Using Serious Games to Enhance Recognition of Combatants Training for Electro Optic and Infrared (EO/IR) Sensors

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ABSTRACT

The Night Vision Electronic Sensors Directorate (NVESD) and AEgis Technologies is designing and developing a customized game-based training solution that is being integrated with NVESD's Recognition of Combatants (ROC) Interactive Multimedia Instruction (IMI) training programs for use in recognition of combatants using Electro Optic and Infrared (EO/IR) sensors. The scope of this effort includes modifying the core functionality of Combat ID, an interactive, on-the-move training game developed by AEgis, and integrating it with the NVESD Recognition of Combatants - Vehicle (ROC-V) and ROC Reconnaissance, Surveillance, Targeting and Acquisition (ROC RSTA) Training Programs. The game-based training solution enables soldiers to view vehicles as they would in real-world missions and include intelligent tutoring, enhanced character behaviors, and efficient use of terrain databases. The training focuses on surveillance and reconnaissance skills as well as combat identification of humans to determine threat levels in order to avoid civilian casualties and collateral damages. The customized training architecture shall provide performance feedback, select appropriate instructional strategies and tailor learning content to focus on the individual needs of the user. The game was incorporated into the ROC-RSTA training package and is available for use. This paper will describe the development effort, user evaluations at the NVESD perception lab, and plans for the future including training effectiveness and performance measures.

1.0 RECOGNITION OF COMBATANTS OVERVIEW

The ROC program was developed by the US Army Communications, Electronics, Research, Development and Engineering Center (CERDEC), Night Vision & Electronic Sensors Directorate (NVESD) at Fort Belvoir, VA specifically to "address the US military's continuing need for not only a viable technical solution to combat vehicle identification (CVI), but also the imperative to improve our overall combat identification (CID) training" (Rierson, W. and Ahrens, D., 2006). The ROC computer-based training addressed the gap demonstrated by advanced sensor operators who could not successfully exploit the Forward Looking Infrared (FLIR) technology to correctly distinguish between threat and non-threat vehicles in the Persian Gulf War. Analysis led to the lack of adequate training, especially newer fielded technologies such as FLIR systems, as the major culprit in the performance gap. Since that time, the ROC-V program has provided high-quality, reliable and effective self-paced training to develop combat ID skills that improve discrimination of targets and threats. The ROC product family has expanded situational awareness training to include buried target detections, threat and non-threat personnel, threat Unmanned Aircraft Systems (UAS) detection and assessment, and military operations in underground facilities.

1.1 Origins of the ROC Training Programs

Since the initial development and integration of Electro-Optical and Infrared (EO/IR) sensors into United States military vehicles, there has been a need to train warfighters how to use the sensors to acquire, identify and recognize vehicles to prevent "fratricide", or the killing of friendly forces. Combat Identification (CID) is a challenging task, especially when compounded by the "heat of the battle". As noted by Rierson and Ahrens

> "CID is made up of a multitude of facets: Situational awareness and target identification within specified rules of engagement are the cornerstones. Individual and collective training is the glue that binds these aspects together" (Rierson and Ahrens, 2013).

As misidentification of vehicles has been a major cause of combat vehicle fratricide since the First World War (O'Connor, J. and Bates, C., 2013), the US Army's primary methods for CID training were flashcards, equipment recognition guides and playing cards to assist soldiers with CID (O'Connor and Bates, 2013). However, the number of fratricide incidents during Operation Desert Storm in 1991 and Operation Iraqi Freedom (OIF) in 2003 demonstrated that these methods were not doing enough to prevent deaths from friendly fire, likely because soldiers did not know how to exploit the thermal signature cues that provide a tremendous amount of information to use as the basis for target discrimination.

It is widely acknowledged that CID is a critical need, but it is not always a formal requirement from the field. In response to this need, NVESD performed the research and development to derive a family of computer-based training programs based on sensor phenomenology and human perception experiments conducted to determine how the human brain interpreted thermal information. The experiments also tested whether there was an increase in successful recognition and identification performance if the sensor operators were trained on relevant "hot spot" cues unique to each vehicle. Before the tests, sensor operators were provided with thermal signature cues using real imagery of actual vehicles collected at a variety of ranges and conditions. The operators then used those cues in the experiments to demonstrate an increase in the human performance task of target discrimination, and the results of the experiments became the basis for the ROC Interactive Multimedia Instruction (IMI) applications. The IMI design draws on a comprehensive library of sensor imagery and data associated with combat and civilian vehicles, buried target detections, weapons, and personnel. The resulting training enhances visual identification skills of threat and non-threat targets, using both visible and thermal signature exploitation techniques.

1.1.1 The ROC-V Program

Recognition of Combatants – Vehicle (ROC-V) is day/night optics and thermal sight training program developed by the NVESD in support of the Forward Looking Infrared (FLIR) sensor programs. This computer-based, multimedia training program was developed to serve as an individual tutorial, collective trainer and standardized testing tool at individual, institutional and unit levels. More than 80,000 copies of the ROC-V software have been distributed, and international agreements with the United Kingdom and Canada have resulted in collection and inclusion of their vehicle thermal signatures. Additionally, a project agreement with France is underway, which will result in an increased library of thermal signatures.

