Cognitive Map-based Modeling and Simulation for Tactical Decision Training

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ABSTRACT

Modeling and simulation of combat scenarios during training can provide opportunities for developing tactical decision-making skills without the risks or resource outlays of actual combat or large-scale situational and field training exercises. The success of a tactical decision hinges on a leader's ability to rapidly assess the situation at hand, make a decision, and communicate that decision to his subordinate leaders. At present, there appears to be little, if any, institutional or unit training focused on developing the tactical decision making abilities of inexperienced Infantry platoon leaders through the use of tactical simulations.

This paper describes fuzzy cognitive maps (FCM) as useful decision support tools due to their ability to model scenarios consisting of relevant concepts or events and the causal relationships among them. FCMs are particularly suitable in situations where complex interactions among concepts or events make it difficult to construct an analytical model. FCMs are also relevant where the nature of information and knowledge about the tactical battlefield during actual engagements with enemy forces is imperfect and incomplete. Knowledge of critical decision factors relevant to actual combat engagements and how they influence one another can be elicited from subject matter experts (typically, veterans with recent combat experience) and reflected in cognitive maps. Each such FCM can be used to model a possible course of action (COA) for a given tactical situation that requires a leader decision. Simulation of such models can produce comparative values representing measures of success for different courses of action. The FCMs also provide a platform for student self-directed analytics and after action reviews, which serve to reinforce the lessons learned in tactical decision making. This paper describes the structure of CM-TDSS – the Cognitive Map-based Tactical Decision Support System currently under development at Columbus State University, GA. The theoretical basis, structure and functionalities of this system, and its use as a tactical decision making training tool are presented.

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INTRODUCTION

Infantry platoon leaders are among the least experienced leaders on the battlefield and yet they command tactical units which historically are in the most frequent contact with the enemy. Due to the nature of close combat, the tactical decisions infantry platoon leaders make can often mean the difference between life and death. Their decisions are frequently influenced by an extreme sense of urgency. Timeliness means everything in tactical engagements with the enemy. The decision making challenge is further compounded in close combat by what the 19th century military theorist Carl von Clausewitz called the "fog of war." Knowledge, particularly about the enemy, is always imperfect in combat. This is especially true of close combat where chaos pervades the battlefield. The sounds, sights, smells, and emotions of close combat tend to overwhelm the senses and distort reality. Under these circumstances, the leaders who make the best decisions are those with the greatest amount of combat and combat training experience. However, actual tactical training for an infantry platoon leader is significantly limited during his institutional training. During the 16-week Basic Officer Leader Course for infantry officers, a newly commissioned second lieutenant will be fortunate to be placed in five tactical leadership positions. Moreover, some of these leadership positions may actually be squad leader and platoon sergeant assignments. Even when assigned as platoon leaders the position is rarely held for more than four hours before being rotated to another student. The result is that new infantry platoon leaders generally graduate with no more than 20 to 25 hours of evaluated platoon leader position time. Even if a new infantry platoon leader attends the US Army's

Ranger School (a course which is considered the premier military leadership course in the US Army) following his basic infantry officer training, the number of leadership positions assigned will usually be similar to those experienced in his infantry officer training and generally follow a similar pattern for evaluated time. Under the best of circumstances few Infantry platoon leaders will leave the institution with more than 50-hours of evaluated tactical leadership time. It is important to note at this point that the evaluation received by an infantry platoon leader attending basic infantry officer training or Ranger School focuses on the larger domain of leadership; it does not focus specifically on decision making. The evaluation usually aligns with the phase of the mission for which the platoon leader is assigned. For example, if assigned as the platoon leader during the planning phase of a mission, he will be evaluated on those leadership skills and competencies required during this phase. These include: troop leading procedures, effective use of time, delegation of tasks, order preparation and issuance, etc. None of these competencies involve the intense decision making required in a tactical engagement with the enemy. While decisions made during this phase may have dramatic consequences during mission execution, they are not decisions made on a tactical battlefield while engaged with an enemy force.

