An Agent, a Bot and a CGF Walk into a Bar…

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Abstract. Artificial entities in virtual environments have many associated names: agents, Bots, Computer Generated Forces (CGF) and Non-Player Characters (NPCs). Understanding the differences and similarities between these will allow for jokes to be made and progression of artificial intelligence (AI) research due to knowledge exchange and re-use. The major difference between games and military simulations is the purpose: games are created to entertain, whilst military simulations can have objectives related to operations research or training. Twelve critical areas for comparison of the AI are examined: goals of the AI, cognitive model choice, actor variance, faithfulness, level of detail, modularity, performance, visualisation, visibility, repeatability, cheating, and validation and testing. This basic framework can be used as a basis for comparing a given computer game to a military simulation and thereby allowing for knowledge transfer between the two communities.

1. INTRODUCTION

A decade ago, military simulations represented the pinnacle of achievement and state of the art in the area of virtual environments. Today, computer game technology has developed at such a rate that in some areas it is comparable to, or more advanced than some simulation technology. Recent advances in computer graphics and a drive to more realistic imagery has meant that the visual aspects of games have been a major driving factor. It is expected that in the near future areas such as artificial intelligence (AI) will gain greater prominence [6]. Hence, AI is an area in which meaningful and useful comparisons can be made between military simulation and game applications.

Pondering the conclusion to the joke posed by the title might fill a few minutes of light-hearted whimsy, but there is a deeper significance. This particular genre of jokes finds humour in the differences between characters. By providing evaluation criteria allowing a superficial comparison to be made of the technologies associated with the generic view of AI (agents), the view of AI from the games industry (Bots) and military simulation (computer generated forces), this paper will enable consideration of their similarities and differences.

This topic is interesting from a computer science, software engineering and cognitive science research perspective. Both military simulations and computer games have a basis in computer science, so it is interesting to investigate how the two fields of research and development differ. From a software engineering perspective it is useful to understand how purpose changes the implementation. Designing models of human or other behaviour is at the very core of modern research in the cognitive sciences.

When considering using computer game tools for military simulations or vice versa, it is essential to understand where the two areas converge and diverge. A closer interaction will help the progression of this type of AI for both domains and allow re-use of virtual worlds. For instance, there is a large community that uses first-person shooter games to investigate new AI techniques [13]-[15] for use in academia and the computer games industry.

The goal of the paper is not to identify places were current technology cuts across the three domains, although the paper inevitably uncovers the more obvious of these. Rather this paper should be seen as the first draft of an AI evaluation framework allowing the alignment of research and development with the long-term and perhaps unrealistic goal of reunifying AI.

2. VIRTUAL ENVIRONMENTS

A definition of the virtual worlds that will be explored gives a better understanding of the comparison space is obtained.

2.1 Military Simulations

The term military simulations can encapsulate many definitions. This paper refers to simulations of the military environment for use in research and training within defence, not computer game military simulations such as racing or flight simulators.

Military simulations can range from having no humans and running faster than real time (operations research), to having only one human in the loop (training simulators), to having only humans (experimentation). Purposes for military simulations include:

- Platform/system acquisition advice

- Tactics and concepts of operation (CONOPs) evaluation and creation
- Platform/system/human factors analysis
- Training

Computer Generated Forces (CGF) is a term used to describe all actors in a simulation that are not controlled by a human. In DSTO – Air Operations Research (AOR) branch, intelligent agents are used as the underpinning technology for modelling the human decision-making component in military simulations for Operations Research (OR) [3].

2.2 Computer Games

The computer games considered in this paper include both console and PC games. The purpose of games is to entertain the player.

Similar to military simulations, computer games can range from no humans (spectators only), to one human against one or many computer opponents, to many humans playing in teams or against each other without any computer opponents. Usually computer games are run in real-time, however some strategy games (e.g. building a civilisation over hundreds of years) are run faster than real-time.