The ROC-V training program helps soldiers learn to identify the thermal signatures of combat vehicles through the use of an interactive curriculum that teaches the unique patterns and shapes of vehicle "hotspots," and overall vehicle shapes and characteristics. ROC-V also provides soldiers with practical experience in the use of their thermal sensor image controls. Through the use of virtual sight controls, soldiers learn to effectively adjust their thermal image to find targets and bring out their thermal ID cues. However, the ROC-V program provides only static images of the vehicles and lacks an interactive component that would enable the soldiers to view the vehicles as they would in real-world missions. As effective as the ROC training has been, it lacked the "pizazz" to gain and hold the attention of the younger soldiers of today for the reasons described below.

1.1.2 The ROC-RSTA Program

Recognition of Combatants – Reconnaissance, Surveillance, Targeting and Acquisition (ROC-RSTA) is a day/night optics and thermal sight training program developed by the NVESD in support of RSTA systems that are used for a broad variety of missions, including perimeter security. This computer-based IMI training program was developed to serve as an individual tutorial, collective trainer and standardized testing tool at individual, institutional and unit levels. Where the ROC-V program focuses on combat vehicles, the ROC-RSTA training program focuses on using EO/IR security systems to identify potential threats based on actions of humans and the potential threat they pose to the safety and security of the area under surveillance.

ROC-RSTA development was initiated in September 2012 by the Project Manager Terrestrial Sensors (PM TS), with the goal of creating standalone software capable of training basic RSTA sensors capabilities and user skills in order to maximize the effectiveness of sensor use at the company, platoon, squad and individual levels. The training approach is based on the "Soldier as a Sensor" concept, wherein the intelligence gathering contributions of the individual soldier, combined with the expedient deployment of available sensors, are maximized to provide commanders with the most accurate and current intelligence. Recent engagements, including the 2012 attack on Camp Bastion, indicated that available sensors have not always been effectively employed in cases where they could have had a significant impact. Commanders may not be fully aware of the capabilities the sensor systems available to them can provide, especially when deployed in a complimentary way. The interoperability of current sensor systems can be a significant force multiplier by providing a more complete picture of the battlespace and allowing the commander to zero in on specific areas, activities, or persons of interest. Additionally, soldiers often lack adequate RSTA skills necessary to achieve the full benefit of these sensor systems. Raising the commander's awareness of available sensor assets and capabilities, together with improving the effectiveness of these systems by elevating the RSTA skills of individual soldiers, can significantly improve combat effectiveness and force protection.

2.0 THE CHANGING CULTURE OF LEARNING

The generation born between 1976 and 2001 has become to be known collectively as Millennials, a group of 80 million young adults that will comprise nearly half (46 percent) of all US workers (Lynch, 2008). Millennials view the world differently than the Generation X or Baby Boomer generations, with their own unique definitions for personal and professional success (Brack, 2012). Millennials were raised on technology, making them tech-savvy multi-taskers that study while simultaneously playing Angry Birds, listening to the music mix they created on SoundCloud, sending text messages and posting updates on Facebook. This flies in the face of convention of the Baby Boomers and Gen Xers, who take a very serial approach to their daily tasks and value working individually. In contrast, Millennials were raised under constant supervision instead of a world where children rode off every summer morning on their bikes and were only expected to come home when there was trouble or in time for dinner. They are a product of their environment - their early and closely supervised exposure to team sports has made Millennials the best team players and collaborators in generations (Brack, 2012). They also grew up in schools that use rubrics, "scoring tools that divide an assignment into its component parts and objectives, and provide a description of what constitutes acceptable and unacceptable levels of performance for each part" (Spiegel, 2010). Most were given rubrics as part of the assignment so they would know exactly what to do to earn a specific grade.

These differences between previous generations and Millennials makes training them a challenge, as they crave collaboration, instead of the individual approach to life and work taken by the "cowboy generations" of Gen Xers and Baby Boomers (Brack, 2012). Millennials'' tech-savvy, multi-tasking nature means that they don't respond to traditional PowerPoint-based lectures and other classroom-based instruction doesn't stimulate them, probably because they don't supply Millennials with the five learning-theory prerequisites or desiderata (quoted directly from Foreman, 2003):

1. *The ideal learning situation is customized to the very specific needs of the individual.* Every student approaches a learning situation with a unique knowledge level and a particular set of dispositions. Optimal learning takes place when instruction targets an individual's proximal zone and learning styles.
2. *The ideal learning situation provides students with immediate feedback.* Because learning extends what is known and can be understood, a student working with new material will inevitably encounter some confusion and uncertainty. Optimal learning takes place if a student is able to seek immediate clarification or amplification when he or she encounters problems.
3. *The ideal learning situation is constructive.* It allows students to explore learning environments (preferably multisensorial) that encourage the active discovery of new knowledge and the development of new kinds of comprehension.
4. *The ideal learning situation motivates students to persist far in excess of any externally imposed requirements*. If students are engaged in what they perceive as a personally meaningful and rewarding activity, they will devote more time to the effort than is prescribed in the course: witness the willingness of the game generations to play videogames for thousands of hours.
5. *The ideal learning situation builds enduring conceptual structures*. It ensures that concepts and procedures are committed to long-term memory and are available thereafter for the analysis and interpretation of related but novel real-world experiences.

