Combining Constructive Models with a 3D Game for Enhanced Immersion

Marjorie A. Zielke, Ph.D.
University of Texas at Dallas
Richardson, Texas
margez@utdallas.edu

Joe R. Gonzalez Jr., MS
Texas A&M University
College Station, Texas
joe-r-gonzalez@neo.tamu.edu

Gary Hardee,MA
University of Texas at Dallas
Richardson, Texas
ghardee@utdallas.edu

ABSTRACT

Incorporating constructive models into a 3D game is an effective, realistic and nonlinear way to prepare warfighters for operational environment complexities. In its third development spiral, The Hybrid Irregular Warfare Network-defeat Toolkit federation, or HINT, sponsored by TRADOC G2 Intelligence Support Activity, combines an immersive 3D game-based simulation – The First Person Cultural Trainer (FPCT) – with the One Semi-Automated Force (OneSAF) and the Joint Non-kinetic Effects (JNEM) models in a hybrid model framework federation. This paper drills down on this methodology, focusing on benefits, challenges and lessons learned from integrating the OneSAF and JNEM models with the FPCT 3D game. In FPCT, the player discovers IED and insurgent networks through populace relationship building. The player wins by positively affecting the mood and cooperation level of the virtual population, thereby facilitating the collection of “golden nuggets” of information. To create this gameplay, FPCT exchanges and incorporates OneSAF data, which simulates force-on-force activity, and JNEM data, which provides well-defined civilian influences such, as mood and cooperation of a heterogeneous population in an area of operation. The player then can positively affect the JNEM-driven mood and cooperation state through culturally correct populace interaction. If populace interaction is effective, critical information golden nuggets are collected during gameplay and published back to OneSAF and JNEM to model second-and third-order effects of ongoing military stability operations. Multiple data exchanges from OneSAF, JNEM and FPCT simulate dynamically changing operational conditions. The HINT methodology for combining constructive models with a 3D game provides a platform for lessons learned and also suggests other potential ways to develop simulations in this way. FPCT won the IITSEC Serious Games Competition government category in 2011, the Innovations in Department of Defense Gaming competition at the 2011 GameTech Conference, and the NTSA Cross-Function award in 2010.

ABOUT THE AUTHORS

Marjorie A. Zielke, Ph.D., is an assistant professor of Arts and Technology at the University of Texas at Dallas and the principal investigator on the First Person Cultural Trainer. Dr. Zielke has served as principal investigator and project manager on a series of culturally related military-funded simulations over the last several years. Her areas of research are cyberpsychology and hyper-realistic simulations, and she works in the cultural training, health and marketing sectors. Projects on which Dr. Zielke has been principal investigator, including the First Person Cultural Trainer, have won awards from the National Training and Simulation Association, the Department of Defense, the Society for Simulation in Healthcare and the I/ITSEC Serious Games competition. Dr. Zielke received her Ph.D. from the University of Texas at Dallas, and also has an MBA and a master’s in international business.

Joe R. Gonzalez Jr., MS, works for the Texas Center for Applied Technology, a center of the Texas Engineering Experiment Station, Texas A&M University System. He is currently supporting the development of COE capabilities for the TRADOC G-2 Intelligence Support Activity and PM OneSAF. He is also the System Integrator for the Hybrid Irregular Warfare Network-defeat Toolkit (HINT). Mr. Gonzalez is a retired Army officer. He holds a MS in Mechanical Engineering from Kansas State University and a BS in General Engineering from the United States Military Academy.

Gary Hardee, MA, is Research Manager for the University of Texas at Dallas' Institute for Interactive Arts and Engineering. He also is a doctoral student in UT Dallas' Arts and Technology program with a research focus on narrative in virtual environments. Gary is responsible for managing the development staff of the First Person Cultural Trainer (FPCT), which was named Best Government Game in the 2011 I/ITSEC Serious Games Challenge. He also works as a development manager and the lead writer on a game-based medical simulation project designed to improve physician-nurse communication. He has more than 30 years of professional corporate media experience in print and web journalism. He received his master's degree in Arts and Technology at UT Dallas and a bachelor's degree in journalism from the University of Missouri.