The term “Bot” is short for robot and refers to the computer opponents in first-person shooter games. Human-like characters are called Non-Player Characters (NPCs) when the AI is more benign.

2.3 Comparison of AI Roles

Within both military simulations and games, the “AI” can take on a number of roles within the virtual environment. See Table 1 for a list of possible roles of AI in computer games and military simulations.

Table 1: Roles of AI in computer games and military simulations

Computer Games [6]	**Military Simulations**[1]
• Tactical Enemies & Partners • Support Characters • Strategic Enemies • Units • Commentators • Racing Opponents	• Representation of Humans • Representation of Systems • Exercise Management • System Management • Infrastructure

[1] Categorisation emerging from a recent TTCP meeting exploring the utility of intelligent agents in military simulation.

3. COMPARISON OF VIRTUAL ENVIRONMENTS

Although in many respects military simulations and games appear similar on the surface, it is the level of differences and similarities that must be explored. When using game tools and techniques for military simulations and vice-versa, an understanding of how the military simulations and games compare and contrast is needed in order to be able to modify the tools and techniques to suit the new usage. Twelve characteristics have been chosen as the basis for further studies in this area:

1. Goals of the AI
2. Cognitive Model Choice
3. Actor Variance
4. Faithfulness
5. Level of Detail
6. Modularity
7. Performance
8. Visualisation
9. Visibility
10. Repeatable
11. Cheating
12. Validation & Testing

3.1 Goals of the AI

The purpose or goal of the AI itself may not be the same as the purpose of the overall game or simulation. Game AI can be defined as any decision made in a game [2], this includes random number generators, like in Tetris [9]. The "suspension of disbelief" of the player is the main goal of game AI [11], not passing the Turing test or being a test-bed for AI research [9]. Behaviour that results in the player having fun is more important than “interesting” behaviour [2]. Game AI can be too successful (by beating the human player consistently). AI should enable, or facilitate immersiveness as a way of making a game entertaining; smarter AI does not always make for a more entertaining experience [2]. Other sub-goals of game AI are to [9]:

- Challenge the player
- Not do dumb things
- Be unpredictable
- Assist storytelling
- Create a living world

The goals for AI in military simulations can be exactly the same as above depending on the purpose of the simulation. For instance, training simulators require the trainee to be challenged and can require a storytelling aspect. OR simulators do not necessarily require these two goals.

Bad AI is most easily noticed when the character does something “stupid”; good AI is often not consciously noticed by the researcher or game player, i.e. a human cannot immediately notice the difference between an artificial actor and a human actor. It is a waste if the AI isn’t visible to the game player [2] or doesn’t contribute to the outcome of the military simulation.

3.2 Cognitive Model Choice

The cognitive model used to implement human decision-making behaviour depends on the purpose of the simulation. In AOR,

For example, in AOR, DSTO, one of the cognitive models used is based on Boyd’s Observe-Orient-Decide-Act decision-making loop [1]; a well known model of military decision-making, this has been implemented on top of a Beliefs-Desires-Intentions based agent architecture[3]. Agent models in computer games are diverse; ranging from finite state machines using schedules and the Observe-Decide-Act loop to include neural networks and genetic algorithms.

3.3 Actor Variance

Actor variance is due to different physical and emotional states. It manifests in two manners: across subject variability is where two actors will react to the same situation in a different manner; and within subject variability is where the same individual will react to the same situation differently [12].

Military simulations will only include actor variance such as differences in learning, emotion and personality in CGF when these factors affect the decisions of the agent and therefore change the outcome of the scenario. Both in games and military simulations, tactics & behaviours that work well with humans should work well with AI enemies [6], in order to train the operator for the real world.

In games and training simulators, level of difficulty design must be considered. The computer opponent must be at a similar level to the player and improve at the same rate as the player during the progression of the game or training.

By including variability, more engaging, unpredictable characters can be created in game AI, leading to more fun for the player and "suspension of disbelief". A less risky, cheaper, less time consuming (both in CPU time and development) solution to create unpredictability and engaging qualities is to use randomness and consider other aspects of the game.

