An Overview of Training Simulation Research and Systems

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ABSTRACT
The use of computer simulations is a practical, limited-cost alternative to expensive physical training. Simulations also offer training where physical training cannot be conducted easily (natural disasters, large-scale terrorism). Well-designed virtual world-based simulations can be motivational, interactive, educational, flexible and, not to forget, fun. In this paper we review the history and current trends in both research and industry and the resulting technology and systems currently on offer. In this we focus on identifying which aspects have been much explored, such as graphic and audio technologies and scenario planning, and those less explored, such as other interaction modalities and agent behaviours including language and adaptability.

Categories and Subject Descriptors
A.1 [**Introductory and Survey**]

General Terms
Documentation, Design, Theory

Keywords
Simulation, Game, History, Trend, Characteristic

1. INTRODUCTION
With the development of computer technology, simulation has become more and more widely used in many fields of society. Simulation techniques not only play important roles in scientific study, but also occupy important places in education, military training, entertainment and almost any field imaginable. The basic concept of simulation is a technique of imitating the behaviour of some situation or process (whether economic, military, mechanical, etc.) by means of a suitably analogous situation or apparatus, e.g. for the purpose of study or personnel training. Computer based simulations are today used in a variety of fields, supported by a growing simulation industry.

The simulation industry presently produces simulation software for a variety of purposes, ranging from military training to management, dynamic systems engineering, computer games and the production of networked environments. The usage of computerized simulations ranges as far back as graphic computers, for example, the US Military developed a modified version of the electronic game *Doom* called *Marine Doom,* as a target practice simulation [13, 7].

The research and development sections of military institutions worldwide used to be the primary development ground for new simulations, however, in the past two decades, the civilian industry has rapidly outgrown the military budgets [9]. In recent years, the computer games industry has come to dominate the publicly known simulation market, and currently institutions such as the military are attempting to harvest the results of the massive research and development in the games industry. Apart from the military and games sectors, engineering companies, medical suppliers, emergency responders, education technology specialists and other groups are heavily engaged in the development of simulations for a variety of purposes, to the extent where the non-game part of the civilian sector outranks the military and games sectors [21].

Simulation technology is today highly advanced graphically, and with respect to audio, interface and similar issues. However, substantial research effort is currently being directed at improving the artificial intelligence (AI) of all types of agents, integrating better LiveSpeak capabilities between trainees/players, and improving language technologies of agents. These research efforts are concerned with handling factors such as emotion, behaviour, gesture, cognitive modelling and user modelling. Such factors are very difficult to program and thus present a new level of challenge that the simulation industry only recently has developed some capacity to tackle.

Simulations for the military, police and civilian emergency responders are increasingly developed on top of graphics and physics engines developed by the games industry simulations [7]. The games sector has developed numerous visually realistic simulations of military combat or police operations (e.g. Special Weapons And Tactics (SWAT)), produced as games. These types of electronic games are simulations; however, they are not expressly developed for training, but for entertainment. But because of the visual appeal of the game sector simulations, institutions such as the US military have adapted several commercial combat simulators for use in military training (e.g. [9 , 13]).

Simulation technology (all types) is today the focus or a major component of several academic conferences, including the Autonomous Agents & Multi Agent Systems (AAMAS), International Association of Agricultural Students (IAAS), Language Resources and Evaluation (LREC), Technologies for Interactive Digital Storytelling Entertainment (TIDSE), Serious Games Summit, International Game Developers Association (IGDA) Expo, Electronic Entertainment Exposition (E3) and the Institute of Electronics and Electrical Engineers (IEEE). Several academic journals are dedicated to the field, each usually specific to a defined branch, e.g. engineering, medical simulations, or combat oriented simulations. These include: *International Journal of Intelligent Games & Simulations Game Studies Journal of Game Development* Finally, several organizations exist to support and promote the use of simulations in various fields, such as the *Simulation Industry Association of Australia* (SIAA). As such,

simulation technology today forms a coherent if somewhat multidisciplinary field of research, and the publication rate is substantial due to the variety of applications for simulation technologies (e.g. [7, 6, 20]).

