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APPLICATIONS OF VIRTUAL REALITY TO NUCLEAR SAFEGUARDS

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ABSTRACT

This paper explores two potential applications of Virtual Reality (VR) to international nuclear safeguards: training and information organization and navigation. The applications are represented by two existing prototype systems, one for training nuclear weapons dismantlement and one utilizing a VR model to facilitate intuitive access to related sets of information.

INTRODUCTION

This paper explores two potential applications of Virtual Reality (VR) to international nuclear safeguards: training and information navigation. The applications are represented by two existing prototype systems. Section II describes a VR system for training nuclear weapons dismantlement, while Section III presents a system incorporating both visualization and intuitive hypermedia access and navigation.

The term "Virtual Reality" encompasses a large body of research and applications. In the context of this paper, VR may be separated into the following levels:

1. *Static worlds*
2. *Simple worlds with simple behaviors*
3. *Complex worlds with simple behaviors*
4. *Complex worlds with complex behaviors*

The first, static worlds, is perhaps the most familiar. In this type of virtual reality, the virtual environment might represent an object, landscape or architectural structure, such as a building or factory. The VR may be very detailed and realistic, but one cannot interact with it other than to "fly" or "walk" through it and to view it from any vantage point. As an example, Figure 1 shows a virtual reality model of an airport.

Figure 1: 3D model of an airport

The second type of VR incorporates simple behaviors for objects in the virtual world. A good example of this type of VR is video and arcade games. The third type is best embodied in the U.S. military's large war-gaming simulation known as STOW or DIS. STOW permits hundreds of combatants at different locations to participate in a large-scale simulated military maneuver. While the simulators are very complex, the simulation behaviors are limited to operating the specific simulator and firing one's weapons.

The fourth type of VR, complex worlds with complex actions, is required for training of individuals and small teams. In this type of VR, participants interact with the virtual world and with each other to carry out complex tasks. Examples of this type of VR are Sandia National Laboratories' medical emergency response trainer and weapons dismantlement trainer (described below.)

VR might be applied to safeguards at any of the levels described above. Below we present two potential applications that fall into categories two (a static world augmented with "simple" behaviors that permit access to information) and four (a fully immersive, hands-on trainer.)

II. VIRTUAL REALITY TRAINING OF PROCEDURES

Figure 2 shows two trainees in immersive VR gear: users wear a head-mounted display and position trackers on their head, hands, and back. The headmounted display provides a fully immersive view of the virtual world, while the trackers are used by the system to update the user's view and the posture and position of his/her graphical body (called an avatar.)

Figure 2: Two trainees in VR gear

Figure 3 shows two avatars in a virtual environment for training the procedure for removing the parachute from the tail piece of a nuclear bomb.

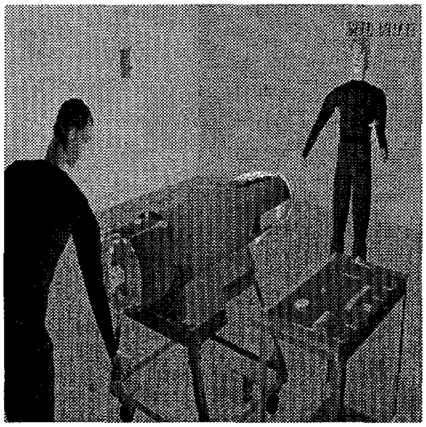

Figure 3: Trainee/avatars performing parachute removal procedure

There are several potential benefits to the use of interactive VR for training. First, because it is *experiential,* it permits the user to practice the steps of a procedure -- to essentially learn by doing. Clearly there is a benefit in becoming familiar with a procedure in this manner versus simply reading about it or even watching it being done by someone else. In addition, there are procedures, such as inspections and weapons dismantlement, that inherently have a great deal of variation. Virtual Reality can provide experience with many different scenarios, whereas live hands-on training is often limited to the most commonly encountered events. This can be especially important in procedures were rare events are the result of a dangerous situation and, therefore, cannot be recreated for a live exercise or rehearsal. Similarly, the VR permits trainees to learn from their mistakes, without dire consequences. It permits the results of an action to be realistically presented without exposing the trainee to any harm. This can be a very powerful learning tool, as we tend to learn well from our mistakes.

VIEWPro: Virtual, Interactive Environment for Weapons Procedures

The *VIEWPro* system, developed at Sandia National Laboratories, is an example of a Virtual Reality system for procedural training. VIEWPro is a prototype system for training nuclear weapon dismantlement procedures. The initial, unclassified, procedure is the removal of the parachute from the tail of a bomb. The procedure consists of several steps, which must be performed in a specific order, some of which may require the coordination of two workers. In addition, there are several places where an error could result in damage to a component.

System Components

The virtual environment created for this work is shown in Figure 3 above. It consists of a model of a disassembly cell, along with a realistic model of the weapon tailpiece and its constituent components. The tools required for the procedure, such as torque wrenches, are also modeled.

Users wear immersive VR gear, as shown in Figure 2, and are represented within the VR as full figures. This permits each worker to see where his coworkers are and what they are doing.

