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APPLICATION OF VIRTUAL ENVIRONMENT (VE) TECHNOLOGY FOR EXPLOSIVE ORDNANCE DISPOSAL (EOD) TRAINING

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The primary job of an EOD technician is to deal with unexploded ordnance. There are over 20,000 different technical publications covering items in the ordnance inventory. The large number and variety of ordnance effectively precludes memorizing the identifying characteristics and render-safe and disposal procedures for more than a few common items. Although ordnance can be blown up in place, each technician must be trained to disarm and dispose of ordnance as if the conditions do not allow it to be blown up in place.

The technician's job involves several distinct steps. First, the technician must conduct a site reconnaissance to determine the tactical situation. This may be performed personally or with a remotely operated vehicle (ROV). Next, the technician attempts to identify the unexploded ordnance from visible features. This can be very difficult if the ordnance is damaged or partially buried in the ground. Identification can also be difficult if the ordnance is an uncommon inventory item, or when it is a new model of an existing item. As a result of these factors, there may be a great deal of uncertainty about the identity of the ordnance.

But, once the ordnance is tentatively identified, the real work begins. The technician must match the ordnance with the Series 60 technical manual that contains the render-safe and disposal procedures. The technician will then review the associated Series 60 publication, and memorize the render-safe procedures. Because manuals are in a traditional text with graphics format, it is not possible to practice EOD render-safe procedures before they are performed. This makes the job more dangerous than it should be. Other than technical publications, there are few aids available to the technician for procedural review and practice.

Once the render-safe and disposal procedures are memorized, the technician must select the tools required to perform the procedures, and then actually disarm and dispose of the ordnance. The tools of the trade are quite varied, and part of evaluation in training is the correct selection of the tools. It can reasonably be presumed that if the technician develops a good mental model of the disarming and disposal procedures, the work will proceed in a safe and uneventful manner.

Procedural skills are believed to be highly perishable. Frequent practice and review is normally required to reach and maintain acceptable levels of performance on complex procedural tasks. But again, the very nature of the ordnance universe does not support traditional training techniques. EOD tasks involve coordinated use of sensory, cognitive, psychomotor, and memory faculties, so one would expect that the EOD training environment would be very realistic, and the standard for realism is the ordnance itself. Ordnance disposal is analogous to just-in-time training. That is, a technician trains on a procedure just before the procedure is to actually be performed.

In the school setting, training may be accomplished by the use of live and inert ordnance, or with mock-ups. But the use of live or inert ordnance may not be the best way to train for correct identification, disassembly methods, or render-safe procedures. It is inherently unsafe to use live ordnance for training, and realistic practice usually involves costly supervision and strict safety procedures. Both live and inert ordnance may be very expensive, and may be damaged or destroyed in the process of completing the render-safe and disposal procedures. In addition, there may not be sufficient ordnance available so each student will have his or her own example to practice on. The use of mock-ups can also be a problem because of low-fidelity and functionality problems.

The work discussed here incorporates interactive graphical models and animated demonstrations into the technical training material. Prior research has suggested that realistic 3D representations are vital in learning the spatial and procedural relationships underlying device construction and operation, and may enhance learning of the spatial characteristics of ordnance, giving students the opportunity to encounter, resolve, and practice multiple options for disposing of live ordnance.

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VE technology seems to be well-suited for training in this context. Ordnance is clearly three-dimensional. Technicians must walk around ordnance, and in certain cases hold and rotate ordnance in their hands. There are great changes in scale from the technician's perspective during the procedures. In addition, there are dynamic interactions between the technician and the ordnance that frequently involves the use of tools required to safely disarm and dispose of the ordnance.

In spite of the promise of better training from the use of VE technology, there are problems associated with implementation of advanced computer technology in the military school environment. Perhaps the greatest problem is the reluctance of the schools to change the current system. The system is based upon traditional lecture supplemented by demonstration and practical exercise. The current system works well but new technology probably works just as well and requires fewer instructors and administrators.

A secondary issue is the cost of creating the courseware to be implemented at the school. Much of the cost is related to the creation of the models used in courseware. Although engineering drawings of ordnance already exist, CAD/CAM models are virtually nonexistent. So, much of the cost of a virtual training systems is the expense of building the 3D interactive models. One technology competing with VE is animation, and embedded animation can also be used to train or review ordnance render-safe procedures with a much lower development cost than a fully interactive virtual model.