In the following section we review the interplay and overlap between simulation systems and game technology. In section 3 we define some of the characteristics, types, approaches and technologies commonly in use. In section 4 we describe three databases we have developed related to this field. Emerging patterns appear in section 5. Our conclusions are given in the final section.

2. THE INTERPLAY BETWEEN GAMES AND SIMULATIONS

There is much variety in the type of simulations which can range from mathematical algorithms predicting variance or molecule behaviour to training. However, reports on the use of simulations in our area of interest (training software for military, police and emergency responders) are not so common. Noteworthy contributions have been produced by Herz and Macedonia [7], and Kavakli [9]. These surveys, which attempt to further develop the links between the computer games industry and security applications, offer a good review of the games/military interplay from the 70s onwards.

2.1 The Past

Herz and Macedonia [7] stated that even though commercial gaming and military simulations have common antecedents, since the 1970s they have developed differently. Commercial gaming started off as a smaller and weaker industry that was run by enthusiastic programmers. They did not have access to large financial resources or institutional support, and personal computers were very slow. Military simulations on the other hand were funded well and developed technologies ahead of the civilian and commercial markets. This resulted in, for example, the first DARWARS simulators (a funded project by the Defense Advanced Research Projects Agency (DARPA), hence the title DARpaWARS).

As the Internet became accessible to the general public in the early 1990s, the commercial computer game community took advantage of it. In 1994 the *Doom level editor* was released and there was an explosion of player modifications that were released through the Internet. The internet caused a boom in the commercial game industry, and alongside personal computers getting faster, the discrepancy between military simulations and commercial games vanished.

In 1999, the U.S. Army established the Institute for Creative Technology (ICT) to explore the use of commercial entertainment technology and content for military training and education [10]. Is it surprising that it is situated at the University of Southern California, in Los Angeles, so close to Hollywood to take advantage of the entertainment industry, with its expertise in story, character, visual effects gaming and production. The ICT is working with STRICOM and commercial game-development companies to create training simulations.

From the emergence of the internet, nearly every commercial strategy and combat game came with a built-in level editor and other tools to modify the game. The *Doom* editor was used to develop *Marine Doom*, a modified version used in training US marines, via the US Army funded *Institute for Creative Technologies* at the University of California (still existing and just received 100 million USD in funding).

Technologically, the military and games industries somewhat equalled through the 90s, however, the games sector was vastly more innovative, and spawned simulation industries within a range of fields, e.g. engineering, architecture (where True Virtual Reality (TVR) evolved), the molecular sciences etc. What the commercial field had which the military lacked was user driven innovation: Herz and Macedonia [7] suggest that the commercial games industry became successful due to its cultural infrastructure: Extensible applications constantly modified and improved by the player base, a highly motivated, globally networked, self-organising population of millions, all striving to outdo one another. With the innovation of persistent worlds, a new type of social online ecologies developed, and Herz and Macedonia [7] recommended that the US military adopt the same strategies in their training and simulation regimes not only to build tactically, but also culturally, within the military.

The Naval Postgraduate School in Monterey, California had already come to this conclusion and have developed a number of games [16] similar to consumer games Counter Strike, Delta-Force and Rainbow Six in the Modeling, Virtual Environment and Simulation (MOVES) Institute. Through MOVES, the U.S. Army launched a computer game called America's Army over the Internet [10]. America's Army consists of two separate games; Soldiers, a role-player based on Army values, and Operations, a shooter game that takes players on combat missions. The game accurately depicts military equipment, training and the real-life movements of soldiers.

2.2 Now and Beyond

Today, the field of simulation technologies spans several academic fields. As mentioned in section one, conferences are held almost monthly and several journals are dedicated to various aspects of simulations, such as medical, agent control etc. Most countries or regions have associations or societies of simulation companies and developers. On the military side, the use of simulation for training purposes has spilled over to police and emergency responder training, such as the *HazMat* simulator for learning about the appropriate handling of *Haz*ardous *Mat*erials.

Non-commercial simulations are often based on commercially available computer game graphics engines (world editors), as these form a vastly cheaper platform than the military method of developing graphics engines for the specific application.