The result is that most new platoon leaders will report to their first unit of assignment with little, if any, real experience as tactical platoon leaders. Depending on when the platoon leader arrives at his first unit of assignment within the ARFORGEN (Army Force Generation) Cycle will determine how much time he will have to train with his new platoon prior to his Brigade Combat Team's scheduled rotation to

Afghanistan. In some cases he may have months, in other cases he may have only weeks to prepare and hone his tactical abilities to include his decision making before he takes a platoon into his first baptism under fire.

Data from Iraq and Afghanistan show that the mortality rate of Army second lieutenants was 19% higher in Iraq than all other officer ranks. With the relative risk of death of all military personnel who fought in Iraqi Freedom normalized at 1.0, the relative risk of death of lieutenants was 1.66. The relative risk of death for a lieutenant exceeded all ranks, enlisted and officer. However, if an infantry platoon leader survived his first three months in combat he had a fairly good chance of surviving the remainder of his unit's deployment (Preston & Buzzell, 2006). The data appears to indicate that not only does a second lieutenant, regardless of branch, suffer higher than normal mortality and casualty rates in combat, these rates also are much higher in the first three months the infantry platoon leader is in combat. It also indicates that during his first three months he is accumulating the combat experience that increases his subsequent probability of survival as well as that of his platoon. At this juncture it seems reasonable to draw some conclusions from what is known. Currently, the institution provides limited tactical leadership experiences from which tactical decision making abilities can be developed. Likewise, the time available for Infantry platoon leaders to gain valuable decision making experiences prior to deployment with their unit to Afghanistan is also problematic. The result is high casualty rates for Infantry platoon leaders during their first three months in combat, a time during which most are gaining the experience they need to succeed but one for which they pay a terrible price when they fail.

The question now becomes what can be done at the institution and within the unit to provide the tactical decision making experiences needed upon deployment to a combat theater and overcome the steep learning curve historically experienced by new infantry platoon leaders. The answer to this apparent conundrum is CM-TDSS (Cognitive Map-based Tactical Decision Support System). This tactical decision simulation system uses FCMs (Fuzzy Cognitive Maps) to provide a visual depiction of critical decision factors and their relationships to one another and calculate relative values for competing courses of action. Development of CM-TDSS was made possible through a federal grant for $1.6-million to Columbus State University. The grant is administered by the US Army RDECOM. The advantages of using simulation as opposed to actual field exercises are myriad – simulations are effective and virtual experiences have been proven to be every bit as valuable as actual experiences. The cost of leader learning via simulation is substantially less than through tactical training exercises in the field. Simulated decision exercises can also be varied as to complexity and environmental conditions, thus providing an almost limitless number of situations. Simulations are immediately repeatable which facilitates and reinforces learning via playback. The application of computer-generated smart tutors offers structured and controlled self-analysis and a comparative assessment of tactical options. The review, trending and analysis of performance data facilitate student comprehension and focused and analytical learning. Finally simulations allow leaders to learn by failing without the catastrophic results of failed decisions in combat.

The efficacy of tactical decision making hinges on a the infantry platoon leader's ability to: rapidly determine the critical factors that must be considered in evaluating the situation at hand; performing a greatly truncated evaluation of options that are available based on these critical factors; and deciding on an optimal course of action.

According to Bakken (2008), in complex dynamic situations, there is little scope for unambiguous feedback for decision guidance. Processing is largely intuitive, and analytic processing is rarely invoked. Intuitive processes are integral to complex dynamic decision making, and repeated exposure to decision making in such situations can improve upon intuition. Research by others (Hogarth, 1981; Cohen, 1982) also shows that people make poor decisions due to the lack of opportunity to learn from feedback. Bakken (2008) further states that in the absence of an adequate mental model of the decision task, a decision maker cannot assess feedback appropriately. Similarly, the absence of meaningful feedback makes the establishment of a representative mental model

problematic. This Catch-22 situation can be alleviated by presenting a mental model of a decision environment. This model, described in this paper in terms of a fuzzy cognitive map, would help a student to appropriately assess feedback received after a decision is made as part of a learning exercise and consequently build upon or adapt this model to enhance their decision making skill.

