DATA COLLECTION AND ANALYSIS: THE KEYS FOR INTERACTIVE TRAINING FOR COMBAT READINESS

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ABSTRACT

The challenge for training in the next decade is networking combat vehicle simulators to allow low-cost simulation of platoon, company, and battalion-level exercises incorporating the tactical, logistics, and communications elements critical to real field operations. This paper describes a DARPA-sponsored advanced research project to interconnect manned, microcomputer-based combat vehicle simulators on a common network. A real-time computer image generation system in each simulator provides a multi-window view of the simulated battlefield, with all other combat vehicles shown at the positions and orientations determined by the cumulative control inputs of their crews. Each simulator on this simulation network has a microcomputer capable of processing all the messages (data packets) it receives from other simulators, as well as sending all the necessary data packets on its state to other simulators. Without any special simulator instrumentation, these data packets provide the capability to monitor an exercise in real time (as it actually happens). They can also be recorded and used later for after-action review. Other Data Collection and Analysis capabilities allow generation of measures of crew and unit performance in the exercise, as well as measures of training effectiveness.

INTRODUCTION

Field training of combat troops is becoming increasingly difficult in these days of budget constraints. Safety and environmental concerns place further limits on the preparation of combat-ready soldiers. Today's armed forces are looking to computer-based simulation to provide a cost-effective means to supplement field training. However, traditional computer-based simulations are limited by their portrayal of the opposing force. Too often the soldier gets the impression that he is playing an elaborate video game where the opponent is a computer program rather than a human being. SIMNET (for SIMulator NETwork) is a DARPA-sponsored advanced research project that is developing the concept of interactive simulation. Interactive simulation allows the soldier to directly control the actions of his simulated vehicle and fight against other soldiers on a combined arms battlefield. The soldier trains as he would fight: against a manned opponent rather than a computer program.

Even the most advanced simulator system falls short of its potential if it does not provide the soldier and the chain of command with an idea of how well each is doing. The SIMNET Data Collection and Analysis (DCA) system automatically collects and rapidly reduces data on the performance of crews and units engaged in training exercises on a simulated combined arms battlefield. Replay of this data on the Plan View Dispay allows detailed after-action review of crew/unit performance, providing valuable feedback. Reduction and analysis of performance data by the data analysis system allows measurement of the effectiveness of training and the readiness of the unit.

This paper defines SIMNET, describes how it works, discusses the contribution of the SIMNET DCA system to the training process, and describes efforts underway to enhance SIMNET's effectiveness as a training system.

WHAT IS SIMNET?

SIMNET (for SIMulator NETwork) is an advanced research project into interactive simulator networking being conducted by the Defense Advanced Research Projects Agency (DARPA). The goal is to create a complete combat world that includes force-on-force combat vehicles (fully crewed simulators), a vertical slice of the chain of command (command and control), essential combat support (artillery, mortars, close air), and combat service support (refueling, rearming, maintaining). Flanking units can be portrayed without heavy manpower requirements through use of a human controlled, semi-automated force that allows an individual operator to control the tactical employment of several companies of simulators.

SIMNET, now in its fifth year of development, currently simulates a variety of combat vehicles including the M1, M2/3, generic rotary and fixed wing aircraft, and the Line of Sight Forward Heavy (LOS-F-H) component of the Forward Area Air Defense System (FAADS). These simulators are now being used for interactive training at sites in the United States and Germany. Recent experiments have sucessfully demonstrated their ability to interact long-distance over a dedicated telecommunications line. Simulated features of SIMNET vehicles include:

- Detailed vehicle dynamics such as engine, transmission, and drivetrain characteristics as well as suspension, track, and soil interaction. Vehicles speed up or slow down depending on the slope and type of terrain on which they are driving. Vehicles also get stuck in unfordable rivers, and throw a track when traversing a too steep slope.

- Weapons systems dynamics such as turret and gun kinematics (azimuth/elevation) and main gun ballistics. The interaction between the laser range finder, ballistics computer, and manual inputs by the gunner effect whether or not the shell impacts the intended target.