Game engines such as UnrealEd 3.0 and Hammer are highly advanced in terms of in-world physics, lighting and texture effects. However, language technologies, human-agent interaction and AI are still greatly lacking in realism and utility. These subjects form some of the key research areas in today's simulation industry, and it is also here that the greatest room for innovation lies.

3. CHARACTERISTICS OF SIMULATIONS

3.1 Definition

Simulation is a method for implementing a model over time [18]. Rothwell and Kazanas [17] defined a simulation as an "artificial representation of real conditions". Simulations form a type of learning process utilizing computers, intended to be engaging, educational and highly interactive. It is important to realize that computer simulations cannot replace practical experience because

the number of variables programmed is fewer than needed for complete reality, and the simulated environment does not feature the physical limitations of the real world. Commonly, simulations are used as supplements to practical experience between the lecture room and physical training and simulation/real world, for example fire brigade trainees use the HazMat simulator to conduct training in handling emergencies before continuing to physical, staged simulations. A huge advantage of these training programs is that it is cheaper to train people in a virtual environment than staging similar physical simulations (for example, training fire fighters to put out a fire that has been set to a house in virtual environment, using technology such as Virtual Reality (VR) incurs less financial cost (and none beyond runtime) in comparison to the same action in the real world).

The categorization of simulations varies from publication to publication. Deborah Farber [5] recognized two overall categories:

1) Experimental simulations place the learner in a particular scenario and assign the user a role within that scenario. The user takes on the role and responsibilities in a virtual environment. Thus, the user gains valuable problem-solving and decision making skills. Related to experiential simulations is **problem-based learning**, used in many medical schools.

2) Symbolic simulations depict the characteristics of a particular population, system or process through symbols. The user performs experiments with variables that are a part of the program's population. Symbolic simulations present the user with a **scenario**, and the user must formulate a response to the situation, in order to receive feedback. Many computer based training simulations are of this type.

A different set of categories were presented by Boyle [2]. He identified three types of simulations based on the level of student activity that is required. The first of these is **passive simulation**, where the student observes the operation of a simulation as it unfolds. Secondly, **exploration simulation** is an unfamiliar environment where a student selects from multiple paths to navigate through. Thirdly, **task-based simulations**, which are of greatest educational value, are where students interact with objects or characters in realistic situations to achieve a specific goal.

Davis [4] and Prensky [16] classified training simulations into three groups: virtual, constructive, and live simulations. In virtual training simulations, the user is immersed in a virtual world. In constructive simulations, tactical and strategic decisions are made testing the user's ability to use the resources effectively. Live simulations allow users to practice the physical activities with the real equipment.

Simulations are widely used as learning tools for training students in various fields, such as combat, command, fire safety, driving and so forth.

3.2 Features

No matter the categorization used, problem-based virtual reality simulations for military, police and emergency responder training share a few characteristics. We analysed the characteristics of computer games [3] and training simulations [12]. They also share similar characteristics. This similarity might be the reason for the adoption of computer games as training simulations. These may be represented as follows (with the titles referring to the characteristics of games defined by Crawford [3], and the rest referring to the characteristics of training simulations defined by King [12]):

- Virtual Representation of the Reality: They provide the user with practice in representative aspects of real situations
- Safety: They form a practical alternative when the real experience is too dangerous, too expensive, too slow, too rapid, or impossible to experience
- Conflict: They provide a method for rehearsing what to do in stressful situations
- Interactivity: They provide a method for analysing problems before taking action. They provide discovery through immediate and direct feedback. They give an opportunity to reproduce a chain of events that could not be repeatedly observed in a natural setting

Depending on specific uses and programming, the following can also be applicable to training simulations:

- Some simulations include the opportunity for change and development during all sequences of the activity
- Simulations can include interaction among participants, if group activities are included
- Depending on programming, they can provide informative feedback
- Depending on programming, they can provide a critique or debriefing period

There are various limitations and problems as well, notably [12]:

- Simulations cannot react to unexpected 'sub-goals' which learners may develop during the process
- Simulations may be more time consuming than alternative learning activities
- Learners may become wrapped up in the simulated activity (especially if game based) and lose sight of its objectives
- Learners will have varying experiences and may not complete all components
- Success of the simulation will depend heavily on the design
- Negative biases may exist in the design, and undesirable attitude changes may be produced as a result
- Published research on simulations is sketchy and in many cases inconclusive
- No widely accepted criteria have been established for decisive evaluation of simulations
- Simulations to date are limited in their language technologies, agent-based design issues are many, and AI of agents next to non-existent, providing problems with realism and autonomous agents. This problem can however be

overcome with live instructors and by making simulations team-based (see below).

