GUARDFIST
THE GUARD UNIT ARMORY DEVICE, FULL CREW INTERACTIVE SIMULATION TRAINER

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Abstract

The Guard Unit Armory Device, Full-Crew Interactive Simulation Trainer, or GUARDFIST, is a tank appended, gunnery simulation system. GUARDFIST uses available technology in microcomputers and videodiscs to provide a full-crew, interactive tank gunnery simulation. The combination of videodiscs and computer generated imagery will provide the crew with a variety of tasks in a real world environment.

This paper describes the initial research and development effort to apply this technology to a tank gunnery simulator, as well as the intended training applications. Although GUARDFIST was initially intended for use on Army National Guard and Army Reserve tanks, continuing research indicates a number of potential applications for this technology.

Introduction

"Simulation technology today permits developing full proficiency in nearly any conceivable training objective without deploying actual equipment, firing of real ordnance or risking man or machine."*

GUARDFIST was created by a need for a low-cost simulator for training Reserve Component tank crews at home station, i.e. the armory or reserve training center. The increasing cost of fuel, ammunition range availability and repair parts, as well as time constraints were prime considerations in the development of this concept.

System Characteristics

The system is designed to provide the tank crew with a series of real-time, interactive battlefield scenarios for tank gunnery training. Although these scenarios are presented in a tactical environment, they are in fact keyed to tasks in the appropriate tank gunnery manual (Field Manual 17-12 series), thus allowing for developing skills leading to basic and intermediate qualification of crews. GUARDFIST will allow each crew member to interact with the scenarios presented, as well as with other crewmembers, to accomplish a large variety of gunnery tasks. Because the system is appended to actual equipment, realistic tactile sensations are maximized.

GUARDFIST will provide the illusion of movement by color video inputs to each of the various sights/periscopes on the vehicle. All apparent movement will be interactive with the tank's controls, particularly those of the driver and gunner.

The scenarios presented will allow the crew to utilize all tank mounted weapon systems both individually and simultaneously. The scenarios will present a variety of realistic, moving, stationary, single and multiple targets at ranges of 300-2,000 meters. Targets will be both Threat and friendly.

A microprocessor will compute the appropriate ballistics for the complete complement of ammunition for each weapon system. Computer generated imagery, superimposed on a filmed background, will depict hits, misses, and tracer burn time to the crew in near real-time.

The system will score the crew's performance based on parameters for each exercise and display and/or record the score and performance data for critique purposes. Hard copy print-outs will be provided for after action reviews. GUARDFIST will have the capability for the instructor/operator or the student to freeze an engagement and then restart.

The Electronic Information Delivery System

Using a generic microprocessor such as the Electronic Information Delivery System (EIDS), will minimize the initial hardware costs. This new microcomputer system, in its basic form, consists of an 8086 16-bit microprocessor with 256K of random access memory (RAM) and a laser videodisc player. Although both items have been compacted for storage and movement, they are essentially proven, off-the-shelf items.

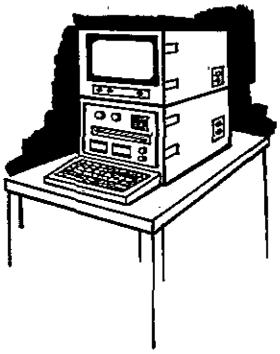

Figure 1. Concept drawing of the Electronic Information Delivery System (EIDS).

Plug-in peripherals include keyboards, additional RAM, floppy disc drives, hard disc drives, digital graphic pads, joysticks, lightpens, printers and plotters. Additional plug-in devices will allow the microprocessor to manage up to 12 videodisc players.

Some Trade-Offs

In this day of computer generated imagery and digitized terrain data bases, the choice of real world imagery stored on videodisc may seem unusual. Recent advances in cell texturing do provide greater detail and realism with fewer edges; however, the hardware requirements to perform such a large number of computations in real-time is prohibitive for a device to be fielded in large numbers.

The availability of EIDS and the inherent fidelity and realism of the videodisc imagery (currently the original is 35mm motion picture negative stock, mastered onto the disc) is unmatched by any computer generated imagery system. The obvious limitation is the inability for "total" freedom of movement common in most CGI systems. Yet, the interactive videodisc does permit ample freedom of movement for a device designed as gunnery trainer.

Unlike the Conduct of Fire Trainer (COFT), GUARDFIST *will present tactical* scenarios that will also fulfill FM 17-12 series tank gunnery qualification requirements. The primary purpose of GUARDFIST is to allow tank crews the opportunity to train at basic and intermediate levels, without large expenditures of time, ammunition, fuel, and repair parts. The sytem will complement, rather than replace actual operational and live-fire experience.

