Serious Game Design for Military Training

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Abstract. Improving the quality of military operations is a driving force for many of the advances in soft and hard technology development. Examples are the development of the aircraft, nuclear power, computer, semiconductor, internet and the space communication and earth observing industries (Ruttan, 2006). Military operations both help develop new industries and also benefit from these industries. Recently we also see a lot of interest from the military personnel in the modeling, simulation and game development tracks of conferences. One reason for this interest is the capacity of games for increasing common battlespace awareness and assured real-time information among the military units. Common battlespace awareness and assured real-time information allow for a greatly accelerated operational tempo, as well as highly accurate identification of friend and foe on the battlefield (Hong, 2005). In this paper, we will be describing a game design framework within the context, tactics and rules of military training.

Author Keywords
Serious games, military training, game technology

INTRODUCTION
The official categorization of the use of models and simulation within the military is to divide them into three large application groups:

The first is for use in “research, development and acquisition”. By this means, an insight into the cost and performance of military equipment, processes and mission that are planned for future is gained. Scientific enquiry is used to discover or devise facts and theories of relevant phenomena. Later any discoveries are transformed into physical representations.

The second category is exploring “advanced concepts and requirements”. Multi-variations are explored on a new weapon or tactic and attempts are made to measure the effectiveness of them. They may also explore different processes for organizing and executing a mission. This requires an understanding of processes and the interactions that occur between the different steps in the processes.

The third category is “training, education and military operations”. Models that are embedded in a simulation system are used to stimulate individuals and groups of personnel with specific military scenarios. The goal is to determine the degree to which they have learned to execute doctrines they have been taught. It also gives them the opportunity to experiment with new ideas and to determine how useful these might be in a real warfare situation.

Pringle (2007) supports the use of game technology in military training. He suggests that the extent to which Serious Games (SGs) are expected to play an increasing role in training will depend on an ability to blend technologies in such a way that the training benefit is maximized. In Roman & Brown (2008), it is indicated that there are very few well defined or accepted standards for the specific measurement of the effectiveness of SGs and few military organizations conduct the required studies but rather seem to accept the use of Serious Games on faith.

Zyda (2005) suggests that a serious game is, “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”. Zyda (2005) explicitly points to the desirable goal of using “entertainment” to further the goals of the organization, to harness entertainment, fun, engagement, challenge, and trial-and-error to get people to learn more or to learn faster.

Systems like America’s Army provide an environment for experimentation and training in the military, a device to enhance Army recruitment and education about the military lifestyle, and a game for use by anyone looking for a little excitement in their free time (America’s Army, 2010).
As a result, we are proposing to develop a consortium to start up a project about effective serious game design for military training. In this project, we are proposing the following:

1. Investigate and find out at what level the Norwegian Military uses serious games for training.

2. Design metrics for measuring the effectiveness of the games that are being used and carry out measurements.

3. Design a serious game framework that will either use an existing game or develop a new game for increasing effectiveness of serious games in military training.

The framework will be designed according to the context, tactics and rules of military training. In this paper, we will describe

- A possible framework and what kind of military operations such a framework will include.
- An example military case and how it relates to military training game framework described.
- How the end-product game will work.

The wars within the scope of this paper are not the type of wars which aim at a player audience who is interested in fantasy war worlds or science fiction, or who has interest in recent history and who would like to get a feeling of how wars in the history have occurred through playing war games. The main consideration for wars and battles during recent history is the change from mainly infantry and cavalry forces to using various other technologies, including mechanized tanks, planes, helicopters, and missiles [Darby, 2009]. Following are the most recent wars: World War 1, World War 2, Battle of Britain, Vietnam, Korean War, The Falklands, Gulf War, Afghanistan, and Iraq War.

Following innovations are expected with the suggested game framework:

1. More realistic environment design, e.g. bomb explodes and character is affected but the environment is not, e.g. the bushes around.

2. Live sensory information integration and making decisions real-time. Integrating real-time sensory data into the serious game for military training for the purposes of receiving real-time information from weapons, robots, military vehicles on the field to make tactical and strategic decisions.

3. Teaching the squads the tactics and strategies.

4. Developing animations for explaining difficult concepts.

MILITARY SIMULATION SYSTEMS

First we will give some information about the nature of the current military operations. During the Cold War time, military operations focused on large combat operations that occurred on a specified battlefield where all participants were expected to be combatants (Smith 2008a). Recently, focus has also been on small unit operations in urban areas where units are called to duty for operations ranging from performing humanitarian operations, search and reconnaissance, facility defense, to combat operations. Hence the virtual environments must represent a more diverse set of objects and interactions as well as very high levels of detail in the area of operations (Smith, 2008a). The virtual environments should also allow for person-to-person communications that will lead to building up of knowledge that can be useful for future missions. This requires investigating into the models of group and personal relationships from highly cultural, social, and geographical perspectives. Virtual Environments that are able to represent such a diverse world accurately and effectively will be a significant challenge and a significant focus in the future (Smith, 2008a).