In the research described here, VE technology was used in a module intended to train students to perform the render-safe procedure for a single ordnance item. The objective of this project was to demonstrate that EOD procedures could be taught by a virtual ordnance model. The specific technology used in this project was determined by the funding level, model development costs, command desires, and the potential for implementation. Our strategy was to select off-the-shelf hardware and software as much as possible to meet the stated objective of the project.

The ordnance selected as the prototype for the project was the SUU-25 flare dispenser. This is a device by which flares that are intended to illuminate a battlefield are dropped from an aircraft. The dispenser may contain live flares that are in themselves explosive, as well as mechanisms to force them out of the dispenser. The dispenser is made safe by a sequence of actions that involves cutting wires, removing ejection cartridges, removing an access door, inserting a shorting pin, and removing any live flares. This particular piece of ordnance is the family prototype used at the EOD school. The dispenser is inert and attached to a helicopter in that environment. Since the device is inert, students are trained and tested by describing the render-safe and disposal procedures.

Command and fiscal restraints required that training be performed on a personal computer in the form of a traditional computer-based training module. Authorware Pro was selected as the instructional development software, 3D Studio for the modeling software, and World Toolkit for Windows as the virtual environment software. At the time of initial development, a 133 MHz Pentium processor was state-of-the-art, and the fidelity of the model and its characteristics was reduced to accommodate these restrictions. The actual flare dispenser is cylindrical but the model is 12-sided to restrict the number of polygons to about 20,000. In addition, the model does not rotate continuously but in 10 degree steps to speed up the response on the screen. The slow response of the model during rotation was perceived as a problem by the development team but not by the users at the EOD School. As personal computer technology advances, the virtual model will become more responsive or the level of fidelity can be increased with the same response time.

When the model was first tested at the EOD School the instructors suggested other changes to the level of fidelity. For example, screws on an access panel had to be removed one by one before the panel could be opened. The instructors felt this was a waste of time, and they suggested that after the removal of just one screw the door should disappear. This principal was applied to other aspects of the render-safe procedure. The unintended side effect was a noticeable change in the perceived fidelity of the model. But, the change was necessary to get the support of the instructors.

One unique feature of the user interface is the tool kit. Every ordnance procedure requires the use of tools, and testing usually involves the selection of the correct tools for the procedure. The tools required to perform the procedure in our module are shown on the screen as icons. The user must select the correct tool to perform a step, and the cursor changes to the icon of the tool. If the wrong tool is selected, the step cannot be performed. During training, selection of the correct tool is guided by the courseware. During testing, the user must select the tool to be used at that step. Selection of the wrong tool or performing a step out of sequence is noted as an error.

The virtual model is embedded in the instructional software by design, and cannot be called outside of the instructional module. The purpose of this restriction is to comply with the instructional philosophy of the EOD School. At the school, most procedures are taught by demonstration and practical exercise, and free play is frowned upon. In fact, it is very dangerous in the real world to violate the stated procedures. Safety considerations permeate all aspects of instruction at the School. An alternate implementation suggested by the instructors is to incorporate the model into an instructor-controlled demonstration of procedures.

The training module is organized around seven lessons. The virtual model is used in only two of those lessons, one for step-by-step training and the other for testing. The time required to complete the entire module is about forty minutes. However, only ten minutes are allocated at the School for training the entire family of this type of ordnance, and it immediately became obvious that the module would never be implemented in the present form. But, students are required to perform two hours of study on their own each evening, so this may be the best mechanism for formal testing. It is clear from our pilot test that the virtual model is as good as lecture and demonstration, but a transfer of training experiment is required to demonstrate that it is effective and is without negative transfer.

In summary, we believe that virtual worlds will have an important role to play in individual training. The fact that they seem to work as well as traditional instructional methods should encourage us to build more applications. But practical consideration may severely restrict the form of the implementation, and consequently the conclusive evidence that we need to convince others to build more models. In addition, until the cost of building high fidelity applications drops dramatically, it may be difficult to find users willing to take our models and implement them in a training context.