Likewise, GUARDFIST is not intended to be a replacement device for the COFT, the Videodisc Gunner Simulator (VIGS) or the Tank Gunnery and Missile Tracking System (TGMTS). Although there is some overlap in tasks trained, GUARDFIST provides a more complete and comprehensive training scenario before validation on more sophisticated simulators or live-fire ranges.

The size and low cost nature of GUARDFIST will permit it to be distributed down to the unit (company) level. Due to high cost and space requirements, both COFT and TGMTS will only be distributed to the organization (battalion/squadron) level in most areas. The availability of VIGS and GUARDFIST at the unit level, combined with the limited availability of the COFT and TGMTS, and the existing scaled ranges will allow a complete gunnery program to be conducted at home station.

Interactive Software/Videodisc Development

Surrogate travel, in its videodisc application, attempts to recreate the video spatial relationships of a real world environment, thus providing the viewer with a kind of "video map". Such travel, however, tends to be jerky and often appears not "real", since true *motion, ordinarily, is smooth.* Surrogate travel, therefore, does not necessarily constitute simulated motion. The challenge for GUARDFIST was to film the terrain in such a way that, when played back, it would provide the user with surrogate travel through the *simulation of true motion. The solution* was found to be mathematical. Production/post production techniques, computer programming functional requirements, and a programming algorithm were developed accordingly.

Based on the premise that motion is distance through time, it was clear that precise increments of distance must be retrieved and displayed at varying rates, if motion were to be simulated on the videodisc. By recording photographs of the terrain in one foot increments, each frame on the videodisc would equal one foot. In effect, 22 frames per second (or 22 feet per second) would equal 15 miles per hour. An experimental videodisc demonstrated that this basic premise was accurate.

One foot distance increments, however, suggested that GUARDFIST's "cruising range" would be severely limited. Fifty-four thousand frames (or feet) would only equal ten linear miles. Also, a videodisc player with a maximum play speed of 30 frames (or feet) per second would provide a maximum speed of 20 miles per hour. While this may be adequate for some vehicles, it would be unsatisfactory for many of the newer tracked and wheeled vehicles. The solution to increasing speed and conserving videodisc space was found by "jumping" to recording the terrain at three foot increments when the speed reached twenty miles per hour. The computer software was able to determine at what point the distance increments increased and automatically reduced the stepping speed of the videodisc player, while still maintaining the simulated motion. This saved videodisc space and permitted acceleration up to 60 miles per hour. It was clear that recording terrain at smaller distance increments was needed to depict slow speeds, stopping, and starting, and at greater increments to simulate travel over open terrain or along roads.

Figure 3. Prototype hardware using Apple II+ microcomputers.

To test this *feasibility*, a flatgridded terrain was recorded on videotape. As the camera traversed the terrain, bursts of video were recorded at precise increments of one foot and three foot distances. Nineteen images were recorded to recreate a 180 degree field of view. These multiple views of each distance increment were transferred as single frame edits to a Direct Read *After Write (DRAW) videodisc system*. Computer software was generated to play back the videodisc at varying speeds to simulate tank travel over the recorded terrain and to access different perspectives that simulated turret rotation and gun elevation. This exercise demonstrated that surrogate tank travel, turret rotation and gun elevation were technically feasible using a "simulated motion" production technique. However, for GUARDFIST, this technique posed a serious problem.

The simulated motion technique required the recording of terrain at precise, one foot increments. Smooth turret rotations required nineteen discreet images per distance increment. This suggested that, to simulate one linear mile on the videodisc would require 100,320 video frames, or nearly two videodiscs, while providing no freedom of movement to the driver.

The problem was solved in the computer software. Using digital optical effects, wide angle perspectives were generated by combining multiple images. Then, a computer generated graphic "window" was simulated in video and multiple images were recorded on the DRAW disc. Each image revealed new terrain as the "window" moved across the field of view. The result, when played back on the DRAW disc, simulated motion over a wide angle view of the terrain by manipulating a computer generated matte or "window" over the multiple video images.

The feasibility of GUARDFIST had become a reality. The wide angle view of terrain, recorded in precise, small distance increments, and then revealed through a computer generated "window", produced the simulated motion and freedom of travel required, as well as the interrelated/interdependent turret rotation and gun elevation.

Training and Evaluation

Since GUARDFIST is appended to actual equipment already located at the unit's home station or local training area, there is no additional requirement for space. Because of the systems microelectronic technology, GUARDFIST should enjoy an extremely high rate of availability.