Since the value of the CM-TDSS is based largely on its use of the FCM and its utility in making decisions, the first section of the paper describes the FCM and its value in comprehending a concept and visualizing critical decision factors and their causal relationships with one another. With a foundational understanding of the FCM, the paper continues with a discussion of the construct of the Cognitive Map based Tactical Decision Support System (CM-TDSS). The primary vehicle used for training via the CM-TDSS are battlefield vignettes.. Knowledge elicitation, a process for extracting relevant knowledge from subject matter experts, is used in developing these vignettes. The discussion involving vignettes also includes how the student is involved in analyzing and reviewing his own decision making performance and how this reinforces the lessons of experiential learning. The paper concludes that CM-TDSS is a valuable tool needed to fill a gap in the institutional and unit preparation of Infantry platoon leaders for decision making in combat.

MODELING AND SIMULATION USING FUZZY COGNITIVE MAPS

The tactical battlefield is generally a very dynamic, confusing and chaotic place. Numerous variables exist that influence decision makers and their decisions. While some factors are known and observable such as the weather, terrain, vegetation, natural obstacles, built up areas, and friendly force dispositions, other factors are either unknown or less observable. These variables include the enemy, his leadership, his strength and weapons, and his intentions. The military model used to portray these variables is METT-TC (Mission, Enemy, Terrain and Weather, Troops Available, Time and Civil Considerations). It is through an understanding of the most critical of these variables and their relationships with one another that the decision maker attempts to isolate the important from the unimportant and arrive at decisions which result in a high probability for mission accomplishment. The variables are often dynamic, and evolve in time and space through a sequence of interactions among related variables. The FCM is simply a visual depiction or model of how the decision maker views situations as they occur on the tactical battlefield. As in the case with the actual tactical battlefield, CM-TDSS uses the FCM to replicate the critical decision factors considered by students when making tactical decisions during situations and engagements represented in a tactical vignette. The student's decision is a reflection of those critical decision factors he has identified, their importance in making the decision, and their relationship with one another. The fragmentary order he issues to subordinates to favorably resolve tactical situations or engagements is simply a manifestation of his decision in a form that is actionable by subordinates and supporting elements.

Feedback plays a prominent role in updating the concept states by propagating cause-and-effect through multiple pathways of possible outcomes. Analytical techniques have been used to address well-defined problems, but they are inadequate for decision making in dynamic and uncertain environments such as in tactical military operations. A modeling tool that can accept inexact linguistic expressions of expert opinion and help us construct a representation of a specific tactical situation with all relevant parameters and their interactions would be particularly suitable for analyzing the situation and learning to make quality decisions.

The Fuzzy Cognitive Map (FCM)

A fuzzy cognitive map (Kosko, 1986; Lee et al, 1998; Khan, Quaddus & Intrapairot, 2001; Khan, Khor & Chong, 2004; Khan, & Khor, 2006) essentially consists of two components: a set of nodes representing events or concepts, and a set of edges representing causal relationships among the nodes in the map.
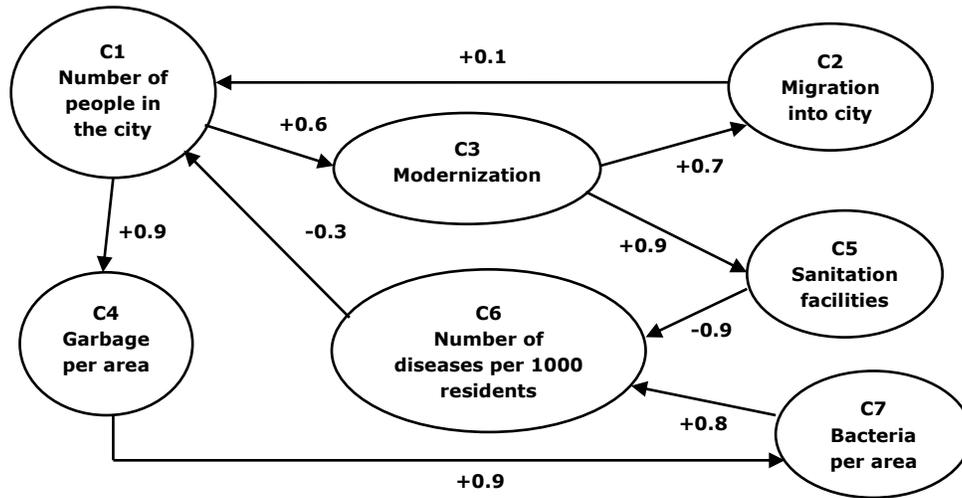
Figure 1. An example fuzzy cognitive map dealing with public health issues in a city (Hagiwara 1992).
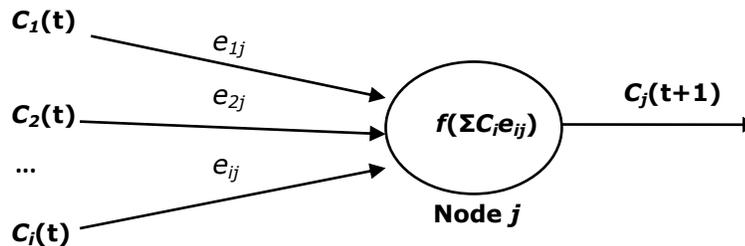