Contributing authors: Desmond Blair, Michael Kaiser, Brandon Keown, Ryan Zeigler and Djakhangir Zakhidov.

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University of Texas at Dallas
Richardson, Texas
ghardee@utdallas.edu

INTRODUCTION

Integrating constructive models with a 3D game in a hybrid model framework offers a new simulation approach that presents the information from discrete and somewhat abstract models in an interface which facilitates realism and immersion. This type of game-based simulation also allows for modeling of second-and-third order effects of actions within an operation area. Further, a gaming environment also allows for varied representations of time, simultaneous gameplay in different, but related, operational scenarios and other unique representation paradigms. The Hybrid Irregular Warfare Network-defeat Toolkit federation, or HINT, sponsored by TRADOC G2 Intelligence Support Activity, is an example of this type of a simulation – combining the One Semi-Automated Force (OneSAF) constructive and the Joint Non-kinetic Effects (JNEM) analytical models with an immersive 3D game-based simulation, the First Person Cultural Trainer (FPCT). The HINT methodology of integrating constructive models with a 3D game such as FPCT suggests a new highly flexible simulation paradigm that can be applied to multiple applications in defense and other industries.

HINT -- DATA FROM CONSTRUCTIVE MODELS FOR IMPROVED REPRESENTATION OF THE OPERATIONAL ENVIRONMENT

HINT is a prototype federation that enables soldiers to interact with local culturally accurate emulated indigenous leaders and determine, over time, the composition and disposition of adversary networks, support personnel, and supporting mechanisms. These pieces of discoverable information are termed golden nuggets. HINT is designed to train current and future force officers, non-commissioned officer leadership, and soldiers at the tactical and operational levels. HINT allows users to interact in diverse cultural settings, understand the consequences of force activities in these settings, and hone negotiating skills. Further, HINT is designed to be used in training, analytical, and testing environments.

Four models currently comprise HINT and establish a linkage between the constructive and gaming world as well as the integration of kinetic and non-kinetic effects. The federation members are OneSAF, JNEM, FPCT and the Process–Oriented Data Visualization (ProDV) Tool. The HINT federation is enabled by the MATREX Data Exchange Architecture (MATREX DEA), which establishes and maintains data exchange between the models.

The OneSAF brigade-and-below simulation is the ground maneuver model that can create, adjudicate, and allow response to both kinetic and non-kinetic activities. JNEM is the noncombatant effects or relationship model that resolves the changes in mood of the population as a result of all external activities occurring in their neighborhoods. FPCT allows the tactical leader a first person virtual interaction with indigenous community leaders within varied cultural contexts and conditions to accomplish intelligence-like penetration of the battle space. ProDV provides a real time visualization of the mood and cooperation of the affected non-combatant populations. A massively multiplayer online environment (MMO) or alternative means of achieving distribution to provide a combat training center (CTC)-like environment for HINT is under consideration as a wrap-around to the federation.

In a hybrid model framework such as HINT, distinct models developed for specific purposes are combined via a federated architecture. Output and data from each model are also shared and combined via the federation to create an emulated environment that encompasses more components of the operational environment (OE) than possible with any individual federate member. Blending the data in a hybrid model federation provides a more broadly integrated representation of the target operational environment. Further, data generated in one simulation affecting data and outcomes in another simulation enables a more robust coupling of cause and effect. This sharing and combining creates a de facto blended data base at the federation level.