Most, if not all, of legacy training courseware developed prior to 2000 does not provide any of the five desiderata described by Foreman, which is why learning theory has evolved to adapt to the newest generation of learners. Much literature exists documenting that Millennials learn differently than people from previous generations, so it stands to reason that legacy learning applications such as the ROC Training Programs need a sort of "technology refresh" to provide effective training to Millennials.

2.1 Learning Theory Desiderata Provided by the ROC Training Programs

The initial development for the ROC Training Programs began in 1997 as a means to train vehicle recognition before target acquisition performance experiments. The applications have the look and feel of an "interactive PowerPoint presentation", rather than a state-of-the-art Level 3 Interactive Multimedia Instruction (IMI) course. As shown in **Figure 1**, the ROC programs provide limited participation for the students, where the student makes simple responses to instructional cues (please note that only the Start Screen is shown due to the Distribution limitations in place from US Army). Thus, the ROC family of IMI Training Programs is considered to be Level 2 IMI in accordance to the definitions of IMI Levels in MIL-HDBK-29612-3, which states that Level 2 allows the student to make simple responses to instructional cues (MIL-HDBK-29612-3, 1997).

Figure 1. ROC-V Provides Limited Ability for Student Participation.

2.1.1 Learning Theory Desiderata Provided by ROC-V

To assess how effective the ROC-V program is for training millennial soldiers, the authors performed an informal assessment of how ROC-V compares against the five Learning Theory desiderata. While not scientific (and actually quite subjective), it does help to justify the Serious Gaming effort underway to enhance the Recognition of Combatants training for EO/IR sensors:

1. *First Desiderata (ideal learning situations are customized to specific needs of the individual)*: The ROC-V instruction only partially targets an individual's proximal zone and learning styles.
2. *Second Desiderata (ideal learning situations provides students with immediate feedback)*: Students are not able to seek immediate clarification or amplification when he or she encounters problems.
3. *Third Desiderata (ideal learning situations are constructive):* ROC-V doesn't enable students to explore learning environments that encourage the active discovery of new knowledge and the development of new kinds of comprehension, but it does provide some constructive feedback.
4. *Fourth Desiderata (ideal learning situations motivate students to persist in excess of any externally imposed requirements):* While many US Army and Marine Corps personnel have used ROC-V as part of their fratricide prevention training, there is no indication that they devote more time to the effort than is prescribed in the course.
5. *Fifth Desiderata (ideal learning situations build enduring conceptual structures):* The multiple aspect of each vehicle is presented to the ROC-V students, which does help ensures concepts and procedures are committed to long-term memory. However, ROC-V lacks the ability to provide students to perform an analysis and interpretation of related but novel real-world experiences.

2.1.2 Learning Theory Desiderata Provided by ROC-RSTA

Similarly, the authors also performed an informal assessment of how ROC-RSTA compares to the five Learning Theory desiderata, with nearly identical results to the ROC-V assessment. This assessment also helps to justify the Serious Gaming effort underway to enhance the ROC training for EO/IR sensors. As expected, the legacy ROC-RSTA training courseware did not consider any of Foreman's five desiderata for effective training when it was developed.

3.0 SERIOUS GAMES – A TRAINING REVOLUTION

Serious Games have evolved the means to address these five desiderata, and Clark Abt is credited with coining the phrase "serious games" when he first used the term in his 1970 book "Serious Games" (Abt, 1970). While his references were primarily directed towards the use of board and card games, Abt gave a general definition which is still considered applicable today:

> "Reduced to its formal essence, a game is an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context. A more conventional definition would say that a game is a context with rules among adversaries trying to win objectives. We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement."

The Serious Games Movement started in 2002 when the U.S. Army released the video game *America's Army* as a free online download (Gudmundsen, 2006), which was then promoted by the Woodrow Wilson International Center for Scholars (Wikipedia, 2015). There exists an abundance of literature about the evolution of Serious Games, so in this paper we focus on one of the key enablers for enhancing Recognition of Combatants (ROC) training for EO/IR sensors: Highly Interactive Virtual Environments.

3.1 Highly Interactive Virtual Environments

In her 1999 Dissertation, Michele Dickey studied the design and implementation of three-dimensional (3D) virtual worlds for educational purposes, noting that 3D environments offer an intuitive visual representation of space and place for users to interact in (Dickey, 1999). Since that time, these 3D environments have progressed to the point to where they can be considered Highly Interactive Virtual Environments (HIVEs), where the player navigates throughout the environment and is given the ability to interact with a variety of objects, other players, and/or non-player characters (Fuller and Beck, 2015). Vogel et.al noted in 2006 that one of the most critical aspects of digital learning environments is increased levels of interaction (Vogel et al., 2006), which has been validated via the success of game-based HIVEs for military training that have resulted in increased task performance and unit cohesion (Ratwani, Orvis, & Knerr, 2010; Smith, 2010). These improvements are not limited to the military, greater academic gains over traditional learning environments have also been demonstrated in HIVES (Chatham, 2011; Richter & Livingstone, 2011).

