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Review

COMPUTER GAMING TECHNOLOGY FOR MILITARY TRAINING – SERIOUS GAMES

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Abstract: *Information Age brings technologies that provide unparalleled opportunities for military and security force, including Army of the Republic of Macedonia, to develop and adopt new operational concepts for training and experimentation that may radically enhance their competitive edge. Serious games show to have positive impact on training results. Advantages of simulation games lay in the provision of a safe training environment, where users are able to play, test and probe without serious consequences. The purpose of this paper is to give a brief info about computer gaming and serious games, and in line with that to describe a new approach for building a firearms simulator based on a serious game and motion sensor technology. It also compares this model with the similar models that are in use in NATO allies and it describes challenges and our plans for future work. At the end, we are giving initial assessment of suitability of this kind virtual environment for military training.*

Keywords: *computer gaming, serious games, simulations, inertial sensors, education.*

Introduction

Military training had made a big progress from the time of the first war training techniques that were used in the Prussian armies (see more in Frank W. Brewster 2002). That progress is mainly driven by the advantages that are brought by the new computer, sensor and micro-processing technologies. These technologies are used like a particular replacement of the traditional training programs in the Army. Mainly for: better readiness of the military, lowering the costs for training, longer use of the real equipment and combat technique, and because they are ecofriendly.

The dawn of the Information Age brings with it concepts and technologies that provide unparalleled opportunities for the military and security force, including Army of the Republic of Macedonia, to develop and adopt new operational concepts that may radically enhance their competitive edge. According to Herz J.C. and Michael R. M., "The military is undergoing a major cultural shift in its approach to simulation. The use of entertainment technology is not a new phenomenon in the military. What is different today is the emergence of a culture that accepts computer games as powerful tools for learning, socialization, and training" (see more in Herz J.C. and Michael R. M. 2002).

In many fields, training and learning activities are cost and time intensive, and often fail to

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answer specific knowledge needs in the workplace (Cross J. 2007). In domains such as security, military and surgery, a simulation or simulation game can help to increase effectiveness of training by providing a flexible, safe and realistic environment (Macedonia M. 2002, p. 32-37; Bonk, C. J. & Dennen, V. P. 2005; Zyda M. 2005, p. 25-32). According to Gwenda F. "Such simulations or simulation games support the training of particular behavior and strategies. Learning such a behavior or strategy from a game, in oredr to adopt it to the 'real' world, makes the game for the player a meaningful experience" (see more in Gwenda, F. 2006).

There are many benefits from the use of computer gaming technology for military training. First, there is a low level of risk and low cost of using commercial off-the-shelf software. In developing a game for commercial release, the developers would no doubt have allocated a significant budget toward research and development of a robust game engine with leading edge technology. We are thus able to leverage the sophisticated game technology already in place, at a fraction of the cost, by creating custom game content to serve as proxy worlds for the exploration of warfighting concepts. Second, the game-development toolkits released by the game developers provide a layer of abstraction from the underlying code, allowing experienced mod makers to create game content with a relatively short turnaround time on the order of days to weeks. Third, The ease and responsiveness of modifying an in-game mission greatly facilitates timely probes into any interesting behaviors observed as the simulation is being run. This may be achieved by tweaking a scenario offline to introduce new or unexpected events or enemy behavior in order to elicit an adaptive response from the participants in subsequent simulation runs. At last, the Army also recognizes that games serve as effective vehicles to reach out to this technology-savvy generation of soldiers. Unlike traditional military simulators, little user training is required when games are used, as most soldiers are already familiar with the standard game controls and are very comfortable playing in networked gaming environments. We seek to leverage on the familiar medium of computer games to engage our soldiers in military experimentation by encouraging them to interact and address operational challenges within these virtual environments, free from the constraints of current doctrine or technology (see more in Gwenda, F. 2006).

