Innovative Learning of Solar System using Augmented Reality for Primary School Children

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Abstract. Learning is an important part of life which is a constantly changing necessity. Traditionally, an individual is part of a group in the class led by a teacher in a particular class. The advancement of technology and the growing importance of the World Wide Web has enabled teachers to cultivate new ways of teaching and learning in the classroom environment. In Malaysia, the Science subject is one of the core subjects in the upper primary level where students would have to sit for it in the UPSR (Primary School Evaluation Examination). This paper describes a development of the Solar System Planetary for Standard 4 students through Augmented Reality Technology. The materials is expected to help students to learn the subject easier, ensuring that the teachers are able to transfer the appropriate knowledge to the students

Keyword : Solar System, Augmented Reality, Science Subject

1. Introduction

The advancement in technology has resulted in a tremendous change in the field of computer science and its development. The rising popularity of computer graphics has given birth to new technologies like Virtual Reality (VR) which is an application where the users are totally immersed in the environment. Meanwhile, the development in VR has been widen to the extent that we are able to extract and utilize the virtual objects in the real environment. This is where the Augmented Reality (AR) comes into existence [1]. According to Webster's Dictionary, the word 'Virtual' has been defined as 'not actual, unreal or artificial'. It means that the object, material or environment created is not real but seems real, or artificially real. The word 'Reality' on the other hand, means the state or quality of being real, or an actual existence [2]. Figure 1 shows how users interact with the real world through the virtual objects composited in it.

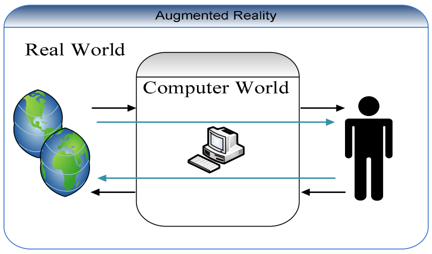

Figure 1: Conceptualisation of Augmented Reality

AR is one of the variations of VR where it is a different application where the virtual objects are superimposed upon or composite in the real world and the users are interacting with this world in real time [3].The virtual objects appear as if they are part of the scene as the users navigate in the environment. The goal for an AR system is where the user cannot differentiate the real world and the virtual augmentation of it [4]. AR is different from VR where VR can be defined as a computer-generated, interactive, three-dimensional environment is which a person is immersed [5].

2. Application Of AR In Education

In the past decades, there are many research conducted in examining the effect of 3D computer technologies to support learning with very positive and encouraging results. Findings include better symbolic

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retention of human cell organelle information [6], enhancement in spatial understanding of architectural spaces, significant higher scores on performance and achievement tests[7], more accurate and complete understanding of engineering concepts, increase in learning speed-of-life skills [8], long-term retention of the atom, improvement in the ability to identify and draw perspective of pyramid [9] and the improved ability of low scorer to draw mental models of ecology [10].

AR is an emerging technology that will enable learners to learn and explore the world of knowledge through the manipulation of virtual objects in real world. It has shown great potential in developing and creating an interactive and a more interesting learning environment for the learners. There are already many AR systems with features that allow two-way interaction between the users and the system being developed for educational purposes.

One of the systems is the Earth-Sun Relationship application which shows the seasonal transitions in light and temperature of the Earth. The virtual sun and earth can be manipulated with a handheld plate in such a way that the users can orient the virtual objects' position with respect to their viewing perspective [11]. Another AR application is Construct 3D which is designed for teaching mathematics and geometry. It is a 3D geometry construction tool that provides a basic set of functions for building primitive forms of geometry [12]. Apart from that, the Augmented Chemistry application is a virtual chemistry laboratory that allows the users to view simple atoms and construct complex molecules according to subatomic rules [13].

3. Problem Statement

Many students face difficulties in comprehending spatial related knowledge which involved complex concepts, phenomena and theory. There are a few research studies revealed that students have difficulties in developing an understanding of astronomical phenomena [14].

