

## 3D Virtual Reality for Education in Nuclear Engineering

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### 1. INTRODUCTION

Traditional education methodologies involving written text and video tapes are useful but lack interactivity. Assessment of the education imparted is also difficult due to lack of a direct feedback in the absence of interactivity. It is for such reasons that an interactive and virtual training paradigm shows some promise towards achieving the education goals in engineering. Three dimensional, interactive models can be an effective tool for engineering education [1]. Similar to the 3D computer games popular with teenagers; students can “play” these “educational games” and thus have a better experience of a range of concepts and scenarios. While these models can be fruitful on commonly available display monitors, they can also be “exported” to Virtual Reality (VR) formats and then displayed in the 3D, immersive VR environment for an even more realistic education and training experience.

### 2. DEVELOPMENT PLATFORMS

Several 3-D software platforms that can realize virtual models exist and are in use. Some of these focus on 3-D model development, such as Maya [2] and 3dsMax [3]. Others are good in providing interactivity between players and models, as is the case with gaming engines. A combination of platforms is used in this paper for VR model development. These include the *Unreal Tournament* engine, OpenGL, etc.

In *Unreal Tournament* engine, all basic elements for a model are developed in the “*level editor*” of the *Unreal Editor*. It provides the user with four windows, which show the top, front, side and 3-D views of the *level* developed. As details are added to the model, they are simultaneously updated in these four windows. Figure 1 is the screenshot of *Unreal Editor*. All the Unreal models are built in this “*level editor*”. The major difference between the *Unreal Editor* and some other 3-D modeling platforms is the way the model is built. Whereas one needs to add items in an empty space in most other 3-D modeling platforms, modeling in *Unreal Editor* starts with a solid (filled) world that *level* designers need to subtract from to create the desired space. Usually, *Unreal Editor* is used to build structures, such as buildings and areas surrounding buildings. On the other hand, smaller size items such as chairs or tables are usually developed in Maya or 3dsMax and then imported into the Unreal model. In addition to *Unreal Tournament*, we have also used OpenGL and C++ to either build educational model from scratch or to modify and add features to models already developed on other platforms [4].

### 3. DISPLAY PLATFORMS

Several options are available to display the models with varying degree of realism. For example, three-dimensional models can be shown in an immersive environment on Visbox. Visbox is a VR system, manufactured by Visbox Inc. (see [www.visbox.com](http://www.visbox.com)), and in use at the Nuclear, Plasma and Radiological Engineering (NPRE) department at the University of Illinois at Urbana-Champaign (UIUC). This device projects the image using two projectors to display 3D models on the screen which when viewed using special, tracked glasses, give a feeling of immersion in the environment. Though much cheaper than 4-6 walled CAVES and CUBES, this single walled system can still be expensive. An even less expensive alternate is now available through new video cards that display two, shifted (red and blue) images on ordinary monitors, which when viewed using colored glasses also give the feeling of immersion [5]. In these devices above, motion of player can be controlled by the mouse or joystick.

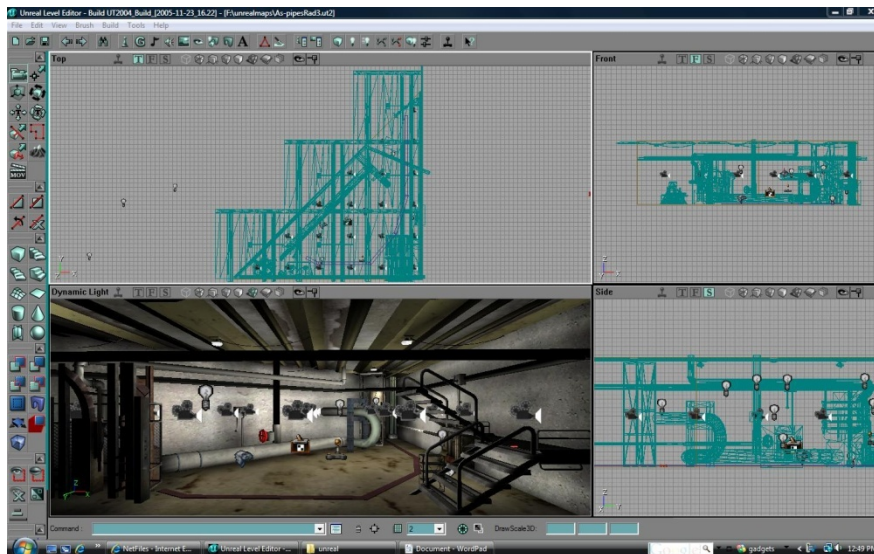


Figure 1. *Unreal Editor* with four windows.

### 4. MODELS

Several educational models are being developed. Three of these that are largely completed are described here. The 3D interactive model of a tokamak fusion nuclear reactor is an example of a VR model used for educational purpose at the NPRE department at UIUC (see Figure 2). The basic 3D model of the tokamak framework has been downloaded from the General Atomics website. Magnetic lines and particles trajectories have been added to this model in a realistic configuration. Color coded rings are the magnetic field lines. The smaller particles are electrons while the bigger ones are ions. Because of the Lorentz force, these particles rotate along the magnetic lines with different radii and in opposite direction. Students can learn how a fusion nuclear reactor works, and interactively experience with the 3D model. With special glasses, students feel these particles fly around them and they could even *touch* these particles.



Figure 2. A model of a Tokomak showing particles moving along the magnetic lines under Lorentz force on Visbox.

