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ScienceDirect

Procedia Computer Science 135 (2018) 457–464

Procedia Computer Science

www.elsevier.com/locate/procedia

3rd International Conference on Computer Science and Computational Intelligence 2018

Web based Augmented Reality for Human Body Anatomy Learning

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Abstract

Human body anatomy becomes an important topic in Biology subject that must be understood since junior high school. Learning materials are mostly available in form of book and anatomy mannequin (puppet), but it is still insufficient enough to help students in understanding human body anatomy. Augmented Reality (AR) is a technology that combines a real thing into virtual environment interactively. This research purpose is to develop an AR application for human body anatomy learning to be more interesting and easier for student to understand. This application enables student to learn human body anatomy with 3D object interaction while previously using textbook and mannequin. Research method in for this study is by using quantitative method that collects data and then develops the prototype to prove the impact. Application development method is done by using waterfall method that includes planning (collect data and analysis), design (user interface and diagram), implementation, and testing. Research result is AR application for human body anatomy learning that contains 3D object, organ explanation and position that can be accessible on web.

Keywords: human anatomy, augmented reality, 3D object, human organ

1. Introduction

Augmented Reality (AR) is the incorporation of real and virtual objects in real environments, running interactively in real time, and there is integration between objects in three dimensions (virtual objects integrated in the real world) [1]. Many AR technologies are used in everyday life, such as medicine, transportation, game, or human body by adding certain organs [2]. Virtual Reality (VR) and AR have also been introduced in the education sector. The challenge that must be faced is the improvement of student learning outcomes through this technology [3]. AR is processed and manufactured in real time [3]. AR is defined by three main characteristics: a combination of real and virtual, real time interaction, and 3D [4]. AR syncs real-time images with virtual objects [5 6] and offers an environment not perceived by sensory organs [5]. Research on AR has been conducted in various industries since the early 1990s in

10.1016/j.procs.2018.08.197

the fields of medicine, manufacturing, aeronautics, robotics, entertainment, tourism, social and education [4 8 9 10 11 12]. AR has also been used for enhancing students' understanding of science, micro-biology [13] environmental science [14 15], and biomedical sciences [16].

Anatomy is the study of body structure. It will be seen that a human has so many elements that make up his body. The element is a body organ consisting of tissues and composed of cells. Some important elements are the respiratory system, the circulatory system, and the digestive system [17]. Human body anatomy is essential as a basic knowledge of some relevant fields of science [18]. It is also important to learn it at an early age. So, people can know basically the bad conditions if there is a disease that attacks their body (organ). They can anticipate in the form of prevention for the body health. That's why learning the human body anatomy becomes an important topic that must be understood since junior high school on Biology subject. Mostly learning materials are available in form of book and anatomy mannequin (puppet), but it is still insufficient enough to help students in understanding body anatomy. Although human body anatomy is essential, some literature states that many children may not be able to conceptualize it. In addition, teaching anatomy is also complicated because much of the related anatomical content can not be directly observed [19]. Using 2D images to teach the structure of 3D objects is usually tricky, especially if the organs are too complex structured [20]. From an anatomical learning background, the human body faces the problems that exist: Visualization that is 2D through conventional media such as textbooks, visual aids and interactive CDs is difficult to apply in practice field; It is difficult to visualize the shape of the body anatomy, the position of organs, the relationship between organs; Learning through interactive CDs costs a lot.

Concerning the difficulty of understanding this and the future development of AR, a web-based AR application is developed to support the human body anatomy learning. Web-based is one of the media that is suitable to support learning because it is easily accessible with computers, tablets, and mobile phones that connect to the internet. Web-based is chosen because it's independent interface to billions of sources [21]. Students with various mobile platform (OS) and specification can access the web application through their phone or tablet or PC. Hugh Durkin, Senior Product Manager at Intercom, states that the average American now downloads zero apps per month. Users are familiar with browsers [22]. David Moth states that 85% of consumers favor apps over mobile website, because it is seen to be more convenient (55%), faster (48%) and easier to browse (40%) [23].

Based on those problems, purposes of this research are: (1) To help student in learning the human body anatomy more easily and interesting; (2) Provide an alternative method of human body anatomy learning before using textbooks and props; (3) Developing an AR application that can interact in form of 3D objects; and (4) Provide solutions for users who have difficulty in visualizing the body anatomy of 2D shapes (images) into the form of 3D practice. Not just images in the form of 3D, the object of AR also displays other multimedia elements such as sound, animation, text, and video. With this perspective, students will find it easier to understand the shape of the human body anatomy. Authors provide solutions by developing AR application for human body anatomy learning with 3D object features. AR application that has the advantage of displaying virtual 3D objects in real environment can be a solution of visualization difficulties. With 3D anatomical objects in the live environment, student can visualize the body anatomical shape in a more real way.