Figure 2. Computation of a node's output in a fuzzy cognitive map.

Figure 1 above shows an example of a fuzzy cognitive map used to model the public health scenario of a city. The domain-specific knowledge represented by this FCM consists of an event "Migration into city" (node C2), and a number of concepts (nodes C1, C3, C4, C5, C6 and C7). The causal relationships that exist among pairs of nodes are shown as numerical values associated with edges connecting the nodes. The events or concepts, and the strengths of causal links relevant to any given scenario or system under study are elicited from domain experts - in this example, urban development specialists. Strengths of causalities between nodes in an FCM are usually expressed by experts in imprecise linguistic phrases such as "very strongly decreases" or "slightly increases", and are converted into numerical values during the FCM construction

process. It may also be possible to derive the causality values through an iterative training process (Khan, Chong & Gedeon, 2000).

The interconnection strength between FCM nodes, i and j, is e_{ij}, with e_{ij} assuming any value in the range -1 to 1. Values -1 and 1 represent, respectively, full negative and full positive causality; zero denotes absence of causal effects; and all other values correspond to different degrees of causality within the -1 to 1 range. The FCM structure can be viewed as a recurrent artificial neural network (Michalewicz, Schmidt, Michalewicz, & Chiriac, 2007), where concepts are represented by neurons and causal relationships by weighted links or edges connecting the neurons. Given the inputs to a node j at time t, the computation of its output for the next time step t+1 is

based on the combination of a summing operation followed by transformation using a non-linear function f. As shown in Figure 2 above, the summing operation involves multiplying each input, C_i (causal influence arriving from another concept node i), with the weight or strength, e_{ij}, of the corresponding causal link between nodes i and j.

At any point in time, the FCM is characterized by its state vector, the elements of which are the outputs of individual nodes. Each of these node output values at any instant represents the degree to which the event associated with that node (e.g., "Modernization") has happened, or, in case of a concept associated with it (e.g., "Sanitation facilities"), its magnitude. Thus, the FCM state vector at any instant gives a snapshot of any situation modeled by it. Given the matrix of causal relationships and the state vector defining the FCM-based model, it can be executed on a computer to observe the unfolding of a scenario under study. This simulation can lead to one of three possibilities:

(1) The state vector converges to an equilibrium state – the so-called fixed point state, in which the event or concept values stop evolving with time.
(2) A limit cycle is reached, in which the state vector of the cognitive map repeatedly cycles through a set of values.
(3) The cognitive map moves into a state known as the chaotic attractor, in which the state vector continues to evolve instead of stabilizing as in (1) and (2) above.

Each of these three outcomes can be useful depending on the user's objectives. A fixed point attractor can provide straightforward answers to causal "what if" questions. The equilibrium state can be used to predict the future state of the system being modelled by the FCM for a particular initial state. A limit cycle provides the user with a deterministic behaviour of the real-life situation being modelled. It allows the prediction of a cycle of events that the system will find itself in, given a certain initial state. A chaotic attractor can assist in further simulation by feeding a simulation environment with endless sets of states so that a realistic effect can be obtained.

