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On the Use of Virtual Reality-Based Engineering Education

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Abstract: Uses of virtual reality are very much increasing day-by-day in the era of science and technology. Many areas of engineering education, training, demonstration, researches and higher education using virtual reality offers more innovative and challenging opportunities. The cost of engineering education is always very high. In this area, learner improves their skills and knowledge by using the different tools, techniques and processes and reduces the cost. After improving software and hardware, tools and instruments by virtual reality the engineering education are now in easier, sophisticated way, attractive and cheaper. Here, more difficult problems like as 3D digital technologies, medical training, and military training etc. in engineering education are presented and analyzed by using the implementation of virtual reality, so that the learner's get educational benefits by using virtual reality technics.

Key words: engineering education; researches; training; virtual reality; 3D digital technologies
JEL codes: I230, A200

1. Introduction

Virtual Reality (VR) is an impetuous development of technology leading to amazing change in human life. This VR technology deliver us new educational thinking and deal with difficult problems. Computerized systems provide wide variety of learning approaches such as multimedia presentations, teaching tools, realistic simulations of situations, complex question-and-answer sessions so that students can be benefitted. Besides, some of the approaches are quite costly and hazardous to bring in the classroom in reality. As a result, the usage of computers is increasing more and more as it provides better education. So, VR technologies are now developing widely and new methods are continually emerging.

The Virtual Reality engineering lab teaching system has a complete engineering method. The lab operator handles the engineering method of the classroom of different virtual environments through the controlled device. The user can experience and notice different elements at a closer range.

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Students can know the better of all engineering experiments, although immersive learning, learners better immersed in their own, feel the presence of learning and fun (P. Häfner, V. Häfner, J. Ovtcharova, 2013). During the observation process, the lab operator can also be in the hands of the controller for the required observation of the engineering method to observe the beginning of the lab operator can be the best visual point of observation and learning, this is completely beyond the reach of traditional teaching methods and effects clearly. Each method with a voice introduction, the operator in the process of operation effects due to the impact of voice through immerse learning. In subtle natural learning and objectives, this part behaves as a traditional learning. Finally, by using the VR technology, engineering methods can easily be understood to all the learners. So, teachers not only can guide students to learn, but also can explain other students synchronously though the display screen using in the VR environment. Most of the engineering sectors using this classroom like as Computer engineering, Chemical engineering, Civil engineering, Mechanical engineering, Architecture engineering, etc.

In this paper, an engineering educational class is designed and developed with the VR equipment for some students and implemented for taking the class in VR environments. In the class, students wire the VR devices and feel the thrills of using the VR classroom, gather the engineering knowledge more effectively and with better understanding and realization of the engineering knowhow.

2. Review Works

Virtual Reality (VR) are of two types based on the level of interaction and immersive environment and they are immersive virtual environment and non-immersive virtual environment. In immersive virtual environment, environments are presented on multiple, room-size screen, i.e., through a stereoscopic, head mounted display unit. On the other hand, non-immersive virtual environment, computer simulation is represented on as the conventional personal computer and usually explored by keyboard, mouse, joystick, or touch screen (A. H. G. Abulrub, A. Attridge, M. A. Williams, 2011; M. Hashemipour, H. F. Manesh, M. Bal, 2011). Special hardware equipment such as gloves, suits and high-end computer system might be needed in immersive VR environment. VR computer simulation has been defined as a highly interactive, 3D computer generated program in multimedia environment which provides the effect of immersion to the users (E. A. L. Lee & K. W. Wong, 2008). Users are able to become a participant concrete spaces which is a computer generated version of real world objects or processes. These simulations could take many forms, ranging from computer rendering of 3D geometric shape of highly interactive, computerized laboratory experiments (B. Balakrishnan, P. Woods, 2009). There are 5 identified key properties of good VR learning experience are presented here, so that one can easily apply the appropriate Virtual Reality application for one's targeted field.

Virtual Reality experiences in education should have following properties:

a) Immersive: Designers should strive to create the feeling that users are in an experience. For example, if one develops a medical app, make organs or bones come realistic for medical students.
b) Easy to use: Reduce the need to have special skills to interact with a VR app.
c) Meaningful: The VR experience must be made meaningful to students so that they can grasp the concept or idea. It would be a very good idea if the VR learning is delivered through a story. Stories quite simply provide better understanding of something.
d) Adaptable: VR realization should allow students to explore at their own pace. The app should provide complete control over the level of difficulty. Designers should establish how students learn and then use

this knowledge to design VR products that allow effective learning.

e) Measurable: Each education tool should provide measured influence. Teacher should be able to track the metrics of education so they can measure the resulting knowledge of a subject. When designing VR experiences, it's essential to choose appropriate metrics and make it clear what criterion will be used to measure success and failure.

The aim of this work is to enhance student learning more effectively and the more engagement of the students in the class. In this process, the delivered educational content transform more properly by allowing the users to interact with it.

