learn the preview function through the simple flowchart.

• Tag printing: users can print visual tag needed when previewing products with the AR technology. 3D virtual products can be shown on the visual tag, and users can preview the compatibility between products and real environments.

Display function category:

• Product choice: this function allows users to select from one product to another. Users can utilize the catalogue index on the cover selecting products to browse.

• Product information: users can obtain more information about products. It introduces products, manufacturers and extended information through interactive multimedia.

• Product preview: users can preview their favored products. The functions include photo preview, 3D photo preview, 360 degrees virtual product preview and AR product preview.

(d) The construction of human-computer interface

The human-computer interface is consisted of these four areas to construct a digital shopping catalogue as shown in Fig. 2.

1. Product choice area: in this area, users can use the right and left arrows in the range of number one to flip the virtual pages and select products. Besides, users can browse all the contents mentioned in this study.

Fig.2. Division of four areas of digital shopping catalogue

2. Product introduction area: it displays some text allowing users to get the required product information within the shortest time.

3. Product information area: it contains AR product preview function, hypertext information of products and multimedia information. In this area, AR utilizes interaction between visual tag and 3D Product Model to display. The hypertext information of products is mainly consisted of image and text to deliver product information. In addition, multimedia information is provided to users from various angles through multimedia.

4. System menu area: it is on the top right corner allowing users to go back to the initial menu area during their browsing process.

(e) The construction of information display

The information arrangement of digital shopping catalogue can be divided into the following four areas.

1. Product area: this area contains image-text information of products. Though it looks like the arrangement of paper books, users can still use 3D images created by interactive multimedia software to preview products in 360 degrees.

2. Product display with AR technology: This study adopts the monitor-based type which all images are displayed by monitors without requiring expensive equipments and thus, it has great commonality. Users only need to have mobile devices with camera, and this increases popularity of AR application. In previous testing researches [6], users were able to complete AR preview without having operation errors. Its operation is as shown in Fig. 3.

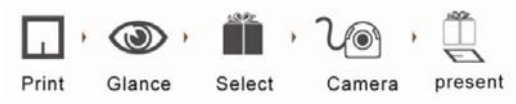

Fig.3. AR Product Display

Fig. 4 shows actual operation of AR product display. First, users put the visual tag in a real environment in part (A). Then, they focus the webcam on the visual tag and start the product preview function of AR in part (B). Afterwards, they can preview the real size and ratio of product displayed on the photo to in part (C). Finally, they can turn the direction of the tag to see the virtual object from different angles in part (D). It provides a new interactive and interesting AR product preview.

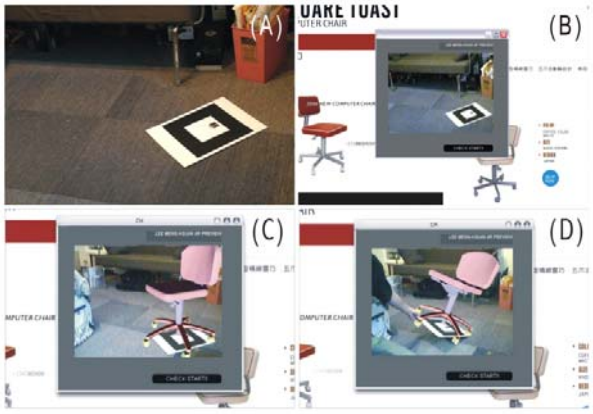

Fig.4. Actual operation of AR product display

3. Hypertext information of products: this part contains more information about products. The image-text information about relative products is further explicated. Finally, hyperlink information is used to extend product information for users.

4. Interactive multimedia of products: the design information of interactive multimedia video in this digital shopping catalogue can deliver the information of product styles and introduction through “stimulus-transmission-feedback” process.

(f) The design of visual tag

The AR display function in this study requires just one single visual tag. Users can hold the visual tag or put it in life space. It is a real paper card. The design is visualized in Fig.5.