There are varying degrees of VR, which add to the user's perception of reality in the simulated environment. Kavakli & Kavakli (2004) found that a computer game may reinforce learning of a historical event with the presentation of a proactive and interactive learning environment that is suitable for legitimate peripheral participation. Situated learning is usually unintentional. Learners become involved in a community of practice which embodies certain beliefs and behaviours to be acquired. This is called the process of "legitimate peripheral participation". Navigation is an important concept in situated learning. Computer games emphasize active perception over concepts and representation. This may cause automated recognition of the presented facts by evoking players' attention.

Games that attempt to combine simulations with game-rules and entertainment include *Counter Strike* and *SWAT*. As the images become larger and the interactive controls become more sophisticated, the suspension of disbelief and the immersion of the user in the virtual environment increases. Devices that increase this perception include wrap-around display screens, motion-capture suits, wearable computers, odour generators and haptic controls that let the user feel simulated objects. These more advanced versions of VR are here referred to as True Virtual Reality (TVR).

3.3 Agents

Agents are currently being applied in domains as diverse as computer games and interactive cinema, information retrieval and filtering, user interface design, electronic commerce, autonomous vehicles and spacecraft, and industrial process control. Agents can have any number of characteristics, including being **autonomous**, having **reactivity**, **social ability** and **pro-activeness**. An autonomous characteristic means that agents can operate without the direct intervention of humans. Reactivity means that agents can perceive their environment and respond in a timely fashion to changes that occur in it. Social ability means that they can interact with other agents, and pro-activeness enables agents to do not simply act in response to their environment, but are able to exhibit goal-directed behaviour by taking the initiative.

There is in addition the issue of how the agent interacts with the human user of the simulation. Some of this interaction is through movement cues, but language is another major modality. The simplest form is a one-way one, agent to user, through canned text uttered by the agent. More sophisticated is the use of language that is not pre-defined. In this situation there are two directions to be considered: agent to user (requiring language generation by the agent) and user to agent (requiring language understanding). For agents to generate language, interaction with the graphical aspect needs to be considered, so for example the facial expression should match the language utterance, tying in with any emotional expressivity of the agent; system with this kind of capability is the talking head RUTH [19].

In the other direction, language is a particularly natural way for a user to, for example, give directions to the agent, rather than writing scripts, using a mouse (for which it is difficult to give general or conditional instructions; for example, "if a military vehicle enters the checkpoint, open the gate"), or other means. A system which allows for this is one developed at the Center for Modeling and Human Simulation at the University of Pennslvania [1]).

All of these systems, however, are still primarily within the research community, with many issues still to address.

3.4 Game Engines

Since the release of the level editor of *Doom*, limited versions of most popular game engines are currently freely available. For substantial modifications, licenses have to be bought from the producers, and such licenses can cost in the hundreds of thousands of US dollars, as is the case with the UnrealEd 3.0 engine.

Commercially produced game engines are of interest to the simulation industry involved in developing simulations for military, police and emergency responder training software, because a game license is vastly cheaper than the production costs of a new virtual world system. However, game engines are strictly VR-based, and thus research projects focusing on TVR training environments have been forced to develop their own graphics engines (see e.g. [14]). One notable exception is the A-Rage produced *Dino Park*, which uses a modified *Quake III* engine in a TVR environment (see http://www.a-rage.com).

There are hundreds of game engines, with various strengths. Only a large handful are however complete systems of super-high calibre like the Hammer 4 and the Doom 3 engine. A good overview and lists of game engines is provided at: http://cg.cs.tu-berlin.de/~ki/engines.html. We introduce a few of the well - known engines next.