The process of constructing an FCM is relatively straightforward. The main steps followed are:

Step 1: Identification of key events or concepts (referred to as *critical decision factors* in this paper).
Step 2: Identification of causal relationships among these critical decision factors.
Step 3: Estimation of causal link strengths.
Step 4: Encoding of the knowledge elicited in steps 1 to 3 using a representation scheme for computer execution.
Steps 1 through 3 above comprise the knowledge elicitation phase of the FCM construction process.

Tactical Decision Making and the Tactical FCM

Tactical decision making is a function of a leader's knowledge about his tactical situation (some refer to this as situational understanding), his accumulated experiences in combat and tactical training, and what Clausewitz termed, "the fog of war" (Howard & Paret, 1989). The latter represents the unknown, the unpredictable character, or even the randomness of warfare. No battlefield decision is ever made with perfect knowledge. Warfare is characterized by making decisions based on probabilities with a perpetual focus on reducing uncertainty while facing the reality that certainty is not achievable. Consequently, the result of a FCM excursion, when visualizing a tactical decision, compliments and indeed replicates the "fog of war" construct of warfare as proposed by Clausewitz.

The FCM is a particularly valuable tool for tactical decision making. It provides an effective visualization of the critical decision factors (concepts or nodes) and these critical factors can be assigned values that reflect their relative importance to a specific decision or a given mission while the causal links (relationships or edges) that join the critical decision factors reflect the degree to which the factor influences a related decision factor (positively or negatively). By running simulation excursions for cognitive maps built to reflect various courses of action considered as solutions for a specific tactical event, a value score can be derived for each course of action. The course of action whose cognitive map achieves the highest positive score is determined to be the best among all courses of action. The relative ranking of each course of action's FCM relative to a specific tactical problem or engagement is vetted by a

group of subject matter experts to ensure the validity of the FCM scores.

An example of a tactical FCM used to reflect a single course of action is provided at figure 3.
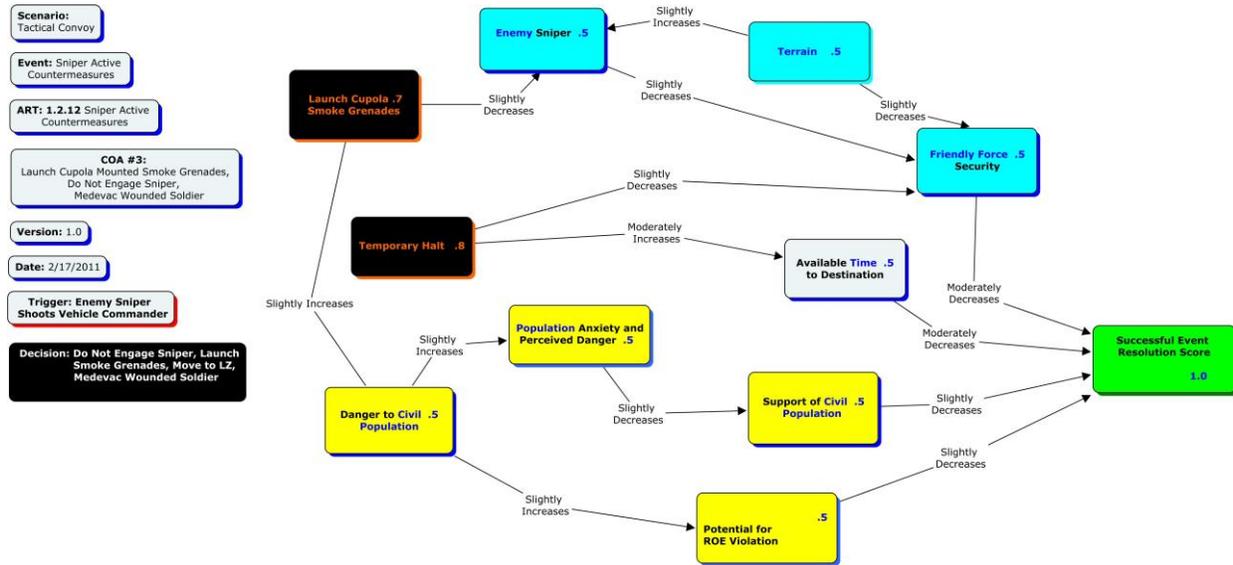

Figure 3. A Fuzzy Cognitive Map for a Vignette Involving Sniper Active Countermeasures.