- Damage and failure simulation for electrical, hydraulic, weapons, and other systems. SIMNET vehicles use fuel at rates representative of the actual vehicles. They use ammo at a rate determined by how frequently the crew members fire the weapons. They break down in accordance with mean time between failure rates. They can also be damaged by misuse or by enemy fire.

WHY IS SIMNET DIFFERENT?

The two key characteristics that make the SIMNET simulation different from other simulations are:

- It is a distributed simulation
- It is an interactive simulation

Distributed simulation means that there is no central computer directing the activities of the various simulation elements. Instead, each simulator has its own microcomputer, which is in continuous communication with each of the other simulation elements. One significant advantage of this approach is that, as the simulation network expands, each new simulator brings with it all of the computer resources necessary to support its computational requirements. This means that adding new simulators does not involve modifications to simulators already on the network. Further, technical problems with a single computer do not affect the overall simulation.

SIMNET is an interactive simulation that differs sharply from conventional simulation. In conventional simulators, crew members are alone in their simulated world. They can interact among themselves and control the actions of their vehicle, but other inputs into the simulation (such as the threat) are generated either by a computer or by a human controller who is not directly involved in the simulation. In SIMNET, the crew of one simulator can see and respond to the actions of other crews on the battlefield. SIMNET does not pit man against computer or student against instructor. In SIMNET, soldiers fight against other soldiers who are trying to fight and win on the same battlefield.

Training in SIMNET is conducted by the chain of command of the participating unit. The commanding officer is responsible for planning, conducting and reviewing the training activity. In this way, everyone in the unit gains training value from a SIMNET exercise. There are no "trainers" or "controllers" in a SIMNET training session, just the members of the unit performing their duties under the direction of their normal chain of command.

HOW SIMNET WORKS

A SIMNET simulator performs actions by transmitting specifically formatted data packets over the network. Data packets contain information about the status of simulated vehicles (such as vehicle appearance), or about specific events that occur on the simulated battlefield (such as vehicle collisions and ballistic impacts). Each packet contains the information necessary for the other simulators to update their views of the world. For example, a vehicle appearance packet for an M1 simulator contains information on vehicle location, hull and turret orientation, velocity vector components, and gun tube elevation. It also contains other descriptive data such as the presence or absence of a dust cloud.

Once the packet is broadcast over the network, any other simulator in the exercise can interpret this information and paint a picture of that particular M1 in the correct location on the battlefield. SIMNET packets describe vehicle appearance and status, firing data, location and type of shell impacts, collision information, and repair and resupply operations.

SIMNET DATA COLLECTION AND ANALYSIS

The SIMNET Data Collection and Analysis (DCA) system collects, replays, reduces, and analyzes the data packets generated by a SIMNET exercise. The three major components of the SIMNET DCA system are the data logger, the Plan View Display (PVD) and a data analysis system.

Data Logger

The data logger is a mass storage device consisting of both hard disk and magnetic tape recording devices. It records all the data packets broadcast over the SIMNET network directly to disk or to tape. All of the appearance, firing, logistics, and other data generated during the exercise are stored for later analysis. The data logger can later play back this complete time history of the battle by transmitting all recorded packets from disk onto the network. The action can be viewed on the Plan View Display, which provides a birds-eye view of the battle. An additional playback capability is "time travel", i.e., the ability to play the exercise back into a simulator and allow the soldiers to drive around the battlefield and observe the exercise from ground level. Playback also has VCR-like capabilities such as fast-forward, freeze, or playback starting at a specified time.

Plan View Display

The Plan View Display (PVD) contains a copy of the terrain database and presents a relief map of the area on its screen. The map includes the roads, rivers, and geographic features of the terrain. Several features can be added or removed from the map including shading, contour lines, and map grids. Data can be displayed on the PVD from a currently active simulation on the SIMNET network, or from a recorded simulation played back from the data logger. The PVD interprets the data to superimpose color-coded icons representing vehicles, artillery shell impacts, and direct fire shots in the correct location on the terrain map.