3. Virtual Reality Based Education

Virtual Reality (VR) is a new concept where immerging people watching the display in 3D digital environment with great thrilling. One can interact with the display and receiving information by virtue of computer-generated images and contents with animation. In this environment, one can feel the senses by using the sight, hearing, touch, etc. and achieve realization that is close to the real environment though it is an artificially developed and arranged environment. Virtual reality environment can be built up by using a digital 3D computer equipment and VR display equipment instead of the normal display. A simulation process for the virtual environment requires two main components and they are headsets, all-direction treadmills, special gloves, goggles, etc. (A. Z. Sampaio, P. G. Henriques, O. P. Martins, 2010). These VR tools provides natural, high-quality images, more realistic and more interactive. Accuracy and better performance of these devices depends on image resolution, field of views, refresh rate, motion display, pixel persistence and audio/video synchronization. To accomplish them, they need headset, a computer smartphone, or another machine to create a digital VR environment and a motion tracking device in many cases. A headset display content before a user's eyes, while a cable (HDMI) transfers images to the screen from a computer (W. K. Liou & C. Y. Chang, 2018). The other option is headsets working with smart phone, such as Google Cardboard and GearVR that is a phone act as a display and a source of VR contents.

Some vendors apply lenses to change flat image into three- dimensional. Usually, a 100/110-degree field of sight is achieved with VR devices (Z. Guoliang and M. Caiping, 2010). The next key is the frame rate per second, which should be 60fps at a minimum to make virtual simulations look realistically enough.

For user interaction there are several options:

- Head tracking: Head tracking system in VR headsets follow the movements of your head to side and angles. It assigns X, Y, Z, axis to directions and movements, and involves tools like accelerometer, gyroscope, a circle of LEDs (around the headset to enable the outside camera). Head tracking requires low latency, i.e., 50 milliseconds or less, otherwise, users will notice the lag between head movement and a simulation.
- Eye tracking: Some headsets contain an infrared controller which tracks the decision of your eye inside a virtual environment. The major benefit of this technology is to get a more realistic and deeper field of view.
- Motion tracking: Though not engineering and implemented well enough yet, motion tracking raise VR to a totally new level. The thing is, that without motion tracking you'd be limited in VR-unable to look around and move around. Through concepts of the 6DoF (six degrees of freedom) and 3D space, options

to support motion tracking fall into 2 group, optical; and non-optical tracking is typically a camera on a headset to follow the movements, while non-optical means the use of other sensors on a device or a body. Most of existing devices actually combine both options

4. Implementation and Analysis

4.1 Implemented in the Classroom

There are some methods for implementing the Virtual Reality (VR) and they are: Simulation-based VR, Project-based VR, Desktop-based VR, Head mounted display VR, Avater Image-based VR, etc. The proposed system is based on the combination of Simulation-based VR and Head mounted display VR. To implement the virtual reality enabled classroom environment 2 GB RAM, VR headset, Screen display at least 5.0 inches, Android 5.0 higher (For iPhone iOS 8 or higher), VR app- Cardboard or VeeR, Quality Headphones for Immersive Experience. VR technology has been implemented in a classroom in the Computer Science and Engineering Department of the Faculty of Science and Information Technology of the Daffodil International University (DIU), Bangladesh as a test case. For that a VR device is installed and set to the students of the class. The students have enjoyed the environment and also filled thrill in the class. Without the VR device the class has been performed and enjoyed for some engineering topics on a class of students. And also the class with the VR devices in the same set of students and the same topic has been taken and measured. The engineering class with using the VR devices is found better. The implemented class environment with using the VR devices are depicted in the Figures 1-3.

Figure 1 Students Wired the VR Device

Figure 2 Students Feel the VR Class Device

Figure 3 VR Setup Class Room

4.2 Data Analysis

The proposed system has been implemented in a classroom of the Daffodil International University which has 23 students with the VR equipment. Students using in this class are found very much excited for learning the matters and all of them are found very happy. Among all the students a combination of the two methods are working with the proposed method and the comparative output is presented in the following Table 1.

Table 1 A Comparative Analysis with the Proposed System

Methods/Characteristics	Positional Tracking	Audio Input/Output	Real World Environment
Head Mounted VR	√	√	√
Simulation-based VR	√	x	√
Proposed Method	√	√	√

5. Conclusion Advantages and Disadvantages

Some identified advantages and disadvantages are presented below.

Advantages: Applications of Virtual Reality has some advantages. The identified advantages of Virtual Reality applications are presented below:

1) Increase knowledge area
2) Active experience rather than just passive
3) Helps to understand complex concepts, subjects or theories
4) No any distractions while the study
5) Boosts student's creativity
6) Creating Interest
7) Improves Educational Value
8) Expands learner's efficiency to gain knowledge
9) Outstanding Visualization

Disadvantages: There are also some disadvantages for the applications of Virtual Reality. The identified disadvantages of Virtual reality applications are given below.

1) Lacks Flexibility
2) Ineffective Human Connections

3) Getting Addicted.

6. Conclusion

A virtual reality based classroom has been designed and developed for a group of students for Department of computer science and engineering department in the Daffodil International University and has been implemented for an engineering class. It is found as the doorstep of engineering education system that will change the classroom as the technologically advanced place of learning. It is realized that by using VR technology a significantly increasing student's engagement is found in learning system. This can be applied for all engineering education system where it be needed and will be appropriated.

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