The left portion of the map contains information about the FCM. The top box indicates that this FCM is related to a scenario involving a tactical convoy. The other information is specific to the course of action being considered which is to tow a supply vehicle that has become disabled.

In this particular example, a Stryker platoon was assigned a convoy escort mission from the airfield at Kandahar, Afghanistan to a Forward Operating Base in Helmand Province. While en route to their destination, the last supply vehicle in the convoy radios the Stryker platoon leader that the vehicle has a broken rear axle and cannot be repaired on site. The platoon leader stopped the convoy in a temporary security halt and is now considering his options. The course of action (CoA) reflected in the FCM at Fig. 3 provides a quick solution to the problem but it will slow the convoy down and make it more vulnerable; however, the CoA does get the convoy back on the road again quickly and moving toward its destination. The critical decision factors for this course of action centered on: the convoy's mission, convoy security, civil considerations, and time. Time in this example involves the time lost while at a temporary halt and the increased time required to reach the convoy's destination now that it must move at a slower convoy speed. Each of the critical decision factors were

derived by applying the tactical assessment model of METT-TC.

The FCM provides a simple but effective visualization of the relationship between the critical decision factors, how they impact one another, and ultimately how they contribute to successful event resolution and mission accomplishment. In this particular case the Successful Event Resolution (SER) score would be compared to the SER scores from the FCMs associated with the other CoA considered by the platoon leader. The SER is a unique feature of the tactical FCM. The SER is a reliable and quantifiable quality attribute for a CoA which facilitates it's comparison to other CoA being considered as problem solutions. The FCM with the highest positive SER score represents the optimal and therefore preferred CoA. The SER for this course of action was .673 which was the highest among all CoA considered for resolving this specific tactical problem.

THE CM-TDSS SYSTEM

The Cognitive Map-based Tactical Decision Support System (CM-TDSS), currently under development at Columbus State University, is designed for use in BOLC B, (Basic Officer Leader Course for Infantry

officers) training at the Maneuver Center of Excellence, Fort Benning, Georgia. The primary goal of this training tool will be to help improve the tactical decision making ability of new infantry platoon leaders. Figure 4 that follows shows the high level functional modules of CM-TDSS and the users of the system.
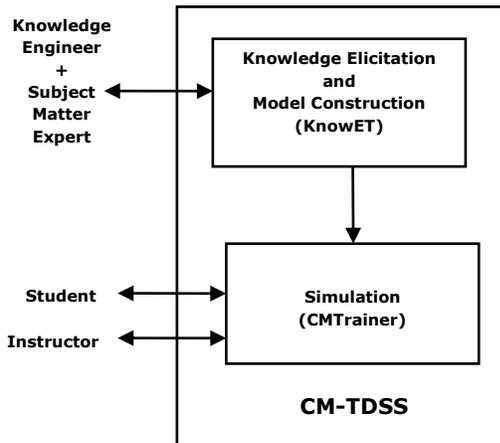

Figure 4. A schematic view of the cognitive map-based tactical decision support system. (CM-TDSS).

Knowledge Elicitation

Knowledge Elicitation is the method used by the Knowledge Engineer and those trained in knowledge elicitation procedures to obtain information from a subject matter expert (SME) relative to an actual tactical event. This event has the potential for developing into a tactical vignette; knowledge or information developed in this way is termed, cognitive task analysis (CTA). While the process is time-consuming, it is also extremely beneficial in that it captures actual events not hypotheticals. Through the knowledge elicitation process an individual trained in this technique is able to identify and capture the nature of tactical environment, the tactical problem, critical decision factors that were considered by the decision maker, the relationships between these factors, various options that were considered, and ultimately derive a mental model of the decision. At the end of the process, a fully-vetted vignette will have been developed.

