Advanced AI Applied to Human Character Simulation for ISR Training

Alex Broadbent

VT MÄK

Cambridge, MA

abroadbent@mak.com

ABSTRACT

In 2009, the Marine Corps Tactics and Operations Group (MCTOG) identified a gap in the capabilities of its current training simulations used during the "Spartan Resolve" pre-deployment exercises. Existing simulations did not allow for training on counterinsurgency and IED defeat tactics since they did not adequately represent the information available to the Company Commander in the Battalion Operations Center from the latest Intelligence Surveillance Reconnaissance (ISR) assets. MCTOG identified the requirement for simulation of the ISR assets along with a very realistic representation of the subtleties of human behavior and activity, all to be integrated into current training systems. Using artificially intelligent human characters that look, act, and react realistically is a critical factor in providing valuable training. It keeps the attention of our young videogame generation soldiers while they take part in virtual pre-deployment training.

MCTOG's enhanced training system required robust simulation of friendly force tactical behavior at the squad level, representation of the enemy "human networks" by modeling the disparate group of people and specialists that make up the insurgent team, and the simulation of civilians by focusing on pattern of life and their reaction to ongoing events and interaction with friendly force and insurgents.

The Marines believed that the ability to modify training scenarios in real time enables the simulation to adapt to suit the training level of a trainee and thus increase training effectiveness. These flexible training simulations allowed the trainees to experience a large number of situations where their observational skills are repeatedly challenged. What if training instructors could ensure that important events involving realistic human behavior occur at a time when the student is capable of observing and reacting to them? To achieve that level of flexibility, MCTOG's simulation needed to have semi-autonomous entity behaviors and intuitive role player interfaces.

MCTOG and US Air Force Special Operations Forces (AFSOF) have recognized the value of real-time dynamic training with realistic simulated humans. With help from the DI-Guy team at VT MÄK, these organizations achieved dynamic Intelligence Surveillance Reconnaissance (ISR) training using advanced artificial intelligence (AI) applied to human character simulation.

This paper details how the Marines, along with parts of the Air Force, are using human simulation with advanced AI to present tactically significant ISR video feeds to trainees. Both systems rely on the ability to represent complex scenarios with large numbers of human characters and to dynamically control the action to ensure the scenarios support specific training objectives.

ABOUT THE AUTHOR

Alex Broadbent is a Project Manager and the Director of DI-Guy at VT MÄK. Alex has worked closely with Marine Corps, Army and Air Force Special Operations for more than a decade to support operations in Iraq and Afghanistan. He has worked on countless pre-deployment training exercises and after-action reviews. He has also taken part in live fire exercises with the USMC and training for multiple federal law enforcement organizations. He is an expert at using simulation to develop advanced training practices. His background is based in the entertainment industry where he was an animator at CNN and ABC Sports, as well as a developer of special effects for music videos, commercials, and motion pictures.

Advanced AI applied to Human Character Simulation for ISR Training

Alex Broadbent

VT MÄK

Cambridge, MA

abroadbent@mak.com

FILLING THE GAPS IN TRAINING

Each year the US Marine Corp holds multiple training exercises for combat operations center staff who are about to be deployed to Afghanistan. They also hold several battalion training exercises on large scale operations in potential hot spots. Some of the newly promoted Marines are just two weeks away from deployment. The goal of this training is to emulate the situations and operations the Marines will be facing on the battlefield and exposing them to ISR assets that they may not have ever encountered before.

Before the Marines started working with MÄK's DI-Guy team to develop the Enhanced Company Operations Simulation (EcoSim) for training they realized there was a missing component to the simulations they had been using – a dearth of non-kinetic simulation portrayed in simulated ISR feeds. Even during major operations, the majority of a soldier's day is often spent performing activities that do not involve firing a weapon; for example, interacting with civilians is often a vital part of "winning the hearts and minds." Most insurgents, on the other hand, don't carry around a weapon in plain site; their identifying characteristics are much more subtle, like their participation in a network that provides funding, support, and shelter.

To fill this training gap, the Marines wanted to portray believable, culturally accurate civilians and an unarmed insurgent population that could stimulate ISR assets. The solution was realized by implementing multiple layers of robust AI to control civilians, opposing forces (OPFOR), and even non-player friendly forces with which the soldier or ISR asset would interact during a mission. These computer generated characters were programmed to react intelligently to gun fire, explosions, interpersonal conversation, and other meaningful events in a manner consistent with past observation. A schedule-based "pattern-of-life" capability was added to inject human activity into the scenario throughout the day. The characters were programmed with enough AI to realistically react and adapt to likely situations.

