A REVIEW OF AUGMENTED REALITY IN FIELD OF ELECRICAL ENGINEERING

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Abstract— This paper studies and reviews on Augmented Reality in different fields of Electrical Engineering and Education. These techniques have the great potential to be successfully integrated with the education based software programs and hardware tools to improve pedagogical methods, such as the MATLAB and SIMULINK, which can be used for data analysis, numerical simulation and advanced computing.

I. INTRODUCTION

In the modern age, technology has advanced considerably and there is a desire, among us, that we want takes the reality to the next level to aid us in different aspects. With the aid of technology this is possible in two forms of man-made realities. They are known as Augmented Reality (AR) and Virtual Reality (VR). These two terms are very loosely terms and interchanged mistakenly. AR is a type of VR, which is defined as “the use of real-time digital computers and other special hardware and software to generate a simulation of an alternate world or environment, which is believable as real or true by the users” [1]. In other words, the subject who is exposed to virtual reality feels as though they are moving and interacting in a completely non-real environment, usually generated digitally. They cannot perceive there are surrounded in. In contrast, AR enhances the reality we all know by supplementing it with a virtual layer of information, thus merging the two types of realities we are aware of. An example of Augmented Reality (Figure 1) and Virtual Reality (Figure 2) is displayed for better understanding. Simply, augmented reality maintains the real

Fig - 1

world in the background and “augments” extra information on top of the view for its necessary purpose. Nowadays, AR and VR are being used in many sectors for various purposes. We will be focusing on the benefits of its use in the health and engineering sectors.

Fig -2 Miligram’s reality-virtuality continnum

II. OVERVIEW OF AUGMENTED REALITY HARDWARE AND SOFTWARE

Because human-computer interaction is the central issue for any VAR applications, all VAR hardware and software are aimed at managing this critical interface between humans and computers. In order to appreciate their potentials and limitations in product realization applications, we include here a brief overview of hardware (computer, tracking, input, and output) and software commonly used in VAR systems.

First, three terms, namely refresh rate, update rate and latency (or lag), which are commonly used in describing VAR system performances, must be explained. The refresh rate defines how often the screen of the display device is refreshed with the same or a new image. Typically, a refresh rate of 72 Hz is required for human eyes to view the images steadily without flickers – an important requirement for VAR realism. The update rate defines how frequently the content of the image is updated on the display device. The update rate is determined by the computing speed at which software is executed. The latency or lag is the time delay between an event occurring and its observation. In a VAR system, the latency can be the time elapsed between a tracker detecting a new head position and a user seeing an updated image rendered on a display.

a. VAR Graphic systems

VAR computers come with all different processing powers and storage sizes, ranging from desktop PCs to graphical workstations to supercomputers. Their processing limitations, however, ultimately determine the scope and complexity of VAR applications they can support. VR-based interactive games from entertainment industries commonly work on powerful PC-based game machines equipped with multi-media capabilities. These PCs are optimized for interactive graphics, 3-D sounds, and limited 3-D input/output devices. However, their limited processing powers can only give partial immersion with limited realism and interactivity that restrict their applications in product realization. Most VR-based systems in the product realization domain require the power of high-end graphics workstations or supercomputers often used in the simulation industries. These high-power machines are often equipped with specialized multi-channel image generators to produce real-time, panoramic views at high update rates..

b. VAR tracking devices

The realism of VR comes largely from the system's ability to update computer images automatically according to changing user viewpoints. This requires tracking technologies to continuously monitor the real-time position and orientation of the user's head and hands, and sometime the entire body for some applications. The tracking technologies currently used in VAR applications include mechanical, optical, ultrasonic, inertial, and magnetic types each has their strengths and limitations. Latency (or lag) and update rate, which determine the time taken between measuring a position and its availability to VAR software, are most important to trackers. If too much delay is encountered, navigation and interaction with virtual objects could become very cumbersome. An example of an electromagnet type tracking device is Ascension Flock of BirdsTM, as shown Figure 3.

Fig – 3 Motion tracker - Ascension Flock of BirdsTM

A typical mechanical tracker is a reverse robotic arm jointed at the shoulder, elbow and wrist. When one end is fixed in space, the position and orientation of the other end is calculated by measuring the joint angles using suitable transducers. This type of tracker has high accuracy and low latency, but its active volume is restricted and its operation is quite intrusive.