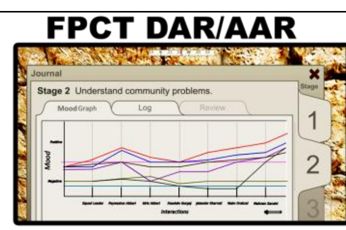
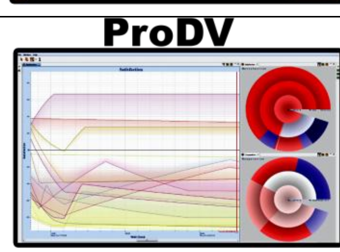
As part of the process, analysis is conducted to either integrate elements for multiple-federate representations of a single OE component or correlate elements in one federation simulation with like elements in another to link discrete OE components. Examples of integrated elements are HINT group attitudes in JNEM and initial non-player character (NPC) attitudes in FPCT. Correlated elements could be HINT IED network artifacts in OneSAF and FPCT. In this way, a more comprehensive representation of the OE is created that contains dependencies and cause and effect consequences internal to the simulation framework which directly manifest in training audience performance. This paper specifically focuses on the integration of the constructive models OneSAF and JNEM with the 3D game -- FPCT.

Essential Linkages

To create the hybrid model framework federation, essential linkages must be created between the constructive models – OneSAF and JNEM, and the 3D game – FPCT. The federation architecture is one such linkage. However, many other important connectors are critical to this section of the federation framework. These essential linkages include the source of the non-kinetic mood and cooperation data that is created from the force-on-force activity modeled in OneSAF. The kinetic activity is a major driver for the JNEM mood and cooperation factors. These JNEM mood and cooperation factors are mapped to the NPCs in FPCT that are driven by the game virtual human system (VHS). The FPCT VHS includes models that equate the mood and cooperation settings to endemic behavioral, cultural, and psychological factors for the geography in question. The VHS also creates a model for how NPCs in the virtual population interact with each other and share information about the player and the environment, which ultimately also factors into the varying level of mood and cooperation within the community.

Further, the game prologue or start point in FPCT matches JNEM geographic locations. FPCT then presents a high-fidelity 3D visualization of the geography in question – to date, locations in Afghanistan, Iraq, and Nigeria are available. The purpose of FPCT gameplay is to build rapport with the virtual population in a culturally effective way to obtain intelligence-like golden nuggets of information important to missions. Positively changing the mood and cooperation level of the virtual populace and discovering golden nuggets allows the player to successfully complete the game and win. The player keeps track of progress on these two measures – effective populace interaction and the discovery of golden nuggets – throughout the game via the FPCT during action review (DAR) and after action review (AAR). Ultimately ProDV links to the FPCT AAR and DAR and visualizes the aggregate performance of the full HINT model. Table 1 summarizes the base federation hybrid model components and essential linkages throughout HINT.

Table 1. HINT Hybrid Model Framework and Essential Linkages

	**OneSAF kinectic activity affects JNEM group attitudes. OneSAF exchanges golden nuggets with FPCT.**
	**JNEM adjudicates group attitudes based on OneSAF and FPCT activity and exchanges data with FPCT.**
	**FPCT translates JNEM data into mood for populace. FPCT conversations reveal golden nuggets that are exchanged with OneSAF.**
	**FPCT tracks mood for individuals and populace throughout game and exchanges data with JNEM.**
	**ProDV functions as AAR tool for HINT federation.**

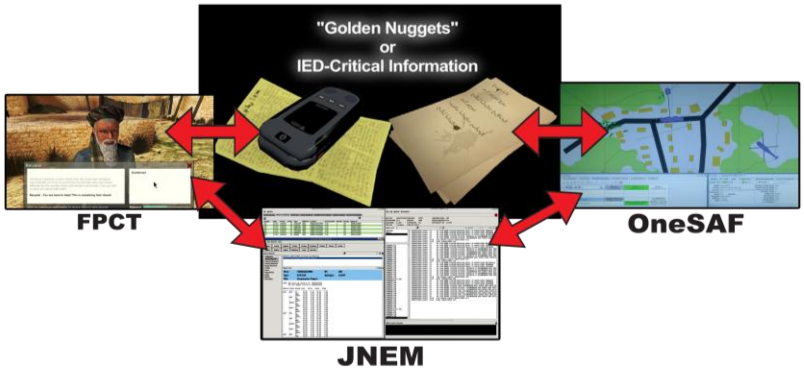


Figure 1. Golden nuggets of information are exchanged between FPCT and OneSAF. Actions taken in FPCT and OneSAF, as a result of the information exchange, influence changes in JNEM's calculations of civilian satisfaction.

