WEAPONS TEAM ENGAGEMENT SIMULATOR

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ABSTRACT

The Naval Training Systems Center is developing a Weapons Team Engagement Trainer that will allow up to nine people to practice and rehearse close combat training exercises such as low-intensity conflict, light infantry, SWAT and security operations. Typical events might include security operations, hostage rescue, shoot-no-shoot, ambush training situations and routine law enforcement operations in a common team scenario environment. The trainer requires no live ammunition or aggressor actors and is safe.

This paper highlights new technology that was developed to make this trainer more realistic than similar currently available trainers. Improved realism is achieved in this trainer by causing the targets to interact when killed. Killed targets disappear from the scenario and permit branching of the video scene, based on the teams performance. Targets shoot-back at the trainees who wear infrared sensors to detect if they took sensible cover when the aggressor shoots. If a trainee is wounded or killed by the aggressor, an alarm warns him and his weapon is disabled. Interactive targets and aggressor shoot back serve to increase training realism and stress. To eventually accommodate up to nine shooters, a high speed infrared spot tracker was developed to allow all nine team shooters to operate in a common threat scenario.

INTRODUCTION

The requirement to maintain a high state of readiness during austere budget times and to simulate close combat training effectively has placed new requirements on the training device community. Increased use of small echelon military operations to perform anti- terrorist, anti-drug and law enforcement functions have placed some unique and new emphasis on simulation and training .

This trainer can replace firing live rounds that has in the past resulted in fatalities. A typical trainee can expend over 5,000 rounds during one week of training. The potential cost savings in ammunition alone are very beneficial. In ranges that fire live rounds a risk also exists to the instructors from air-borne lead poisoning.

The authors identified what they determined to be four weaknesses in existing shoot-no-shoot trainers.

These weaknesses are:

1. **Aggressors are not removed from action when hit as they do in the real world. Some trainers lack branching capabilities.**

2. **Current trainers do not require the trainee to seek sensible cover and concealment. The current devices permit the trainee to engage targets while fully exposed to aggressor shoot-back.**

3. **Current trainers lack the capability to gather shooter performance in the context of a team consisting of up to nine trainees in a common threat scenario. They also lack scenario playback capability.**

4. **Current trainers lack the capability to simulate a mix of weapons such as the AT-4, rifles and pistols etc. Explosions are not graphically displayed.**

A test bed was developed to perform research to remove these four basic weaknesses.

The test bed and methods used to solve these four problems are described next. The Test Bed is shown in Figure 1.

THE TEST BED

The test bed was developed to perform Research and Development on the disappearing targets , shoot-back, weapons effects and tracker. The test bed accommodates only two trainees. However, the tracker has been designed to handle nine team trainees. A system block diagram is shown in Figure 2.

The two man Test Bed will be demonstrated at the IITSC.

A large field of view, nine man prototype model will be fabricated , for prototype testing starting in 1991.

The video scenarios in the test bed are projected on a 100 inch diagonal screen by a very bright projector. The source for the videos is a disk player, under computer control. The video disk player also provides the computer with the frame it is projecting.

The computer is a 386 based machine.

Digital inputs and outputs to the system are performed by an A/D board and digital I/O board. The A/D board samples the analog tracker and drives the infrared emitting diodes (IREDS) on the weapons. The digital I/O board drives the IREDS that are used to simulate shoot-back and also reads the rifles status (ie, trigger pull, selector position). The computer also contains a graphics board that is used to make the targets disappear when hit. This board also creates the explosions from larger weapons such as the AT-4.

A collimated source of infrared energy is located on the end of each trainees weapon. Figure 3 shows the IRED source on the end of an M-16 rifle.

The source is an IRED which is eye safe and can be coded for better signal discrimination and detection using electronic filters. The aggressor shootback is simulated with IREDS mounted above the screen. Each trainee wears a torso harness containing optical detectors and a sonoalert from the MILES program (Multiple Integrated Laser Engagement System). Trainees wearing the MILES detector torso harness are shown in Figures 3 and 4. New detector electonics was developed to replace the MILES electronics. Located on a long bar over the screen is an IRED array. Each IRED has a six degree beam, which is pointed in the direction the aggressor shoots. To avoid being killed the trainee must seek cover behind various opaque articles in front of the screen. This cover prevents the aggressor IREDS from illuminating the MILES optical detectors located on the trainee.