Curry (2010) and Richter and Livingstone (2011) concluded that HIVEs may have low barriers to participation; allow for increased communication; facilitate the creation of informal mentorships and bonding formed by semipermanent in-game groups; provide opportunities for collaborative problem solving; produce an exceptional level of engagement; and support the importance of participatory cultures in learning experiences – in other words, they meet most of not all of the five learning-theory desiderata (Foreman, 2003). *America's Army*, *DARWARS Ambush!*, *Littoral Combat Ship Readiness Control Officer*, *Re-Mission*, *River City*, *Tactical Iraqi*, and *Virtual Battle Space 3* (VBS3) all capitalize on the immersion and collaboration benefits of game-based HIVEs (Alion Science and Technology Corporation, 2013; Chatham, 2011; Navy Air Warfare Center, 2013; Ratwani et al., 2010; Richter & Livingstone, 2011; Shilling, Zyda, & Wardynski, 2002; Tate, Haritatos, & Cole, 2009). As the ROC family of training products teaches recognition of combatant fundamentals, supplementing the legacy training products with a HIVE-based Serious Game seemed to be the logical step in enhancing the EO/IR training and incorporate some of the five learning theory desiderata previously discussed.

4.0 THE *COMBAT ID* SERIOUS GAME

The *Combat ID*™ game was developed in 2012 by The AEgis Technologies Group, Inc. (AEgis) as an entrant in the annual Serious Games Showcase and Challenge (SGSC), an annual competition held in conjunction with the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC). AEgis has used the ROC-V IMI program in our role as the sole developer of the 3D Common Moving Models (CM2) on the US Army’s Synthetic Environment Core (SE Core) Common Virtual Environment Management (CVEM) program, as well as for 3D model development efforts for the Dutch Ministry of Defense. AEgis saw the opportunity to create a Serious Game that mirrored the training recognition of combatant objectives of the ROC family of IMI products, but in a HIVE instead of a Level 2 IMI application. As indicated previously, our assessment of the ROC training programs was that the static views and video clips lacked the ability to present “real-world” situations where vehicles and combatants were obstructed by other objects in the environment (e.g., trees, buildings, people, etc.). Thus, AEgis began developing an interactive, on-the-move HIVE training game that would enable soldiers to view vehicles as they would in real-world missions and include intelligent tutoring, enhanced character behaviors, and efficient use of terrain databases.

4.1 Original *Combat ID* Functionality

The initial design of the *Combat ID* HIVE focused on the concept of a “Training Garage”, an interactive, 3D area where players could scroll through and select different types of vehicles that could be spun by the player as show in **Figure 2**.

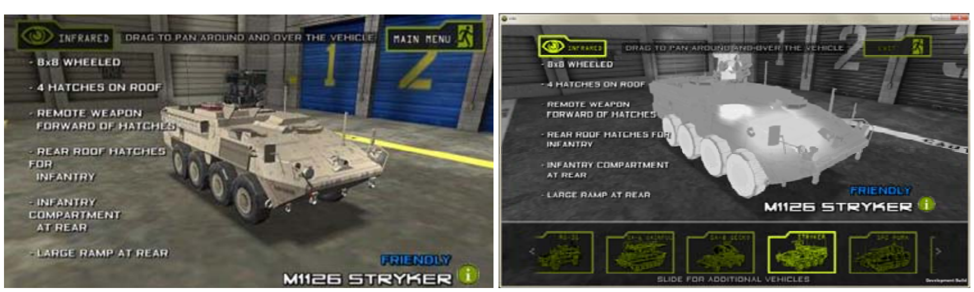

Figure 2. The “Training Garage” in the Original Version of the Combat ID Game.

Players were given the opportunity to acquire knowledge about the set of friendly and threat vehicles available in the “Training Garage”, boosting their confidence in their abilities to recognize and identify them in the gameplay.

4.2 Original *Combat ID* Game Levels

The original Combat ID game had four levels of increasing complexity to provide players with the ability to test the vehicle knowledge they had obtained in the Training Garage. As shown in **Figure 3**, these levels were based on scripted paths that moved the eyepoint through the HIVE, and players were challenged by obstructions such as smoke, clouds or 3D terrain features that partially obscured the vehicle from the selected eyepoint. The first level allowed players to toggle between daytime EO views and IR views, and once the vehicle was selected by the player, the game presented eight (8) possible vehicles to the player as candidates for identification. Points were awarded based on the amount of time required to correctly identify the vehicles – the less time taken, the more points were awarded.

Figure 3. Gameplay in Original *Combat ID* Game.

4.3 After Action Review in Original *Combat ID* Game

Napoleon Bonaparte is credited with saying that "A soldier will fight long and hard for a bit of colored ribbon", a concept that has been embraced by the gaming industry. In fact, a game cannot be on the Microsoft Xbox Live or the Sony Playstation network without having "achievements" (Blair, L., 2011). An Achievement, also known as Trophy or Badge, is an in-game accomplishment based on meta-goals that the developers design outside of a game's parameters (Hamari and Eranti, 2011). For most games, Achievements are a means to extend playing time by serving as "extrinsic motivators" for the players (Blair, L., 2011). Thus, the original version of *Combat ID* awarded achievements to the players to reward their gameplay, however, these were not driven by any doctrinally correct military learning objectives as shown in **Figure 4**.