Also, there are some challenges of use of computer gaming technology for military training. First, there is limited realism of games. Despite the many benefits of using games to facilitate concept exploration, several challenges need to be considered and addressed. The first of these is the lack of realism, a critique commonly levied at simulation systems. Several aspects of games commonly highlighted as not realistic are the limited ways that intangibles such as morale, camaraderie, fear, and fatigue are modeled in games, as well as the restricted peripheral vision and spatial auditory cues presented to players. We are of the opinion that some departure from realism is acceptable in a simulation that facilitates creative thinking, as long as the essence of the specific contexts being explored is distilled and modeled with sufficient fidelity. Second, tehere is variability in player proficiency. Challenge of using games is that the results of the gaming simulation largely hinge on the participants' familiarity with the game controls and their tactile dexterity. This may somewhat be mitigated by conducting familiarization runs for each batch of participants in an attempt to bring all participants to a base proficiency level, but the time-critical nature of first-person shooter games often exacerbates the performance difference between expert and novice gamers. However, this variability in player proficiency may be acceptable as a simulation of the different levels of marksmanship possessed by soldiers on the ground (see more in Paul A. R., Doug B. 2008).

Computer Gaming

When we are talking about the computer gaming we can use some of the existing definitions. "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" (according to Abt, C. 1970).

In this article, 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 or entertainment. Serious Game can be defined as "a mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives", (according to Zyda, M. 2005).

In game-based training, we often find an interplay between three main fields (see Figure 1 from Martens, Diener, and Malo 2008), which are learning, simulation and games. Training simulations, like for example used in the military domain, medicine or in business science, are used to teach and train facts using simulations. The simulation's role is to show the underlying system behavior – as realistic as possible (which does not necessarily include demanding graphics, but close to real-life models). Leaving out simulation aspects, i.e. combining learning and games, leads us usually to simple edutainment games, which are often used in primary school settings (e.g. learning how to spell a word in a game-based manner) (according to Dennis M., Martina W., Alke M. 2012).

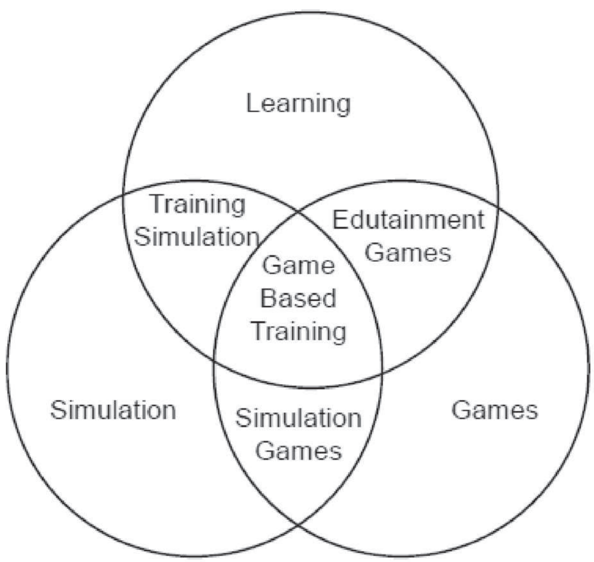

Figure 1 - Learning, Simulations and Games
(Source: Martens, A., H. Diener, and S. Malo. 2008. "Game-based Learning with Computers – Learning, Simulations, and Games". Transactions on Edutainment, LNCS 5080:172–190.)

Leaving out the training aspect leads to simulation games, which sometimes come as real simulations (in the sense of experimenting with systems consisting of models, including a temporal aspect) – sometimes, they come as games with a simulation appearance, but no core simulation functionality (see for example Martens, A., H. Diener, and S. Malo 2008). Only in the area, where all three fields overlap, a game-based training simulation can be found, which covers all aspects: games, simulations and learning (according to Dennis M., Martina W., Alke M., 2012). Our approach is located at this central field.