System simplicity will allow individual crews to use the system under the supervision of a unit trainer or the tank commander using a preprogrammed training sequence. Additionally, when used in conjuntion with other available systems, such as VIGS, TGMTS and the COFT, a crew can accomplish all required gunnery tasks short of Table VIII (live fire, crew qualification) without firing a round, driving a mile, or using a gallon of fuel.

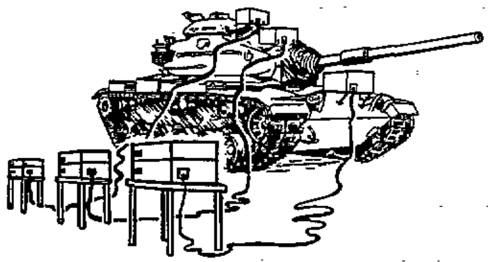

Figure 2. Concept drawing of GUARDFIST.

As mentioned earlier, the system will have a built-in capability for evaluation and feedback as well as a system self-test. Student evaluation is essential in a device that is capable of training individual gunnery tasks as well as collective crew tasks. The feedback available, in the form of print-outs or "instant replays", will permit a structured advancement of each individual and crew.

Technological Findings

Interactive videodisc production techniques can be used to depict surrogate travel and to create simulated motion. Terrain images can be photographed in wide angle perspective and recorded at one foot increments to emulate conditions of slow speed, starting, and stopping. Images can be recorded at greater increments to emulate motion at accelerated speeds across open terrain or along roads and to conserve videodisc space.

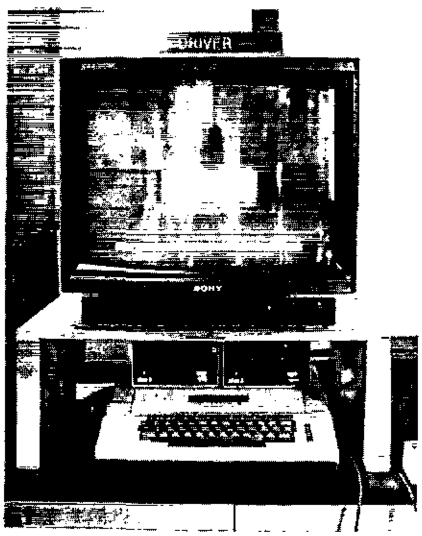

Figure 4. Driver's station of prototype GUARDFIST.

Simulated tank travel, turret rotation, and gun elevation can be attained through computer manipulation of a graphic matte over multiple video images, thus creating a "window" that moves across a wide angle view of the terrain, as shown in the demonstration model. In a production GUARDFIST, when appeded to *tank optics, the video will* be digitized in storage buffers so that the images will move behind the optics (which then remain stationary).

Conclusions

Simulation training may never completely replace the requirement for hands-on operational experience. Yet there is ample evidence available indicating that simulation training can enhance and acclerate operational training while at the same time reducing logistic and time requirements.

The repetitive nature of simulation training increases the potiential for the transfer of necessary skills. This is further enhanced by the embedded feedback and evaluation capabilities of GUARDFIST. The system also allows for year-round training without regard to range availability and weather conditions.

Availability of the entire family of gunnery training devices from VIGS, *TGMTS, COFT* and *GUARDFIST, will allow* tank crewmen and crews to progress from basic individual tasks, to more complex and demanding collective tasks, thus developing cognitive as well as psychomotor skills. Tank crews will be able to conduct sustainment and cross training, at home station, in a realistic environment, with little or no demands on the logistic support system.

References

*Burton, Richard, "Skills Through Training", Defense & Diplomacy, April *1985*, Page 49.

About the Authors

MAJ George W. Smith is an Army Nation Guard officer on active duty. He is currently assigned to the Office of the Deputy Chief of Staff for Operations and Plans, HQDA, as a Staff Assistant to the Army Science Board Summer Study on Training and Training Technology. Prior to this he was assigned to the Training Support Branch of the National Guard Bureau. He has served in Active Army and National Guard units as a unit commander and Operations and Training Officer at both battalion and brigade level. He is a graduate of the Armor Officer's Basic and Advanced Course and the Command and General Staff College. MAJ Smith was commissioned in Armor from the University of Oklahoma ROTC program.

Dr. William A. Stembler, Operations Manager of Computer Sciences Corporation (CSC), provides technical advice and support to the Army Communicative Technology Office (ACTO), particularly in the area of interactive videodisc design and production. Dr. Stembler has produced all of ACTO's interactive videodiscs. Additionally, he conceived and supervised the creation of the

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