Torque: The Torque engine is the currently most popular "indie" game development engine, used by freelance programmers worldwide. It is not as advanced as Unreal or Hammer 4, but versatile and simple to use. It is coding heavy, however, it features a built in world editor. Torque is a cross-platform game generator, and is fairly well supported community-wise. For more information see: http://www.garagegames.com/pg/product/view.php?id=1

UnrealEd 3.0: Developed by Epic Games, the Unreal engine is the second of the two currently most advanced engines – barring perhaps the new *Doom 3* engine. The toolset is highly advanced, even in the free version that comes with most retail games using the engine, and is supported by a massive community. For more information see:http://www.unrealtechnology.com/html/technology/ue30.shtml

AURORA: This is the toolset for the Bioware produced CRPG *Newervinter Nights* game series. While not as realistic and adaptable as UnrealEd 3.0 and Hammer 4, the AURORA toolset allows for virtually unlimited customization and comes with a build in games master/instructor feature, which is a huge bonus for anyone wishing to include a live instructor. AURORA has however mostly been used in fantasy-themed MODs, not for real-world inspired combat MODs as Hammer 4 and UnrealEd 3.0 has. For more information see: http://nwn.bioware.com/builders/

Hammer 4 (HL2-SDK): Hammer 4 is the modelling tool (Source SDK) that was used to generate Half Life 2. Sporting amazing graphics and the Havok dynamics engine, it currently sets the standard for game graphics and physical realism together with UnrealEd 3.0. For more information see: http://www.steampowered.com/?area=news

Havok 2: Havok 2 is a dynamics engine, not a development tool as such. Havok 2 is used in the commercial game Full Spectrum Warrior, a modified version of a simulation originally developed to train US infantry in urban combat by the ICT. Also used in the WWII game Medal of Honour. The Havok engine is currently one of the best for simulating physics, gravity, objects etc. For more information see: http://www.havok.com/

Doom 3 Engine: The Doom 3 SDK was released by producer ID Software at the same time as the game. It is loosely based on Quake 3 radiant, but with powerful upgrades and differences, notably in relation to dynamic lightening, the particle system and bump mapping. The engine is graphically strong, and is compatible with the usual externals such as Maya. Until the release of Half-Life 2, the only serious competitor was the Far Cry engine. For more information see: http://iddevnet.com/doom3/basics.php

Far Cry Engine: Used in the production of the first-person shooter Far Cry, producer Crytek is comparable to the Doom 3 Engine, but as depicted in the game especially useful in generating lush, open areas and similar interior environments, where the Doom 3 Engine with its advanced shadowing system is developed for dark, interior and intense environments. The current version of the Far Cry Engine (Cry Engine) is 1.3. The Cry Engine MOD SDK was released shortly after the game, and includes the full suite of development tools including exporters, plug-ins, source code etc. For more information: http://www.farcry-thegame.com/uk/home.php

Gamebryo: Gamebryo is a cross-platform 3D graphics engine, which is optimised for the PC, XBox, PlayStation 2, and GameCube. More than 100 titles have shipped or are in development using Gamebryo, including e.g. the MMORPG Dark Age of Camelot. The engine is also used in the simulation industry, e.g. the EST 2000 Small Arms Trainer by Cubic Defense Systems, architectural walkthroughs and medial training. The engine is based on C++. For more information see: http://www.ndl.com/gamebryo-engine.cfm

Quake 3 Engine: Just like the Doom 3 engine, the Quake 3 engine was developed by iD Software. It is also designed for first-person perspective games. While a few years old, the Quake 3 engine has been the vehicle of choice for a series of military games/simulations, such as Medal of Honor, Call of Duty and Soldier of Fortune II. In terms of graphic capability the engine is not notably outdataed, and a huge mod community continues to use the engine, although users are gradually switching to the doom 3 engine. For more information see: http://www.planetquake.com/quake3/

4. DATABASES FOR TRAINING SIMULATIONS

As part of a training simulation project for crime and terrorism assessment, we conducted a web-based survey of simulations which uncovered around 50 simulations in total relating to either military, police or civilian training; the latter specifically concerned the training of emergency responders (firemen, medical staff). We have summarized the simulations into a Simulation Database (SD). For each simulation a range of condensed information has been collated. The level of detail of information varies from simulation to simulation, according to the level of information available online. More detailed information than is presented in the database generally will require direct contact with the research groups or developers in question. We have further created two databases specific to risk management for crime and terrorism:

- Terrorism Incident Database and
- Airport Security Scenarios Database.