Figure 4. Options and Achievements in Original *Combat ID* Game.

5.0 *COMBAT ID* ENHANCEMENTS FOR NVESD

NVESD representatives saw the *Combat ID* game at I/ITSEC 2012, and liked how AEgis had mirrored the recognition of combatant training objectives of the ROC family of training products. After discussing AEgis' interest in working with NVESD on integrating *Combat ID* within ROC, AEgis responded to the 2012 NVESD Broad Agency Announcement (BAA) Solicitation W909MY-13-R-D006 for "Night Vision and

Counter-Buried Hazards Technologies" with a proposal to provide a customized version of the *Combat ID* game for NVESD to integrate into the ROC-V and ROC-RSTA training programs. This work began in October of 2013 to provide the ROC-V and ROC-RSTA functionality described below.

5.1 Development Effort for Enhanced *Combat ID* Functionality for ROC-V

Since *Combat ID* was initially developed for the Serious Games Showcase and Challenge, the development efforts didn't specifically consider any of Foreman's five Learning Theory desiderata. Since the target audience of the ROC version of the game shifted from generic "gamers" to "warfighters" that needed to learn how to prevent fratricide, AEgis worked with NVESD to establish requirements to ensure that the revised game provided doctrinally-correct vehicle recognition and identification training while retaining the immersive nature of the game and satisfying Foreman's Learning Theory desiderata. This section describes how the enhancements were developed to meet the need for EO/IR Sensor Training and the requisite Intelligent Tutoring enhancements to improve the training effectiveness for the United States military.

5.1.1 EO/IR Sensor Training Enhancements

The initial development effort focused on a more interactive version of the ROC-V EO/IR sensor training, with the following enhancements to address specific learning theory desiderata:

Desiderata 1 - The ideal learning situation is customized to the very specific needs of the individual. This instruction should target an individual's proximal zone and learning styles. The "Zone of Proximal Development" or ZPD, has evolved since first proposed by Lev Vygotsky in late 1920's to mean "an area of learning that occurs when a person is assisted by a teacher or peer with a skill set higher than that of the subject" (Penguin dictionary of psychology, 2009). The ROC-V *Combat ID* enhancements emphasize a combination of learning styles (e.g., Solitary, Visual and Verbal) to present the information to the users in a modified HIVE, while using Intelligent Tutoring as "scaffolding" to guide the learning through focused interactions between the user and the game. Scaffolding is a process where the tutor (in this case the game, acting as a more competent peer), helps the student as necessary in their ZPD between what a learner can do without and without help. As shown in **Figure 5**, the revised version of the *Combat ID* game provides additional Visual and Verbal instruction to the students in the earliest (Solitary) levels through additional hints and student feedback to tailor the learning to needs of each individual.

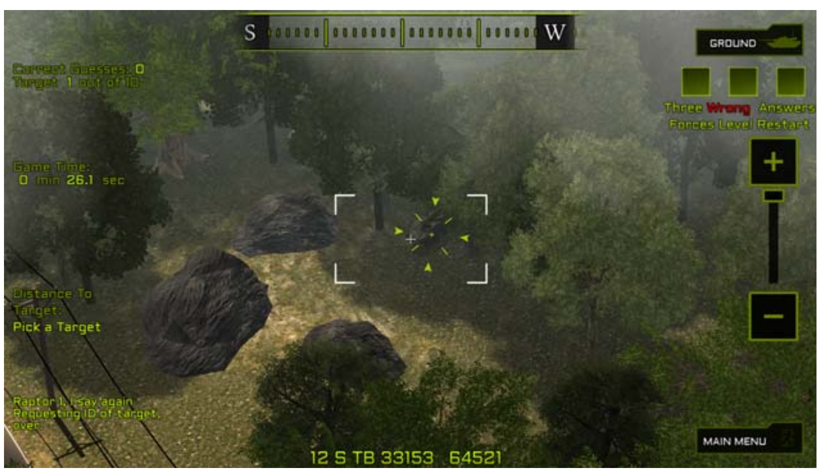

Figure 5. Enhanced ROC-V Version of Combat ID Provides More Visual and Verbal Cues.

Desiderata 2 - The ideal learning situation provides students with immediate feedback. The original version of the *Combat ID* game were released on Google Play and iTunes stores, which meant that the goals and feedback were limited by International Traffic in Arms (ITAR) restrictions to be generic situations and feedback that weren't in accordance to US military doctrine. Therefore, AEgis developed enhancements to the *Combat ID* gameplay to use doctrinally-correct information for students seeking more immediate clarification or amplification when encountering problems, avoiding negative training.

Desiderata 3 - The ideal learning situation is constructive. While the original *Combat ID* game was a HIVE that provided a multisensory learning environment that encouraged the active discovery of new knowledge and the development of new kinds of comprehension, the focus was more on achievements that weren't relevant to CID training using EO/IR sensors. Therefore, AEgis and NVESD worked together to modify the Options and Achievements shown in **Figure 6** to provide a constructive learning situation that mirrored the learning objectives within ROC-V. These Achievements also serve as the rubrics desired by the Millennials to guide them on what constitutes acceptable and unacceptable levels of performance (Spiegel, 2010).