A second model developed for education purposes at the Department of NPPE at UIUC is that of the nuclear fission chain reaction (see Figure 3). This model simulates the dynamics of neutrons, from birth to thermalization and to eventual absorption or fission of a Uranium nucleus in a nuclear reactor. Standing in front of Visbox, students see fission reactions occurring around them. The big yellow spheres are U235 atoms, and the smaller blue spheres are water molecule, which are used to slow down the fast neutrons. The tiny moving dots are the neutrons. As the neutrons slow down, they change color to indicate their energy level (energy group). When they turn green, these neutrons have thermalized and are much more likely to cause fission. After getting hit by thermal neutrons, some U235 atoms split into two fission products, which are identified by *waste* in the model. Sound has also been introduced in this model. The model makes a short “ping” sound every time a fission reaction takes place. With joystick, students can go close to these atoms, seeing nuclear reactions happening around them.

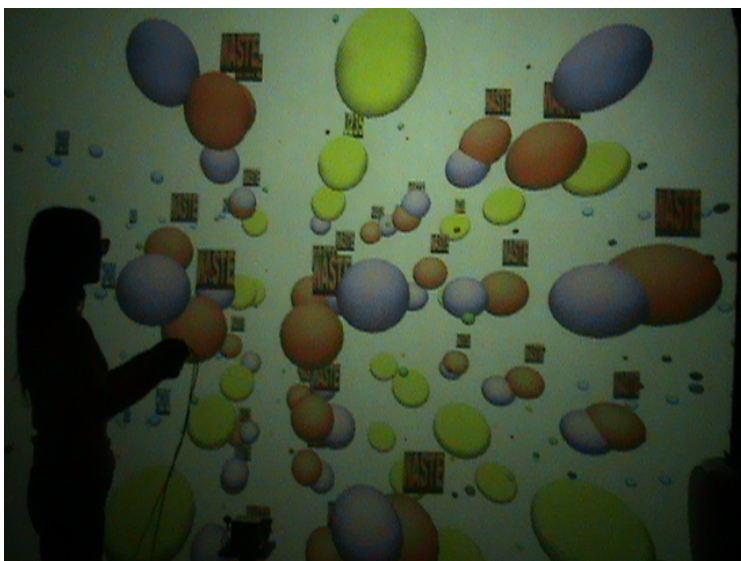


Figure 3. A 3D, dynamic display of thermalization and fission reaction shown in Visbox.

A third example is a model of a nuclear reactor [6] (See Figure 4). Model of the UIUC TRIGA reactor has been developed in *Unreal Tournament 2004*. Using TRIGA reactor as a model, detailed structure of the facility is included in the model. Besides the structure simulation, this model also has several interactive scenarios. The color coded radiation map is also developed to show the radiation dose level in this model. Scripts are written to display radiation on the map using different colors based on the radiation data. Red floor means higher radiation doses. Blue and green areas are used for increasingly lower level of radiation, respectively. Some virtual security cameras have also been added in a control room of this model. In a manner similar to placing a video camera at some prescribed location in the physical world to transmit live videos to some control room for monitoring purposes, virtual security cameras are meant to monitor virtual spots in the virtual model.

To give users more immersive experience, this model can be *exported* and displayed in Visbox. Using special glasses, students could experience the 3-D structure of the reactor. Joystick is used to control players' direction and movement.

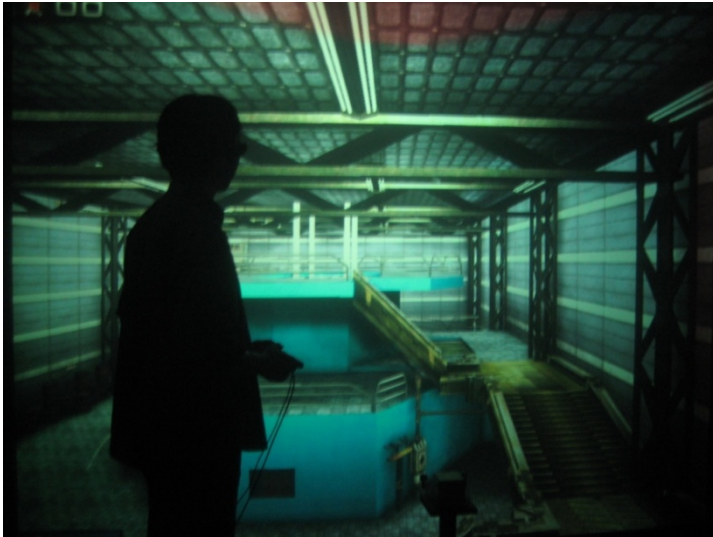


Figure 4. Model of the UIUC TRIGA reactor shown in Visbox. The model was developed in *Unreal Tournament editor*.

The three models described above can all be shown on Visbox. They also can be viewed in 3D on PC monitors with the help of new graphic cards and red and blue glasses.

## 5. CONCLUSION

This paper reports some of the recent progress made toward virtual 3-D models for nuclear engineering education. Virtual models can be used in education to simulate processes and environment to help better understand the physical processes and concepts. Using virtual reality is a safe and efficient approach to nuclear engineering education.

## 6. ACKNOWLEDGMENTS

The authors would like to acknowledge the contributions of Joel Dixon. This work was supported in part by a grant from US Nuclear Regulatory Commission.

## 7. REFERENCE

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