The system has two levels of machine intelligence: each object contains knowledge about itself (position, use, state, etc.) and about the objects with which it is permitted to interact. These objects communicate as a user carries out a step in the procedure, making the desired action occur and updating and announcing their state to the rest of the world. For example, a torque wrench "knows" when it is being held and that it is being applied to another object. If the object is, for example, a screw, the two objects collaborate to permit the user to unscrew the screw with the torque wrench.

The second level of intelligence contained in the system is more global and is embodied in what we call the "world engine". The world engine keeps track of the state of all objects (including the users' avatars) and the global state of the procedure. When a user attempts a step in the procedure, the world engine determines if this is a correct and allowable step. If so, it permits the action and updates the state of the virtual world. If not, then it imposes the consequences of the action or does not permit it at all.

This same method might be used to train safeguards inspectors in the various duties that they are required to perform. Such duties might involve the use of sensors and instruments, as well as the carrying out of specified procedures. The VR system could be designed to expose the inspector to many different scenarios, in addition to familiarizing him/her with common routines and findings.

III. VIRTUAL REALITY BASED INFORMATION ACCESS

Virtual Reality can also provide a unique method for organizing and navigating disparate types of information, from text and hypermedia to procedural methods and conceptual groupings. Another aspect of the VR work at Sandia is exploring the use of the virtual world as a method for presenting information in an intuitive and easily understood form.

Figure 4 shows how this works. The weapon model and its components are used as primary access points into related information about the components, as well as the parachute removal procedure step involving the specific component. The system has been designed to utilize both a conventional interface (monitor, keyboard and mouse) and an immersive interface. The user requests information by selecting an object. The system then identifies the object and displays additional information, if available. Such information might include photos, animations, the manual page for the specific object/procedure, etc. In addition, the system can be requested to show the user how a specific step in the procedure is performed or to present color-coded groups of conceptually related data to the user. For example, the user might request highlighting of all connectors; of objects which might be dangerous if mishandled; or of objects that are known to have caused problems in the past (for example bolts that have been known to stick and thus might need to be cut.)

IV. ACKNOWLEDGEMENTS

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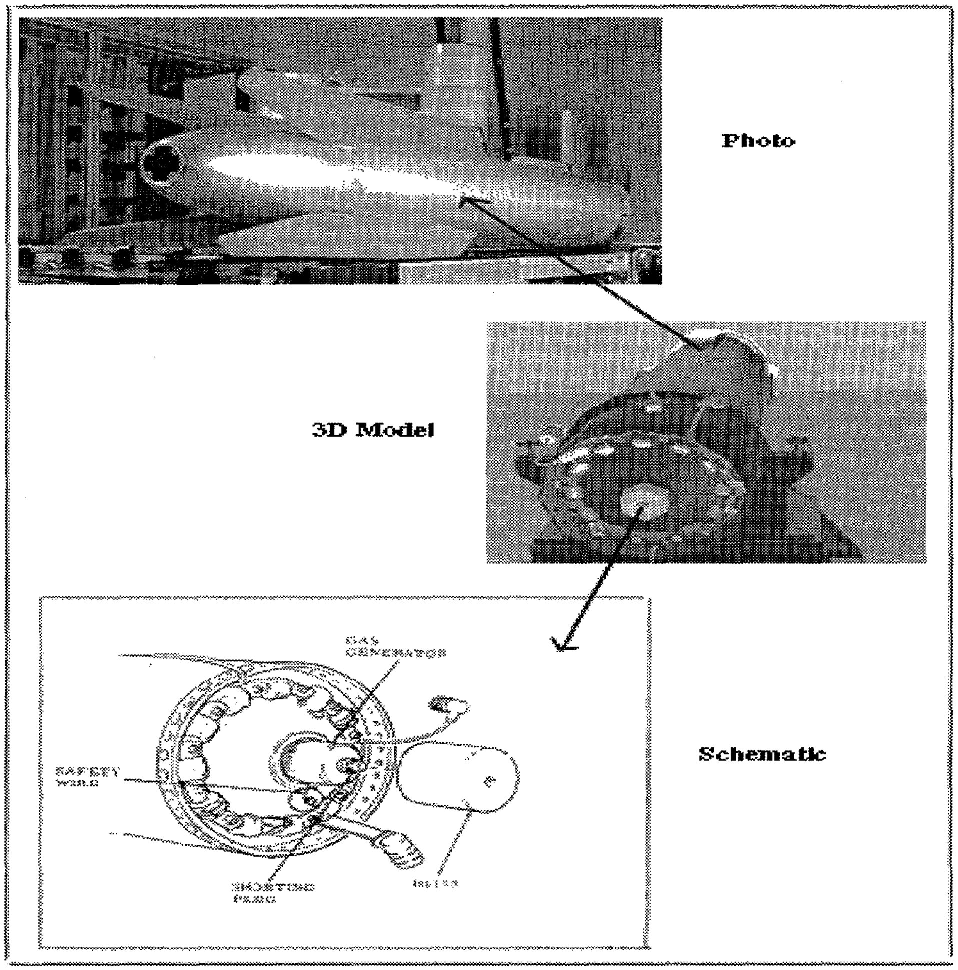

Figure 4: 3D model of weapon used to access related information