Taking the above explained characteristics of the current military operations, dynamic modeling of military systems and missions often focuses on the following activities (Smith, 2007a) where the relationships among these activities are as given in Figure 1:

Movement:
Dynamic representation of movement captures the change in an object’s position over time.

Perception:
Military objects move about the environment in order to interact with other objects. One of the first steps in this interaction is to perceive or detect the existence, position, and identification of the other object.
**Exchange:**
After moving and detecting, models are needed to allow objects to exchange materials and information with each other. Battlefield operations often lead to the depletion of materials like fuel, ammunition, food, medical supplies, vehicles, and people. A logistics model may be used to represent the ability of the military to constantly deliver these materials to units and objects in operation.

**Engagement:**
An engagement model typically includes the exchange of weapons or firepower from a shooter to a target. This exchange decrements the capability of the shooter by expending ammunition in one of its many forms (e.g. bullets, missiles, bombs, rockets, grenades, artillery rounds).

**Reasoning:**
Reasoning models often rely on the techniques developed within the Artificial Intelligence field. Techniques like finite state machines, expert systems, rule-based systems, case based reasoning, neural networks, fuzzy logic, means-ends analysis, and others are used to organize information and create decisions that are similar to those of living humans.

**Dynamic Environment:**
The evolution of the simulated environment happened from static state structures to dynamic representations of features and their interactions with military objects.

*MILITARY CONCEPTS: TACTICS, TACTICAL OPERATIONS, STRATEGY, ACTIONS*

**Tactics**
Tactics, in its proper sense, is knowing how to utilize multiple units and their supporting assets to find, fix, and destroy the enemy (Steelbeasts.com, 2010)

For example, tank commanders have tank platoons as their assets. The tank platoon can survive and win in battle, however, only if it is well trained, effectively led, and highly motivated. Crews who utilize them must be aggressive, and their tactics must reflect the tempo and intensity of maneuver warfare. Platoon training must prepare them to operate in hostile territory with the enemy to their front, flanks, and rear.

As stated in (GlobalSecurity.org, 2010), the Tank Commander maintains situational awareness by using all available optics for observation, by eavesdropping on radio transmissions, and by monitoring the intervehicular information system (IVIS) or appliqué digital screen (if available) in a tank battle space (Figure 2).

**Tactical operations**
Tank and mechanized infantry battalion task forces apply their combat power to:

- Conduct sustained combat operations in all environments with proper augmentation and support.
- Conduct offensive operations.
- Conduct defensive operations.
- Accomplish rapid movement and limited penetrations.
- Exploit success and pursue a defeated enemy as part of a larger formation.
- Conduct security operations (advance, flank, or rear guard) for a larger force.
- Conduct stability operations and support operations as part of a larger force.
- Conduct operations with light infantry forces.

An example military tactic: Deceit
Each country has its own deceit tactics. For example, it is common in Turkish military to form a crescent around the enemy and then the crescent closes inwards and the enemy is enclosed inside.

The army starts in a line which is divided into three equal groups as shown in the figure. The right and the left groups hide such that the enemy only sees the group in the middle.

In the next stage, a fight between the middle group and the enemy group happens as shown in Figure 4. At the last stage, the fighting middle group acts like they are losing, and they retreat back to where they were standing originally while the enemy follows them behind. This leads to the last stage of the crescent tactic as shown in Figure 5.

It is difficult to explain the crescent tactic and other tactics by a drawing on a paper or on a board, and it would be very useful to employ animations instead to teach these tactics to the soldiers.

Strategy
Military strategy deals with the planning and conduct of campaigns, the movement and disposition of forces, and the deception of the enemy. Broadly stated, strategy is the planning, coordination, and general direction of military operations to meet overall political and military objectives. Tactics implement strategy by short-term decisions on the movement of troops and employment of weapons on the field of battle. The great military theorist Carl von Clausewitz put it another way: "Tactics is the art of using troops in battle; strategy is the art of using battles to win the war." (Wikipedia, 2010).
Strategies are grouped into two: offensive and defensive. Examples of offensive and defensive strategies are given below (Wikipedia, 2010).

**Examples of Offensive Strategies**

- Attrition warfare - A strategy of wearing down an enemy to the point of collapse through continuous loss of personnel and materiel.

- Bait and bleed - A military strategy similar to the concept of divide and conquer.

- Battle of annihilation - The goal of destroying an opposing army in a single planned pivotal battle.

- Bellum se ipsum alet - A strategy of supporting an army with the potentials of occupied territories.

**Examples of Defensive Strategies**

- Defence in depth: It seeks to delay rather than prevent the advance of an attacker, buying time and causing additional casualties by yielding space.