Fig.5. Early visual tag in AR (left) Visual tag in this study (right) AR

Validation and user evaluation

The object of this experiment is to figure out subjective assessment of users toward General type and AR type mobile commerce systems. It constructed two operation procedures of mobile commerce systems, General type and AR type respectively, as experiment samples which is only different in AR application. After operation, participants filled out the questionnaire.

This experiment included 30 participants (15 males and 15 females). Age of participants was not limited, but basic computer operation skills and online shopping experience were required. The environment was indoor space well illuminated by fluorescent light. Participants can sit or stand, holding the tablet computer with a distance 30 cm from eyes to screen. Distance between the visual tag and webcam can be adjusted by participants upon their browsing content. To prevent users from interference of connection speed while linking to the websites, we had stored the two experiment samples, General type and AR type mobile commerce systems, in panel computer in advance adopting internal linking of single machine. Visual tags were also printed out in advance for participants.

(a) Experimental equipment

Mobile device adopted in experiment adopted was Acer ICONIA Tab W500 with operation system Microsoft Windows 7, processor AMD C50, 1GHz, RAM 2G, 10.1" capacitive multi- touch screen, COMS 1.3M pixels for both front and rear camera, supporting Wi-Fi / WLAN,3G / WCDMA networking. The experiment selected mainstream mobile devices. Interfaces of the experiment samples were both touch screens, and AR type used mobile devices with camera.

(b) Experiment procedures

After participants had basic idea about the system, we let them try the operation and formally started the procedure. Participants can decide operation sequence for General type or AR type and repeat operating the two experiment procedures. After confirming participants had finish operating two experiment procedures, a questionnaire was given to participants. Every participant was given 30 minutes to finish this procedure.

The questionnaire was designed according to five criteria proposed by Nielsen and our research purpose, proposing hypothetical questions consisted of six sub-questions for General type and AR type mobile commerce systems[7, 8]. This questionnaire adopted Likert scale as rating method, using seven-points scale assuming that the weight number of every level was the same, on a scale from lowest -3 to highest 3. We analyzed experiment results to compare the mean of "product awareness", "ease of learning", "efficiency", "memorability", "error rate" and "satisfaction" for participants using General type and AR type mobile commerce systems.

(c) Verification Method

This study utilized mean, standard deviation and independent samples T test to analyze six sub-questions and a gender factor in the questionnaire. It analyzed mean and standard deviation to compare mean of "product awareness", "ease of learning", "efficiency", "memorability", "error rate" and "satisfaction" for participants operating General type and AR type mobile commerce system.

Independent samples T test was used to explore whether there is difference on "product awareness", "ease of learning", "efficiency", "memorability", "error rate" and "satisfaction" for participants operating General type and AR type mobile commerce system. It figured out whether gender factor made difference toward each question.

Results and discussion

The experiment results were analyzed by SPSS statistics software and descriptive statistics. T test was then conducted to analyze relation of various independent variables, dependant variables and population. Independent variables in this experiment included: General type and AR type commerce systems. Dependant variables included: "product awareness", "ease of learning", "efficiency", "memorability", "error rate" and "satisfaction." Population included: male and female.

(a) Product awareness

Gender-inclusive results. Average scores for AR type ranged from agree and strongly agree, was higher than General type ranged from neutral and somewhat agree. T test for product awareness for General type and AR type mobile commerce system is -12.54, significance $p<0.05$ reaching the significant level. That is, there was significant difference for participants in product awareness toward various systems. The mean showed that participants considered product awareness of AR type was better than that of General type. We presume the reasons is: AR type allows combination of products and users' real-world environment, and gain higher awareness of real products by previewing the compatibility and real size between products and real environment. The results are shown in Table 1

Table 1. "Product Awareness" T-test result of Gender inclusive results

Product Awareness	Independent Variable	Mean (Std Dev)	T	P
			-12.54***	.001
	General Type	0.3 (0.91)		
	AR Type	2.66 (0.47)		

*p < .05. **p < .01. ***p.001

(b) Ease of Learning

Gender-inclusive results. Average scores for AR type ranged agree and strongly agree, was higher than General type ranged from somewhat agree and agree. We presume the reason is after experiencing the interactivity of AR, participants were highly interested in it, and their concentration and desire for learning was increased, increasing the ease of learning for the system and interface.