The difficulty in developing an understanding in astronomical concepts occurs due to the requirements to have an understanding on the relationships of the objects in 3D spaces and viewing the events between these objects from different perspectives. Many learning situations require students to transform 2D objects in dynamic 3D objects within some particular process or state of being. In addition to that, learners may need to translate among reference frames, describe the dynamics of a model over time, predict how changes in one factor influence other factors, or reason qualitatively about physics processes that are best explored in 3D space in order to understand these science concepts. These supportive findings have motivated the educators to examine the possibilities of using 3D technologies as an approach to support students in constructing and visualizing scientific phenomena (Parker & Heywood, as cited in [14]. Most astronomy resources currently available to students are in the form of 2D charts and images in text books that attempt to emulate 3D scientific phenomena [5]. Students viewing these images currently lack the sense of depth or scale of these phenomena that is needed to understand the dynamics of the concepts [10].

4. Related Work

Science and technology play an important role in meeting Malaysia's aspiration to become a developed nation. Therefore, the provision of quality science education from an early age in the education process must be ensured. According to Abdul Ghani, students feel that science subject is one of the hardest subjects to learn and experience [16]. Apart from that, she also mentioned that many classroom activities are not engaging and exciting for the children.

For instance, technology in AR can be applied in helping the students to understand the "earth-sun relationship" and molecular structure chemistry lessons. During the astronomy lesson, the students can manipulate the virtual sun and earth on a small hand-held platform that changes its orientation and coordination as the view of the students move. From here, the students can understand how the unseen elements work with other elements as they can control the angle of viewing. With this Earth-Sun Relationship AR system, students will learn about the seasonal transitions in light and temperature of the Earth [9]

The Augmented Chemistry is an application of AR used in the chemistry class where the students can acquire simple atoms through virtual drag-and drop technique [9]. They can combine the atoms in order to become a complete molecule. Once they complete with the combination and a complete molecule is formed, labels that state the names to the structure will appear [9]. Through this interactive method of learning, the students can learn the construction of complex molecules and subatomic rules at the same time. This method is considered to be better than the traditional way of learning which used Styrofoam, straw and book as the main medium for chemistry class.

5. Proposed System

Building a system to deal with Solar system experiential learning environment is one of the best ways to tackle the problem as experiential learning is best conducted through the active excursion to the informal learning environment such as the science center. Informal learning environment can create the motivation for the learners to learn, which it is able to create good experiences that benefits the subsequent experiences.

AR is considered as a good platform to teach about planets as it is able to draw the learners' attention [9]. It is identified as a promising technology which can significantly improve the learners' motivation and interest in educational context. The proposed system develop an interface for astronomy learning using AR technology which will make the astronomy learning process more interesting and enjoyable for the users.

6. Methodology

In order to design and develop the AR-Solar system, effective and careful planning was conducted and some potential users (Students) were included in the design and development process to ensure that the AR-Solar system created would be useful and effective for the users. The development methodology adopted needed the students to participate actively in the process to ensure that the AR- solar system created and modeled, meet their need effectively. Figure 3 represents the system architecture.

The input of the system is a video stream from a webcam. Initially, the system will search for the markers by finding the 3D position and orientation of markers. During this stage, the image taken into the video are converted into binary image which is a black and white image. The positions and orientations of the markers relative to the webcam are then calculated. When the desired marker is detected, the position and orientation of the virtual objects are determined so that the 3D objects are rendered in video frame. As an output of the system, the virtual objects are overlaid on the markers in the.

The system design is then carried out. Firstly, the textures of the planets are obtained and information about the planets is acquired during the data collection stage. It is followed by coding and development stage by using FLAR Toolkit, Action script 3.0, 3Ds studio max and Photoshop followed by the coding is implemented into the system. A webcam is used as a tool in capturing the image of the markers. When the marker is detected as described in the system architecture, the system output which is the virtual objects are projected on the marker. Figure 4 represents the system design of AR Solar System Planetary.

6.1. Development of prototype

- FLAR Toolkit: is a software library for building Augmented Reality applications in Flash. This means that FLAR will bring Augmented Reality to your web browser when you have a webcam and a recent Flash Player. FLAR is the AS3 version of [ARToolKit] but not ported from the original C version. The port is based on the Java version which is called [NyARToolKit]. FLARToolkit will detect the marker from an input image and calculate the camera position in the 3D space.

