The Virtual Combat Training Center:

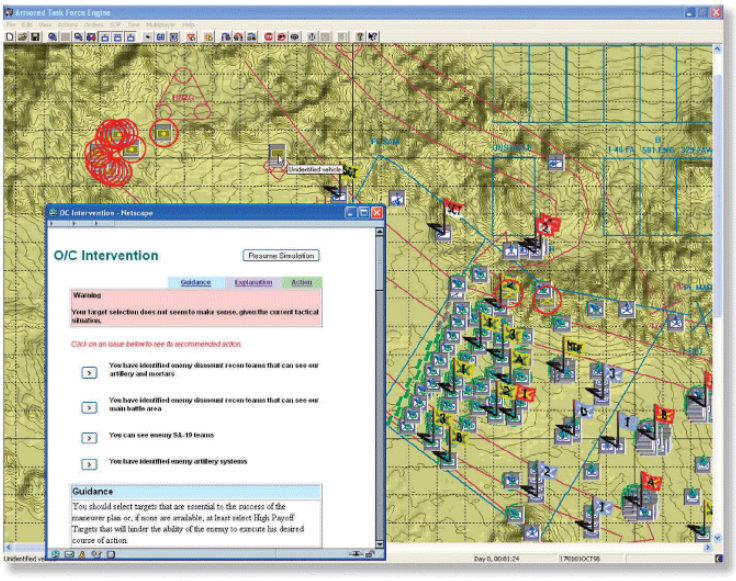
An Intelligent Tutor for a Tactical Simulation

A PC-based simulation of a combat training center (CTC), an intelligent agent observer-controller (O/C), popup guidance and After Action Review (AAR) all make for a "Virtual CTC". **William R Murray**, **Michelle Sams**, and **Pat Proctor** describe the V-CTC and how it works.

The Virtual Combat Training Center (V-CTC) is a PC-based simulation of a combat training center (CTC) and an observer-controller (O/C). The virtual O/C provides pop-up guidance during a mission, followed by an After Action Review (AAR). The virtual O/C capabilities are based on intelligent tutoring system (ITS) technologies that are typically labor intensive and expensive to develop. V-CTC, however, amortizes this cost across simulations by separating the ITS component from the simulation and through an architecture designed for reuse. V-CTC tutor capabilities are demonstrated in an example for battalion fire support officers using the tactical simulation Armored Task Force.

The Need and Opportunity

Army training in most FORSCOM units revolves around preparing for and participating in Combat Training Centers (CTC). At these centers, the troops fight against intelligent, experienced live opponents using equipment and tactics of enemy forces. The CTCs provide invaluable live training opportunities, however these training experiences are limited due to their availability



Above
Figure 1. Virtual O/C advice with suggested targets highlighted by red circles

and expense. For example, in a typical National Training Center (NTC) rotation, there is only enough time to practice two to three missions on offense and on defense. According to some estimates, it costs one million dollars a day for a brigade to train at NTC. Commanders are often reassigned to new positions after a CTC rotation, leaving the new commander of the unit to learn anew what his departing predecessor has just learned.

The benefits of these live training experiences can be extended by providing low-cost, readily available, realistic, and relevant PC-based training prior to CTC rotations to better use the time there and subsequent to rotations to enhance retention. The purpose of V-CTC is to provide this training. It could allow commanders and staff officers to better learn tactics prior to an NTC rotation, for example, in LTP (leader training programs), allowing a greater focus on TTPs (tactics, techniques, and procedures) while at NTC itself.

An Example of Operation

It is best to describe the V-CTC tutor's capabilities with an example. In this scenario the commander is defending the Brown-Debnam passes at NTC.

Before the first wave of enemy battalions descends a combat reconnaissance patrol (CRP) is sent out. Let us suppose the trainee, who takes the role of the lieutenant-colonel of the defending battalion, targets the CRP lead tank with BBDPICM (base-burn dual-purpose improved conventional munitions) from the 3 M109A6 howitzer batteries available.

There are several problems with this action that most players would never find out about without tutor feedback, or another player's helpful guidance. In this case the tutor pauses the simulation and pops up the guidance shown in Figure 1.

