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Students' perception of mobile augmented reality applications in learning computer organization

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Abstract

Augmented reality is a human-machine interaction tool that presents information generated by computer on the real world using a camera. Augmented reality technology has the potential to draw students' attention to visualize a layer of information on real objects using handheld devices such as tablets and smartphones. The objective of this study was to assess students' perception of the use of augmented reality in learning microprocessor. Therefore, a mobile application was designed and developed by integrating elements of augmented reality for teaching and learning this topic. This study was conducted based on the ADDIE model that consists of five phases: Analysis, Design, Development, Implementation and Evaluation. The study found that students' perception of the use of augmented reality is positive based on the average mean score. However, the disadvantage of this application is the use of images as compared to the use of real microprocessor as the learning object. An area for future study is to assess the students' perception of the use of real objects as the learning object in using mobile augmented reality application.

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Keywords: mobile augmented reality; teaching and learning; computer science

1. Introduction

Computer organization and architecture is one of the core subjects in the computer science programs. The importance of this subject was stated in the IEEE / ACM Computer Science Curriculum 2008 report in which all computing students need to gain an understanding and appreciate the functional components in a computer system, its features, performance and also the interaction between the components (Stallings, 2013). One of the main

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components which is also the most complex component in the computer system is the central processing unit (CPU) or microprocessor. Providing a learning environment that can engage students to learn continuously this complex component is difficult because the materials are very theoretical and hard to visualize. Thus, there are several learning tools that have been developed such CPUsim tool for simulating the operation of microprocessor (Mustafa 2011). However, there is still a lack of teaching aids that links between theories and the real microprocessor.

The problem in engaging students in learning this complex material has motivated this study to use augmented reality (AR) technology as one of the learning technology. The aim of this study is to identify the students' perception towards the use of AR technology in learning complex materials. Therefore, the objective of this study is to design and develop an AR based application for learning microprocessor, and evaluate students' perceptions on the use of AR in learning this complex subject.

2. Background

AR technology was born after virtual reality technology. Virtual reality replaces reality with a simulation. On the other hand, in AR technology, a view of a reality can be modified by addition of digital information so that it can improve a person's perception of the reality. In AR, there are four main components: (1) a camera to capture a target information, (2) marker which is the target information, (3) mobile phones to store and process information when the captured image is the target information (marker), and (4) digital content is the content that will be displayed on the screen when the camera is able to track the marker. Fig. 1 shows an example of an AR application where the marker is a real memory stick called random access memory (RAM). When the camera phone has tracked the RAM, the phone will then display digital information associated with the marker on the screen.

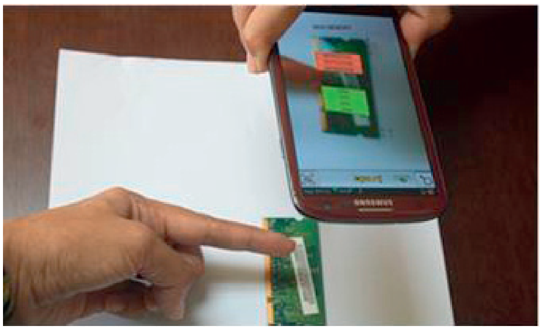

Fig. 1. AR technology can add digital information on the real object through the mobile phone screen

Now, the use of AR in education has become more widespread and practical. Table 1 shows four main features for some applications in education. These features are: environment, instructional approach, level and peripheral. The first application, Alien Contact! (Dunleavy, Dede et al. 2009), for example, is developed for outdoor environment. The instructional approach for this application is based on role, the level is school and the peripheral used is handheld devices. Instructional approach is classified based on the use of AR in which Wu et al (2013) divided the usage into three categories: role, task and instruction. AR-Dehaes toolkit (Martín-Gutiérrez, Saorín et al., 2010) is an application that is based on task. This application had positive responses from engineering students. Therefore, the question of this study is whether a mobile AR based application can get positive response from computer science students in learning complex materials?

Table 1. Examples of AR application in education

Application	Environment	Instructional design	Level	Peripheral
Alien Contact! (Dunleavy, Dede et al., 2009)	Outdoor	Role	School	Handheld devices
ACCampus (De Lucia, Francese et al. 2012)	Outdoor	Location	University	Handheld devices
EULER (Liu et al., 2009)	Outdoor	Task	School	Handheld devices
AR-Dehaes toolkit (Martín-Gutiérrez, Saorín et al., 2010)	indoor	Task	University	Desktop

3. Methodology

The ADDIE model has been used as a research methodology. In this model, there are five main phases of analysis (A), design (D), development (D), implementation (I) and evaluation (E).

3.1. Analysis

In the analysis phase, the content of the application was selected based on a specific topic in the computer organization and operating systems course. Since microprocessor is an important topic in this subject, a set of exercises has been identified with four main sub topics:
(1) Introduction
(2) The main functions of microprocessor
(3) Components on a motherboard
(4) How microprocessor processes data

3.2. Design

In the design phase, the application was designed based on five layers: application, the application programming interface (API), Metaio software development kit (SDK) and operating system. In the first layer (application layer), the main focus is user interface and logic operations. There were four main buttons for four different sub topics. In the second layer (API), Android SDK based on Java was selected. The third layer involves Metaio SDK where there are three major components: capturing, tracking and rendering. Capturing component will capture images from the camera. Then, the tracking component will process the image based on the specified markers. In this study, an image of a motherboard was used as a marker. When images recorded by the camera have been identified similar with the marker, then the rendering component will display the specified digital content on the mobile phone screen. The last layer in this architecture is the operating system where android mobile phone platform was chosen in this study.

