Semi-Automated Forces Dismounted Infantry in the SIMNET Battlefield

Mikel D. Petty, Clark R. Karr and Scott H. Smith
University of Central Florida
Institute for Simulation & Training
Orlando, Florida

ABSTRACT

Dismounted infantry, in useful numbers, is conspicuously absent from the SIMNET battlefield. That absence creates an unrealistic, and possibly negative, training environment. Dismounted infantry, both in reality and in SIMNET, is difficult to see and very dangerous to vehicles when armed with antitank missiles. Tank crew trainees in SIMNET do not learn to consider this threat, and consequently can learn behaviors that increase their vulnerability to dismounted infantry.

The Institute for Simulation and Training was charged with the task of developing a prototype computer generated forces system capable of generating useful numbers of dismounted infantry at minimal cost. This was done by specializing IST's Computer Generated Forces Testbed into a Semi-Automated Forces Dismounted Infantry system, which can generate dismounted infantry fireteams and their associated fighting vehicles in the SIMNET battlefield.

ABOUT THE AUTHORS

Mikel D. Petty is Principal Investigator of the Intelligent Simulated Forces project at the Institute for Simulation and Training. He has earned a M.S. in Computer Science from the University of Central Florida and a B.S. in Computer Science from the California State University, Sacramento.

Clark R. Karr is a Software Engineer in IST's Intelligent Simulated Forces project. He served as the Team Leader for the Semi-Automated Forces Dismounted Infantry project. He has earned a M.S. in Computer Science from the University of Central Florida and a B.S. in Biology from the University of Denver.

Scott H. Smith manages several IST projects related to the development of Distributed Interactive Simulation, including the Intelligent Simulated Forces project. He has more than 13 years of experience in software engineering and operating system design. He has earned a B.A. in Anthropology from the University of Florida and a M.S. in Computer Science from the University of Central Florida.

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INTRODUCTION

An overview of SIMNET

The U.S. Army/DARPA SIMNET is a well-known distributed interactive simulation system. In SIMNET, individual vehicle simulators are connected via a computer network, permitting them to coexist in a common, shared simulation environment and to interact (e.g. engage in combat) through the exchange of network packets. SIMNET is used to train tank and vehicle crews in cooperative team tactics. (The documentation of SIMNET is extensive; [14] and [16] are good examples.)

Computer Generated Forces

In a SIMNET exercise, the simulated opponent for the trainees can be provided in at least three different ways. First, two groups of trainees in simulators may oppose each other ("force on force"); this has the disadvantage of presenting the trainees with opponents who use US tactical doctrine. A second technique is to use instructors who are trained to behave in a way that simulates threat doctrine. This method is expensive in terms of manpower. The third technique is to provide a simulator that generates and controls one or more simulation entities (e.g. vehicles or fireteams in the SIMNET environment). Such an opposing force is usually referred to as either a semi-automated force (SAF or SAFOR) or a computer generated force (CGF); this document will more often use the latter term. The SIMNET CGF system implemented by Bolt, Beranek, and Newman Systems and Technologies (BBN) is usually known as the SIMNET SAF system and is described in [1], [4] and [6].

Under contract to DARPA and STRICOM, the Institute for Simulation and Training's (IST) Intelligent Simulated Forces (ISF) project has been conducting research in the area of CGF systems. IST has developed a SIMNET compatible CGF Testbed. The IST CGF Testbed (which previous reports on the Testbed referred to as the IST SAFOR Testbed) is a hardware/software system that connects to the SIMNET network and provides a mechanism for testing CGF control algorithms. Using the IST CGF Testbed, IST has tested the applicability of various artificial intelligence techniques to CGF systems. The IST CGF Testbed is documented in [5], [10], [11], and [15]. IST's artificial intelligence investigations are described in [2], [3], [7], and [10].

Dismounted Infantry in SIMNET

At this time, dismounted infantry (DI) is conspicuously absent from the SIMNET battlefield. Although the SIMNET network protocols and image generators include the necessary features to represent and display DI entities, the SIMNET SAF system does not generate them. The manned dismounted infantry module (DIM) developed by BBN and documented in [8] is an interesting and useful technical accomplishment. However, the cost of a DIM workstation and the fact that each one generates only a single DI squad mean that it is not practical to generate the large numbers of infantry needed to populate the SIMNET battlefield realistically. Consequently, SIMNET trainees are free to drive about the battlefield oblivious to the serious threat posed by DI armed with anti-tank missiles. The absence of realistic numbers of DI reduces the effectiveness of SIMNET as a training environment.