DATA EXCHANGE AND INTERPRETATION BETWEEN ONESAF, JNEM, AND FPCT TO CREATE GAMEPLAY

Unique from other games that accept input from constructive models, FPCT utilizes soft factors which represent mood and cooperation of geographic areas. As explained above, ultimately the ability to affect mood and cooperation drives the capability to collect golden nuggets of information. This section further describes the relationship between OneSAF, JNEM, and FPCT to create gameplay.

Initially, OneSAF begins by simulating force activity. Force activity in OneSAF is sent to JNEM. JNEM then interprets data received from OneSAF and breaks down the effects on individual neighborhoods. These effects change soft factor values – autonomy, culture, quality of life, safety, and clout. These soft factors generate population mood, which maps to FPCT's emotion variables among the NPCs. Current NPCs display animations of four emotions: happiness, sadness, fear, and anger, as well as a neutral state that is the absence of any emotion. Since JNEM does not model individuals within a given neighborhood, the conversion to mood within FPCT is used as an average baseline mood for the entire community. To get some level degree of variation, mood is applied with a normal distribution curve to the population centered on the received mood value. The newly applied mood becomes the NPC baseline.

JNEM Neighborhoods and FPCT Game Maps and Prologues

JNEM neighborhoods correspond to FPCT scenarios – set in the game map's prologue. In this way, FPCT receives and parses JNEM data and uses data received from JNEM to set population cooperation and mood. These data affect group mood, cooperation, and group satisfaction values. These moods, cooperation, and group satisfaction values are distributed across the population at the beginning of the first stage of gameplay and assigned to individual NPCs. Gameplay affects the mood and cooperation level of the NPCs and therefore the ability to collect golden nuggets. Golden nuggets are published to a single entity in OneSAF at the time of discovery. During gameplay sessions, multiple golden nuggets can be published and received from OneSAF.

Injections of new mood and cooperation data can occur at various stages of FPCT gameplay. The mood and cooperation inputs can occur on a timed interval or at specific points in the gameplay scenario. In order to have contextually relevant dialogue, FPCT also listens to events broadcast from JNEM that can give some indication of causality in the case where there is a rapid spike in community mood or cooperation.

Other parameters have been developed in the FPCT VHS to develop realistic behavior among the NPCs. For example, influence is a representation of how much effect an individual can have on others in their social network. The outcome of a conversation with an influential NPC could have greater effect on other NPCs than speaking to an NPC that is not influential.
An influential NPC is affected less by another influential NPC than an NPC with low influence.

ADVANTAGES OF USING GAMING ENGINES AND PARADIGMS IN HYBRID FEDERATIONS

Combining constructive models such as JNEM and OneSAF with a game engine-based simulation such as FPCT brings specific advantages to HINT. For example, gaming constructs naturally accept rules and objectives along with starting points and parameters creating a base case for the JNEM and OneSAF inputs.

This basic structure of rules and objectives allows players to effectively manage or change the JNEM and OneSAF parameters as part of gameplay. In addition, games are often built in levels. This capability allows for the representation of second-and-third order effects based on gameplay as well as stages which can represent cause and effect. Game constructs can also create memory in virtual characters.

Games also allow varying perspectives on data from first person, third person, or God view, of the ground actions. As Figure 2 below illustrates, a game engine also allows for flexibility in representing time and space – affording flexibility in time of day, the ability to span time, and multiple gameplay instances.

Another characteristic of a game construct is that it offers cinematics, or animated videos, which provide environmental cues, time transitions, points of synthesis, level transition and other ways to connect information. Multiplayer game constructs allow for the realistic involvement of several actors and decision makers in scenarios.

As illustrated in Figure 3 on the next page, game representation affords macro and micro decision making, allowing warfighters to zoom in on specific geographic areas, immerse in cultural, visual and auditory acuity – and experience an immediacy of character and environment. Further, social networks, other relationships between individuals, the environment and action choices, can be represented in a game along with different perspectives. In short, a game construct allows for a closer parallel of real life within simulations.