3.4 Faithfulness

Faithfulness or fidelity refers to the similarity of the artificial system to the real-life system being modelled. When modelling a pilot in a military simulation, the requirement is to represent actual human decision-making behaviour only if this affects the outcome of the system or tactics that are being researched. For both game AI and CGF there is no need to include a feature or characteristic that isn’t relevant to the problem that is being solved.

Faithfulness to reality or human intelligence must be considered when the virtual character is supposed to be human-like. For instance when the game is set in a fantasy world with slug-like aliens, they may not be required to be smart or act like a human [9].

3.5 Level of Detail

Level of Detail programming is where objects that are not in the player's field of vision will be culled, that is use a less detailed representation for that object, such as more basic physics, graphics or behavioural model. This occurs for games and military training simulations. Objects that are far away need to be monitored to confirm that they aren't “stupid” or acting outside the constraints of the environment; a higher level of detail is used when the object moves into view [4][9].

In military simulations for OR, all systems must be modelled to the required level of detail consistently throughout the simulation. That is, systems that are not essential to the outcome of the simulation can be modelled to a low level of detail consistently and will never be modelled with a higher level of detail representation.

3.6 Modularity

Modularity or replaceability is the ability to exchange humans for artificial agents in any combination. In military simulations this function can be used to examine "human in the loop" experimentation, or to interchange agents with more or less detailed representations of humans. Computer games usually have at least one human and want to allow the player choose their role.

3.7 Performance

Performance or speed of the system is important for both military simulations and games, however the emphasis is not the same. Games must run whilst the player is immersed in the game and are often run in real-time. Turn based games must complete decisions quickly whilst the player is waiting, although the AI has access to 100% of the CPU.

In OR, military simulations need to be run several times faster than real time, in order to be able to complete multiple runs to find likely outcomes of the scenario.

3.8 Visualisation

Visualization or animation is used to help understanding of results and analysis in OR military simulations, it is not the primary goal. Physics and decision-making of the agent is more important than the appearance of the virtual world.

In computer games and training simulators, visualisation is very important. Physics only needs to be believable; graphics need to be good enough to immerse the operator in the virtual world.

3.9 Visibility

Visibility means that it is necessary to have available the detail of the intelligence, i.e. what the decision-making process is and how a particular behaviour was generated. Output data aids researchers and game testers in the areas of:

- Debugging – making the AI react in a desirable manner;
- Training – deciding if problems lie with the operator or the AI;
- OR – determining why a given outcome was obtained.

Resulting behaviour used to be more important than how that behaviour was generated in computer games. Given the increasing complexity of game AI, visibility is now a requirement [5].

In the computer game *Black & White* (Lionhead Studios), the player is in control of a creature that can be taught (see Figure 1). When the creature does something undesirable, you slap it; when it does something you want, you praise it. During gameplay the creature changes states quickly, by the time you are able to slap or praise the creature it can be doing a new activity and you will teach it the wrong actions. In the upcoming *Black & White 2*, the creature will become less of a "black box" and the player will be able to gain direct insight into its brain, so that the player knows exactly for what purpose they are training the creature [7].

Figure 1: Screenshot of a curious tiger – interacting with your creature in *Black & White* (Lionhead Studios)

3.10 Repeatable

Repeatability requires that each run of the simulation can be exactly replicated. It is required to assist in the verification and validation of the results that are produced by a simulation for OR. The introduction of a human element, such as a trainee in military training simulators, makes it impossible to make runs repeatable.

Apparently at odds with the requirement for repeatability is actor variance. Wray and Laird are beginning to implement variability that can be validated across different artificial agents in military simulations [12].

Adaptive AI or AI that can learn is generally not desirable in OR military simulations since it means that runs are not repeatable. This is particularly true in war-games of a statistical nature in which hundreds or thousands of variations the same scenario are run. Adding a learning capability will affect the overall statistical results from run to run as a particular agent learns and adapts a particular tactic. In many OR cases it is the tactic itself that is being studied and hence must remain a constant.