Dismounted Infantry in the IST CGF Testbed

To study the feasibility of generating DI in SIMNET and to demonstrate the capabilities of the IST CGF Testbed, STRICOM asked IST to produce a CGF system capable of generating and controlling semi-automated forces dismounted infantry (SAFDI) in the SIMNET battlefield. In response, IST enhanced and specialized the IST CGF Testbed with capabilities specific to DI. The resulting version of the IST CGF Testbed, referred to as the IST SAFDI system, generates up to twelve DI entities per pair of low-cost person al computers. The SAFDI system, and especially the capabilities of the entities it generates, is the topic of this paper.

SAFDI SYSTEM CONFIGURATION

The SAFDI system is composed of two major subsystems: the Simulator and the Operator Interface. Each subsystem is an IBM compatible personal computer running IST developed SAFDI software and is a node on the SIMNET network.

The SAFDI system generates entities that are fully functional in the SIMNET environment; the SAFDI system generates and accepts SIMNET network packets (often called protocol data units, or PDUs) allowing the SAFDI entities to interact with the entities on the SIMNET network.

Simulator

The SAFDI Simulator generates the SAFDI entities in the SIMNET battlefield. The Simulator computes vehicle dynamics, tracks other simulation entities with dead reckoning, performs Line of Sight (LOS) determinations between entities, and calculates combat results.

The Simulator also generates the behavior for the SAFDI entities, using its autonomous behavior modeling mechanisms. These behaviors are usually initiated by commands from the operator via the Operator Interface. Once initiated, each behavior may consist of several steps and decision points which are performed automatically by the Simulator without operator intervention. Investigations are underway at IST and elsewhere that address the issues of automating more complex CGF behaviors and decision making a ctivities.

Operator Interface

The SAFDI Operator Interface provides the operator with the ability to create and control simulated entities in the SIMNET environment. It does not actually control the entities; rather, the operator's commands are communicated via the network in the form of non-PDU packets to a Simulator node which executes them. An Operator Interface node acts as a front end to one or more Simulator nodes.

The Operator Interface and Simulator software are designed to allow an Operator Interface to control entities simulated on multiple Simulators and for a Simulator to simulate entities which are individually controlled by separate Operator Interfaces. During entity creation, the Operator Interfaces automatically balance the load of entities onto the available Simulators.

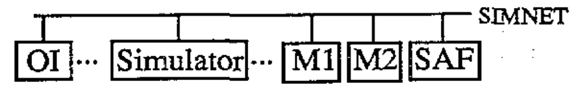

Figure 1.

SAFDI FUNCTIONAL CAPABILITIES

This section gives an overview of the functional capabilities of the SAFDI system. A complete functional description and details of the implementation are provided in [11] and [15].

SAFDI Entities

The SAFDI system can generate US and opposing force (OPFOR) fireteams. The SAFDI fireteams represent a generic five man fireteam, which includes an ATM gunner, a machine gunner, and three riflemen.

In addition to fireteams, the SAFDI system generates and controls certain types of vehicles closely associated with infantry; specifically, the Soviet-made BMP and US M2 Bradley Fighting Vehicle (together referred to as infantry fighting vehicles, or IFVs). IFVs may be used in support of SAFDI fireteams or independently to supplement a detachment of manned simulators in a SIMNET exercise.

SAFDI Fireteam Capabilities

The following minimum set of SAFDI fireteam capabilities were identified for IST by SIMNET users. All of these capabilities have been implemented in the IST SAFDI system.

1) Communicate with headquarters
2) See and report enemy entities within Line of Sight (LOS)
3) Be seen
4) Kill enemy DI and vehicles
5) Be killed
6) Move and change speed
7) Mount and dismount vehicles

SAFDI IFV Capabilities

SAFDI IFVs have similar capabilities, except that they can transport fireteams rather than mount and dismount vehicles.

Advanced SAFDI Capabilities

To increase the realism of SAFDI entity behavior, enhancements in the following areas have been made to the basic SAFDI capabilities.
1) Sighting model
2) Target selection
3) Fire distribution
4) Triggered fire
5) Suppression
6) Exhaustion
7) Automatic posture changes

These capabilities, basic and advanced, are discussed in the following sections covering communication with headquarters, sighting, combat, and movement. Unless otherwise noted, the explanations apply to both fireteams and IFVs.