- Retreat: A withdrawal of military forces.

- Boxing maneuver: A strategy used to "box in" and force and attack on all sides at once.

- Withdrawal: It is a type of military operation, generally meaning retreating forces back while maintaining contact with the enemy (Wikipedia, 2010).

**Strategy, Tactics, Actions - Hierarchy**

In Figure 6, it is shown that a strategy can be achieved by using different tactics and a tactic requires employing different actions.

![Figure 6: Strategy, Tactics, Action Hierarchy](Diagram)

**GAME TECHNOLOGY**

Commercial computer games present a core set of technologies that have value to many industries beyond entertainment, including military simulations. The technical core of game technologies that military industry can take advantage of includes the following as given in (Smith, 2008b):

- **3D Engine** – presentation of simulated world

- **Graphical User Interface** – easy access and manipulation of the game system

- **Artificial Intelligence** – small and compact AI that can fit on a single processor

- **Physical Models** – Movement, Detection, Communication, Engagement, etc.

- **Global Networking** – on-demand connectivity among players around the world

- **Persistent Worlds** – larger context for small unit missions. Also a 3D portal for tactical and intelligence data

**Enhancing military simulations by the use of game technology**

There is not yet much overlap between the military simulations and the game technology as can be seen in Figure 7. Military simulations focus on terrain data, Information Assurance (IA), Networking, Interoperability Standards, Facilities, etc. whereas Game Technology has focus on developing 3D engines, physics, Artificial Intelligence (AI), Massively multiplayer games, etc.

![Figure 7: Military Simulations vs. Game Technology](Diagram)
However, the military industry has begun to benefit from the use of game technology and by that the training applications became cheaper to build and have more realism in them (Thatcher, 2010).

CURRENT USE OF VIDEO GAMES FOR MILITARY TRAINING
A number of Army organizations began to invest in their own game-based tools, creating training systems for things like learning how to control robots, use new rifles, steer remote-control machine guns, and convey basic “Army 101” information.

America’s Army Game, an online video game developed internally that relied on the Unreal game engine created by Epic Games Inc., took center stage in the effort. The game attempts to simulate the experience of an Army soldier by allowing users to play out a variety of scenarios. Instead of just containing fight scenes, the game tries to educate users about the Army and the various career paths different soldiers can take.

Unlike most war-based video games that emphasize killing enemies, America’s Army awards points for factors such as teamwork, responsibility, and good values—traits the Army deems essential.

The goal of America’s Army was to attract young men and women to their local recruiting offices. It was a hit.

The US Army Program Executive Office for Simulation, Training, and Instrumentation (PEO-STRI) reports the use of the Operation Flashpoint game as a tool to teach teams of people how to perform specific missions.

Fielding of DARWARS AMBUSH! to Iraq and Afghanistan has shown that games can contribute to real missions. Collaborative mission review, intelligence analysis, and training, environment, Rehearsal for Live Training Events are what military can benefit from by training with MMO (massively multiplayer online) games (Smith, 2007b).

Characteristics of Military Missions and Their Virtual Versions
As stated In Urlocker (2007), military needs change and these changing needs are stated as follows: to respond to current situations, soldiers require individualized training, whether it is teaching a medic how to evacuate a fallen soldier from a street, training an interpreter how to interact with local leaders, or teaching a convoy driver how to spot a potential ambush. Most traditional Army training has tended to emphasize widely used skills, not the customized learning these new technologies enable.

For example, one of the great advantages of new PC-based game systems is the high level of detail it offers, which is valuable in simulating street-to-street combat (Urlocker, 2007).

Military operations contain a great deal of dynamic behavior which is carried out from orders sent down the command chain. The individual vehicles, avatars, and objects that reside in the virtual world need models which can mimic their behaviors in the real world. This requires the use of better graphics, animations as well as Artificial Intelligence techniques.

In Virtual Worlds, there needs to be models of movement, engagement, communication, suppression, and hundreds of other actions that can be triggered by orders delivered from external sources. Most virtual worlds lack the modeled behaviors that are central to first person shooter games – the automated patrols, attacks by enemy avatars, the exchange of gunfire, the resulting attrition of forces on both sides, and the decisions by AI to retreat from a lost engagement.

There is also lack of exploitation of other game types than First Person Shooter Games.

SERIOUS GAME FRAMEWORK FOR MILITARY TRAINING
In this section, we will describe a possible framework based on what has already been said about military simulations, game technology, and the current use of game technology in military training.