Simulation gaming is a means, which can tackle some of the challenges described here, and at the same time provides a nearly realistic experience within an authentic training environment. It includes the advantages of being time and place independent, and, once developed, asking much less capacity of training staff. Games offer an environment where students are able to play, probe, make mistakes and learn (Gee, J.P. 2003). Serious games make use of visual, textual and auditory channels for feedback, challenges, and further components. They enable the player to enter virtual, artificial worlds, while being able to establish a strong relationship to the real world (Greitzer, F. L., Kuchar, O.A., Huston, K. 2007). With their combination of the game dimensions of challenge, phantasy and curiosity (Malone, T. W. 1981), simulation games additionally work very motivating. Motivation to play a game also improves the learning and training effect of a simulation game (Garris, R., Ahlers, R., Driskell, J. E. 2002).

Computer game technologies offer a compelling environment, multiplayer capabilities, world-class visualization, cognitive stimulation, rapid scenario customization, and extreme portability. Many of the military's initial experiments have focused on the modification of a commercial game to create trainers. However, as we master these technologies and understand how they are valuable for our missions, we will be able to create training tools that specifically meet our needs, rather than being limited to the structure of the commercial products. Though there are questions about the modeling accuracy of a commercial game, there is nothing inherent in the technology that prevents military users from inserting the most detailed and validated models available (according to Smith, R. 2006).

Using computer gaming in military training permits a player to fight hundreds of scenarios, make thousands of tactical decisions, experiment with different tactics, and learn from mistakes. We know the penalty for mistakes, for mis-reading the situation, for making decisions too late. Hundreds of simulated men can died in botched assaults, poorly laid positions, and as a result of unexpected enemy actions in order to teach these lessons. In this situation we can examined the ground, checked the line-of-sight, positioned the units, and supervised the units in contact so many times that the key tactical principles have become ingrained as second nature. The historical methods for teaching tactics, walking the ground, working through the examples in the manuals, tactical decision games, and actual field exercises, are important and must be done by all leaders. Schools and units must focus on real leaders, real units, and real ground. To augment this practical training however, leaders need to experience the chaotic challenges of combat hundreds of times. As an inexpensive and easy-to-use tool to teach a military leader the dynamics of tactics, the simulation based on computer gamming technology is matchless.

Meaning of a game can refer to its educational impact, or to actions one has to take in the game. Reality of a game refers to how realistic environment and objects in the environment of the game are designed. The play element of a game relates to game elements such as competition, challenge, rules etc. (Heide L., Theo van R., Alexander V. 2012). Fidelity defines the degree to which the game emulates the real world and includes many more dimensions than only the visual design of a game, like auditory, vestibular, olfactory, proprioceptive etc. as elements of *physical* fidelity of a game. Functional fidelity defines how the serious game acts in response to the player's actions. Psychological fidelity is related to the notion of presence in a game, and to emotions like stress evoked by the environment (see also Alexander et al. 2005).

Serious games show to have positive impact on training results. Advantages of simulation games lay in the provision of a safe training environment, where users are able to play, test and probe without serious consequences. At the same time, it is important to engage learners by providing a motivating, challenging environment, which becomes meaningful to the player when skills and knowledge acquired within the game are transferrable to real work tasks (see more in Heide L., Theo van R., Alexander V. 2012).

Concept for Using Serious Games in the Army Training

In Macedonian Army the acquisition and implementation of this new technologies, combined with the models made from our own research and capacities, will rise the quality of training and education for a different type of users, like the: cadets in the Military Academy, regular and special forces, pre-deployed training of staff, crisis and rescue personal and police forces.