Use of CM-TDSS for Training

CM-TDSS was designed based upon the user's requirements as provided by the MCOE. The simulation supports both mounted and dismounted infantry tactical vignettes. The visuals are realistic employing the latest gaming graphics. While the leader is currently replicated in the vignettes by a generic avatar, it is possible that in future versions the student will be able to design his own avatar. Although designed initially for institutional use at the MCOE, it can also be used at the unit level with minor modifications. The intent is to provide units with the ability to tailor training to specific METL tasks associated with assigned contingency missions. The vignettes can be also be modified based on Army force modernization actions changes in tactical doctrine, and lessons learned. However, the simulation is not designed to augment live training or for integration with similar trainers at other centers of excellence because such requirements are not viewed as relevant to a simulation focused strictly on decision making.

The Commander, 2nd Battalion, 11th Infantry Regiment at the MCOE, who is responsible for training and certifying all infantry officers, added the following requirements to the design and development of CM-TDSS.

The simulation should require minimal and preferably no instructor involvement or intervention. Standalone vignettes should be the priority for development, not scenarios consisting of a sequence of vignettes. The vignettes should last no longer than 20-minutes from beginning to end. The vignettes should be computer generated and evaluated. Initial vignettes developed for infantry officer training should reinforce existing field and situational training exercises. Accordingly, the CM-TDSS has been designed and developed to meet all relevant MCOE and proponent requirements. CM-TDSS is designed to be delivered by the web to multiple platforms: personal or desk top computer, notebook computer, smart phones, X-Box, PlayStation 3, Wii, and possibly VBS2. Instructor involvement is minimal. When the student accesses the CM-TDSS website for the first time he is required to complete several student tutorials: (1) a system demonstration of how

to use and navigate within CM-TDSS and how to access a vignette; (2) a "Crawl" demonstration of a tactical vignette by the system's intelligent tutor; a "Walk"-through of a vignette which is student led and uses a step-by-step approach assisted by an intelligent tutor; (3) and, a "Run" vignette excursion which is student led and graded but not recorded for record. During all tutorial vignette exercises, the student will be required to do an analysis of his performance as compared to the system's SME performance. The student, self-directed performance analysis involves all steps of the decision process from problem identification to decision selection and a review of the cognitive map. Follow completion of the performance analysis the student then completes a self-directed after action review (AAR). The AAR uses the insights gained from the performance analysis to complete the AAR. The AAR uses a format that is an expanded version of the standard Army developed format. Once the student has completed the "Run" for practice tutorial he then is prepared to execute Tactical Vignettes in the "Run" mode for record. The performance analysis and the AAR reinforce and focus the learning derived from the vignette excursion. Both are viewed as integral components to learning and retention. They are the culminating point of the virtual experience.

Vignettes

CM-TDSS maintains a data base of tactical vignettes. Vignettes are stand-alone, virtual re-enactments of actions, occurrences or enemy engagements that take place during the course of a virtual mission for which a small unit leader must conduct a rapid analysis and make a decision. The decision is quickly followed by implementing instructions and/or orders to his subordinates or attached elements under his authority to execute his decision. Tactical leaders frequently become involved in battlefield engagements as part of their mission; these engagements or actions must be successfully resolved prior to continuing the tactical mission. The CM-TDSS tactical vignettes focus on tactical problem resolution.

Almost all tactical decisions are impacted by the element of *Time*. One of the major considerations involved in assessing student performance centers on the student's ability to judge and respond with a sense of urgency appropriate to the event at hand.

All vignettes within CM-TDSS use the same basic format. This includes an introduction to the vignette and truncated extracts from the operations order with sufficient information to provide the essential environmental background needed to make a decision. Such information includes: friendly and enemy force information, relevant terrain and weather data, the platoon's mission, commander's intent and rules of engagement, an abbreviated concept of operations, and any relevant subunit tasks.

Once the vignette introduction is complete, the student is prompted to "Run" the Vignette. The initial ten to 30 seconds of the vignette is used to develop the student's visual and aural awareness of his virtual environment. It also may include radio traffic with subordinates, supporting elements, or higher headquarters. At a point, an event will occur that requires a response from the student. This occurrence is a cue which is referred to as a "trigger." The trigger indicates a problem, action, or engagement to which the platoon leader must respond by making a tactical decision. What the platoon leader decides to do is a function of his understanding of his mission, all of the information conveyed to him in the background to the vignette, his situational awareness based on what he has seen and heard since the start of the vignette, his knowledge and tactical experiences, and his interpretation of the trigger event.