2. Related Works

Yeom (2011) states that the core problem of students is the visualization they learn in 2D through conventional media such as textbooks, visual aids and interactive CDs that is difficult to apply in practice field. Although interactive CDs have been developed quite well, students continue to experience problem in price. Yeom states that AR technology is a new research era, with its investigation and implementation can be developed with various methodologies [24]. Patirupanusara (2012) states that there is still much future development of AR to be applied to the medical field or learning [25].

In 2012, Blum has developed an AR application for teaching anatomy [26]. The system uses a depth camera to track the pose of a user standing in front of a large display. It's also costly because it needs large dimension of TV screen. Blum concludes that his application gets positive feedback from children and attracts their attention. In 2015, Jamali has developed AR application prototype for learning human anatomy [27]. The application can run only Android tablet platform, and can't be executed in mobile phones or other platforms. Blum claims that students were satisfied with his application in terms of its usability and features. Kiourexidou (2015) has also developed an AR prototype for learning human heart anatomy by using web platform [28]. He evaluates the application in two different facets. First,

evaluates the feasibility of a 3D human heart module using one investigator under the supervision of an expert. Second, evaluates the usability issues by means of the cognitive walkthrough method. This prototype isn't tested to user.

Moro (2017) tests the effectiveness of VR and AR in health science and medical anatomy [29]. He concludes that participants are more likely to exhibit adverse effects such as headaches, dizziness, or blurred vision. Unfortunately, his application is developed and run on tablet-platform only. Students without tablet can't use the application. Silva (2017) also develops an AR application for segmenting and detailing visualization of anatomical structures based on AR for health education [30]. He notes that the use of interactive visualization techniques such as AR and VR can collaborate with the process of knowledge discovery in medical and biomedical databases. He develops the application on mobile platform and can't be accessed by other students who doesn't have the OS platform.

3. Research Method

This research is using quantitative method involving students of a higher education institution in Jakarta, Indonesia. First, the instrument using for data collection is a semi-structure questionnaire for gathering requirement data. The data requirement questionnaire assesses the level of tool or media for understanding the human anatomy, and application usage and easiness. The sample consisted of 157 respondents. Respondents are students from junior high school, senior high school, or equivalent, who take Biology subject (human body anatomy topic).

Results of requirement questionnaire shows that students mostly learn human anatomy through mannequin (37%) and textbooks (27%); hard to know the organs position in human body (33%), and have unclear picture on textbooks (29%); most students prefer to use the application directly through browser without any installation (44%); and most students prefer AR technology because of easy to visualize (46%) and exciting (31%). Based on data gathered from questionnaire, authors design and develop the application by using waterfall method (Chapter 4). Developed application is evaluated to match the meet of users' expectation. On evaluation session, human body anatomy is visualized according to its function and location and then displayed in 3D view in human body. Evaluation is conducted through SUS-based questionnaire and presented on Chapter 5.

4. Software Development Method

Development method for this application is by using waterfall method. Waterfall method is a software development process sequentially starting from communication, planning, model making, construction, deployment.

a. Communication

In this stage, the authors distribute questionnaires to respondents (junior/senior high school students) to capture the needs of respondents.

b. Planning

1. Data Collection

   At this stage, the authors gather data to support the development of AR application. Data collection method consists of two ways: primary (questionnaire) and secondary data (literature) collection.
2. Analysis
   a. Data Analysis

      After collecting all necessary data, further analysis is done to find out the needs of this AR application.
   b. Similar Application Analysis

      The author performs a comparison with similar applications (Corinth Micro Anatomy Augmented Reality, Daqri 4D Anatomy, Augmented Reality 3D Application, AR Bone Puzzle).

c. Modelling

Application modeling includes UML (use case, and class diagram), described in Fig 1.

d. Construction

This stage is developing the application in form of web that can be embedded in mobile phone app too. 3D object modeling is done by using Google Sketchup and 3Ds Max 2011. Application development is by using ActionScript 3.0 and C# WFC template (Windows Presentation Foundation). Physical tools that are used in this website application are Kinect XBOX 360 and AR Marker.

e. Deployment

Application deployment is done by installation to server and provide simulation according to respondent target.