The sound system provides all weapon sounds and explosions. It is under computer control using a MIDI interface.

DISAPPEARING TARGETS

When a scenario is recorded on the video disk the background is recorded first without any targets present.

During training the scenario background is stored in a frame buffer on the graphics board and is continuously projected on the screen. The computer can position the video disk to play anywhere on the disk or can jump transparently to any section of the disk. At the appropriate time the computer controlled graphics board will place the targets over the background. If the system computer determines from the tracker data that a trainee has killed a target, the original background is placed over the hit target making it disappear on the screen. This method instantly tells a trainee he killed the target he shot at and other team members don't have to worry about this aggressor. This method is more flexible than playing a specific segment or canned scenario and provides instant feedback. This method also allows the video disk player to easily branch as a function of the teams performance. The intensity of the scenario can escalate or diminish depending on the team's performance.

A program has been written that allows a mouse to be used on each applicable video frame to define both the geometry of the target window and the area of target kill. This information is recorded and stored in a file on the hard disk of the computer. Under computer control this data is recalled for use to determine hit or miss. Lead for moving targets can also can be incorporated.

TRACKER SYSTEM

The tracker system is used to determine the x and y pointing coordinates of each trainee weapon . Collimated IRED sources located on the end of each weapon project an infrared spot on the projection screen. They are turned on one at a time by the computer at a precise frequency that is tuned to the tracker. The infrared tracker uses a Position Sensing Detector (PSD) to detect the coordinate location of the infrared spot. The PSD is a device that converts a light spot focused on its surface to continuous position data. The tracker determines weapon coordinate data on all nine weapons at a 50 Hz rate and provides this data to the computer. The tracker is located near the video projector and views the entire projection screen.

A scanning type device like a Charge Coupled Device (CCD) camera requires the scanning of hundreds of thousands of individual detectors while giving only discrete position data. These devices currently lack the speed to handle a team of nine persons, and therefore could not be used in the test bed.

The development of a scanner using a Bi-lateral effect photodetector has the following advantages:

1) Very high resolution
2) Fast response
3) Simple operating circuits.

When a light spot falls on a PSD, an electric charge proportional to the light energy is generated at the incident position. This electric charge is driven through the resistive material and collected by four electrodes. Because the detector resistivity is uniform, the photocurrent collected is inversely proportional to the distance between the incident light position and the electrode. An A/D board in the computer is used to read the four tracker output voltages. The computer solves the simple equations below to determine where the weapon is pointed. This position can be found irrespective of the energy of the incident light.and without handling hundreds of thousands of pixels. The following equations are used to calculate the X any Y locations of the spot on the screen,

$X_{loc} = V_{x2} - V_{x1} / V_{x2} + V_{x1}$ and

$Y_{loc} = V_{y2} - V_{y1} / V_{y2} + V_{y1}$.

The PSD preamplifiers consist of low noise, transimpedance amplifiers. A high-pass filter is used to suppress background illumination and detector noise while detecting the modulated infrared source spot reflected from the video projection screen. The demodulator circuit contains a precision full wave rectifier and low pass filter. The output of the demodulator is four DC voltages that varies as the invisible IR spots are moved to various positions on the video projection screen. The computer determines X_{loc} and Y_{loc} by solving the equations shown above.

AGGRESSOR SHOOTBACK

In past trainers the aggressors did not force the trainee to take sensible cover by shooting back. This section of the paper describes how shootback was added to this team trainer. In this method of shootback simulation each trainee wears a MILES torso harness with photodetectors and an audible alarm attached. We removed the MILES electronics and incorporated a simpler receiver design. To simulate rounds coming from the screen we attached twelve (12) IREDS to the top of the projection screen. Each invisible IRED has a six degree beam width and is controlled by the computer and is synchronized with the video scenario. When an on screen aggressor shoots his weapon an IR emitter beam is pointed in the same direction the aggressor weapon is pointed. If the trainee has not taken cover behind an object during this interval the IR beam will strike the photodetectors causing an alarm to sound. This indicates the trainee is dead.and his weapon is disabled. A different sounding tone will sound if he is wounded. The receiver contains both optical and electronic filters to remove the effects of stray lighting in the training area.

SOUND SYSTEM

The sound system provides sounds of the various weapons being fired by both the trainees and their on-screen adversaries. Background sounds to make the scenarios more realistic and to distract the trainee are provided. The heart of the sound system is a sampler module and a surround sound processor.