Communication with headquarters

In the SAFDI system, the SAFDI operator is considered to be headquarters. Commands from the SAFDI operator are routed to the SAFDI entities. Messages from the entities are routed to the operator via the Operator Interface.

Sighting

The broad area of sighting, which includes Line of Sight (LOS) determinations, sighting models, and sighting reports, is of crucial importance to the behavior of SAFDI entities.

Line of Sight. The problem of determining whether two entities have an unobstructed LOS between them, i.e. whether the line segment joining the two entities intersects any obscuring terrain or object, is a difficult one. IST has studied this problem in detail and has developed improved LOS algorithms; that work is documented in [13]. The following discussion of the SAFDI sighting model assumes the existence of a LOS determination procedure.

Sighting model. Associated with each entity is a "sightings" list. An entity appears on another entity's sighting list only if an unobstructed LOS exists between them. The Simulator periodically performs LOS determinations among its entities and all entities in the environment. However, the existence of an unobstructed LOS does not mean that an entity has "seen" or "noticed" the other. The Simulator periodically determines whether each entity has seen the others based on a sighting model.

An entity on a sightings list may fall into one of four classes: undetected, detected, recognized, and identified. An undetected entity is potentially visible to the sighting entity but has not been noticed. A detected entity is seen but its alignment (friendly or hostile) and vehicle type are unknown. A recognized entity's category is known (e.g. Tank, IFV, fireteam) but its alignment is unknown. An identified entity's category and alignment are known to the sighting entity. SAFDI entities fire only upon identified entities.

Several factors are considered in sighting determinations:
1) Distance between the sighting entity and the entity being sighted,
2) the type and activity of the entity being sighted,
3) the type of the sighting entity,
4) the visibility of the entity being sighted (based on its size, profile, and paint scheme),
5) the vision capability of the sighting entity (based on its equipment and configuration).

These factors taken together produce for each ordered pair of entity types specific detection, recognition, and identification ranges. An entity within detection, recognition, or identification range is potentially "seen". Whether it is actually sighted is based on whether or not it is "noticed". The probability of being noticed is based on vehicle noticeability, movement, and relative location.

Sighting reports. When a SAFDI entity sights an enemy entity, the Simulator passes to the Operator Interface the information necessary to produce a sighting report for the operator.

Being seen. The SAFDI system generates SIMNET standard appearance PDUs which allow the SAFDI entities to be seen by other simulators.

SAFDI Fireteam Combat

Target selection by priority. Target selection by SAFDI fireteams is based on prioritized vehicle categories and the existence of nearby friendly fireteams. Each SAFDI fireteam has two lists of target priorities, for ATM targets and for small arms targets. The operator may change target priorities for a fireteam.

Fire distribution. After a fireteam has been given permission by the operator to fire a weapon type (ATM or small arms), the fireteam examines all of its identified entities and selects the three highest priority targets within the range specified by its rules of engagement. The fireteam then considers the nearby friendly fireteams that are within LOS to determine if there are friendly fireteams to its right and/or left. If there are nearby friendly fireteams to both the right and left, the fireteam selects the target to fire at by excluding the rightmost and leftmost targets. If there are friendly fireteams to either the right or left, the leftmost or rightmost target respectively is chosen as the target.

ATM Firing. There are four phases in fireteam ATM firing:
1) Load weapon,
2) Select target,
3) Setup weapon,
4) Fire weapon.

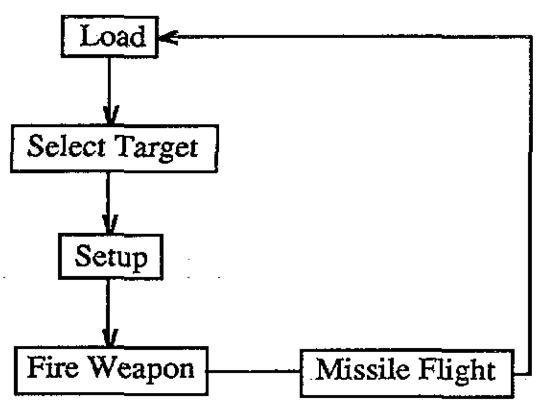

Figure 2

First, the fireteam must load the ATM if it is not already loaded. The time required to load is dependent on the alignment of the fireteam and its level of exhaustion. Second, a target must be sighted and selected, as described above. Third, the fireteam must stop movement, kneel, and set up the ATM. The time required to stop movement is dependent on the rate of travel. The time required to set up the ATM is dependent on alignment and fireteam exhaustion. Fourth, the ATM is fired if the target is still sighted.