Optical trackers use video cameras to record the movement of users by tracking pre-placed markers on their bodies. This type of tracker is not intrusive; but the placement of markers, so that they are always visible from the camera, is not an easy task when complex motions are performed. This type of system can also be used to trace facial expressions by monitoring the motion of small markers attached to the user's face. Ultrasonic trackers employ ultrasonic sound to locate the position of the user's head and its movements. This type of tracker is simple, effective, accurate and low cost. But it is restricted to working within a small volume (much like seeing a volume of space in the form of a fish-tank inside the monitor), sensitive to temperature changes, and dependent upon line of sight. Electromagnetic tracking technology is the most popular type in VAR systems to date. It uses a device, called the source, that emits an electromagnetic field, and a sensor that detects the radiated field to determine the position and orientation of the user's head and hands. The source is often attached to a fixed place in space and the sensor is attached to a head-mounted display or fitted with a 3-D mouse. This type of tracker is non-intrusive, has low latency and no line of sight restrictions. However, its active volume is small (a few cubic meters), and large metallic objects readily distort the magnetic fields, resulting in erroneous head position and orientation readings. As described before, this problem is of great concern to AR applications in product realization where computer-generated images must accurately be projected onto real objects.

Inertial trackers such as gyroscopes can be used together with other motion sensors to make head motion predictions, thus reducing the effective system lag.

c. VAR input devices

A VAR input device must be able to measure all six degree-of-freedom (DOF) movements in space in order to completely control the position (i.e., X. Y. Z displacements) and orientation (i.e., pitch, roll and yaw angles) of virtual objects during interaction and navigation. The input devices commonly used in VR systems are 3-D mouse and data-glove, as shown in (a) and (b). Other more advanced input methods, such as gesture recognition, remain as experimental research tools to date.

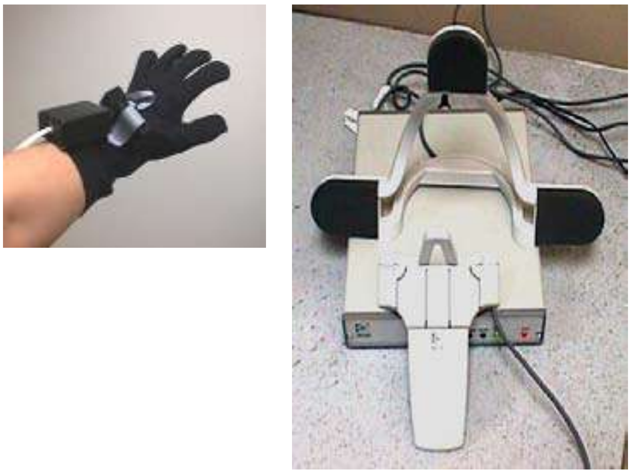

Fig – 4 (a) data glove - 5th Glove TM (b) 3-D mouse –Logitech

Like 2-D mice commonly used for computer inputs today, a 3-D mouse is a hand-held device with a tracker sensor and some buttons. It is used for navigating or picking objects within a virtual environment. Although most 3-D mice are used for controlling spatial movements, there exist more advanced devices that enable tactile and audio instructions and feedback. 3-D mice exist in different forms such as flying mice, wands, and force balls, each with different design features for various application needs.

With a 3-D mouse, it is hard to accurately capture hand gesture, such as pointing or grasping, which are very natural for human inputs. Data (or digital) gloves are designed for this purpose. A simple interactive glove is made of a lightweight material into which small transducers (e.g., strain gages or fiber optics) are sewn to measure finger joint angles. An additional tracker on the wrist also monitors the position and orientation of the hand. Together, these represent a complete virtual hand within the virtual environment for various manipulation actions. They can accurately communicate hand gestures and, in some cases, even return tactile signals to the user's hand.

d. VAR output devices

Three main types of output devices, namely visual, audio and haptic, are needed in VR systems. Visual output devices are 3-D graphical displays, which are most popular in VR applications to date. Haptic devices that provide force and tactile feedback are the least developed types of VR output devices. An example that uses mechanical robot arms to provide force feedback is PHANTOMTM.