The sampler digitizes, stores and plays back sound effects under the control of a MIDI (Musical Instrument Digital Interface) port. The MIDI port is connected to a MIDI controller board in the computer, which runs the entire simulator. During a scenario the computer sends appropriate commands to the sampler via the MIDI interface. The sampler creates the appropriate sounds and sends them either to the surround sound processors or directly to the mixer for the appropriate channel depending upon whether the sounds are background or foreground sounds. Background sounds are processed by the surround sound processor.

Foreground sounds are sent directly to the appropriate channels of the amplifier section.

The sampler uses both a 3.5 inch 800 kbyte floppy drive and an 80 Mbyte SCSI hard disk to store digitized sounds. Depending on sample rate, the 80 Mbyte SCSI disk can hold as much as an hour or more of sampled sounds that can be mixed and sequenced by the sampler to generate essentially unlimited amounts of audio feedback.

Sounds generated by the sampler and the surround sound processor go to a 4 channel mixer/combiner, which mixes the appropriate sounds onto each channel for amplification by the power amplifiers. The front channels are bi-amped using an electronic crossover to drive one amplifier which drives the horn sections of the front speakers and a second amplifier which drives the woofer sections of the front speakers. The two rear channels consist of a third amplifier driving a pair of Surround Speakers.

The sounds that are digitized and recreated by the sampler come from a variety of sources. Some are commercially available sound effects purchased on compact disk. Some are recorded in the field using both regular and DAT tape recorders. Still others may be synthesized. The Army's HEL provided several recordings of actual artillery rounds exploding. The sounds have been edited and sometimes normalized before being digitized.

CONCLUSIONS

The addition of aggressor shoot back, target interaction and multiple trainees using a variety of weapons has introduced a quantum improvement in the realism of shoot-no-shoot trainers.

The development of the new tracker was instrumental in allowing faster data rates and more shooters than conventional CCD cameras. This new technology will be applied next year to develop a large field of view protoype trainer for nine trainees in a full size room or rooms. The trainee will be free to maneuver within the trainer with no cords attached to the computer.

ABOUT THE AUTHORS

Mr. Albert H. Marshall is a Team Leader/ Electronics engineer at the Naval Training Systems Center. He has specialized in developing weapon fire simulators using lasers, electro-optics and microprocessors. He holds twenty four U.S. patents. He has Master's Degrees in both physics and electronics engineering from Brown University and the University of Central Florida.

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Mr. Robert T. McCormack is an Electronics Engineer at the Naval Training Systems Center. Specializing in weapon fire simulators, he has worked on computer program development and sensor interface to computers. Mr. McCormack graduated in 1985 from the University of Central Florida, where he is currently pursuing a Masters Degree in Computer Engineering.

Mr. Edward J.Purvis is an Electronics Engineer at the Naval Training Systems Center. He has specialized in developing weapon fire simulators using electro-optics, microprocessors, video processors, and graphics. He has a Masters Degree in Digital electronics from the University of Central Florida.