The PVD also provides map manipulation and analysis tools. For example, the user can zoom in or out of any selected area of the battlefield and pan the display in any direction. Elevation and map coordinate values can be obtained for any point. Further, the user can obtain inter-visibility readings between points or vehicles and examine a graphic representation of a cross section of selected terrain from one point to another. By selecting a vehicle, the user can obtain detailed information such as vehicle ID, location, speed, ammunition, fuel, and repair status. Overall, the PVD allows the chain of command to observe the exercise as it occurs, then control a detailed playback as part of an after-action review. Thus soldiers and commanders are provided with the knowledge required to evaluate individual crew and unit performance during the exercise.

Data Analysis System

The data analysis system runs on a MicroVAX cluster equipped with GPX high-resolution color terminals. The tape of the exercise can be taken from the data logger and ported to this system. Two analysis software programs, DataProbe™ and RS/1®, are designed to extract, organize, and analyze the data of immediate interest.

DataProbe

DataProbe is an interactive graphics-oriented data analysis and display system. Its main feature is the ability to extract desired information from immense quantities of data and perform complex analysis operations on it. For example, DataProbe can be used to extract pertinent movement and shot data from a recorded exercise and use those data to make a plot of the unit's distribution of fire during the exercise.

Figure 1 presents such a plot for a platoon participating in an engagement on a SIMNET simulation of an actual gunnery range. This gunnery range was constructed to allow platoons to practice for the 1987 Canadian Army Trophy Cup (CATC) competition. This plot was provided to the tank crews before their next day's training to give them graphic feedback on their distribution of fire. The plot gives them a picture of the order in which the targets appeared on the range, which crew engaged which target, and whether they hit it or missed. DataProbe also generated a table containing the cumulative hits and misses for the training session, as well as distance and azimuth error data on missed shots (Table 1). Other output displays that DataProbe can make include x-y plots, time plots, spectral plots, and tabulations. Tabulations can be formatted several ways, and relayed to RS/1 for further analysis.

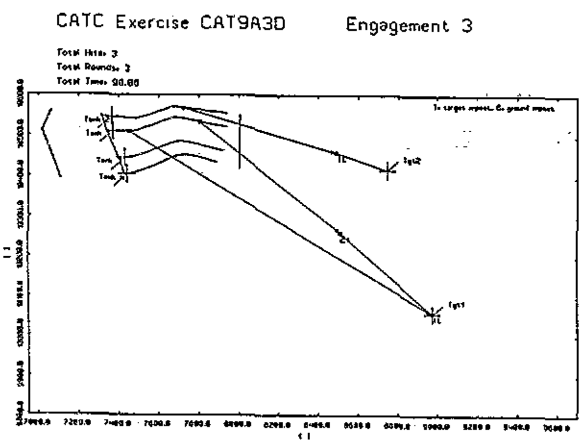

Figure 1: CATC Engagement Plot

EXERCISE: CAT9A3D Engagement: 3

Engagement starts at 288.25 secs, and ends at 378.33 secs

Shot Sequence

NUMBER Tank	NUMBER Target	NUMBER Shot	Time of Shot	Time Target Appeared	Time Until Shot	Actual Range m	Actual Azi. mil	Actual Elev. deg	Error Range m	Error Azi. mil	Error Elev. deg
1	1	1T	297.19	288.25	8.94	1584.6	1895.8	-0.54	0.0	0.00	0.000
2	2	1T	345.31	337.72	7.58	772.9	1743.5	-0.22	0.0	0.00	0.000
1	1	2T	358.82	288.25	70.56	759.4	1977.7	-0.30	0.0	0.00	0.000

Engagement Statistics

	TANK NUMBER 1	2	3	4
TARGETS				
Attempted	1	1	0	0
Hit	1	1	0	0
Missed	0	0	0	0
SHOTS				
Hits	2	1	0	0
Misses	0	0	0	0