The essence of the CM-TDSS simulation is what occurs next. In almost all situations following the trigger, the leader first must determine how much time he has to make a decision. In some cases, the decision must be instantaneous because the trigger event is life threatening. In other situations, time may be important but not immediately life threatening. In those instances the platoon leader must quickly process all available information, make a rapid assessment, and communicate his decision to subordinates. It is the communication of his decision by way of a fragmentary order that he makes his selected tactical option actionable. Once his decision is communicated the vignette continues by reflecting his decision visually until the situation is resolved. CM-TDSS is also counting the time from the end of

the trigger event until the student communicates his decision. Decision time is always a factor on the tactical battlefield and is only one of several recorded and evaluated performance measures.

LEARNING AND BECOMING AN INTUITIVE DECISION-MAKER

CM-TDSS is a learning tool that uses simulated tactical situations presented to the student virtually to build a mental library of virtual experiences. These virtual experiences, when combined with tactical training experiences, and actual combat experiences provide the total experiential base upon which tactical decisions are made. It has been determined that training, education, and most importantly experience allow us to base our decision making in time critical situations largely on intuition, rather than on deliberate decision reasoning or analysis. Forming relevant patterns and mental templates from realistic training and virtual experiences allows us to associate current problems with past examples and to select appropriate and effective options. Infantry second lieutenants, as previously noted, do not receive sufficient training experiences during their institutional or unit training to develop the intuitive skills needed during their first deployment to a combat environment. CM-TDSS provides the means to gain that expertise by focusing exclusively on decision making, developing an analytical basis for and understanding of tactical decisions, and applying this to making more intuitive decisions. CM-TDSS is a bridge to expertise.

CM-TDSS establishes a framework for the student to use in thinking through and analyzing a tactical problem. As the student completes more tactical vignettes, the process of identifying critical decision factors and considering courses of action becomes more of a subconscious than a conscious or deliberate process. Continuous and iterative use of CM-TDSS vignettes facilitates the development of a heuristic approach to decision making by applying cognitive rules of thumb that allow platoon leaders to make the rapid mental calculations that are necessary for quick decisions. It also facilitates subconscious sense-making by creating links that makes sense of tactical situations. Students learn by creating new patterns in the brain. The more connections made with new patterns (vignette experiences), the more they learn and the greater competency for tactical decision making they develop. In fact, the ultimate objective of iterative and continuous training using CM-TDSS vignettes is to make the decision making process intuitive.

CONCLUSION AND FURTHER WORK

Tactical decision making is a leadership ability that is generally acknowledged to be a function of competence, knowledge, situational awareness, and experience. The most difficult quality to acquire among these is experience in tactical decision making, which CM-TDSS delivers through simulation. The use of fuzzy cognitive maps in CM-TDSS enables the identification of critical factors and their causal relationships in situations requiring tactical decisions making. The comparative value scores produced by simulating the FCM-based situational model can determine optimal courses of action, which in turn become best case decisions. The visual nature of FCMs representing different courses of action also makes it highly suitable for after action review and analysis by students.

Work is currently in progress to develop a library of vignettes and scenarios consisting of multiple vignettes. The next major step in the development of the CM-TDSS is the integration of automated FCM generation based on voice command inputs during training sessions. The FCM generator will add flexibility to the course of action selection step by eliminating the current limitation of pre-defined courses of action that a trainee has to select from.

The real benefit of the CM-TDSS is in its value in training inexperienced leaders to make timely and quality tactical decisions without risk or major expense. Although only a longitudinal study of the system, once it is completed and put into practice, can establish the validity of the cognitive map-based approach, there is every reason to believe that FCM-based simulations can be used to significantly reduce junior leader casualties during actual combat. CM-TDSS has the potential to revolutionize how we train and develop our tactical decision makers.

ACKNOWLEDGEMENTS

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