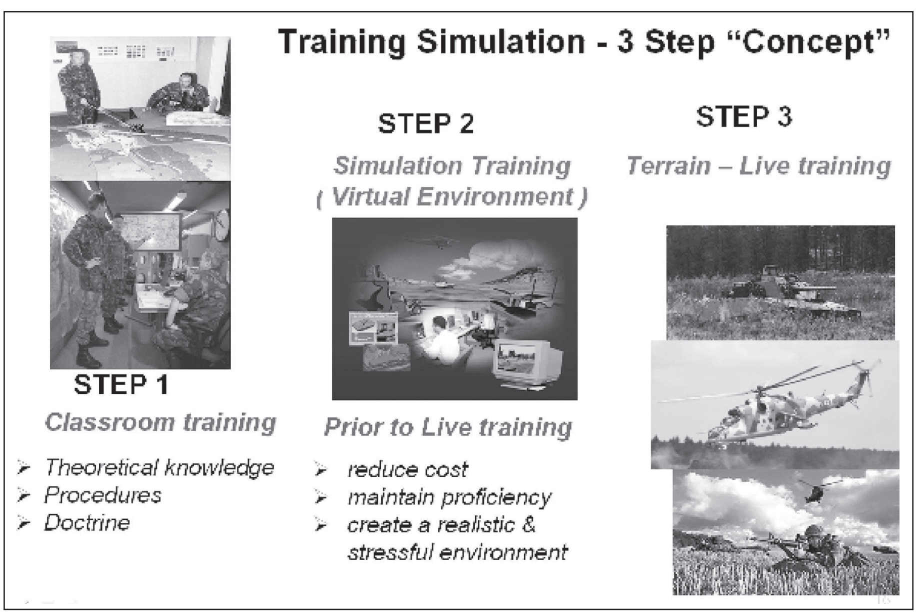

Figure 2 - Concept for military training in three steps

Firearms simulators are using the new sophisticated 3D and laser technology for training in: marksmanship skills, weapon handling, better accuracy, individual and team based shooting exercises, target acquire, judgmental shooting and sleep second decisions. Combined with live-firing training they produce soldiers that are being able to use their weapons in an adequate manner in combat situations.

The concept that we plan to use for combined training is represented in Figure 2.

Military training will be executed in three steps. First step – traditional education in classroom/laboratory, for theoretical knowledge, learning procedures and doctrinal issues. Second step – prior to execution of field training with combat techniques, there will be simulated practice of the procedures and tactics. In this way, trainees will achieve high standards in training. Third step – at the and trainees will have field training with combat techniques in real conditions. We will tailor the use rate of the steps, by our own demands, but without exclusion to one or more of these three steps.

Today there are a variety of companies producing firearms simulators and competing for law enforcement and military business. Before looking at some examples of such simulators, it is worth highlighting that there is an amazing choice of different firearms simulation systems. The major players are: Meggitt Training Systems (formerly FATS), Cubic Defense Simulation Systems Division, Thales and Laser Shot, companies such as Raydon, Fidelity Technologies, E-COM, ELI, Noptel, ZEN Technologies and AIS, and they all provide a range of equipment to both the military and law enforcement markets.

For the scope of this paper we will represent and compare only a few top rated firearms simulation systems.

a) VBS2 module – Tactical weapons simulator is a tailor-made software solution for virtual firing ranges or virtual convoy training solutions, with wide range of battlefield effects, from explosions through to wind-affected smoke and also realistic damage modeling. VBS2 allows commanders, crew, soldiers and support elements to be immersed in the VBS2 environment across multiple simulation systems in an endless number of different configurations. Also it has a realistic and configurable ballistic for the weapons used in range or convoy training. The Figure 3 is representing the workflow of VBS2-TWS (see more in VBS2 Whitepaper 2010, and VBS2 Tactical weapons simulator).

b) VirTra 100 MIL is the higher standard among single-screen small arms training simulators. Marksmanship mode supports up to 4 individual firing lanes at one time with full ballistics and qualification courseware. The optional Threat-Fire1 device safely simulates enemy return fire with an electric impulse (or vibration), reinforcing performance under pressure. The system is extremely compact and can even share space with a standard classroom or squeeze into almost any existing facility. System is represented in Figure 4 (see more in VirTra Systems Specifications).