Table 1: CATC Exercise Tabulation

RS/1

The RS/1 software package combines data base management and statistical analysis features. Once tabulated, data can be rearranged, statistically analyzed, and graphically displayed. Statistical analyses include standard descriptive statistics as well as t-tests, F-tests, analysis of variance, correlations, and curve-fitting. Graphs include x-y graphs, bar graphs, three-dimensional graphs, and pie charts. Individual analysis procedures on RS/1 can be performed interactively or pre-programmed using RPL, a PL/1-like programming language. These procedures can be used to examine recorded data and provide measures such as hit rate or range distribution of hits. Figure 2 presents the range distribution of hits and misses

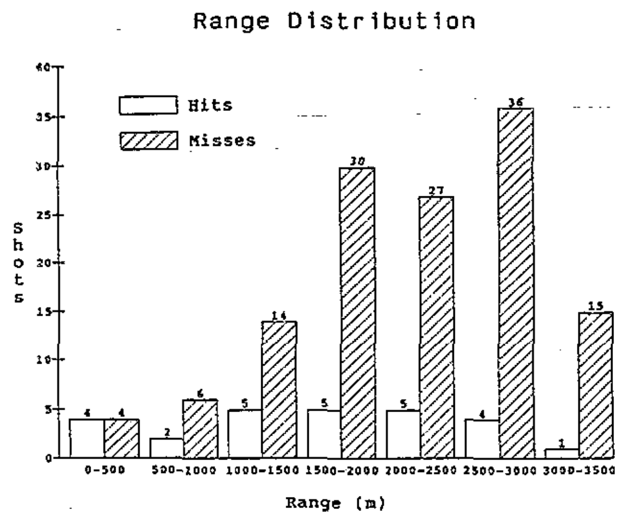

Figure 2: Range Distribution of Hits and Misses

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RS/1 is a registered trademark of BBN Software Products Corporation.

for a unit engaged in a SIMNET exercise. The unit was engaged in a company-size, force-on-force combat operation. Extracting this data on a daily basis over the course of a week of exercises can help the unit commander gain insight into both training effectiveness and troop readiness.

Other measures that the SIMNET DCA can routinely extract include:

- Percent of successful engagements
- Percent of forces lost/surviving
- Hit rate
- Number of rounds per kill
- Shots, hits, kills, and losses over time

These measures can be generated for individual vehicles or for different combinations of vehicles. Additional measures can be calculated from the basic data recorded by the data logger.

SIMNET FUTURE CAPABILITIES

While SIMNET's combination of interactive simulation and data collection and analysis capabilities provides a unique and effective training environment, efforts are underway to further enhance SIMNET as a readiness tool. These efforts include improving both the authenticity of the SIMNET battlefield and the speed and power of the DCA system.

New elements being incorporated into the SIMNET battlefield include:

- smoke, haze, and other obscurants
- night operations
- mines and anti-tank obstacles
- dynamic terrain, i.e., the ability to rapidly change the terrain database as a result of ongoing combat (e.g.,blowing a bridge)
- human-controlled, regimental-sized, artificially intelligent, semi-automated forces
- electronic countermeasures
- dismounted infantry

This improved combat arena will be backed by a DCA system that will generate a standard library of measurements of troop performance and training effectiveness in real time, so that they may be provided to the chain of command during the course of his exercise, and presented to the soldiers during the after action review.

CONCLUSION

SIMNET uses new technology to create, in interactive simulation, a complete combat world including most essential aspects of combined arms warfare, such as command and control and combat support. The critical technologies to this new approach are distributed simulation, which allows many inexpensive simulators of different systems to be networked together, and interactivity. This means that soldiers are able to fight other soldiers on a realistic battlefield.

SIMNET's ability to automatically capture and instantly review crew and unit performance in training exercises provides a valuable tool for training. The ability of the SIMNET Data Collection and Analysis system to generate measures of crew and unit performance offers the potential for improved training which ultimately will improve the readiness of combat troops.

ABOUT THE AUTHORS

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