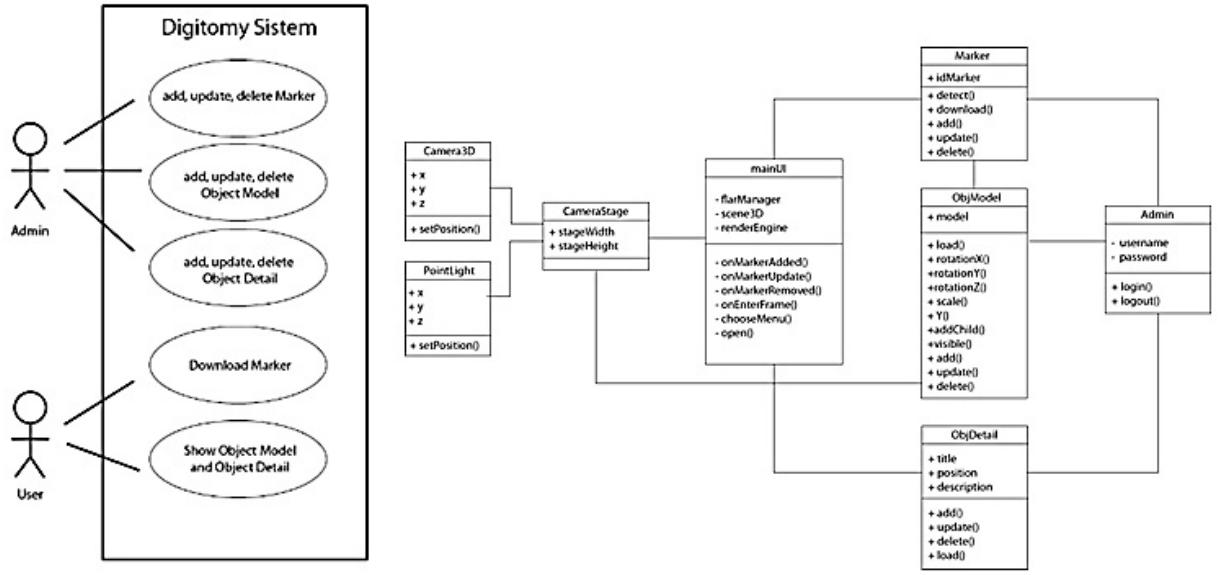

Fig. 1. Use Case & Class Diagram

5. Experimental Results

After the application is done developed, the evaluation questionnaire is distributed to 48 respondents consisting of junior and senior high school students. Respondents access the website, and it will display the home screen (Fig 2.a).

a. Start

On the Start Page (Fig. 2.b), application will display the camera view where student must press the allow button to activate the camera feature so it can be used for scan marker. Once the camera is on, student directs the marker to the camera to display the organ object.

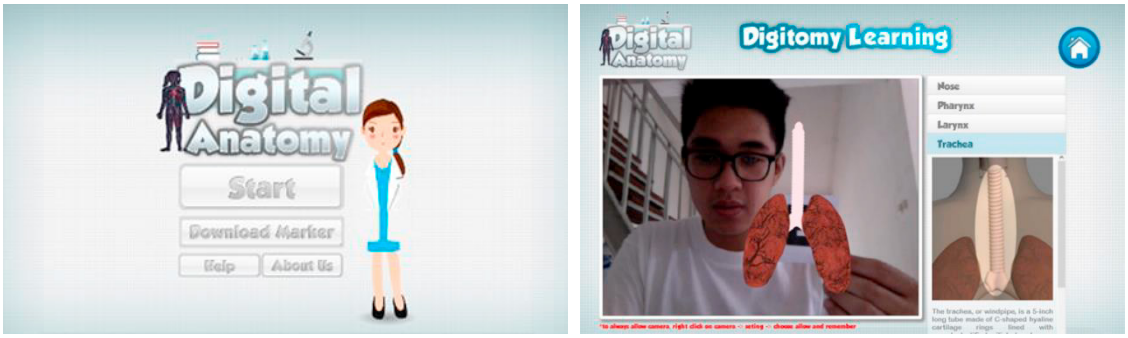

Fig. 2 (a) Home Screen, and (b) Start Page

b. Download Marker

The Marker Download Page (Fig. 3.a) will be displayed while hovering the mouse on application. It will show dropdown menu containing organ type. After the student presses the organ, marker will be downloaded. After that, student should print the marker.

c. Help

For first-time of using this app, student can go first to the Help Page (Fig. 3.b) where displaying the procedure or demo in the form of video.