Figure 6. Revised Options and Achievements in *Combat ID* Focus on ROC-V Training Objectives.

Desiderata 4 - The ideal learning situation motivates students to persist far in excess of any externally imposed requirements. There has been no formal study done to assess how much time "Millennial" soldiers spend training with the ROC-V training program, but a large body of research has shown that Millennials prefer to collaborate (Brack, 2012) using the rubrics to guide them. While the *Combat ID* was originally intended to be a game to be played by individuals without comparing to other players' scores, NVESD and AEgis decided that the Millennial soldiers' desire for collaboration could be satisfied by creating the ability for soldiers to compare their scores with others within their Unit via an interface to the ROC-V program Instructor mode to provide scores for all soldiers within each participating Unit. Future user evaluations will assess the amount of time that the soldiers spend playing the game, with the expectation that the gameplay and competition will motivate them to spend much more than the externally imposed training requirements

Desiderata 5 - The ideal learning situation builds enduring conceptual structures. To ensure that the CID concepts and EO/IR sensor recognition procedures are committed to long-term memory, AEgis and NVESD collaborated on how to ensure that the *Combat ID* game experience involved the students' analysis and interpretation of related but novel real-world experiences. Due to the ITAR restrictions of the commercial version of the game, only generic EO/IR textures were used for the 3D models in the original *Combat ID*. The revised version uses 3D models that AEgis developed for the US Army on the Synthetic Environment Core (SE Core) program, with realistic IR textures validated by US Army Subject Matter Experts. In additional to the improved realism of the 3D models, the EO/IR sensor modes were tuned to more closely approximate the actual performance of US military sensors in real-world conditions. As shown in **Figure 7**, the game levels simulate atmospheric effects in real-world

Figure 7. Enhanced Realism in *Combat ID* Helps Build Enduring Conceptual Structures.

scenarios to ensure the gameplay builds the desired enduring conceptual structures.

5.2 Development Effort for Enhanced *Combat ID* Functionality for ROC-RSTA

Whereas the original Combat ID focused on the same training objectives as ROC-V, the ROC-RSTA focuses on training surveillance and reconnaissance skills as well as combat identification of humans to determine threat levels in order to avoid civilian casualties and collateral damages. The initial development effort in this phase of the contract focused on creating interactive gameplay to supplement the ROC-RSTA EO/IR sensor training, with the following enhancements to address specific learning theory desiderata:

Desiderata 1 - The ideal learning situation is customized to the very specific needs of the individual. Leveraging the ROC-V *Combat ID* enhancements, the ROC-RSTA version of *Combat ID* also emphasize a combination of Solitary, Visual and Verbal learning styles and "scaffolding" to guide the learning through focused interactions between the user and the game. As shown in **Figure 8**, the revised version of the *Combat ID* game utilizes ZPD techniques to provide additional Visual and Verbal instruction to the students in the earliest (Solitary) levels to tailor the learning to needs of each individual. The human characters utilize basic scripting methods to simulate the character behaviors, as neither the funding nor the initial set of requirements justified the need for an Automated Intelligence (AI) engine in first phase of development.

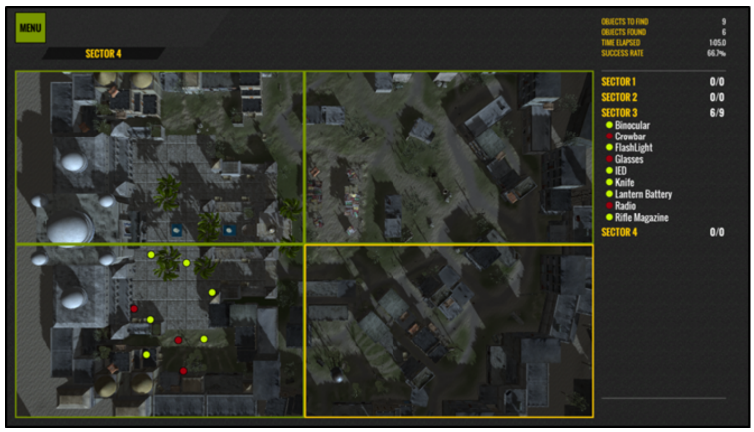

Figure 8. The ROC-RSTA Version of Combat ID Provides Visual and Verbal Cues.

Desiderata 2 - The ideal learning situation provides students with immediate feedback. As with the ROC-V version, AEgis worked with NVESD to develop doctrinally-correct enhancements for *Combat ID* students seeking more immediate clarification or amplification when encountering problems, avoiding negative training.

Desiderata 3 - The ideal learning situation is constructive. AEgis and NVESD worked create entirely new Options and Achievements for the ROC-RSTA version of *Combat ID* to provide a constructive learning situation that mirrored the learning objectives within ROC-RSTA. These Achievements also serve as the rubrics desired by the Millennials to guide them on what constitutes acceptable and unacceptable levels of performance (Spiegel, 2010).

Desiderata 4 - The ideal learning situation motivates students to persist far in excess of any externally imposed requirements. As with the ROC-V version, RSTA version of *Combat ID* satisfies the Millennial soldiers' desire for collaboration by allowing them to compete against other soldiers within their Unit via an interface to the ROC-RSTA Instructor mode. Future user evaluations will assess the amount of time that the soldiers spend playing the game, with the expectation that the gameplay and competition will motivate them to spend much more than the externally imposed training requirements.