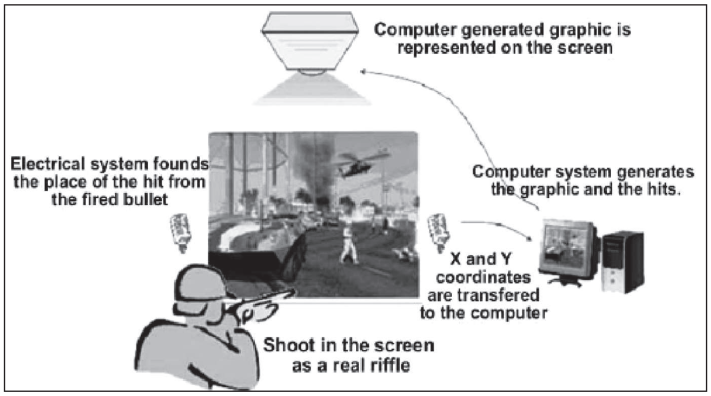

Figure 3 - Workflow of VBS2-TWS
(Source: VBS 2 Tactical weapons simulator, (2008), www.vbs2.com/media/docs/ITSEC_ VBS2_tact_weapons_sim.pdf)

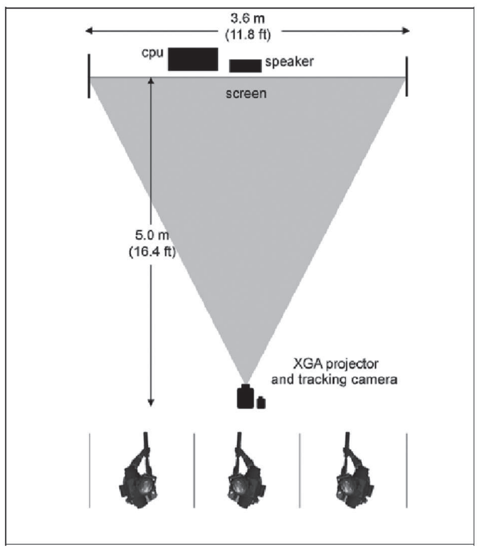

Figure 4 - Technical Specification of VirTra 100 MIL System
(Source: VirTra Systems Specifications, http://virtra.com/products/1/VirTra+100+MIL)

c) Meggitt Training Systems support both individual and collective training in the use of a variety of weapons types throughout the full spectrum of military operations. Individual training consists of Marksmanship and Judgmental training (see more in Meggitt Training Systems):

– Marksmanship training encompasses the fundamentals of individual marksmanship, crew served weapons training and sustainment training for both.

– Judgmental training includes target discrimination, force escalation/deescalation, and individual leadership imperatives.

– Collective training covers an expanse of exercises from branch specific through Joint Combined Arms Tactical Training.

– A single system supports five individual firing lanes and can be networked together with additional systems for up to 15 individual firing lanes.

All of the presented systems use lasers that are placed near the weapon muzzle, and they use the lasers for determination of bullet hits. The question is: Why don't we use these systems? And the answer is: Because they are too expensive, and also there is a big problem with the lasers and accuracy. And because we need our own product that will represent our science and research work in this field.

Model of Firearms Simulator based on Serious Game and Motion Sensor Technology

A) External and Internal Motion Detection

Motion detection is not a new idea. Security systems, medical systems and other systems apply a variety of ways of so called "external" detection of movement.

Until recently computers had a very restricted view of the world around them, and users had very limited ways of communicating with computers. Over the years, computers have acquired cameras and audio inputs, but these have been used mostly for unrecognized input; computers can store and play such content, but it has been very difficult to make computers understand input in these forms.

For example, when people hear a sound, they can make judgments about the distance and direction of the sound source relative to their own position. Until recently, computers had more trouble making such judgments. Audio information from a number of microphones does provide considerable information about the distance and direction of the audio source, but determining this information is difficult for programs to do. Similarly, a video picture provides an image of the environment for the computer to analyze, but a computer has to work very hard to extract information about the objects in pictures or video because an image shows a flat, two-dimensional representation of a three-dimensional world.