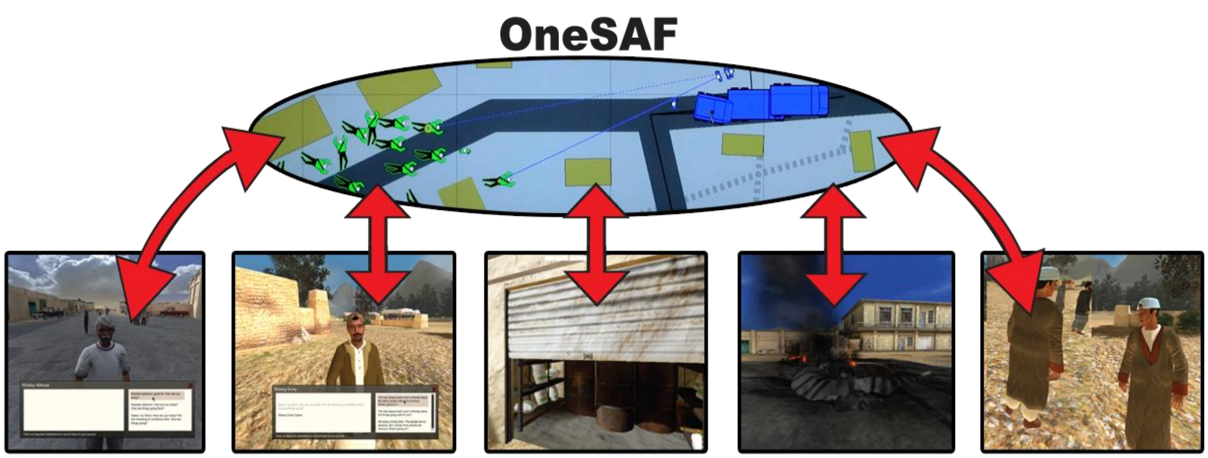


Figure 2. Multiple instances of FPCT gameplay can be integrated with the overall OneSAF training scenario to simulate simultaneous key leader engagements in different geographic locations. OneSAF presents a third-person "God view" of the ground activity, whereas FPCT presents first-person interactions. HINT development currently integrates five Afghan gameplay sessions: two in an urban community, two in a rural village, and one in a semirural location.

Figure 3. HINT allows warfighters to zoom from a macro representation of a specific geographic area, through JNEM and OneSAF, to a micro representation through FPCT. Thus far, FPCT development represents visual, auditory, and cultural characteristics of three regions: Iraq, Afghanistan and Nigeria.

UNIQUE GAMING FEATURES OF FPCT THAT INTEGRATE WITH JNEM AND ONESAF

FPCT is developed in the Unreal 3 Engine -- a gaming platform known for its fidelity and general robustness. Accordingly, FPCT offers all of the benefits that a game brings to a hybrid model simulation as described above. In addition, custom development from the FPCT team further enhances the general capability in tying the game to the JNEM and OneSAF models. This development includes the previously referenced VHS; Conscript™, a massively branching conversation system that responds to player choices and populace mood and cooperation inputs from JNEM ; FPCT gameplay design; the FPCT sensory perception design and the FPCT approach to AAR/DAR that also connect to OneSAF and JNEM input. Each of these is discussed below.

Virtual Human System(VHS)

FPCT gameplay focuses on non-kinetic interactions, both verbal and nonverbal, with virtual characters that are driven by behavioral artificial intelligence (AI). Similarly, the heart of JNEM is its Regional Analysis Model (JRAM), which models civilian group attitudes (JNEM Analyst's Guide, 2011). JRAM is a "highly mathematical and highly abstract" modeling of civilian group attitudes (JNEM Analyst's Guide 2011).