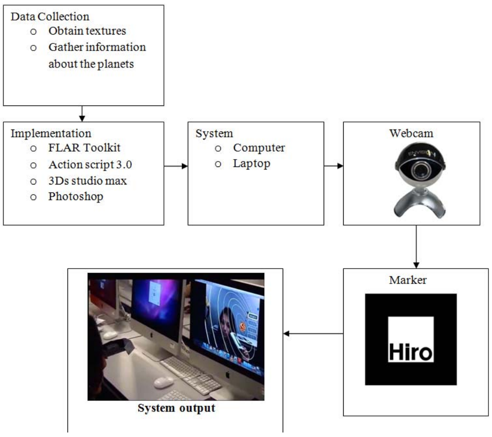

Figure 4: System design

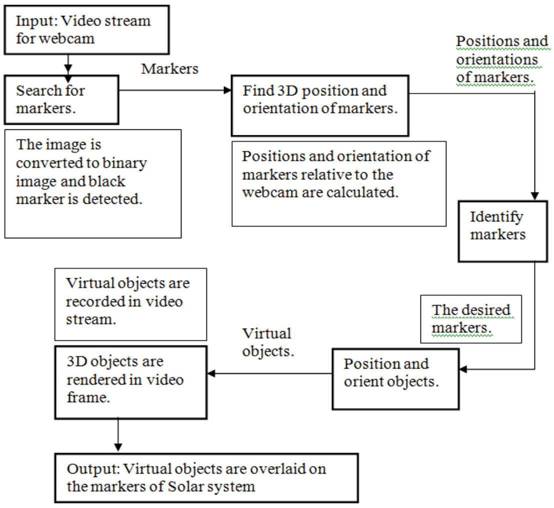

Figure 3: System Architecture

- Action Script 3.0: is a powerful, object-oriented programming language which is regarded as a significant step in the evolution of the capabilities of the Flash Player runtime. The motivation driving ActionScript 3.0 is to create a language ideally suited for rapidly building rich Internet applications, which have become an essential part of the web experience.
- 3d Studio Max: Autodesk® 3ds Max® and Autodesk® 3ds Max® Design software provide powerful, integrated 3D modeling, animation, rendering, and compositing tools that enable artists and designers to more quickly ramp up for production.
- System Requirement : Intel Pentium® IV 1.5GHz or AMD Athlon XP® 1500+ MHz - 1GB of RAM (1,5GB on Windows Vista®) - 64 MB 3D graphics card compatible DirectX® 9.0c (support shaders 3.0). DirectX® 9.0c (included) - 2.0 GB available HD space - A 56k or better Internet connection.
- Webcam: General Webcam will be used to capture the marker. Computers user must provide an external webcam where the laptop, tablet users will have their embedded webcam in the system.
- Marker: Basically any types of Fiducial marker can be used for this AR-Solar System Planetary. For the testing purpose, the system will be using the HIRO markers.

7. Usability Testing Methodology

An S-usability testing of AR-Solar system will be conducted using a case study approach conducted at a Primary school. S-usability testing conducted represents the final testing of AR-Solar system.

7.1. A Case Study

The S-usability testing will be conducted using a case study based on four constructs as follows:

- Effectiveness (easy to read, skim and taking notes with AR-Solar System)
- Efficiency (effective to use AR-Solar System)
- Ease of Use (easy to use the functionalities of mouse interactions)
- Good Visibilities of Image (images, texture and animation AR-Solar System)

7.2. Sample

Samples of the selected case study will be based on random sampling were users of the standard 4 primary school students who are required to take the science subject. The number of samples involved in the case study will be 40 students. Samples will be given the final prototype of AR-Solar system to be tested. The usability testing experiments will be conducted based on the following:

- Overall use of AR-Solar system based on the four constructs.

7.3. Research Instruments

Various research instruments to carry out the experiments will be designed and built. These instruments are as follows:

- A Questionnaire is designed to test on the four constructs: effectiveness, efficiency, ease of use and good visibility of image of AR-Solar System Planetary.
- An interview schedule will be arranged to verify some of the findings based on the other instruments.

8. Conclusion

The development of the AR-Solar System Planetary is focused on helping them understand and learning the concepts. The application will allow students to enhance their knowledge and conduct revision at anytime and anyplace using a computer and a webcam. This system was developed following very strictly the syllabus of the Science subject in Primary 4. This method will make the teaching and learning session more interesting and thereby more effective. The application would be an ideal tool to help students understand and learn better and can be a new method to deliver the lessons instead of the conventional method adopted currently as well as can be used as a teaching aid for learning the subject.

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