THE APPLICATION OF VIRTUAL REALITY IN ENGINEERING EDUCATION

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ABSTRACT

Virtual reality (VR) incorporates high- speed three-dimensional graphics, audio feedback, psychology, and special peripheral devices to produce “realistic” computer generated interactive environment that are indistinguishable from reality. VR offers many benefits to engineering education, including the delivery of information through multiple active channels, the addressing of different learning styles, and experiential- based learning. VR applications have been used in several learning processes that involve visualization and simulation. The educational benefits offered by this technology include the ability to take students into environment otherwise inaccessible, the high memory-retention of “experience” as opposed to passive observation, and the ability of learners to visualize. In order to determine how VR can be apply in engineering education, research should be carried out to study of its strength, weaknesses, and capabilities of VR as applied to a variety of situations. By this mean, it will identify the appropriate application of VR in teaching and learning.

ABSTRAK

Realiti maya merupakan penggabungan grafik 3 dimensi, gerakbalas audio, psikologi dan perisian khas untuk menghasilkan persekitaran “realiti” yang dijanakan oleh computer secara interaktif yang menyerupai persekitaran sebenar. Realiti maya menawarkan banyak kelebihan terhadap pendidikan kejuruteraan termasuklah menyalurkan informasi melalui pelbagai saluran yang aktif, mengenal pasti gaya pembelajaran yang berbeza, dan pembelajaran berasaskan experimental. Aplikasi realiti maya telah banyak digunakan didalam beberapa proses pembelajaran yang melibatkan proses menggambarkan dan simulasi. Kelebihan teknologi ini terhadap pendidikan adalah termasuk kebolehan pelajar untuk memasuki persekitaran yang dikehendaki, ketahanan memori yang tinggi terhadap “pengalaman” yang berlawanan dengan pemerhatian secara pasif serta kebolehan pelajar untuk menggambarkan. Dalam menentukan bagaimana realiti maya boleh diaplikasikan di dalam pendidikan kejuruteraan, kajian perlu dijalankan untuk mengetahui kekuatan, kelemahan, keupayaan kaedah ini untuk diaplikasikan di dalam pelbagai situasi. Dengan menjalankan kajian seperti ini, ia dapat mengenal pasti aplikasi realiti maya yang sesuai dalam pengajaran dan pembelajaran.

1.0 Introduction

Virtual reality is a special kind of simulation, designed to convince user to the greatest extent possible that they are actually within the computer generated simulation environment, whether that environment is a simulation of the real world and imaginary world. Most current virtual reality environments are primarily visual experiences, displayed either on a computer screen or through special or stereoscopic displays, but some simulations include additional sensory information, such as sound through speakers or headphones. VR requires hardware and software that furnish a sense of (1) immersion, (2) navigation, and (3) Manipulation (Helsel, 1992).

Virtual reality technology has been widely proposed as a significant technological advance that can offer a novel form of education. The educational benefit of these applications is the active participation of students in learning process where human remember only 10 % of what they read, 20 % of what they hear, but retain up to 90 % of what they learn through active participation (J. Georgiou, 2007; K. Dimitropoulos, 2007; A. Manitsaris, 2007). Virtual reality offers teachers and students unique experiences that consistent with successful instructional strategies: concept visualization, simulations, field trips, hands-on learning and group project.

At present, in carrying out a project, the use of new computer technologies, in particular, graphics systems and especially those relating to three-dimensional modeling (3D), makes a very positive contribution to improving the transmission of rigorously correct technical information and, in general, to the understanding of spatial configurations in their environment (A. Z. Sampaio, 2006; P.G. Henriques, 2006; Carlos, 2006). These systems support the creation of models defined in three dimensions, providing a distinct type of plane projection, without being limited as to localization, viewpoint, orientation or distance from the observation point. The understanding of the real form is, obviously, rather more intuitive. In addition, VR has also been applied as a complement to 3D modeling, leading to better communication between the various stakeholders in the process, whether in training or in professional practice.

2.0 Virtual Reality and Learning Theories

The development of models of learning has historically coincided with technological developments, from Behaviorist theory's focus on mechanical control to cognitive theory's focus on computer models of the mind. Corresponding to the developments of educational theory and its correlation with technological developments, Winn (1993) claims that, in instructional design at least, there have been four generations of development. The first generation was shaped by behaviorist theory. This theory developed traditional drill and practice tutorial instructional design that focuses on imparting objective knowledge or content to the learner. The second and third generations have been informed by cognitive theory's focus on the processes involved in assimilating and encoding information.