But even with the success of the AI implementation, another detriment to effective training was identified – the difficulty of the scenario definition process hampered MCTOG's ability to set up and adapt scenarios to the specific needs of trainees. With the training resources they had available, they lacked the ability to effectively control fire team, squad, platoon, and company sized elements in time to meet the training schedule. They needed a single person to be able to setup and control a large number of OPFOR, BLUFOR and civilians during an exercise. The solution to this was found in semi-autonomous intelligent entities that could collaborate to form team behaviors. Specific graphical user interfaces (GUI) tools were developed so a single operator could control squad size elements and have them react in a realistic manner to their virtual environment.

The Marine Corp training environment required simulations to run both standalone and to run in a distributed simulation environment to supplement exiting simulations used by MCTOG, such as JCATS and MTWS. The simulation needed to model human behaviors that were interoperable with existing constructive simulations as well as provide the fidelity needed in realistic ISR feeds. The primary goal was to reduce the number of instructor role players needed to conduct effective training.

MARINE PRE-DEPLOYMENT TRAINING

MCTOG uses Enhanced Company Operation Simulation (EcoSim) to train Improvised Explosive Device IED defeat missions. The AI allows them to model sophisticated relationships between friendly forces, opposing forces, civilians, and insurgents. The AI models a dozen types of friendly formations including: Standard Squads, Mortar Teams, SMAW Team, SIGINT Support Team, PSYOP Teams, Sniper Teams. Trainers can also place opposing force units of types like: Enemy Squad, Enemy Fire Team, Enemy Mortar Team, Revolutionary Guard, etc. Within these teams each individual has AI that

controls his behavior, health, and status. The teams then add another layer of AI to ensure that the independent actors maintain reasonable formations and work collectively to carry out the team's mission.

A distinguishing characteristic of this system is the attention paid to civilian AI. Missions operate within a larger backdrop of ambient civilian behavior: farmers in fields, children attending school, families going to marketplaces and religious services. Because the training needs to be sensitive to the location where trainees will soon be deployed, it does not rely on heavily detailed terrain databases that require months of preparation. Instead a geographically specific base terrain is used and operators develop scenarios by adding buildings to the terrain. Each building includes the civilian population that inhabits that building. Buildings can be residences, markets, insurgent hideouts, etc. The inhabitants of each building type come with their own distribution of characters with different motivations. Most civilians will leave their residence and make a visit to the market, or may spend some time gathering and hanging out with like-minded friends in the plazas. The Marines controlling the simulation can quickly develop different background civilian populations simply by placing different kinds of buildings. A "pattern of life" scheduler helps distribute the activity throughout the day, so the operators don't have to pre-plan each action of every individual.

Against this civilian background is a layer of AI that models sophisticated human networks of OPFOR financiers, bomb makers, safe houses, leaders, and emplacers. Characters have been developed for each role and as the simulation plays, the astute Marine can observe the patterns of behavior that lead to potential IED emplacements.

Figure 1. A fire team deploys in a busy urban market, simulating the non-kinetic "hustle and bustle" that is the daily reality in many battle zones.

Marines in the Combat Operations Center (COC) establish orders to conduct searches, patrols, and detentions, all while monitoring the battlefield using simulated ISR feeds and stationary cameras. In addition, the simulation implements a sophisticated reporting capability, mimicking the way the Marines will actually convey and receive information in the battlefield. The training audience requests feeds and allocates ISR assets – watching the events unfold on the ground and making tactical and logical decisions. For example: a TIC (Troops in Contact) is developing and the command and control trainee can allocate an ISR asset to see the ground truth and relay enemy positions to ground forces under fire. This is a great exercise in correctly using ISR before real lives are at risk.