Fig - 5

Display technologies, ranging from 3-D screens, head-mounted displays (HMD), BOOM displays, CAVEs, virtual tables and panoramic screens, are central to any VR system. They offer users different degrees of immersion experiences, and hence have their different application focuses. 3-D screens often require users to wear a pair of polarized glasses to see a sequence of corresponding left and right views of a scene. A typical HMD contains two LCD screens, one for each eye, viewed through infinity optics (i.e., they are collimated to infinity). Since users are completely enclosed within computer-generated scenes that are updated through tracking devices mounted on HMDs, full immersion is achieved. The BOOM display is a high resolution CRT stereo device supported by a counterbalanced arm. As the BOOM is moved about, joint angles in the articulated arm are measured to compute 3-D position and orientation.

e. VAR Software

Many world-building toolkits are now available with advanced graphical user interfaces (GUIs), enabling people without programming experience to create virtual environments and VAR applications. The user can insert predefined objects, drawn from libraries of 3-D clip art or imported from other CAD programs, and then assign necessary behaviors to the objects. Sound and portals are the two important aspects of interactivity in VAR software. Adding sound to a particular event at a specific time can result in an enhanced authenticity to a VAR experience. Portals allow transitions between multiple environments – an important aspect for navigating through the VAR world. When the user traverses one programmed portal, he/she passes through another connected environment or level within the simulation.

III. APPLICATION OF AR IN ELECTRICAL ENGINEERING

a. A first example of application concerning train maintenance is illustrated in Figure 6. The task is to perform an operation on an electrical transformer, where the system uses CAD models of the parts and visual hints for retrieving their names and illustrating to the user the maintenance steps.

Fig. - 6 Screenshot s of a maintenance procedure on an electrical transformer of a train (a) retrieving name of transformer's parts; (b) animations illustrating a maintenance step.

b. Virtual Reality Training System (VRTS) for training of operators in the maintenance of Live-lines in a distribution system.

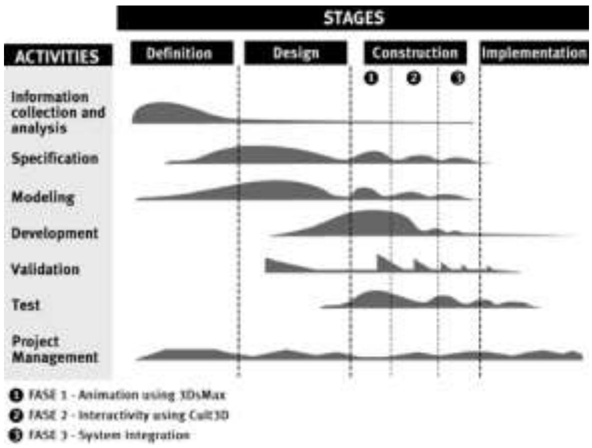

Fig -7 . Stages for development of ALEN 3D system

The system was designed in two phases: a non-immersive virtual reality system and an immersive virtual reality system. The following describes the stages of systems development.

c. The replacement work fuse holder operation must be performed by using a telescoping disconnect stick as a kind of hot stick at a safe distance to prevent harm due to electric spark..

Fig - 8 Some examples of maneuvers for live-line maintenance

d. Matlab and Simulink Applications

Based on the similar ideas from virtual reality and augmented reality, the augmented scene can also be Over verlaid on the virtual scene, which is referred to as augmented virtuality. In order to achieve real time interactions of physical objects and digital objects, augmented reality and augmented virtuality can also be merged together so that the real and virtual worlds are both reached to produce new visual environment.

This technology is referred to as the mixed reality (MR). To improve the quality in teaching and learning for signal and image processing lecture and laboratory classes, some enhanced pedagogical methods ought to be developed over the existing traditional methods, such as the virtual reality, augmented reality and mixed reality. All these methodologies are helpful in establishing convenient and effective communication between faculties and students, which will cultivate students with quick learning and facilitate the deep understanding in simple ways.