The tutor points out that the most important targets are now are enemy observer targets. Why? These observers will call in enemy artillery on friendly units that are dug in (i.e., they have no place to go, or if they do displace, they will lose their defensive advantages). First, the enemy will take out the fire direction centers (FDCs), disabling friendly artillery, and then other high value targets such as Bradley Linebackers (air defense units).

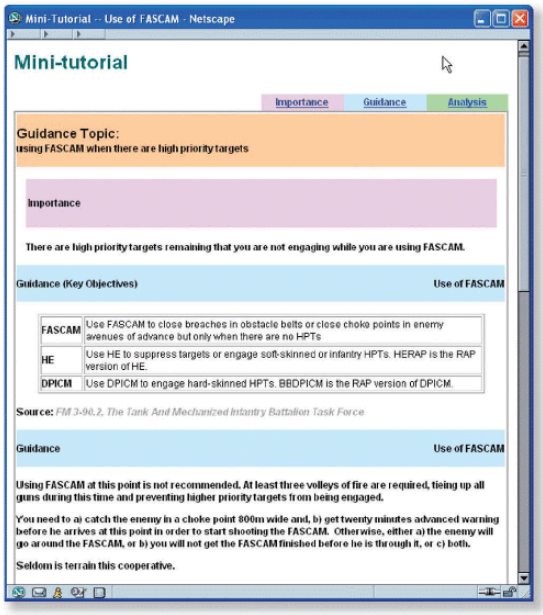
Fortunately, the player takes the advice and dispatches the observers with 1 BN HE (1 battalion high-explosive, or 18 M106A9 rounds) each.

Later, he sees enemy tanks coming down the inlet to the right side, coming through the large red arrow shaped like a rotated shepherd's crook, near the red 2 flag. He decides to block them by firing 3 BN FASCAM (3 volleys of 1 battalion (i.e., 18 guns) of FASCAM). Again, the tutor intervenes, but this time presenting a mini-tutorial on FASCAM. Unfortunately, now is not a good time to use FASCAM, as it will take too long to fire the field of mines, and the tanks will slip by before it is set up. So this mini-tutorial discusses when it is, or is not, appropriate to fire FASCAM. See Figure 2.

Upon completion of the mission, the tutor provides a diagnostic AAR. The AAR includes expert solutions for each mission, along with an analysis of the pattern of errors the learner made, and recommendations for improvement.

As an example of the kind of sophisticated evaluation that such a tutor can provide, V-CTC provides four types of scores for each fire mission in the AAR:

- Target selection – how appropriate the user's target selection is, compared to that required for the current phase of the maneuver plan, which V-CTC tracks,
- Munition selection – given a choice of target, was the type of munition and amount selected sufficient for the goal intended (destroy or suppress target)?
- Observation planning – given the enemy's high value targets, how appropriate is the placement of the player's scouts, COLTs, and FIST teams?
- Observer survivability – have the observer assets been placed in locations where they can survive long enough to be useful?



In the AAR a timeline display shows each of these four measures for each fire mission. For example, Figure 3 shows the feedback for a fire mission where 1 BN of BBDPICM was fired at a BRDM-2 ATGM. The munition selection score is only 60 since one battery alone is typically sufficient to destroy a BRDM-2 rather than 1 battalion. Observer planning was scored as zero as there was another, higher priority target that the player could not see as the scouts were not well placed.

A mini-tutorial may be triggered by poor observation planning, as in the case above, or by poor observer survivability, e.g., if too many scouts are destroyed.

These examples illustrate how the tutor assists the trainee tactically in a similar way to a human O/C. The tutor's advice is, in fact, modeled after the advice that an observer / controller would give at the Army's National Training Center.

Left
Figure 2. A mini-tutorial on using FASCAM
Above
Figure 3. Feedback for one fire mission in the AAR

Technical Approach

Typically, an intelligent tutoring system can be very expensive to build as it may require multiple knowledge-based systems to be built and coupled with a domain simulation. V-CTC is designed to provide a cost-effective solution since:

- The cost can be amortized over many applications – since the ITS component could be coupled to different tactical simulations, and tutoring could occur for different duty positions.
- The GUI's are reusable – a large amount of time is often spent in building the graphical interface for an ITS, and by providing ready-made templates for tutor interactions and mini-tutorials a considerable savings can be realized.
- The O / C teaching strategies are reusable – the specific AAR template and approach to tutorial interventions may be reused for multiple tactical applications.
- Knowledge is represented in an ontology – allowing reuse of shared concepts wherever possible.