JRAM determines a satisfaction level for civilian non-combatant groups through the aggregation of various concerns, four of which are used in FPCT to determine mood. Those four concerns are:

- Autonomy: How well does the group feel it can maintain order and govern itself with a stable government and a viable economy?
- Safety: How much members of the group fear for their lives.
- Culture: How the group feels that its culture and religion are respected or denigrated.
- Quality of Life: How adequate are the region's physical facilities, such as water and power plants, as well as services such as sanitation, health, education, employment, food, clothing, and shelter? (JNEM Analyst's Guide, 2011)

Integrating with JNEM allows FPCT to use its data as a foundation for its VHS, which generates NPC emotional behavior. This behavioral AI is a key component in creating robust interactions between the player and the NPC, and thus greater gameplay. As described earlier, NPCs display animations of four emotions: happiness, sadness, fear, and anger, as well as a neutral state that is the absence of any emotion. Characters in the game are spawned with a mood value that determines which initial emotion they are feeling. Therefore, this mood value is a translation of data provided by JRAM.

Essentially, FPCT uses these mathematical abstractions and puts a 3D face to them. When NPCs are spawned for a gameplay session, mood is distributed with a normal distribution curve to the population. The result is that the player will encounter different characters that have one of the four emotional states. The player's gameplay goal is to determine, through conversation, what factors are affecting the mood of the character and the community. The player must determine what can be done to improve mood, thereby increasing NPC cooperation and the chances of discovering golden nuggets of information.

In FPCT's initial development, the VHS has focused on culture, emotion, and social network modeling. Future development will include additional models that represent physiology, perception of stimuli, and enhanced emotion and personality models.

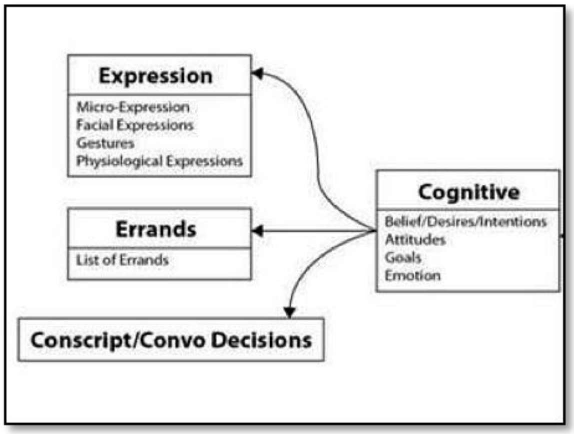


Figure 4. Gameplay in FPCT involves verbal and non-verbal communication with virtual characters whose behavior is driven by a Virtual Human System (VHS) architecture. Initial development has focused on culture, emotion, and social network models. Future development will integrate additional models.

Conscript ™

Storyline is another component of integrating input components from JNEM and OneSAF. FPCT includes a custom story-generating engine called Conscript ™ which accepts the initial JNEM mood and cooperation inputs and affects them through story branch choices made by the player. Conscript ™ is a massively branching conversation system that allows for several dialog paths based on strategies and story. OneSAF golden nugget alerts and JNEM mood and cooperation changes trigger possibilities for new branches of the Conscript ™ conversation tree. These new branches contextually reflect the changes in mood and new information presented by updated OneSAF alerts.

FPCT Gameplay Design

FPCT gameplay focuses on culturally correct interaction with a populace whose behavior and verbal and nonverbal communication is driven by OneSAF and JNEM. The player wins by appropriate interaction with the populace and key individuals, careful observation in the environment and the appropriate recording of these golden nuggets in the journal. As outlined above, the starting mood of the virtual populace in FPCT can change with new injections of JNEM mood changes and notifications of golden nuggets discovered in the OneSAF simulation. These injections bring dynamism to gameplay in FPCT.

For example, in one scenario in the latest development the populace is becoming increasingly upset. The player can discover through conversation with NPCs that a well, which is the populace's only water supply, has been poisoned. The player may receive a OneSAF alert saying the well has been poisoned. Conscript ™ conversation trees will branch based on the variables that trigger context. Visual and audio display within FPCT will also change with the emotional mix. As the player moves through the environment and interacts with the populace, the game is updated with new mood and cooperation levels.

Players who are conducting key leader engagement in FPCT must recognize and respond to these changes. NPCs that were cooperative in earlier conversations may have changed their mood, resulting in a new conversation branch and changed displays of emotion. The player's options for questions to NPCs might change and NPC responses may branch differently based on the new context. Collectively, the injection of changes requires the player to exercise critical decision-making to adjust to the new context.