In this model the method of external motion detection will be accomplished using Microsoft Kinect sensor that is placed in front of the soldier. The Microsoft Kinect sensor bar contains two cameras, a special infrared light source, and four microphones. It also contains a stack of signal processing hardware that is able to make sense of all the data that the cameras, infrared light, and microphones can generate. By combining the output from these sensors, a program can track and recognize objects in front of it, determine the direction of sound signals, and isolate them from background noise (see more in Learn the MIcrosoft kinect API 2012).

Today very attractive is the so called "internal" way of detecting motion. This method is accomplished by sensors placed on a rigid object, usually in the center of mass of the object of interest. They perform measurements of applied force and moments acting on that object, so with further processing of measurements, motion of the object is detected.

Inertial sensors (gyroscopes and accelerometers) are most commonly used sensors for the internal method of motion detection (see more in Titteron, D., 1997).

B) The Concept of the Model

The goal of our model of firearms simulator is to be able to do the targets aiming and the movements like as it would be in real life.

The most important part of the Model of firearms simulator is the connection with the serious game API, but knowing that almost every defense serious games has a restriction on the API, we needed to find a way to emulate the commands without using the API. Our plan is to use Microsoft Kinect, Flexible Action and Articulated Skeleton Toolkit (FAAST) keyboard emulator and Atomic Inertial Measurement Unit (IMU). This plan will give as freedom of use our model with any type of first-shooter serious game.

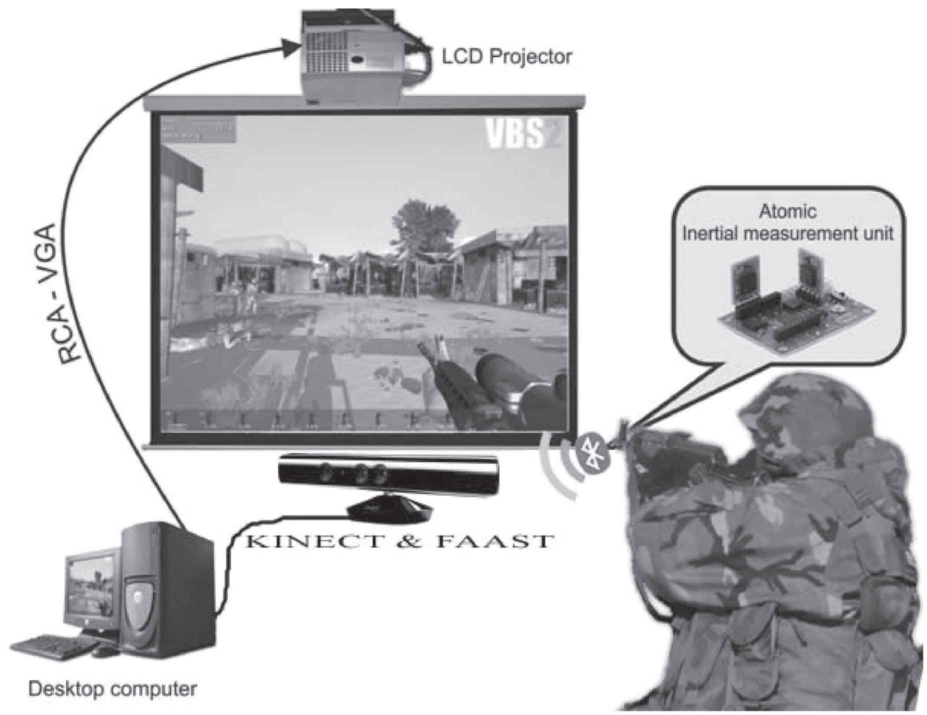

Figure 5: Concept of the model of firearms simulator

FAAST is middleware to facilitate integration of full-body control with games and VR applications using the Microsoft Kinect for Windows skeleton tracking software. FAAST includes a custom VRPN server to stream up to four user skeletons over a network, allowing VR applications to read the skeletal joints as trackers using any VRPN client. Additionally, the toolkit can also emulate keyboard input triggered by body posture and specific gestures (see more in Evan A. S., Belinda L., Skip R., David K., and Mark B. 2011).