Firing an ATM causes the creation of an ATM entity within the Simulator. The flight dynamics of the ATM entity are managed by the Simulator. The fireteam returns to the first phase, loading an ATM, after the Simulator has guided the ATM to its impact point. If during the first three phases the fireteam is destroyed, the ATM firing process is stopped. Destruction or suppression (see below) of a fireteam during missile flyout causes the missile to fly into the ground.

Small arms firing. The basic procedure for conducting small arms fire follows the SIMNET standard protocol. In general, a firing entity determines whether a hit is scored; if so, it sends an impact PDU describing the impact to the target entity. The target entity analyzes the impact PDU and determines what damage it has suffered.

The firing fireteam generates an impact PDU for every executed small arms attack that has any possibility of inflicting casualties; the PDU specifies the firepower intensity of the attack. That intensity takes into account the following factors:
1) strength of firing fireteam
2) range to target
3) concurrent firing/loading of ATM

Triggered fire. SAFDI entities can be ordered to hold fire until a specific entity (the trigger entity) fires. The trigger entity may be a friendly or opposing entity. This capability enables the operator to control the firing of several entities through a single entity.

Receiving fire. When attacked by small arms, the target fireteam uses the firepower value in the impact PDU and a probabilistic procedure to assess casualties.

SAFDI fireteams suffer losses incrementally (i.e. man by man). A single small arms attack may cause anywhere from zero to five casualties in the target fireteam. For the target fireteam, these factors affect the casualty assessment procedure:
1) firepower value of attack
2) posture of target fireteam
3) strength of target fireteam

When a fireteam is attacked by direct fire from a weapon other than small arms (e.g. a M1 main gun or a M2 automatic cannon), the resolution procedure is similar to receiving small arms fire. A firepower strength is derived from munition type and range and the same probabilistic procedure to assess casualties is used.

SAFDI fireteams are also vulnerable to indirect fire. If indirect fire impacts close enough to the fireteam, casualties are assessed based on the munition type and the distance of the impact from the fireteam.

Suppression. An important effect of fire on the battlefield is the suppression of activity. If an impact occurs near a US fireteam that is in the process of firing an ATM, that fireteam may be suppressed (the probability of suppression is based on the distance from the fireteam to the point of impact). If the DI is suppressed and a Dragon ATM is in flight, the Dragon flies into the ground, reflecting disruption of the ATM gunner's ability to follow the target in his sights. In addition, a suppressed fireteam immediately loses whatever target has been sighted and must start the ATM firing sequence over again. Because OPFOR SAFDI fireteams currently fire unguided ATMs (RPG-7), only the second effect occurs when they are suppressed.

SAFDI IFV Combat

Target selection by threat. Target selection by SAFDI IFVs is based on target threat, rather than target priorities, and the existence of nearby friendly IFVs. Threat determination is based on a set of rules which relate target type, distance, and activity to a threat level.

Fire distribution. Fire distribution for SAFDI IFVs is very much like SAFDI fireteams; see the previous description. Note that IFV s consider only nearby IFVs when distributing fire.

Weapon selection. After a target is selected, the weapon used to attack the target is determined by applying a set of rules relating target type and distance to weapon selection. Briefly, the rules specify that IFVs outside main gun range and tanks are attacked with TOWs or Spandrels, infantry entities are attacked with the coaxial gun, and all other targets within main gun range are attacked with the main gun.

Weapon firing. There are four phases in IFV weapon firing. First, a target is selected as described above. Second, the weapon to fire is determined as described above. Third, the weapon is fired. The process of firing a weapon involves aiming the weapon and firing it. Aiming requires rotating the turret and elevating the main gun appropriately. Firing the main gun generates fire and impact PDUs that are sent over the network. Firing an ATM causes the creation of an ATM entity within the Simulator, as described for fireteam ATM firing. After the ATM strikes the target or the ground or the gun is fired, the fourth phase reloads the weapon if necessary. Reload times for each weapon are alignment specific.

Receiving fire. SAFDI IFVs assess damage from direct fire and indirect fire in the standard SIMNET manner.

Movement

Movement of SAFDI entities on the battlefield is controlled by a mixture of operator commands and automated behavior. The operator specifies the destinations of SAFDI entities, sets the speed of travel, and gives permission to begin travel. The process of determining the path to be taken is done automatically for each SAFDI entity.