FPCT Sensory Representation Design

In addition to general game constructs, unique characteristics of the FPCT game enhance JNEM and OneSAF integration. For example, FPCT emphasizes sensory representation – through audio and video fidelity. As has been established, JNEM initially sets mood and cooperation within FPCT, however, the FPCT VHS translates these initial settings to a visual display of the data which can be modified by gameplay and story line.

Similarly, the JNEM settings affect the game environment through audio and visual representation. Depending on the mood settings, the populace displays different behaviors. If the populace is afraid, fewer NPCs are on the streets or some may go up on roofs to watch an event. If the populace is angry, NPCs may gather in crowds and express more anger in their voices. Similarly, ambient sound may adjust based on injection of mood or the force activity that OneSAF represents.

FPCT also allows for more localization, detail, and fidelity of data than is currently found in constructive models. Three FPCT country representations are currently available – Iraq, Afghanistan and Nigeria. These maps include location and spatial detail, audio specification and animations and models that are appropriate to represent the country locations.

Figure 5. Information in FPCT is communicated verbally through dialogue and also non – verbally through activities in the environment. For example, in the above image, the solider is being followed. When interacting with the soldier, the virtual characters can express emotion. Characters are capable of subtle facial expressions, such as the anger displayed in the eyes of the character in the inset above.

Advantages of local representation include the ability to demonstrate an individual's effect on the community and to represent key leader engagement. Game-based models can also allow for a clearer view of abstract and global trends. Through game-based simulation, the impact of individual player decisions can also be modeled.

During Action Review (DAR) and After Action Review (AAR)

The DAR and AAR visualize mood and cooperation changes. The DAR shows throughout gameplay, while the AAR shows an end state. The AAR shows mood and cooperation where gameplay began, where mood and coop level was left with each key NPC conversation, and where aggregately the total population mood was affected. Key NPCs have different levels of influence within the social group and can more greatly affect the aggregate populace mood. When the player clicks on a potential golden nugget, this artifact goes into the journal log.

Whether or not all the golden nuggets were uncovered is seen at the end of gameplay in the AAR score. Some golden nuggets are embedded in FPCT and some come dynamically from OneSAF throughout gameplay. The player also gets a notification on the heads up display (HUD) when a new golden nugget is available. FPCT publishes the results of how player decisions affect mood and cooperation back to JNEM. Discovered golden nuggets are published back to OneSAF. Overall, FPCT creates experience through the input from OneSAF and JNEM, the VHS, the Conscript ™ story, gameplay, the sensory representation design, and the DAR/AAR to complement the overall HINT mission.

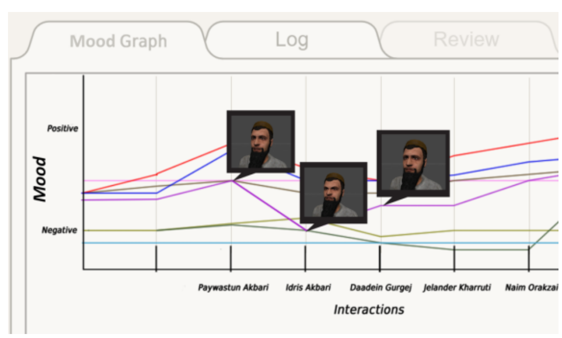


Figure 6. Conversations with virtual characters in FPCT affect individual and populace mood levels, which are logged in the player's journal. A character's individual mood is tracked throughout gameplay. The player can see the character's mood at the conclusion of each conversation. Each character is assigned an influence level, which factors into the populace's aggregated mood.

LESSONS LEARNED

As stated earlier, there are distinct advantages to integrating multiple simulations into one hybrid model federation to represent the complexity of an operational environment. At the same time, such integration presents unique challenges in validating the data linkages and outputs that are shared between each federate member. JNEM, OneSAF, and FPCT each serve as different cause-and-effect simulations. JNEM tracks concerns that influence civilian group attitudes. OneSAF models kinetic, force-on-force effects. FPCT simulates the effects of non-kinetic key leader interactions on the individual and populace mood. Data generated in one simulation affecting data and outcomes in another require careful analysis in order to validate the training experience.