(c) Efficiency

Gender-inclusive results. Average scores for AR type ranged from agree and strongly agree, was higher than General type ranged from somewhat agree and agree. We presume the reason is owing to concentration and desire for learning was increased, participants can operate AR type smoothly through intuitive touch interface design. And through the assistance of AR technology, they can efficiently operate the system.

(d) Memo ability

Gender-inclusive results. Average scores for AR type ranged agree and strongly agree, was higher than General type ranged from somewhat agree and agree. We presume the reason is: the system is simplified and integrated. Through AR product preview function, users' sensual experience is enhanced.

(e) Error rate

Gender-inclusive results. Average scores for AR type ranged somewhat agree and agree was same as General type. There was no significant difference on the mean of the two systems. Operation of AR type is as simple as that of General type, avoiding operation errors.

(f) Satisfaction

Gender-inclusive results. Average scores for AR type ranged from agree and strongly agree, was high than General type ranged from somewhat agree and agree. T test for satisfaction for General type and AR type were -8.944, significance $p<0.05$ reaching the significant level. That is, there was significant difference for participants in satisfaction toward various systems. Mean distribution for gender-inclusive General type and AR type is shown in Fig. 6. Participants all gave positive evaluation toward AR type mobile commerce system, obviously indicating they were satisfied during operating AR type mobile commerce system. The results are shown in Table 2.

Table 2. "Satisfaction" T-test result of Gender inclusive results

Satisfaction	Independent Variable	Mean (Std Dev)	T	P
			-8.944 *	.037
	General Type	1.33 (0.66)		
	AR Type	2.66 (0.47)		

*p < .05. **p < .01. ***p.001

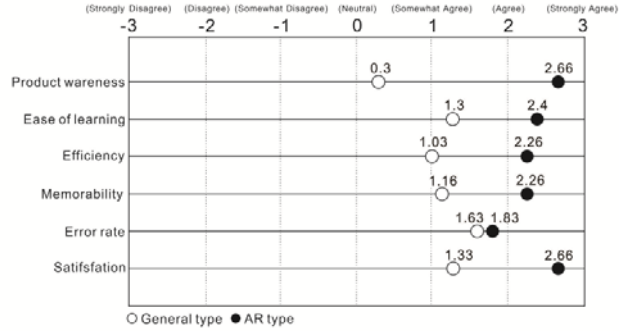

Fig.6. Mean distribution for gender-inclusive General type and AR type

Table 3. The T-test result of "Error Rate for Female Participants"

Error Rate for Female Participants	Independent Variable	Mean (Std Dev)	T	P
			-0.823*	.025
	General Type	1.8 (0.77)		
	AR Type	2.0 (0.53)		

*p < .05. **p < .01. ***p.001

(g) Exploring the gender factor

From the results, we found except for error rate for female participants as shown in Table 3, there was no significant difference on other questions for both genders. Mean of product awareness for male and female in AR type mobile commerce systems were both 2.66. This result showed that there was no significant difference for both male and female on AR type. They both considered AR type was efficient to assist users and give positive evaluation toward the system.

Conclusions

Through validation of General type and AR type mobile commerce systems, we conclude that the mass has high degree of acceptance toward using AR technology in mobile commerce. The study also found innovative interaction technology can increase users' desire for learning. In this study, AR type mobile commerce system was more complicated than General type. However, participants did not encounter operation error and be interrupted. Thus, simplified operation procedure in this study is applicable after validation. This study not only integrates innovative media development and platform, it further explores usability and users' attitude because innovative media technology integration is human-centered. It is hoped that the proposed results can be referred for later studies on academics and industry which design human-computer interaction and development of innovative media integration.

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