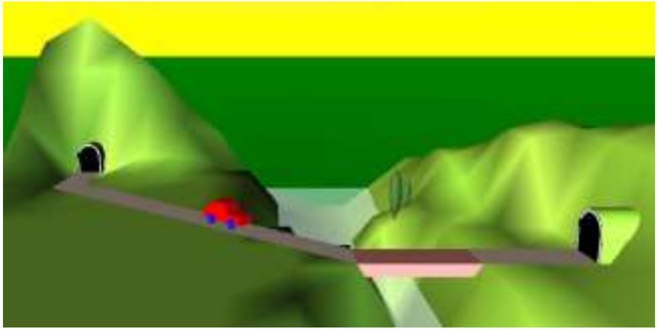

Fig. -9 Enhancing Pedagogy Using VA Toolbox

Information technology provides useful education tools to improve the engineering pedagogy. Matlab, Simulink, Labview and AutoCAD are among the most broadly recognized standard software tools. The integration of Matlab and Simulink with virtual reality, augmented reality and mixed reality gives rise to the further enhancement of student learning. It creates a communication platform for the students to exchange creative ideas. For example, via virtual reality toolbox Matlab/Simulink interface, students can learn about virtual world structures in order to navigate a virtual car along the rough road through mountains. It actually employs dynamic and kinematic principles to model, synthesize and control the position, rotation, and dimension of 3D images so as to make the 3D animation presentation. At the same time, this result can also be viewed using the head mounted display with a real time scene. The demonstration illustrates the effective usage of the virtual reality techniques for engineering education. In fact this virtual reality graphics have been created using the MATLAB and Simulink toolbox with the adjustable parameters. The generation of the virtual scene using this toolbox is a step by step sequence which consists of virtual object creation, location and orientation computation, virtual scene and virtual objects capturing.

IV. LIMITATION

To develop the AR system, there are several limitations in both technological and social aspects that must be addressed. First, there is no repository of databases to utilize as information sources that could be readily used by AR systems because designers and constructors are not motivated to create them. AR systems may require access to a detailed database of the operating environment. For example, there are no ready samples of three-dimensional virtual buried utility designs or as-builts which could be used for trenching and pipelaying training scenarios. Even if such examples exist, the data may not be grouped to segregate the parts of the model that represent one type of buried plant or conduit from another. Thus, a significant modeling effort may be required and should be taken into consideration when building an AR application. Secondly, technological limitations remain the major obstacle for AR systems. For instance, AR requires highly accurate trackers because even tiny tracker errors can cause noticeable misalignments (poor registration) between real and virtual objects. The biggest obstacle to building effective AR systems is the requirement of accurate, long-range sensors and trackers that report the locations of the user and the surrounding objects in the environment. No tracker currently provides high accuracy at long ranges in real time (Azuma, 1997). Another example is occlusion detection. With little or no prior knowledge about the surrounding real world, occlusion detection becomes a very tricky art in Augmented Reality because the need for a digital representation of a virtual object to be partially hidden by a real object is difficult to recognize. Occlusion errors easily ruin the feeling of an integrated environment that the user might otherwise experience. Thirdly, because of the technology development that is yet needed, there is a lack of motivation for AR technology transfer. AR technology adoption is arguably a tremendous leap for late adopters of technology as the construction industry is known to be. Whether AR can be realized as a truly a cost-effective solution in its proposed applications has yet to be determined. There are many research and development questions to be explored to prove to and educate AEC practitioners about the feasibility and profitability of applying AR systems. Finally, social concerns should not be ignored during attempts to move AR out of the research lab and into the hands of real users (Azuma, 1997). For example, if workers perceive lasers to be a health risk, they may refuse to use an AR system with laser-based trackers, even if those lasers are certified as eye safe. Another important factor is whether or not the technology is perceived as a threat to jobs, as an eliminator of workers. However, this concern should not be a critical problem for AR because it is intended as a tool to augment the user's awareness of how to perform, rather than something that eliminates the need for a skill position.

V. CONCLUSION

This paper has introduced a series of novel visual enhancing technologies to improve the learning quality on electrical and mechanical engineering education. Cases of virtual reality and augmented reality have been presented. The virtual reality presents people with virtual objects and the real scene so that the objects being manipulated will be physically creditable. In the augmented reality system, the 3D graphic representations of various objects will be overlaid on the real world scene. Both systems can easily be integrated with some education software such as Matlab and Simulink, which are used to improve the pedagogy methods and enhance the quality of student learning.

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