Routing. The route planning process uses wavefront expansion within a rectangular grid. The wavefront expansion route planner produces a route in the form of a list of route points. The route follower is activated when the entity has permission to travel. It causes the entity to move along straight line segments from its current location through the route points on its route point list.

Movement speed. A SAFDI fireteam's rate of movement is based on the speed requested by the operator, the posture of the fireteam, terrain being covered, and the exhaustion level of the fireteam. A SAFDI IFV's rate of movement is based on the speed requested by the operator and terrain being traversed.

Exhaustion. Exhaustion acts as constraint on the dismounted movement of fireteams. Moving fireteams become "exhausted" and stationary fireteams "recover". As a fireteam becomes exhausted, its maximum speed over all terrain types declines. Both exhaustion and recovery are modeled as non-linear changes in fireteam "energy" based on speed and duration of travel.

In addition to its effect on speed of movement, exhaustion increases the length of time a fireteam takes to load and to set up an ATM.

Mounting and dismounting. One of the basic capabilities of SAFDI fireteams is the ability to mount, be transported by, and dismount vehicles.

Fireteams attempt to mount only those vehicles that have been described in the Simulator as being capable of carrying fireteams. Given the order to mount an appropriate vehicle, a fireteam moves to that vehicle's mounting location (e.g. the back of a M2), remains visible at that location for a certain loading time, and then disappears from the battlefield. The vehicle may then move about the battlefield and engage in any appropriate behaviors. When ordered to dismount, the fireteam reappears on the battlefield after a specific dismount time at the vehicle's mounting location. Fireteams are destroyed if the vehicle that is carrying them is destroyed.

Automatic posture changes. The posture of a fireteam may be changed explicitly by the SAFDI operator. In addition, certain events cause posture changes by fireteams without the intervention of the operator. For example, fireteams fall prone at the end of movement, stand up to begin movement, kneel to fire ATMs, and fall prone when suppressed.

SAFDI SYSTEM DEMONSTRATION

The SAFDI system was tested [12] and then successfully demonstrated at the SIMNET training site at the US Army Infantry School (USAIS), Ft. Benning, Columbus GA. Perhaps the most interesting event during the demonstration was a scenario that included battlefield entities generated by the IST SAFDI system, the BBN SAF system, the BBN DIM workstation, and eight manned simulators (four M1s and four M2s, all crewed by US Army soldiers). The scenario required the manned M2 simulators to stop and dismount SAFDI fireteams, to support their advance, and to engage enemy SAFDI fireteams. The scenario was the first opportunity for soldiers in SIMNET simulators to interact with large numbers of DI.

At the demonstration, a consensus was reached by the military officers in attendance that the IST SAFDI system had sufficient realism and effectiveness to be worth fielding as a training enhancement for SIMNET training sites.

CONCLUSION

Results of the IST SAFDI Project

The SAFDI project had two goals. First, it served as a demonstration and test application for the IST CGF Testbed. Second, the SAF DI project demonstrated the feasibility of adding a cost effective CGF DI component to the SIMNET battlefield and to future networked simulations.

Adding DI to the SIMNET battlefield will increase the battlefield's realism and provide useful training benefits in several valuable ways.

1) The danger of the battlefield would be increased, forcing vehicle crews to visually scan likely positions for hostile DI.
2) Vehicle crews would be given the chance to practice mount and dismount procedures.
3) Vehicle crews would be able to practice supporting friendly DI with direct fire.
4) Vehicle crews and commanders would be clearly shown how the tempo of the battle slows with dismounted infantry.

Future Work

As this is written, a project to convert the IST SAFDI system from a research prototype into a production quality training system is being planned. The project will make the current research software robust and reliable enough for use by trainers, and will also enhance the SAFDI system with additional capabilities requested at the USAIS demonstration.

Additional research related to DI in networked simulation needs to be done. A human factors question that remains unanswered is whether or not any training benefits result from generating visual DI figures that contain articulated parts (the SIMNET visual icons for DI are fixed). Another DI related area of research is the creation of a DI simulator that allows individual infantrymen to participate in the simulation, perhaps through the use of virtual environment technology.

Relevance to CCTT and Future Networked Simulation

The SIMNET battlefield is unrealistic with limited DI. The IST SAFDI system shows the feasibility of incorporating realistic numbers of robust DI in SIMNET, and by extension in any networked simulation, and the importance of doing so. Lastly, it is clear that CCTT requirement for an fully integrated DI component is justified and achievable.

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