# Technical Practice on Virtual Reality and Augmented Reality for Electrical and Mechanical Engineering Education

ZHENGMAO YE[1], HABIB MOHAMADIAN[1], MICHAEL STUBBLEFIELD[1],
SU-SENG PANG[2], SITHARAMA IYENGAR[2]
[1]Southern University, Baton Rouge, LA 70813, USA

[2]Louisiana State University, Baton Rouge, LA 70803, USA

*Abstract:* - Applications of virtual reality and augmented reality have been proposed for engineering education. Cases on some electrical and mechanical systems have been studied. Virtual reality is a technology which allows people to interact directly with the computerized virtual environment. Based on computerized models, augmented reality is achieved by combining the extra virtual information with the real information, so that augmented scene can be generated. Both techniques will enhance the pattern recognition accuracy for electrical and mechanical systems, such as target identification and spectroscopic object recognition. Compared with conventional course instruction of image processing and signal processing, both techniques will significantly broaden the academic background of student learning with better understanding of theoretical methodologies. In addition, 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. Some practical examples in electrical and mechanical systems have been presented in the article.

*Key-Words:* - Virtual Reality, Augmented Reality, Engineering Education, CAVE, Matlab, Simulink

## 1 Introduction

One of main difficulties to instruct signal and image processing courses is the lack of coordination between theories and practices. Virtual reality and augmented reality practices are feasible approaches to solve this problem. It also gives rise to the better understanding and learning of students for lecture and lab courses. Both can be integrated with MATLAB and Simulink programs to improve pedagogical methodologies.

A model that defends the metaphorical design of educational virtual reality systems has been presented. The goal is simply to build virtual world capable of embodying knowledge: the metaphorical structuring in order to make the knowledge accessible to students. Visual interaction greatly changes the way engineering is performed, both in learning new materials and in explaining activities between practicing professionals. It can act as a potential and useful tool for reading, instruction, navigation, interaction, responding, learning, engagement and acceptance [1]. Virtual Reality (VR) has been proved to help students both experience directly some physical properties of objects and events and realize the actual implications of such properties. It favors also the discovery of features because it permits users to look at those elements that can not be seen; on the other hand, it allows users to change one's point of view in a continuous manner by accessing new, unusual perspectives, or making transformations that would otherwise be impossible in the real world [2]. Studying the practical and appropriate usage of virtual reality is a challenge. Efforts must be made to use virtual reality systems to improve the quality of student learning. The theories or models underlie the applications should gradually be developed [3].

The idea of Augmented Reality (AR) is to overlay virtual objects on a real world image by augmenting the real world image which we currently see. This technology has a variety of applications such as in the automobile, medicine and aircraft industries. An educational tool has been presented to serve as an interactive virtual laboratory in teaching processes [4]. AR has potential applications in the broadcasting and entertainment industry to entertain, educate and inform in a variety of environments such as broadcast studios, classrooms and at home. It has become more widely applied with advances in the display technology. Due to practical requirements of production, technologies that merge real and virtual elements in broadcasting include virtual studios and outdoor broadcast systems. It allows 2D graphic images to be merged with video image to display statistics in sports events. Interaction between separate virtual objects is difficult to achieve

as broadcasting systems use separate devices to track each element [5]. The 3D geometric construction tool is designed for mathematics and geometry education. It is based on the mobile collaborative augmented reality system. Spatial abilities present an important component of human intelligence. They cover five components, spatial perception, spatial visualization, mental rotations, spatial relations, spatial orientation. Spatial abilities can also be improved by the virtual reality technology. However, very little work has been done towards systematic development of applications for practical education purposes [6].

The progress of enhancing pedagogical methods of minority students using virtual reality and augmented reality technologies have been presented in this work [1-15], which is focused on electrical and mechanical systems. Technical integration of Matlab and Simulink into these two technologies is also introduced.

## 2  Virtual Reality Applications

In general, the virtual reality environment refers to various virtual experiences of vision, through either stereoscopic displays (e.g. LCDs) or computer screens. Stereoscopic viewing enhances both the perception of depth and the sense of space. Some advanced systems may also include visual, tactile and audio information at the same time. Our application is focused on two applications, i.e., Head Mounted Display (HMD) and Computer Automated Virtual Environment (CAVE).