Fig. 3 (a) Download Marker Page, and (b) Help Page

After that, we compare to other related systems. Here is the comparison of the features from several existing applications (Table 1). Based on the comparison, proposed application has the advantage of having organ explanation, does not require installation and free.

Table 1. Comparison of Several Existing Applications

Component	Corinth Micro Anatomy Augmented Reality	Daqri 4D Anatomy	Augmented Reality 3D Application	AR Bone Puzzle	Proposed Application
Marker	Yes	Yes	Yes	No	Yes
Organ Explanation	No	No	No	No	Yes
Installation	Yes	Yes	No	Yes	No
Platform	Windows 8	Android & iOS	Windows XP to Windows 8	Windows 7	Windows XP to Windows 8
Hardware	1) Tablet / laptop / computer with camera 2) Marker 3) Projector screen	1) Tablet / laptop / computer with camera 2) Marker	1) Tablet / laptop / computer with camera 2) Marker	1) Laptop / Computer 2) Kinect	1) Tablet / laptop / computer and Kinect / Camera 2) Marker
Type	Desktop & Tablets	Desktop & Tablets	Website	Desktop	1) Website 2) TV Wall Apps
Cost	Paid for more features	Free	Free	Paid	Free
Interaction Object	Mouse and Marker	Marker	Marker	Hand interaction	Marker and Hand Interaction
Modelling Objects	3D	3D	3D	3D	3D
Organ System	1) lungs 2) heart 3) ribs 4) kidney	1) Muscle system 2) The bone system 3) Circulatory system 4) The nervous	1) Heart 2) Bone from waist to leg 3) Skull	1) The bone system	1) Lung - Lung 2) Nose 3) Faring

5) heart	system	4) Spine	4) Larynx
6) gut	5) Respiratory system	5) Ribs	5) Trachea
7) stomach	6) The reproductive system		6) Bronchus
	7) Excretion system		7) Bronchioles
			8) Alveolus

Evaluation of the application is also by using System Usability Scale (SUS) as a reliable tool for measuring the usability [31]. Results obtained are presented on Table 2.

Table 2. Evaluation of SUS

No	Statement	Average Score*	Converted Score**
1	Like to use the application frequently	4.25	3.25
2	The application is unnecessarily complex	1.30	3.70
3	The application is easy to use	4.90	3.90
4	Need technical support to use the application	1.30	3.70
5	Various functions in this application are well integrated	4.50	3.50
6	Too much inconsistency in the application	1.30	3.70
7	Learn to use the application very quickly	4.70	3.70
8	The application is very cumbersome to use	2.65	2.35
9	Very confident using the application	4.50	3.50
10	Need to learn a lot before using the application	1.10	3.90
	SUM		35.2
	SUS's VALUE (SUM x 2.5)		88.0

Each statement has scoring (*) scale from 1 (strongly disagree) to 5 (strongly agree). To calculate the SUS's converted scoring (**): (1) For statements 1, 3, 5, 7, and 9 (odd number), the converted score is the average score minus 1; and (2) For statements 2, 4, 6, 8 and 10 (even number), the converted score is 5 minus the average score. Each converted score will range from 0 to 4. Multiply the sum of the converted scores by 2.5 to obtain the overall value of SUS. SUS's value of 80.3 or higher means that it's a good application, people love your site and will recommend it to their friends. SUS's value of 68 or higher means that it's also considered as a good application but need some improvement. Last, SUS's value below 68 means that the application is priority to be fixed. From Table 1, it can be concluded that the application is good and user will recommend it to their friends.

6. Conclusion and Future Work

Conclusions of this study are: (1) The developed application is easier to understand, more interesting and easy to use as the concept of learning the human body anatomy; (2) AR technology in this application can be used as an alternative method for human body anatomy learning in addition to textbooks and props; (3) Applications increase the interest of junior high / high school students to learn more about the anatomy of the human body; (4) Application comes with anatomical explanation and anatomical position of the human body that add insight; and (5) Application provides solutions for student who has difficulty in visualizing the anatomy of a two-dimensional body shape into a three-dimensional practice form.

Some suggestions for further development are: (1) Interaction and menu selection can be done without marker; (2) Developed for other human anatomical systems and using animations; (3) More detailed 3D texture graphics that can be retrieved from the scanned object; and (4) Applied to other subjects.

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