Desiderata 5 - The ideal learning situation builds enduring conceptual structures. AEgis and NVESD leveraged the ROC-V enhancements to ensure that the ROC-RSTA *Combat ID* game experience involves the students' analysis and interpretation of related but novel real-world experiences. The HIVE Game Levels shown in **Figure 9** utilize scaffolding techniques to allow students to require less instruction from the game as they progress through the more complex levels, while simulating real-world conditions and scenarios to build the desired enduring conceptual structures.

Figure 9. Building RSTA Conceptual Structures Through Novel Real-World Experiences.

6.0 *COMBAT ID* USER EVALUATIONS

To assure that these development efforts were achieving the desired effects, NVESD worked with the Army Research Lab in early 2015 to conduct a user evaluation of the ROC-V and ROC-RSTA version of the enhanced *Combat ID* game. The objectives of the evaluation were to gain soldier feedback regarding the look and feel of the game, as well as the tactical utility of the training.

6.1 Participants in User Evaluation

The participants were Maneuver Center of Excellence soldiers from the 3rd Infantry Brigade Combat Team, 3rd Infantry Division Fort Benning, GA. The division "regenerates combat power and deploys on order to conduct Full Spectrum Operations to defeat enemy forces, control land areas, and secure populations and resources in support of US national interests." (Ft. Benning web site, 2015) These soldiers spent a week in the NVESD human perception lab conducting various experiments to perform target acquisition and identification. As a part of the experimentation, the soldiers participated in the user evaluation of the Combat ID game.

6.2 Test Methodology for User Evaluation

NVESD regularly performs human perception research in which known visual stimuli are presented to human observers in a controlled and calibrated environment. The design and implementation of the current test interface supports the development of physics-based target acquisition models and measurements of human performance as a function of the target, sensor, image processing and environmental parameters. Standard test protocol involves participants viewing imagery or video content on a CRT or LCD computer monitor and responding via a computer mouse or joystick. For the Combat ID evaluation, NVESD and ARL established a test methodology that included gameplay and soldier survey feedback. At the start of the evaluation, a tutorial was given to explain the goals, objectives, and basic functionality of the game. Then the soldiers were asked to perform tasks in each of four modules: object detection, base defense, route reconnaissance, and UAV reconnaissance in rolling terrain and the jungle. During each module, the instructor provided assistance as needed and soldier feedback was collected by observers.

6.3 Results of the User Evaluation

The Combat ID game was generally well received by the soldiers. The demographics suggested and proved that the Millennials were far more enthusiastic about the game and provided the majority of the feedback, while the older soldiers concentrated on simply maneuvering through the modules. Feedback included comments such as "should have better solar loading on objects when viewed in the IR mode" and "the scenes could be more realistic by placing items that would actually be suspicious, for example, a keyboard in the business sector would not be suspicious, compared to placing it in an open residential area", and "need more people in the village scenes to use movement patterns as indicators". Additional observations focused on the functionality of the game, e.g., needing the ability to adjust contrast and polarity of the sensors in order to improve the search detection, and the desire to network the game so soldiers could search a scene at the same time. Comments from previous generation learners included "it took longer to figure out how to move and zoom than expected", and "would prefer the tutorial as a hands-on rather than a verbal instruction". The garage was the most liked aspect of the game. The soldiers really liked the ability to turn and drag objects, which helped orient their target acquisition ability. All agreed that they would have performed better in the traditional ROC-V training if they had used the game first. It is interesting to note that the achievement awards gained during the game did not receive any feedback. Does this indicate that Millennials are not motivated by incremental achievements? This is an area that merits additional research.

7.0 FUTURE PLANS

The User Evaluation validated that the interactive gameplay provided by the enhanced version of *Combat ID* developed by AEgis is an effective, doctrinally-correct supplement to the ROC-V and ROC-RSTA Training Programs. The five learning theory desiderata were met, as evidenced by the feedback from the Millennials. Future plans for the Combat ID game include additional user evaluations during the quarterly perception tests at NVESD and by including the game as a part of the Long Range Advanced Scout Sensor (LRAS) classroom training. The modules will include more models, including additional vehicles, people, and weapon/no-weapon objects. The three dimensional models used in this version of Combat ID were taken from those available in the Army Model Exchange, specifically the Synthetic Environment Core (SE Core) models. The next version will include predictive models for expanded ground vehicle identification training.

7.1 Studying Training Effectiveness and Performance Metrics

The fourth learning theory desiderata is satisfied when the learning situation motivates students to spend considerably more time in the learning environment than required by externally imposed requirements. No studies have been conducted by the Army to evaluate how much time soldiers spend using the US Army Training and Doctrine Command's (TRADOC's) mandatory requirement for deploying soldiers to train using ROC-V. However, NVESD is working on conducting user evaluations to assess the amount of time that the soldiers spend playing the *Combat ID* game to determine if the gameplay and competition will motivate the soldiers to spend more time than externally imposed TRADOC training requirements.