### 2.1 Head Mounted Display

The head referenced viewing can provide a natural interface for the navigation in a virtual 3D space and allows for see-around, walk-around and fly-around capabilities in the virtual environment. A typical HMD consists of two miniature display screens and the optical system that channels the images from screens to eyes, thus, presenting a stereo view of the virtual world. In fact, both the position and orientation of the objects and HMD will be continuously measured by the motion tracker so that it allows the image generator to adjust the scene to the real time actual view. The HMD can be used to view a computer generated image superimposed on the real world scene by a partially reflective mirror. Using this system, people can walk through the surrounding virtual environment. In Figs. 1-2, the head mounted display virtual environment at the College of Engineering has been shown.
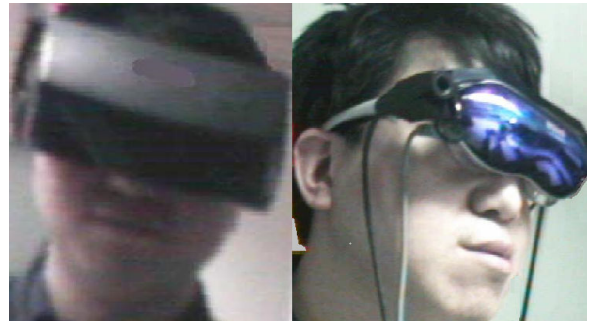


Fig. 1 Typical Head Mounted Display



Fig. 2 Virtual Viewing Using Head Mounted Display

### 2.2 Computer Automate Virtual Environment

Advanced visualization can be achieved using the immersive virtual reality from the CAVE facility. The CAVE system at College of Engineering is one of five Windows 2000 CAVEs worldwide, whose equipment and software provide an illusion of immersion by projecting stereo images on the front-projected floor and rear-projected screen walls of a room-size cube.  It served as the walk-in visualization environment which can hold several people who can enter and walk freely in a floating virtual 3D real time environment. VR also permits people to vary the values of corresponding variables in order to verify the consequences of these changes in virtual environment, while at the same time, the actual perspective is maintained. The head mounted tracking and display system can adjust the stereo projection continuously to the current position of the leading viewer. The human machine interface of CAVE provides the drag and drop capability which leads to a short learning period for students. Data from typical engineering hardware and software tools (e.g. Matlab, Simulink, Labview, AutoCAD, etc) can be viewed in this CAVE system. Generally, VR uses an optical illusion technique based on intentional image distortion to generate stereoscopic vision. Educators, students and researchers can visually interact with the simulation or experiment data together in real time 3D display by wearing stereo glasses and viewing data.

Using these special stereoscopic displays inside the CAVE, the people are fully immersed. Images appear to float in space so that people are free to walk around but maintain a proper perspective. The data fusion and visual analysis software tool is used to support the data exploration, knowledge discovery and visual display. For instance, CAVE allows people to access different functionalities on datasets of geospatial intelligence systems. It can also be used to convert and track the information from the global positioning system. The mechanical layout and the virtual effect of the CAVE system are shown in Figs. 3-4.
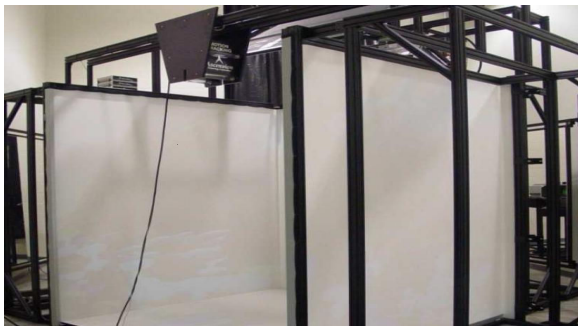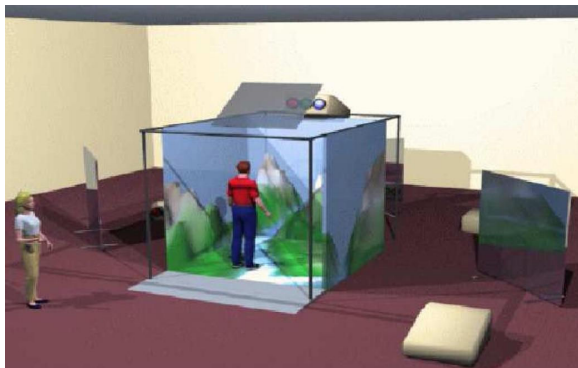