We are currently in tasting stage with FAAST and the results are promising with the body motion tracking and emulating the commands like: movement, stand up, lay down etc., but the tracking of the direction of aiming with kinect didn't give as good results as we planned, that's why in our future work we plan to mount the Atomic IMU on the rifle muzzle. The IMU will measure the accelerations and angular rates that occur during the movements of the rifle. This information will be sent to the computer via Bluetooth. Than we need to develop algorithms for capturing the motion of the rifle. They will be characterized by high speed and precision. The plan is to develop the algorithms throughout experiments where the movement of the rifle will be performed in all possible positions.

Then the movements of the user rifle will be shown on the screen in real time. The plan is to place contact sensors on the rifle. The sensor is going to be placed near the trigger and is going to give signal when the trigger is pressed.

Motion sensors are relatively cheap compared with the laser sensors. They have very high degree of accuracy. One of the main advantages of this model is the absence of detection camera.

In this way the loop is closed and the user will have a feeling that is a part of the simulation and scenario that is displayed. The concept of the model of firearms simulator is shown in Figure 5.

Initial Assessment of Suitability of the Proposed Model for Military Training

Nowadays, simulation games are part of situational and weapon training of military, police and other security forces. It shows that military personnel and police officers who receive realistic training are better prepared for the real scenario, which leads to a more coordinated and appropriate response (see more in Heide L., Theo van R., Alexander V. 2012). Military has a long tradition of using simulations for strategy and combat training, because of the chance to clearly illustrate consequences of actions in a safe environment, without risk of injury or other damage (see more in Bonk, C. J. & Dennen, V. P. 2005, Muehl, W. & Novak, J. 2008).

In our case, primary focus will be on tactical training and mission rehearsal up to the combat team level. Also, to provide a generic simulation of all weapon platforms for combined arms training. Is not intended for large scale simulations, it will be designed to model a Combat Team. It can be operated in either a standalone mode using computer generated opposing forces, or distributed across a LAN or Internet. It will allows scenarios to be quickly created using the 3D mission editor (no additional editor is required for scenario generation). It will supports editing simulation characteristics of units, weapons and vehicles.

The simulation game's main objective is to raise situational awareness in a close protection mission. Situational awareness is understood as the ability to filter out certain details and highlight and extrapolate others, to better understand and control outcome (see more in Heide L., Theo van R., Alexander V. 2012). Different people bring in different experiences and expectations, which makes them having a different awareness of a given situation. Serious games with their ability to represent a non-linear, immersive training experience can help to increase situational awareness and a shared understanding.

For this purpose, we aim to develop a game experience that is meaningful to the player, understood as the user of the simulation game developed. The initial assessment of suitability of this concept of the virtual environment for military training is:

– Battle Drills (React to Contact, and Squad Attack);
– Convoy training missions;
– Tactics Techniques and Procedures (TTPs);
– Refinement of team drills and Standard Operating Procedures (SOPs);
– Vehicle checkpoints and area control;
– Tactical security (rear area, etc);
– Mission planning/mission rehearsal training;
– Mounted and dismounted patrolling;
– Battlefield visualization.

As a preliminary approach, we think this concept could be used for training, education and experimentation on the following areas:

– Fratricide Prevention;
– Convoys and checkpoints;
– Multinational tactical interoperability in a below component level training event;
– Tactical situational awareness;
– Cultural awareness.

Conclusion

Our goal is to have small, highly trained, NATO compatible Army, with the limitation due to the money and staff cutting. In Macedonian Army the acquisition and implementation of the commercial computer gaming technology, combined with the models made from our own research and capacities, will rise the quality of training and education for a different type of users, like the: cadets in the Military academy, regular and special forces, pre-deployed training of staff, Crises and rescue personal and police forces.

With the proposed model we are training to enhance the ongoing process for implementing new technologies in training and education in Military academy and in Macedonian Army, so that will make a step in reaching our goals. Our model compared with other gives: high degree of accuracy, it cost less and doesn't use detection cameras.

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