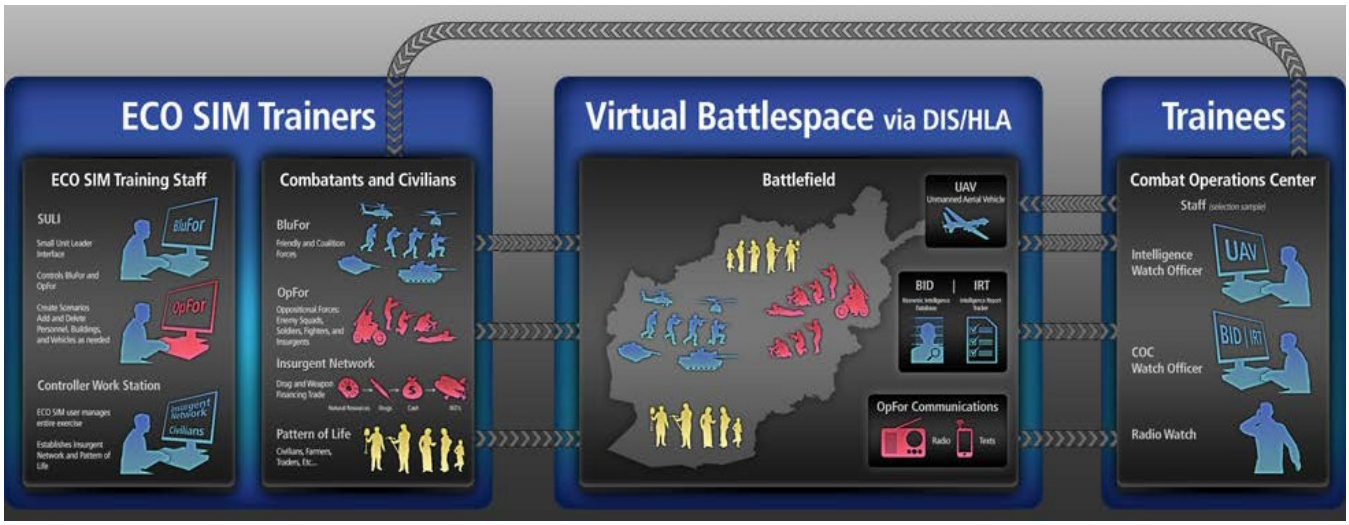

Figure 2. Training System Architecture Diagram

AIR FORCE ISR TRAINING

The U.S. Air Force Special Operations (AFSOF) is also making heavy use of human simulation in their training of UAV/MAV/ISR (Unmanned Aerial Vehicle/Manned Aerial Vehicle/Intelligence Reconnaissance and Surveillance) missions. Realistically simulating human activity is critical to train students to better understand what they are looking at by maximizing ISR best practices. Both the Marines and the Air Force train how to best deploy ISR assets and leverage sensors to better understand ground truth. Interestingly, these organizations already use simulators to teach piloting, but ISR observation is a completely different skill set. Having humans with distinctive walking behaviors, body types, and sizes are important in sorting out the HVI (High Value Individuals). The way a group interacts with a suspected leader or higher rank can also be simulated by a subtle differences in body language. The human character AI plays an important role in coupling physical behavior with the intentions of the actors.

Tracking a HVI that is deliberately getting in and out of vehicles and traveling in traffic to avoid detection is a difficult, yet important, skill to train. Threat assessment is also essential training for convoys and ground force protection. The trainees learn to scan ahead for threats like disturbed earth or concealed forces and to not focus solely on the convoy. During a kinetic event, the trainees must make decisions about whether to follow “squirters” or keep eyes on an initial target. They practice relaying information accurately to the convoy and perhaps rerouting the convoy through a safer passage. The multi-layer approach to AI allows the trainers to plan out the overall intents of characters and let the individual’s AI take care of the physical motions.

Because the AI makes the task of creating scenarios so easy and fast, the trainer has the ability to inject characters and events in real time and alter the outcome of the scenario based on the skill level of the trainee. From a single workstation the trainers can easily control hundreds of characters, ramping up or tuning down the complexity of the situation.