The philosophy of V-CTC is to leverage existing high-fidelity tactical simulations built by domain experts rather than to attempt to build new simulations. Developer cooperation is required to modify an existing simulation so that its internal event stream is made accessible over a TCP-IP socket link. Furthermore, information needed for instruction (e.g., what enemy vehicles can the friendly side see?) needs to be made accessible at tutor request, along with facilities for pausing the simulation and highlighting screen areas.

V-CTC uses several AI technologies, such as a blackboard architecture and Bayesian reasoning, that are described in detail in the project final report, and more concisely in an I/ITSEC 2005 paper. Basically, its operation can be viewed as that of a rule-based system, with modifications to accept real-time events, and with knowledge bases to model knowledge about tactics (the domain) and when to intervene and what to say (feedback and instruction).

Status and Summary

V-CTC is available under a government rights license to those working on government contracts or for the government. V-CTC runs as an overlay (patch) to the commercially available tactical simulation and game Armored Task Force available at www.prosimco.com.

V-CTC is currently at the level of beta-test code and a proof of concept. Testing is still pending. Four scenarios are implemented for battalion fire support officers and two for company team commanders, either mechanized infantry or armor. One scenario is situated in Baghdad, three in NTC, and two more nearby in Death Valley. For more information about V-CTC and to see Flash demonstrations of V-CTC operation please go to www.v-ctc.com/v-ctc/

V-CTC shows what can be accomplished now by combining ITS technology with today's modern tactical simulations available via a laptop. Such a tool can leverage the appeal of popular tactical simulations to provide the hundreds to thousands of hours of practice required to develop expertise in combined arms warfare. It can increase retention of CTC skills, and greatly leverage the value of time spent during CTC rotations.

The Way Ahead

Learning environments, such as high-fidelity simulations, are more effective (i.e., we learn more in less time) with a human tutor/mentor. An intelligent agent that approximates the full capabilities of a human coach/tutor is a challenge for the science and technology community. For example, it is relatively easy for an agent to evaluate quantitative performance in simulations (e.g., ammo expended, number of kills) but it is more difficult to evaluate qualitative aspects (e.g., adaptive thinking, leader skills). Some key areas for further research include:

- Knowledge representation and reasoning;
- Models of learners (individuals, teams, organizations);

- Coaching/tutor strategies;
- Natural language understanding and generation; and
- Authoring capabilities for tutor agents and simulations.

Development and delivery costs of intelligent agent systems can be made more reasonable by adopting the goals of reuse, extensibility, and interoperability.

In the years ahead, training will evolve to a more continuous, life-long learning process. Intelligent agents will be able to utilize a persistent, evolving model of an individual learner and create customized learning activities, as well as dynamically adjust their on-the-job performance support and decision aiding.

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Wargaming and Future Instruction in PC-Based War Games

Military units get to pick what methods they use to train. If the training method is like taking medicine, and alternative methods are available, units will find another way to achieve the same training objectives. I believe that computer-based training has proven itself as equally effective to (and in many cases superior to) live training. Now we must cross the next hurdle, and make it more DESIRABLE.

In its infancy, the simple fact that training was computer-based was enough to encourage units to use the tool. But, as service members become increasingly more sophisticated in their computer knowledge and skills, computer-based training must become increasingly innovative and entertaining to compete with other training methods.

This is where commercial wargaming holds the most promise as the basis for future computer-based training tools. Commercial entertainment products have proven themselves in the marketplace, and are designed with entertainment in mind.

Wargaming's obsessive focus on realism, coupled with its entertainment value, provides a strong foundation for future military training tools. But right now they are like the CTC without the O/C. In the V-CTC work I could see a first step to providing simulated O/C capabilities. In the future, simulated instructors coupled with high-fidelity simulations, like ATF, can provide the best of both worlds: the most realistic tactical simulations possible, coupled with the best tactical tutoring systems possible, both delivered in highly portable computer environments. – *Pat Proctor*