A description of each of these databases follows.

4.1 Overview of Simulation Database

The Simulations Database (SD) contains a list of simulations utilised for e.g. military training purposes. It includes various information such as input devices, graphics mode, purpose, developer etc. The format of the SD enables the user to search any of the information categories. About 50 simulations are treated.

4.1.1 Classification of Simulations

It has not been possible to locate a published classification system for training simulations of the type analysed. Simulations are inherently difficult to classify beyond the categories detailed in Section 3. The vast majority are experiental simulations, based on problem-based learning (e.g. VBS1 (Virtual Battlefield Simulator)). The nature of the problems can vary, from eliminating a fire hazard, flying an F-16 to a target or controlling a contingency of soldiers. There are however a few symbolic simulations, notably the DARWARS and the Weapons of Mass Destruction Decision Analysis Center (WMD-AC), although strictly speaking these are mixtures. Virtually all encountered simulations are task-based, because of the nature of the training (military, police, emergency responder); however, the large scale command simulations in particular include some explorative elements. In the SD, three major classification systems have been constructed. Neither one of these is sufficient to describe any one simulation, but together **Focus, Scale** and **Features** provide a good generalized classification.

- **Focus**: *Police, Military, Civilian* (Fire Brigade, Emergency Responders, Other Civilian). **Military** includes both navy, air force and army purposes, ranging from sophisticated flight simulators to squad-based combat and tactics. **Police** includes all forms of police work, from investigative work to driving or handling suspects. **Civilian** covers all simulations working outside the law enforcement and military sphere, e.g. the HazMat training simulation for firemen, or the WMD-AC simulation which trains city administration officials to handle terrorist incidents or natural disasters.

- **Scale** – either *city-size*, *command-based* (military division), *department-based*, *individual*, *individual + squad-based, platoon* (two or more squads), *squad-based* or *unspecified*. The scale of the simulation is related to its purpose. Military training simulators need to support different features and scenarios depending on whether they are targeted at squad training or officers learning field commanding. Some of the newer simulations from e.g. ICT has several scales available, and DARWARS was originally intended as a simulation system encompassing all levels of military training, from individual soldiers to full command simulations.

- **Features** – There are three key components in this category, notably: 1) whether the simulation uses VR or TVR; 2) what type of input devices are used (mouse, keyboard, headsets, gloves etc.)

and; 3) whether there are live instructor features built into the simulation.

As an example of a brief description using this classification system, the VBS 1 US Marine Corps simulator is a task-based problem-solving learning system focused on squad-scale military combat, featuring standard VR and input devices as well as LiveSpeak capabilities and live instruction features.

Or in short (ideal for tabulating data): Task-based simulation focused on military squad-level training using standard VR technology.

4.2 Terrorism Incident Database

The Terrorism Incident Database (TID) contains data from a variety of sources, notably online incident databases such as the Memorial Institute for the Prevention of Terrorism (MIPT) and the ICT. The purpose of the database is to function as a basis for the formation of an overview of the type of scenarios that anti-terror first and second responder groups worldwide might encounter. One of the features in the SD is whether the simulation is related to counter-terrorism. As this database is very specific to our application area, we do not provide any details here. Readers specifically interested in this domain are invited to contact the authors.

4. 3 Airport Security Scenarios Database

The Airport Security Scenarios Database (ASSD) contains scenarios that would occur during a customs officer versus passenger interrogation. The purpose of this database is to detail the various types of scenarios a customs officer could be faced with. A sample screenshot based on a scenario from the ASSD is given in Figure 1.

Figure 1: Screenshot of the Virtual Environment we have created for the Airport Security World using the Unreal Tournament game engine.