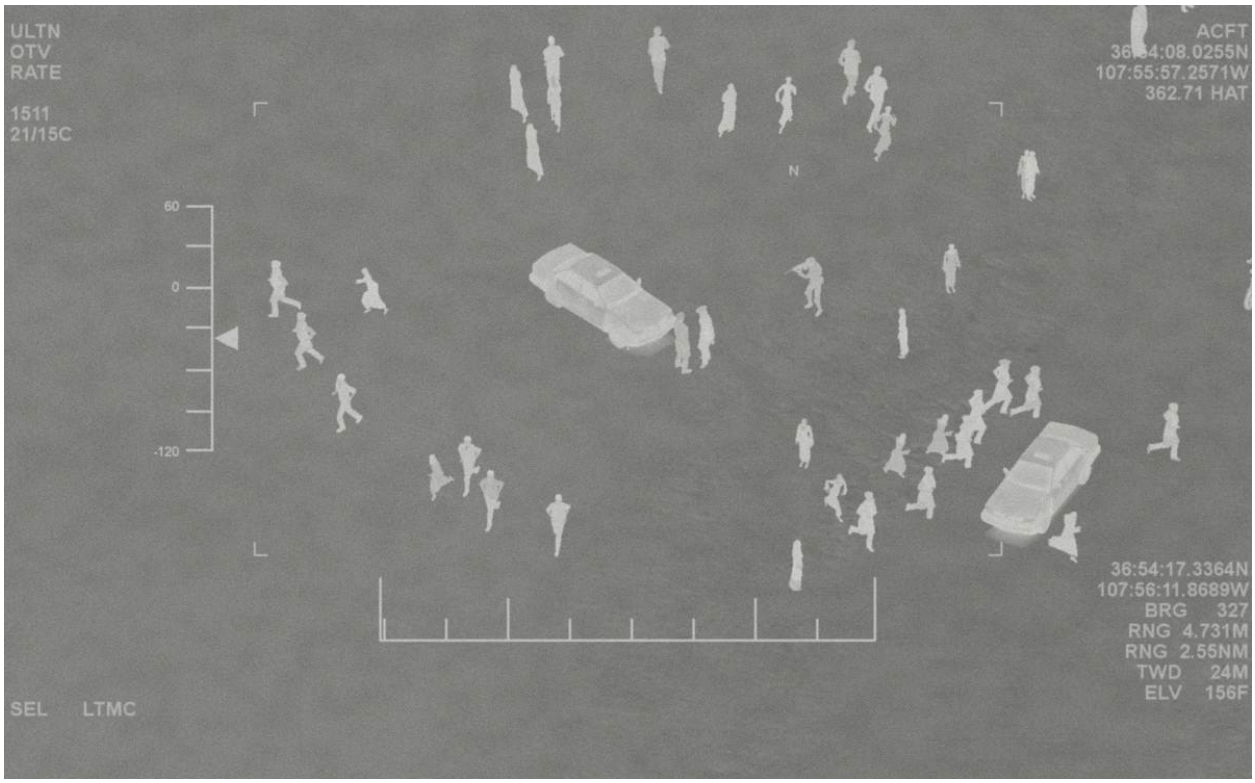

Figure 3. A simulated Predator video feed shows the sophisticated human simulation required for ISR training.

AI SPEEDS UP AUTHORING, LEAVING TIME FOR STUDENTS

During a training exercise the training staff is expected to do a lot of things: they setup up and configure the training systems, they define and initialize the training scenarios, they act as role players (or augments) within the exercise, as well as evaluate the performance of the trainees and refine the scenarios to steer the students through the training curriculum. Time spent managing the complexity of the simulation infrastructure is time away from training soldiers. When using and generating complex simulations that focus on human interactions and subtle behaviors, automation in the scenario creation tasks is critical. Special elements of the graphical user interface were developed to compliment the AI capabilities in the system. Constructs that allow the operator to place squads and manipulate their formation to swiftly make them relevant in the scenario were implemented along with individual controls to taylor the behavior of critical individuals.

The system built at MCTOG enables the trainees and role players to operate the system within an average of fifteen minutes with limited instruction. This out-paced the previous two days of training that had been needed for some Spartan Resolve exercises. Reducing the role player's workload allows them to focus on more important training aspects such as coordination and communication with the trainee. In this way, there is also training value for the role player during an exercise. The primary interface for controlling the BLUFOR and insurgents is the Small Unit Leader Interface (SULI). By automating the behaviors of the individuals within the fireteam and squad, the role player does not need to control the entities individually. By using a SULI, a single operator can control three US Marine/Afghan National Army platoons with over sixty squads. The squads can react to fire automatically and support eight different tactical formations. Figure 4 below shows a user setting up avenues of fire.

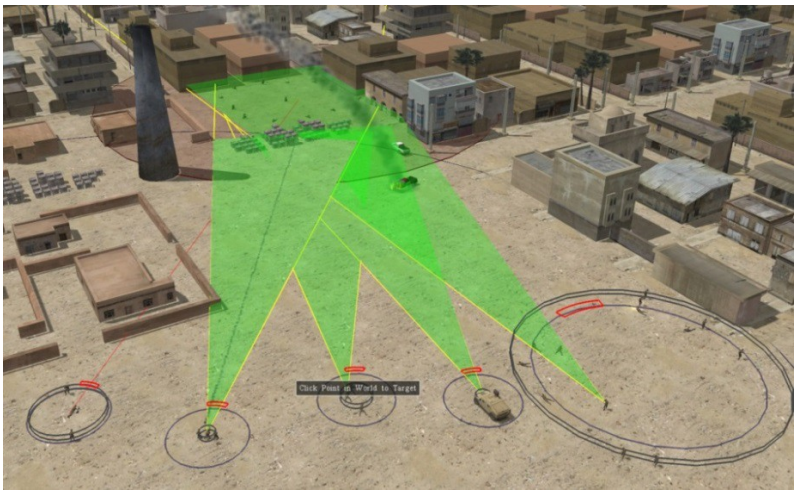

Figure 4. An example of a simple graphic for focusing avenues of fire for a platoon size element.