Fig. 3 Mechanical Layout of the CAVE System



Fig. 4 Virtual Reality in the CAVE System

## 3 Augmented Reality Applications

As discussed in the last session, using virtual reality, people are totally isolated from the real world while completely immersed into the artificial world. In other words, there is no interaction between the real world and artificial world. Thus, another technology can be introduced, which overlays the virtual artifacts onto the real environment. The augmented reality (AR) provides straightforward ways to interact between the virtual and real worlds to enhance the visual scene: either fill the virtual artifact into the real environment or display additional information about the existing real objects. AR brings people with the real world via employing ones' own visual and spatial skills. The computerized system serves as working environment of people with the combination of the real scene and virtual scene. It can be applied to 2D images and 3D objects. In general, images can be captured by CCD cameras, spectroscopic devices, ultrasound arrays, and so on. The stereoscopic 3D illusion can be generated from a pair of 2D images and then reconstructed by the computer, which produces stereo views. AR allows people to examine real 3D objects and simultaneously receive additional artificial information. To implement the augmented reality, 3D graphic models of various objects are overlaid on the actual video scene. Once the position and orientation is known, an AR scene is generated. The enhanced real-time view will generate a broad scene to ease navigation. The combination of real world and virtual scene will show people exactly where the object to be identified is located.
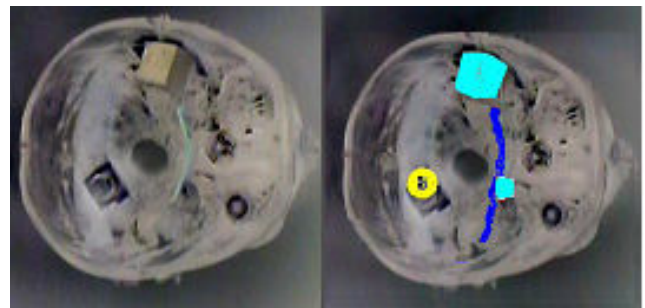


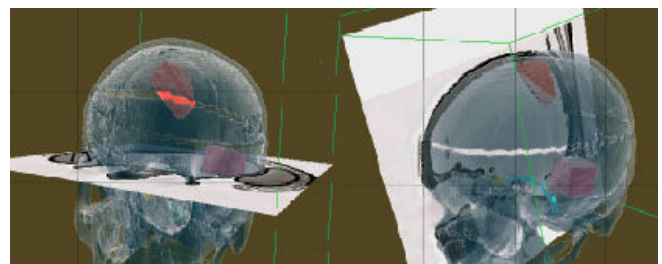Fig. 5 Real Time Augmentation for Objects of Interest



Fig. 6 3D Projection in Augmented Reality

AR is an education and research field which deals with merging of real-world and computer generated data. It has remarkable potentials in automotive, robotic, aeronautical and biomedical applications. As a typical example of AR engineering application, the passive master-slave robot with the miniature camera on its end-effector can be used to produce an accurate augmentation using advanced registration algorithms for different objects. AR scene is generated

via kinematics of a robotic device which has a visual sensing system. The coordination transformations from objects to the camera need to be calculated so as to produce the augmented scene. AR deals with both the real world and computer generated virtual scenes (Fig. 5). Then the image is digitally processed and augmented by overlaying the computer generated virtual graphics. This technology can also be used with 3D segmentation and projection techniques (Fig. 6). The AR data can be obtained from either available geometry data or registered sensing data. Regular procedures to produce the augmented reality scene should include: create 3D models in terms of objects of interest; use registration to determine the position and orientation of the objects and camera; generate the AR scenes and overlay on the objects of interest.

## 4   Matlab and Simulink Applications

Based on the similar ideas from virtual reality and augmented reality, the augmented scene can also be overlaid 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.
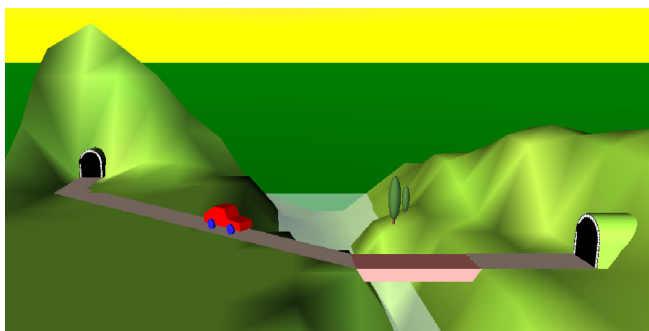


Fig. 7 Enhancing Pedagogy Using VA Toolbox

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 (Fig. 7). 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.

## 5   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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