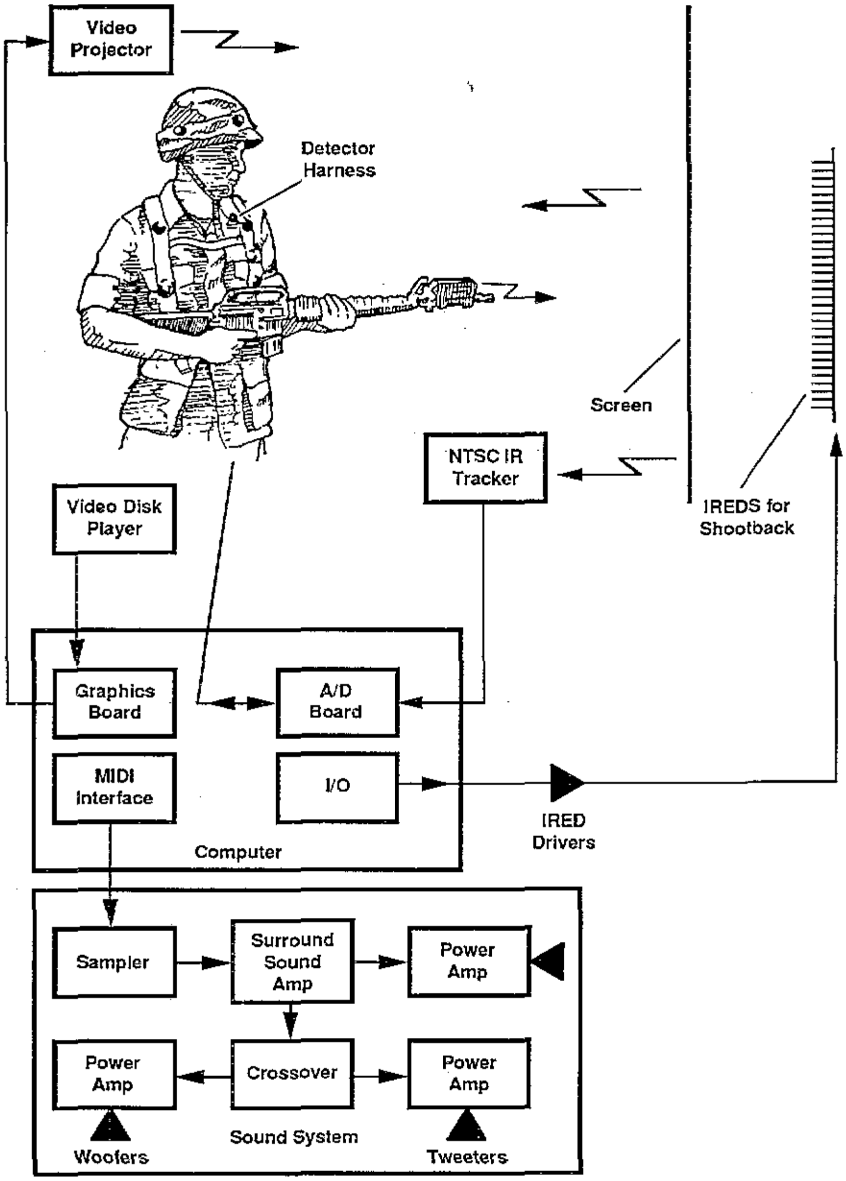

FIGURE 2 WEAPON TEAM TRAINER SYSTEM BLOCK DIAGRAM

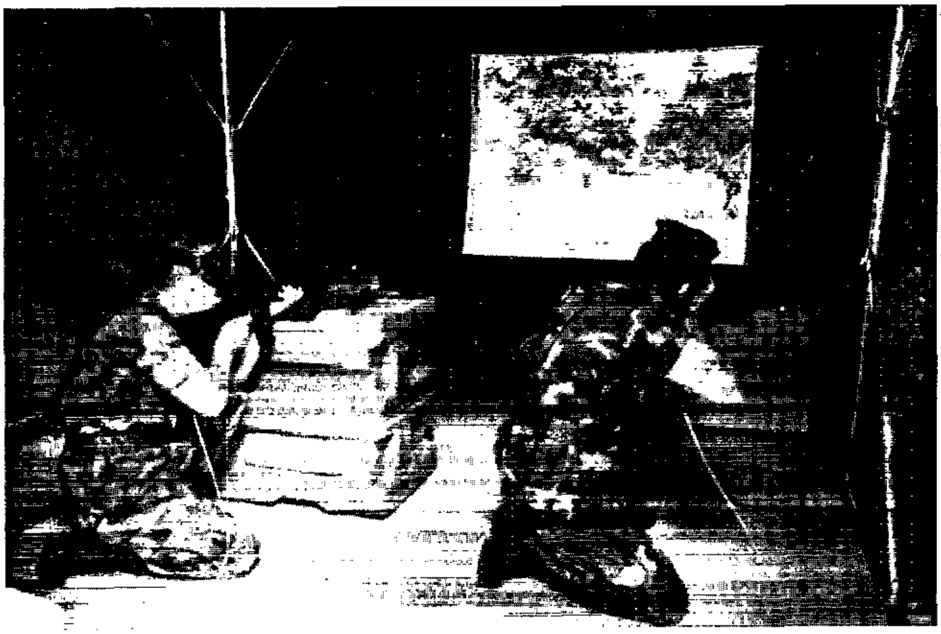

FIGURE 1 TEST BED

FIGURE 3 M-16 TRAINING CONFIGURATION

FIGURE 4 AT-4 TRAINING CONFIGURATION