3.3. Development

In the development phase, three tools have been used:

- Eclipse Integrated Development Environment (IDE) for the development of the Android platform using the Java
- Metaio SDK for the development of AR applications
- GIMP for image editing

In the development phase, the main interface has been developed where there are five buttons, A, B , C , D and E. The E button is for non-academic content. When students click button A and track the image of a motherboard, digital materials displayed on the screen is a video. Students need to answer some simple questions based on the video. When students click button B, the digital information is displayed on the screen along with the audio that explains the concepts and basic functions of a microprocessor. To increase students' knowledge about a number of components on a motherboard, students can click button C to see a list of labels for the main components related to microprocessor. Button D is to help students in identifying how the microprocessor, main memory and bus are working together in the execution of a command. Button E is also included in the application to provide an opportunity for students to relax during practice. When students click button E, a 3D model is displayed on the screen of the mobile phone.

3.4. Implementation and evaluation phase

The fourth phase of the methodology is implementation where the application was used by 24 students in a lecture room while learning computer organization and operating systems course. Students were allocated to a small group where each group consisting of two to four students. Each group used a tablet that was installed with the application. The groups were required to discuss how to solve a set of exercises that have been developed based on digital information displayed on the mobile phone screen. The fifth phase is the final evaluation phase where each student will fill out a questionnaire to determine the level of satisfaction of using the AR application. Questionnaires used in the form of a five point scale adapted from Martín-Gutiérrez, Contero et al. (2010).

4. Results and discussion

Descriptive statistical analysis was carried out to identify the satisfaction level of using the developed AR application in learning complex materials. The mean and the frequency, scale of 4 to 5, were calculated to identify the level of student satisfaction for using the application. It can be seen from Table 2 that item 4 has the highest level of satisfaction with min 4.54 and frequency 24. While item 7 has the lowest level with a mean value of 3.92 and a frequency of 1. The overall mean for each of the attributes are in the range of 3.92 to 4.5. This indicates that the respondents were satisfied with the use of the AR based application in learning microprocessor. Two responses of students who support item 4 are as follows:

"*AR allows content to be more interesting for students to learn and students are more attentive when learning*"
"*This application can be used as a learning tool to attract students*"

This positive response is as expected where AR applications such as AR-Dehaes (Martín-Gutiérrez, Saorín et al., 2010) also received a positive response from the students.

Table 2: Frequency (scale of 4 to 5) for the satisfaction of using mobile apps AR

Item	Satisfaction	Frequency	Mean
1	I am motivated to use AR in learning	23	4.38 (0.58)
2	AR technology is attractive to use in learning	23	4.29 (0.55)
3	Do you think the use of AR can improve spatial skills	22	4.33 (0.64)
4	AR technology is attractive	24	4.54 (0.51)
5	AR technology seems original	10	4.46 (0.72)
6	AR technology seems useful	24	4.16 (0.38)
7	AR technology seems satisfactory	17	3.92 (0.65)
8	Technology AR seems flexible (you can do the training either at university or in your room)	22	4.08 (0.72)

During the implementation of AR technology in learning microprocessor, students enjoyed, interested and active in discussions to complete the tasks. Fig. 2 shows the situation where each student in the group actively gives their opinion in completing the tasks. AR appears to increase student motivation and interest where some students want to practice using AR in the future as shown below:

"*Need a lot of tasks that use mobile AR for every student*"
"*Do more exercises in class with proper supervision from lecturers*"

Fig. 2. Students discuss actively to solve the problem using mobile application based on AR

In terms of flexibility, there were some students who did not agree with item 8 which is AR technology seems flexible. This may be due to some students who did not have a mobile phone or tablet that supports this AR application. AR application requires Android platform 4.0 and above. Feedbacks from students on the use of devices are:

"*Must have affordable device and use the device to do the assignment and presentations*"

However, there are still many a number of students who support that AR seems flexible. One of the comments related to this is:

"*Students can learn and study everywhere*"

For item 7, AR technology is satisfactory, had the lowest mean score, 3.92. This may be because there are some limitations of the developed AR applications. Some comments related to this situation are:

"*Learning using AR can be improved by clear and better audio, sharp visuals and explanation*"
"*Better sound or voice, clear image and video*"

Low mean score may also relate to the use of an image as a marker, not a real object. This is because Azuma et al. (2001) stated that digital information in the form of 2D can be beneficial for collaborative activities, by allowing the spread of information in the physical world. Therefore, further research uses real 3D objects as a marker would be very interesting because this new technology allows us to manipulate real objects as the learning object.

5. Conclusions

An AR mobile application has been designed and developed in this study in order to identify students' perceptions in learning complex materials in a computer science course. This application was implemented to 24 second year students who took computer organization and operating system course. Results of the evaluation showed that most of the students were motivated to use AR in learning. They also think that the application was useful and attractive. However, there were students who did not have suitable devices for using the AR based application. In the future, it would be most likely that there are many students who will have suitable devices so that they can use this application in and outside the classroom.

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