7.2 Predictive Modeling

The traditional method of populating the ROC-V imagery database is to deploy sensors to the location where vehicles are available and collect multi-aspect visual and thermal imagery. While this approach is sufficient for generating training imagery, there are restrictions and recurring costs such as range and vehicle rental, labor to collect and post process the imagery, travel and sensor shipping costs. The limitations of the measured data include constrained aspect angles of measurement, inconsistent backgrounds and scenes for vehicle data, inconsistent vehicle conditions and paint colors, and tactically inaccurate vehicle configurations. The ROC-V training currently uses this measured visual and thermal imagery to train soldiers on the critical visual and thermal cues needed to accurately identify modern military vehicles. Synthetically generated multi-spectral imagery, or predictive modeling, will expand the ROC-V and Combat ID data sets by combining a hyperspectral rendering program with a vehicle signature model database developed for the National Ground Intelligence Center (NGIC). This combination offers significantly lower recurring costs, environmentally correlated imagery, tactical accuracy, data generation in any spectral band, and geographically relevant, mission specific training imagery. Even more important, the predictive modeling provides imagery of high value targets that are not available for data collection, and the incorporation of camouflage, concealment and deception (CC&D) elements into training imagery. While CC&D is the norm on the modern battlefield, foreign camouflage material is unavailable or prohibitively expensive for data collections. Creating the predictive modeling ability from scratch seems daunting and time consuming; however the rendering program and the signature model catalog already exist, making this approach a huge improvement to the ROC training program and Combat ID game data sets.

7.3 Future Development

NVESD and AEgis have discussed the following broad topic areas where there is mutual interest in making enhancements to *Combat ID* for ROC:

- Multi-Spline User Paths: Incorporate functionality that allows users to take random paths through a game level, to allow for more variety in destinations where users travel through an area.
- Simulating Advances in Human Recognition Technology: New functionality such as new human identification techniques; modeling new sensor technology; behavioral recognition and identification; cultural-specific patterns or behavior modeling, etc.
- Threat Recognition: Integrating computer-based artificial intelligence (AI) to create scenarios that include vehicles only, humans only and a mix of vehicles and humans. The scenarios will allow for threat recognition training including, but not limited to, normal, suspicious and known threat behaviors/patterns. Potential research and development areas include the following:
    - Additional Game Levels: Scenarios and different terrains/virtual environments; additional people (avatars); or additional vehicles as required.
    - Expanded Character Behavior and Appearance: Expanded character behavior to include natural human actions and more hidden objects/weapons on people for detection in any mode (EO, IR, etc.). For example, behaviors related to events such as smoking; sitting; talking; shopping at a market place; reacting when there's an explosion nearby or person with gun walks by; etc. This may also include building more realistic looking 3D characters for enhanced realism.
    - Expanded Vehicle Behaviors: Expanded vehicle behavior such as moving, firing, traversing terrain, rotating turrets, smoke, exhaust, tread tracks, etc. This may also include building more realistic looking 3D characters for enhanced realism.
    - Expanded Vehicle/Object List: Expanding the object list with additional vehicles, weapons and objects to the current library into *Combat ID*, or assist with NVESD with integration into the ROC Training Program products.
    - Enhanced Infrared Modeling: Enhancements to the current *Combat ID* Infrared (IR) modeling to include functionality such as pure night time modes; dynamic light sources like fire or street lamps; other Infrared modes (Midwave); the ability to switch Polarity (White Hot vs. Black Hot); adjust brightness and contrast of the IR model; etc.
- Enhanced Intelligent Tutoring: Use the five learning theory desiderata to further enhance the "scaffolding" within *Combat ID* and effectively tailor the instruction to individual needs of each student.
- Instructor Tools Development: Improve and update the current Instructor Tools in the following areas:
    - Porting to Other Platforms: Design, development, integration and testing versions of ROC Training Program products or *Combat ID* to additional platforms (e.g., WebGL; iOS for Mac or Apple devices; Linux, etc.).
    - Leaderboard and Ranking System: Design, develop, integrate and test additional "leaderboard" and ranking functionality inside *Combat ID* to fully integrate with the ROC Training Program products to display information such as: all users that have played; what levels each user has completed; which user has the highest scores and/or most achievements, etc.

- Incorporate Additional Information Screens: Design, develop, integrate and test additional screens within *Combat ID* that provides information about different vehicles, weapons when loading game levels.

8.0 CONCLUSION

The Millennial generation's craving for collaboration and rubrics is making many legacy training products and programs nearly obsolete, as they were not designed to satisfy the five learning theory desiderata described in this paper. To satisfy these cravings, NVESD and AEgis have collaborated to enhance the legacy ROC IMI training programs to provide a doctrinally-correct learning environment that stimulates the needs of the Millennial generation while meeting the training objectives of the ROC training programs. The initial feedback from the User Assessments indicates that our focus on meeting the five learning theory desiderata is a big step in the right direction for making the ROC training programs more appealing to Millennials without sacrificing the training objectives or inducing negative training. Future development in the areas described in the paper will be focused on ensuring training effectiveness while continuing to enhance Recognition of Combatants training for EO/IR sensors through a customized learning environment that provides immediate, constructive feedback, builds enduring concepts, and motivates students to spend more time training.

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