The second stage of instructional design focuses on the designer and strategies he or she may use to reduce the cognitive load on students thereby facilitating instruction. The third generation focuses on the relationship between the user and the information presented. This stage would include intelligent tutors that attempt to adapt to individual learning styles by responding to the user's interaction with the program. The fourth generation focuses on the constructivist assumption that the learner constructs the knowledge and is characterized by discovery and experimental learning. Winn (1993) suggests that constructivism has outdated all other forms of educational theory.

Perhaps the most well known computer application of constructivism is the LOGO Microworld, developed by Papert, which is based on the concept of constructionism learning. Papert (1993) uses the term "constructionism" to label his favored approach to learning. Constructionism is built on the assumption that children will do best by finding for themselves the specific knowledge they need. The goal is to teach in such a way as to produce the most learning for the least teaching. Papert's philosophy of learning and his constructionism approach rely on the computer for realization. He imagines a machine he refers to as "The Knowledge Machine" which would allow children a rich exploration of the world. Primitive examples of this Knowledge Machine would include "interactive video", "electronic books" and "virtual reality". It seems that immersive VR is very much close to what Papert has had in mind when discussing the concept of the "Knowledge Machine".

VR and LOGO are different in terms of interaction. VR represents real experiences in a natural way where the interaction disappears due to the immersive nature of VR. In LOGO, for instance, the keyboard, mouse, or screen comes between the student and the program. In VR there is no interface (Bricken, 1991). Winn & Bricken (1992) argue that interaction with the virtual world is intuitive because students interact with objects in natural ways, by grasping, pointing, etc.

3.0 Virtual Learning Environment

VR learning environment is designed to fit human architecture. A virtual world empowers us to move, talk, gesture, and manipulate objects and systems in a natural way. The skills needed to function within a virtual world are the same skills we have been practicing in the physical world. By using virtual reality learning environment, it offers unique interactivity and can be configured for individual learning performance styles. Sulbaran and Baker (2000) created an online learning system to study the effectiveness of VR in engineering education. They found that 82 % of learners thought learning with VR was more engaging than learning from reading books and listening to lectures using overhead containing graphics or pictures.

Jonassen (1994) proposes six principles of constructivist learning environments that are relevant to VR. Those principles are as follows:

- Provide multiple versions of reality, thereby representing the natural complexity of the world.
- Focus on knowledge construction rather than reproduction.
- Present authentic Tasks.
- Foster reflective practice.
- Facilitate context and content-dependent knowledge construction.
- Support collaborative constructions of knowledge, rather than encouragement of competition among learners for recognition.

Virtual reality technologies typically have the most potential in educational settings when dealing with scenarios that are difficult or impossible to create or re-create otherwise, such as examining internal human physiology, psycho-perceptual phenomena, and non-sensibility environments meant to examine specific cognitive processes. This can be described as “a sense of immersion and inclusion in a virtual environment which allows the learner an opportunity to interpret and encode his or her perceptions in a broader, deeper set of experiences than those existing in current standard educational environments” (Osberg, 1992). Virtual environments provide an extremely rich learning atmosphere where students gain a ‘sense of presence’ within the virtual space (John I, etc, Sai C.M, etc, Anthony J.etc, 2003).

4.0 Virtual Reality for Geometry Education

Normally, three-dimensional geometric models, which are used to present architectural and engineering works, show only their final form, not allowing the observation of their physical evolution. The use of techniques of virtual reality in the development of these educational applications brings new perspectives to the teaching of subject in the area of geometry education. The visual simulation of the construction process need to be able to produce changes to the geometry of the project dynamically (A. Z. Sampaio, 2206; P.G. Henriques, 2006).

Many learning domains including Sciences, Mathematics, Engineering, Statistics, Economic and Financial Sciences, and Art have such learning areas. Recent uses of VR in education include it simulation and training of dangerous phenomena, the creation of virtual laboratories and performing virtual experiments, and to teach difficult concepts. In Technical Drawing the adaptation has been gradual accompanying the appearance of new graphics systems or products supporting plan drawing and modeling. Besides this constant updating of training in the new graphic resources available to engineering professions, and in widespread and frequent use, the School should also adapt its teaching activities to the new tools of visual communication (A. Z. Sampaio, 2206; P.G. Henriques, 2006). Figure 1 show how VR relates to built environment subject areas within the school.