The framework will provide the following aspects of a military situation:

- Training of military personnel for specific cases A case is a scenario which encompasses a location (an unknown building, a map of the building), people (how they look, how they dress), time (what time of the day, the effects of the time to the environment, how the operation can be carried out differently at different hours of a day).
- Compiling a list of cases and designing the interactions and dependencies between the cases.
- Compiling a list of tactics for each case within a given context.
- Real-time monitoring of the environment by military equipment and conveying the information obtained to the game. The specifications about location, people, time, etc.
- The soldiers are dressed according to the natural environment around them, e.g. they camouflage by bushy dresses and then walk, they wear white clothes in snow.
- The core activities of military simulation systems, namely movement, perception, exchange, engagement, reasoning, dynamic environment (Figure 8).
- The main components of game technologies: 3D Engine, Graphical User Interfaces, Artificial Intelligence, Physical Models, Global Networking, Persistent Worlds.
- Allowing the possibility for conducting the tactics and strategies of military operations.
- Taking the social aspects of operation environment into consideration.
- Development of an easy to comprehend user interface.

This framework indicates that a serious game framework for military training will combine the aspects of the military simulation systems, the core aspects of the game technology and the social and the cultural aspects of where the military operations are carried out as shown in Figure 8.

The cases will represent the actual operations within this framework. We propose that a Case-based reasoning (CBR) system can be used to represent general knowledge and store complex, large-scale battle scenarios in the form of cases. This will ease the retrieval, revision, reuse and re-playing of earlier scenarios (cases) for training purposes. It will also be possible to suggest (novel) solutions to (e.g. how to act in) new and novel military scenarios and challenges. More detailed information on CBR and CBR-cycle can be found in Aamodt & Plaza (1994).

An example military case and how it relates to the military training game framework
Search operation in a building: The inside of the building is new to the soldiers. The soldiers do not know how many corridors there are, how many rooms open to a corridor, what objects there are in the room. The soldiers do not know how the enemies inside look like.

The design process:
- The design of the operations environment and its implementation using an open source or a specifically developed game engine.
- Using methodology for storing the context for the given operation (composed of a combination of cases). As explained earlier, the specific cases can be modeled by using a learning technique e.g. case-based reasoning.
- Monitoring and integrating the real-time observations into the game environment. e.g. where the enemy is, if there are any vehicles outside the building.

Figure 8: The Serious Game Framework for Military Training
- A user interface which lists operation types, cases under each operation.

- The enemy avatars (Non-Player Characters) and a list of behaviors of them. A behavior can be as simple as shoot, run-away, take cover but also can be a tactic or a strategy that can be used by the enemy.

- Non-Player Character (NPC) building: realistic engaging characters, usually in the form of enemies.

- A formal language for describing tactics and strategies. A learning inference mechanism for creating new tactics and strategies. (A CI-computationally intensive method e.g. artificial neural networks and/or genetic algorithms can be as complementary to CBR). An action planning system for to achieve the tactics and the strategies (e.g. distributed, parallel, serial etc.) is also needed.

- Development of the animations for the actions within a given tactic or a strategy.

Given the framework, similar military scenario can be used to test the efficiency of the framework e.g. how efficient the soldiers become by training with a game based on the described framework.

**How the end-product game will work**

The personnel under training will be able to communicate with the user interface. The trainee will select an operation, and a case for the selected operation. The related game environment will be loaded, and an avatar will be assigned to the trainee. The trainee now can navigate in the environment virtually in the game environment, learn what is where, understand where such a danger occur in that environment, can get to know his/her enemy physically and strategically.

There is a multiplayer option for when the players are in the team-training mode. The players sitting at different computers will join the military team for the same operation, provided with the same game setting and being able to see each other’s actions and being able to communicate with each other.

**Conclusions**

In the second half of the first decade of 2000s, there has been re-awakening interest in the military world about the use of game technologies for military training. The impressive progress of game graphics, networking, and the use of Artificial intelligence techniques in games have shown that the realism required in military simulations can be achieved by game technologies. Attempts have been made where game technology based training is used in real missions. Expectations have increased towards increasing the overlaps among the military simulations, game technology and the social and the cultural aspects of simulated war fields.

As a result, we are interested in investigating and finding out at what level the Norwegian Military uses serious games for training within that scope. The other interests lie in designing metrics for measuring the effectiveness of the games that are being used in the Norwegian Military and carrying out the relevant measurements. This will be followed by designing a serious game framework that will either use an existing game or that will develop a new game for increasing effectiveness of serious games in military training.

In this paper, we have described the important characteristics of the existing Military Simulation Systems, the Game Technology and proposed a Serious Game Framework for Military Training as a first step. The next step will be to describe the framework to the Norwegian Military and carry out other investigations regarding the levels of use of game technology in the Norwegian Military.

Our first encounters with the Norwegian military show that game technology is becoming interesting for them. Extracting key game technologies and using those to create military specific systems might become a near future focus for them.

The development of the Unreal game engine and other technologies have allowed richer levels of detail and larger battlefield maps, making simulation games far more realistic and scalable than the earlier Doom-based game, hence more capable in meeting military needs.

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