Figure 5 shows how the SULI is used to control a fireteam. On the left hand side is the simple interface that displays location, health, and current task for each squad up to a company-sized element.

Figure 5. An example of controlling an Afghan fireteam moving to a forward potion.

The second interface, shown in Figure 6, controls a "pattern of life" scheduler for the AI civilians. The AI includes just enough random behaviors to avoid the "Stepford wives" type of reactions in the large flow of characters during the exercise. There is also a run-time ability to control the flow with a simple point and click interface. The trainer can slow down the flow of characters or speed it up as needed.

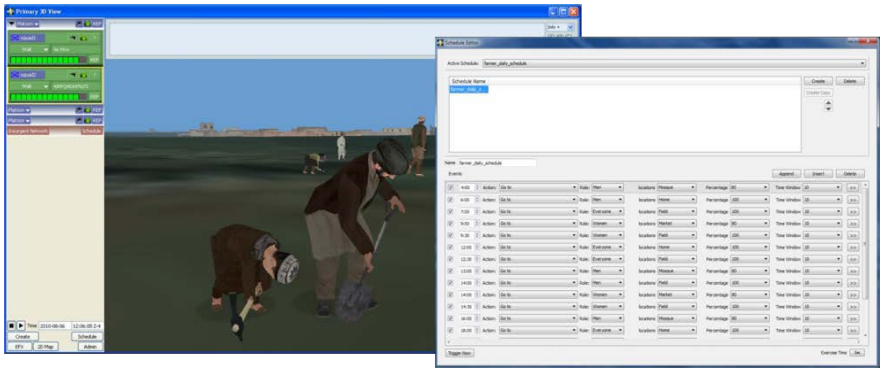

Figure 6. Pattern of Life Interface

JUST ENOUGH AI

Full AI autonomy is not desired in the training environment. If the AI controlled every aspect of the character's behavior, then the trainers would not have the control they need to define how scenarios play out. The Marines, while specifying the system requirements, made sure the AI drove the basic behaviors but was able to be overruled by the trainer when necessary.

The basic AI takes care of schedules, path planning and collision, and obstacle avoidance; movement (individually or as part of a team) including from point to point, wandering, mingling, and following; messages (amongst the team), and reactions such as taking cover and fleeing gun fire.

The AI logic for each entity (or agent) is driven by an extensible Hierarchical Finite State Machine (HFSM). The HFSM receives and processes messages and sensor information (what it can see) incoming to the character from the environment, along with internal state, to determine if a high-level behavior state change should be triggered. Parameters determine the desired Posture and Variant the entity should use when selecting actions. Postures define the basic posture of the action. Variants define an abstract emotional and/or mental state of the character. For example, someone will react differently to being approached if they are "happy" or "angry."

The HFSM is written in Lua, a powerful, fast, lightweight, interpreted scripting language commonly used in games to represent the behaviors of computer generated characters.

The user interfaces are carefully designed compromises between simplicity and access to underlying AI functionality. The level of exposure of the AI to the operator is the bare minimum required to maintain flexibility in the system without making the interface complex to use.

IN SUMMARY

VT MÄK has delivered the Enhanced Company Operations Simulation (EcoSim) to the USMC for training Company commanders and to the AFSOF for training ISR analysts. AI has been judiciously used in EcoSim to enhance the fidelity and realism of behaviors and interactions of BLUFOR, insurgents, and civilians. It also reduces the workload for role players within an exercise without taking away the ability of the trainee to make decisions and allows the trainer to take dynamic control and modify the scenario on the fly.

ACKNOWLEDGEMENTS

I would like to thanks Lt. Col Timothy Barrick USMC for his vision and never ending support. Without his drive many of these concepts and software advancement would never have made it to the hands of the USMC trainers. I would also like to thank Kristin Hernquist at the Army's Infantry Bugler magazine who helped me sort out my thoughts.