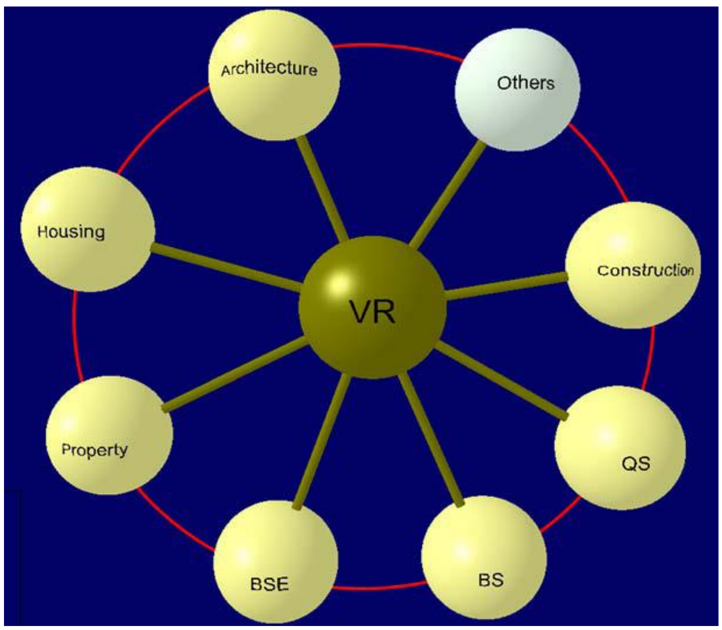

Figure 1: VR and built environment subject areas

Figure 1 show that VR technology can be used in civil engineering education or other engineering education in order to allow learners to experience a sense of immersiveness in the buildings, design and concepts. Furthermore, VR also able to enhance learner's motivation and make learning experience more interesting. In the architecture and construction field, learners can visualize the prototype of buildings, sites and cities and also capable to interact with the building and concept in their entirety views. It also allows the learners to easy changeover between these different views. Virtual reality can be used when teaching using the real thing is dangerous, impossible, inconvenient, too time-consuming or too costly (Pantelidis,1997). VR technology offers learners to learn from multiple viewpoints, and navigate through space in real time.

5.0 Spatial Abilities

Spatial abilities present an important component of human intelligent. The term spatial abilities cover five components, spatial perception, spatial visualization, mental rotations, spatial relations and spatial orientation (Maier, 1994). As shown in various study (Osberg, 1997; Rizzo *et al.* 1998) spatial abilities can be improved by VR technology. Virtual reality is a broad and encompassing term that includes many aspects of computer-generated environments and subsumes various levels of immersion, such as desktop VR, semi-immersive or augmented VR, and fully immersive VR (Fallman 2000).

To this point in time, virtual reality applications in education are scattered and minimal, but promising. Topic areas such as geometry, mathematics, science, and engineering have all been reported successful in VR educational settings, as have spatial ability and visualization skill development (Kaufmann and Schmalstieg, 2002; Smith and Lee, 2004; Smith Et. Al. 2005). There is some debate among researchers as to the innate nature of spatial ability, and whether and how such skills can be developed (e.g. Geary,1998). Although some cognitive scientists feel that spatial visualization cannot be improved, many practitioners in education and industry claim that this ability can be increased. Sorby (1999) differentiated between spatial ability (innate in a person prior to training) and spatial skill (learned or achieved through training). Saito, Suzuki, and Jingu (1998) proposed that courses in descriptive geometry and computer graphics seemed to improve spatial skills. Field (1999) also supported the use of freehand drawing (sketching) in courses to enhance spatial visualization skills, while Kaufmann (2003) felt that the main purpose of geometry instruction is to improve students' abilities in spatial comprehension.

Conclusion

Finding effective ways to use technology to enhance learning is a challenge that educators, academics, policymakers and the technology industry must work together to solve (Gates, 2002).The advantage of introducing new technologies into the creation of didactic material suitable for university and technical education should be made known and applied. There are many other possibilities for the creation of computational models mainly where the subject matter is suitable for description along its sequential stages of development. The applications with these characteristics make the advantage of using techniques of virtual reality more self-evident, especially when compared to the simple manipulation of complete models which cannot be broken down. The pedagogical aspects and the technical concepts must be attended on the elaboration of those both models. The involvement of virtual reality techniques in the development of educational applications brings new perspectives to Engineering education.

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