As the 3D visual interface for JNEM's mathematical modeling, for example, FPCT must represent concerns for safety, autonomy, or quality of life as culturally accurate dialogue, NPC behavior, and environmental mood. How do those concerns look, sound, and feel? These representations must be displayed verbally through changes to branching conversations and nonverbally through changes to NPC facial expressions. One lesson learned in HINT development has been the complexity of correlating the output of such data exchanges.

Another lesson learned arose from the need to balance the federation's methodologies for handling space and time with the realism represented in FPCT's 3D simulation. One of the objectives of FPCT gameplay is to provide the warfighter an immersive experiential learning platform. An essential factor in providing quality experiential training is its proximity to realism. Does the training ring true-to-life? Is the story of the experience plausible as a simulation of real-world events and people? A 3D gaming platform is well-suited for developing accurate environments, characters, and events to capture an operational theater's sense of place and time. However, aligning that 3D representation with the compressed simulations of space and time in constructive and analytical models is challenging. Compounding that challenge is the limited timeframe warfighters have for training. These challenges required FPCT to be designed so that temporal and spatial relationships between events and characters can be calibrated to match either federation training purposes or for stand-alone single-player training. For example, both the speed at which information spreads about an event and the virtual population's reaction to the news can be ramped up or down depending upon the desired effect. Verbal and nonverbal representations of the NPCs' reactions – what they say, their gestures and facial expressions – can be exaggerated for more rapid training impact or lessened to teach nuance and subtlety. FPCT has been developed to serve as both a stand-alone trainer and as part of the federation. Clearly, one of the lessons learned has been accommodating the varying demands of each type of training.

EXAMPLES FROM OTHER DEVELOPERS

Other examples exist for combining external constructive models with a virtual training game simulation, but none focus as clearly on integrating soft factors as the OneSAF/JNEM/FPCT combination in HINT. For example, DI-Guy and OneSAF have a direct, one-to-one correlation between their kinetic entities. Thus, when an NPC unit moves in OneSAF, the same unit moves in the Di-Guy Scenario. (DI-Guy Website, 2012)

CAMX, a multi-agent simulation, is designed to interoperate with existing military simulations such as JCATS, VBS2, or OneSAF by integrating kinetic constructive models in order to represent vehicle traffic and pedestrian behavior. (Levesque, 2009)

Also, the VBS2 game engine and the OLIVE virtual world used OneSAF to populate virtual terrain with kinetic external constructive models from OneSAF in the form of NPCs and dynamic objects such as vehicles and weapons during a distributed Coalition Warfare Training exercise. (Long, 2010) Unlike the mentioned examples, FPCT integrates non-kinetic, or soft data and effects about populace mood and cooperation levels from JNEM via OneSAF, and then publishes information about discovered golden nuggets back to OneSAF and JNEM.

ADDITIONAL OPPORTUNITIES TO APPLY THE TECHNIQUES

The HINT federation raises possibilities for other applications of 3D gaming/modeling integration, perhaps most notably with medical simulations. For example, data on a medical condition's signs and symptoms could be used for behavioral models that simulate changes in a virtual patient's conditions over time or based on player interventions. Such data-driven virtual patients could afford standardized training across a range of health care professions as well as practice with low-volume, high-risk conditions. Opportunities to integrate business or marketing simulations into gaming paradigms using the approaches described here could also provide powerful new experiential decision systems.

SUMMARY

Combining constructive models with a 3D game enhances simulation immersion in a variety of effective ways. Hybrid federation strategies such as presented in HINT and FPCT allow for behaviorally driven populace indicators such as mood and cooperation to be represented in a high-fidelity, game-based simulation. This allows warfighters opportunities to truly experience the data and practice the behaviorally-based techniques to potentially heighten mission success. HINT and FPCT are unique in this non-kinetic, populace focus.

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