Variability can be provided by randomization in both simulation and computer games. To help understand complex behaviours or to conduct verification and validation activities in OR, a simulation run with the same initial conditions should generate the same outcome. There is not such a strict requirement on computer game applications since their purpose is to entertain.

Games that are similar every time the player uses it are boring. While logical consistency (such as physics) must be maintained, randomness is often injected into enemy AI in order to increase the player enjoyment. For instance, by randomising the starting point of Bots on a map, the player does not know exactly what is behind a given corner. Neural networks and genetic algorithms are not generally used in games since reproducibility and predictability, a very desirably quality [2], cannot be guaranteed and producers and developers cannot easily change game behaviour [11].

Games that improve after shipping are highly desirable to developers and producers; games that worsen are not [2] and could cause quality assurance issues [4][9]. In teamed games where Bots are required to interact with a human commander "the partner AI must coordinate its behaviour, understand teamwork, model the goals of the human, and adapt to his style"[6]. Game AI that can learn to adapt to the skill and abilities of a particular player will help address criticisms that game players have about modern complex games.

3.11 Cheating

"Cheating" is giving the AI access to more information that the human actor has available. For games and military simulations, AI is not yet at the stage that it has the same strengths and weaknesses as humans. An enemy Bot can have 100% firing accuracy and 360° vision, which even the best human players cannot achieve; AI in most current generation computer games cannot use anticipation or learning, abilities that good human players demonstrate. AI needs to have all abilities in proportion to the player's; otherwise cheating is obvious and the computer could always win, neither of which is fun for the player. The challenge for a game AI programmer is to allow the AI to cheat only enough to make an enjoyable opponent, e.g. a Bot that puts up a good fight, but allows the human to win in the end.

In military simulations, the CGF should behave in the same way as a human would. To approximate human strengths and weaknesses, problems such as machine vision must be overcome. The environment needs to be implemented in a way that makes it easier for the agent to interpret its surroundings. One method is to "label" objects in the environment with their possible uses. Although this can be termed "cheating" since it is allowing the computer to have access that a human does not, this extra information is merely to compensate for AI weaknesses. This form of terrain analysis is considered to be the next "big thing" for computer games [2].

3.12 Validation & Testing

Validation in military simulations is essential to confirm that the simulation is modelling the appropriate real-life system correctly. An essential part of the game development process is play testing for player's "fun", i.e. the game is not too difficult, it is intuitive and does not crash unexpectedly.

Game AI is play-tested over enormous scenario spaces, while AI for military simulations is highly validated over a very narrow set of scenarios. Compared to games, military simulations have a very small user set, resulting in training of the user not to cause crashes, rather than testing for crash cases.

Another difference is the type of testing that is appropriate. For games, the behaviour displayed to the user is most important – so black box testing is appropriate. When tactical development is examined in military simulations, the displayed behaviour and the decision-making process are important – white box testing is more suitable since the internals of the agent must be considered. The type of testing that is used depends on the simulation or game, and in some circumstances a combination of both types can be appropriate.

4. DISCUSSION

Games and military simulations have been compared based on a number of different characteristics: goals of the AI; cognitive model choice; actor variance; faithfulness; level of detail; modularity; performance; visualisation; visibility; repeatability; cheating and validation and testing. They have most similar AI in the areas of actor variance, modularity and increasingly visibility of AI. Game requirements are similar to military simulations when the game world is supposed to mimic reality. Unlike their game AI counter-parts, military simulations for OR currently demand high repeatability and more complex cognitive models.

The large general differences discussed here may not be significant in the context of a specific game or military simulation. Conversion of a game for military simulation purposes or vice-versa should include consideration of the twelve points developed here and their relative importance for the given case.

Development of complex environments can be a long and costly process for military simulation researchers who should instead exploit the highly stable game environments. Although CGF and Bots are not the same, insight into areas in which CGF need to be improved can be gained by an exploration into the differences between Bots and human-controlled actors [8].