5. EMERGENT PATTERNS

A few generalized patterns can be drawn from the limited research presented in the SD:

1) There is a clear distinction between the types of simulations targeted at military, police and civilian training. **Military** simulations tend towards focusing on helping trainees understand the consequences of strategic decisions in high-risk situations, modelled in hyper-realistic virtual reality or TVR. Examples include: Virtual Battlefield Simulator *(VBS1),* Mission Rehearsal Exercise (*MRE)* and Joint Conflict and Tactical Simulation *(JCATS)*. **Police** training simulators come in two types: a) hand-eye-co-ordination of high-risk situations, such as the apprehension of a criminal, using wall-to-wall screens and laser weaponry; b) driving simulations used to practice e.g. pursuit. A few of the commercial police games/simulators have focused on investigative procedures, however, there do not appear to be any professional applications with the same focus. Examples include: *Police Trainer, Police Tactical Training, PatrolSim III* and *G Police*. **Civilian** training simulators incorporate a wide variety of simulations, most of them focus on emergency first responder training. Examples include *WMD-AC*, *SVS Immersive* (a product produced by Advanced Interactive Systems) and *HazMat*.

2) Following the September 11th attack on the US, increasing support has been granted to anti-terror training simulations worldwide [11, 13]. Most of these appear to be under development, but highly advanced, using e.g. TVR. Examples include *Anti-Terrorism Force Protection,* Special Operations Command (*SOCOM)* and the simulators developed by the Design Academy (US) (see http://www.copybook.com/publications/article.asp?pubID=15&artID=1305). Interestingly, one of the major terrorist organizations (in the eyes of the US) developed their own 3D computer game/simulation. Hezbollah claim that they with their game *Special Force*, where the players embody Hezbollah members fighting against Israeli soldiers, is an attempt to make sure that their version of the conflict in the Middle East is presented [15].

3) Due to the massive research and development in the computer games and simulations industry, the military, police and civilian training simulations are increasingly using existing graphic engines instead of developing their own. Game engines such as *Unreal* (1, 2.0, 2.x and 3.0) have been utilized as platforms for the development of military simulations. They provide a cheaper alternative. Simulations projects that do not focus on avatar-based presentations of the players such as *DARWARS* are however forced to develop individual platforms.

4) Graphic and audio technologies as well as tactical and strategic scenario planning appear to be highly sophisticated in simulations. These areas were very primitive only 10-20 years ago, and formed tangible limitations. Therefore research and development was initially focused on developing more convincing graphics and audio systems. In recent years, an increasing portion of the research in simulations has changed to be targeted at developing better language technologies, the incorporation of emotions and expressive body language in autonomous agents and the construction of TVR environments.

6. CONCLUSIONS

Computer simulations can never capture all of the intricacies of the real world and therefore cannot replace practical experience. They should only be considered as a supplement to the training program because no educational tool is sufficient by itself or is any tool effective for everyone.

If practical experience is unavailable due to certain conditions like limited access then utilizing a computer simulation may be an effective alternative to consider. The users have regarded simulations that are well designed as motivational, highly interactive, educational, individualized and fun. Simulations support a discovery and inductive learning process and could be set up to support collaborative learning.

Simulation and games currently have highly advanced graphics, which is continually being improved. Games are currently lacking in the areas of AI capabilities and human-agent interaction. Although there are some exceptions to this such as the Black and White game that has quite advanced AI. In this game the creature being trained starts out as being unintelligent, but as it learns from the player and other beings in the game it grows in intelligence. It is able to learn from mistakes and understand good from bad. Human-agent interaction is an area that is currently being worked on in both simulations and games and will have the most avenue for improvement.

The future will bring more advanced AI and human-agent interaction such as: intelligent conversations, improved agent learning and more human-like characteristics in agents so that they will be undistinguishable between humans.

In conclusion, the use of computer simulations is a practical, limited-cost alternative to expensive physical training. Simulations also offer training where physical training cannot be conducted easily (natural disasters, large-scale terrorism). Well-designed virtual world-based simulations can be motivational, interactive, educational, flexible and not to forget - fun. They are rooted in the current culture and especially the younger generations feel well at home with them. Computer-based simulations support discovery and inductive learning, and can be designed to support collaborative learning, as is seen in e.g. the MRE and VBS simulations.

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