The norm in the games industry is short project timelines [2], often the producer or the developer of the game is unable to spend time researching new methods that might fail and be costly. Large companies or individuals trying to break into the industry are often the only people who are able to accomplish new research. As a result there is limited scope within the games industry for research. Academic and military research projects are often on a longer time scale, allowing for the input of longer-term research and time for research into higher risk areas.

Comparison of military simulations and games can only be done if the given cases are more globally comparable. Action games are comparable military simulations with tactical enemies and partners are important [6]. Depending on the circumstances, support characters, strategic components and units in both games and their military counterparts may be considered to be comparable to theatre, campaign and mission level models.

In the history of game development, games were sold based on significant improvements in graphics. In the past few years these advances have begun to slow down due to the high realism already seen in graphics. As players cease to buy games based on graphics they will look for other aspects to distinguish each game. Game AI remains an area that needs further development and has the power to make a game be much more immersive, challenging, socially enriching and, most importantly, fun. Links between games and the AI research community are seen to be useful to both areas [10]; the twelve areas discussed here allow for further debate and comparisons.

5. CONCLUSION

AI for games and military simulations have been compared and contrasted based on a board range of attributes. These attributes aspire to be complete and form a basis for a framework by which one can compare the two areas for specific cases. Future work could involve determining quantitative measures for each point of comparison in the framework, thereby leading to the possibility of conversion or re-use from one medium to the other. Keeping in mind their similarities and differences, examining games allows us to gain an insight into methods that may be implemented in military simulations and vice-versa.

Agents, Bots and CGF can be implemented to their full potential when a greater understanding of their differences and similarities is gained. By contemplating the joke entailed by the title their strengths and weaknesses can be considered and exploited.

REFERENCES:

[1] Coram, R., (2002) “Boyd: The Fighter Pilot Who Changed the Art of War”, Little Brown & Co.

[2] Dybsand, E. (2004), GDC 2004 AI Roundtable Moderator’s Reports, http://www.gameai.com/cgdc04notes.dybsand.html

[3] Heinze, C. et al., (2002) “Interchanging Agents and Humans in Military Simulation”, *AI Magazine*, 23:2, pp37-47

[4] Kirby, N. (2003) GDC 2003 AI Roundtable Moderator's Reports, http://www.gdconf.com/archives/2003/Kirby_Neil.doc

[5] Kirby, N. (2004) GDC 2004 AI Roundtable Moderator’s Reports, http://www.gameai.com/cgdc04notes.kirby.html

[6] Laird, J.E.; van Lent, M. (*not yet published*) "The Role of AI in Computer Game Genres". http://ai.eecs.umich.edu/people/laird/papers/book-chapter.htm

[7] McLean-Foreman, J. (2003) “Black & White 2: Dev Diary #2”, Dec 8th 2003, GameSpy.com, http://www.gamespy.com/devdiary/december03/bandw22/

[8] Sandercock, J, (*in preparation*), “Comparison of Artificial Intelligence to Human-Controlled Actors”, DSTO Technical Report

[9] Rouse, R. (2001) "Game Design: Theory & Practice", Wordware Publishing, USA

[10] Woodcock, S., (1999), “Game AI: The State of the Industry – Academia and the Game Industry”, August 20th 1999, Gamasutra, http://www.gamasutra.com/features/19990820/game_ai_04.htm

[11] Woodcock, S. (2003), GDC 2003 AI Roundtable Moderator's Reports, http://www.gdconf.com/archives/2003/Woodcock_Steve.doc

[12] Wray, R.E; Laird, J.E; (2003) "Variability in Human Behaviour Modelling for Military Simulations", Presented at Behaviour Representation in Modelling & Simulation Conference (BRIMS)

[13] Website: http://www.gameai.com/

[14] Website: http://www.planetquake.com/

[15] Website: http://www.unreal.com/