University of Portsmouth

School of Creative Technologies

The effectiveness of learning artificial intelligence in video games.

By

Kieran Mark Grist

814853

Supervisor: Jahangir Uddin

CT6PRO

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# Abstract

The project looks at and assess the effectiveness of Neurological Networks within video games, looking at the current video games and technologies. The project creates and assess a video game created with a learning intelligence inside it and determines how effective it was.

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# Terminology

# Chapter 1: Introduction

Artificial intelligence as a method of controlling characters has been around since the days of Pong. Technology and hardware for the intelligence has been rapidly growing creating new techniques, software and games. Neurological networks are an imitation of our own brain and the network that produces it and it is a close attempt to simulate an intelligence that can learn from its actions.

In the following chapters I will look at and assess the effectiveness of a learning artificial intelligence in a video game. Describe and detail the process of creating the network and assess how effective the project was as a whole.

Primary areas of interest for this project are neurological networks, the workings behind them and programming a game designed around these networks.

The project will create SERE an evasion game where the AI must hunt and capture fleeing players.

# Chapter 2: Literature Review

## 2.1 Introduction into Artificial Intelligence in video games

Artificial Intelligence is a collection of tools and algorithms that attempt to imitate intelligence Gordon, B. M. (2011). Artificial intelligence is used in video games to create non-player characters (NPCS) which interact with the world and player(s). In Real Time Strategy games such as Planetary Annihilation (Star Theory Games, 2015) the NPCs use Artificial intelligence to battle each other in a global battle for dominance, in these styles of games the player will control where the units go but battles are usually automated.

Video game, artificial intelligence uses two main techniques, goal-driven behaviour and behaviour trees. These intelligence algorithms are designed to imitate realistic patterns set out by the programmers and are not designed to be realistic. (Buckland, 2011)

In most video games artificial intelligence is meeting gamers standards with some recent modern games creating challenging AI for players to combat in their objectives in the game. Such games like Heat signature use techniques like procedural generation and goal driven behaviour to create a dynamic and challenging game.

However, the AI can only adapt to a certain calibre of player level, and if players try new and untried tactics the AI may not be able to respond, often is the case that players find the AI weakness’s and exploit that be it game mechanics or bugs within the intelligence of the NPC.

## 2.2 Introduction to Neural Networks in video games

Neural networks are the simulation of a human brain using artificial intelligence, these networks can essentially be trained and learn from their actions and can recognise patterns from data inputted into them and select certain strategies. They can also adapt more easily to player personalities and can model the player behaviour and experience. (Yannakakis & Togelius, 2018)

Neural Networks or machine learning is currently used in most fields of research to answer question which would commonly take humans years of work. Neural Networks however are relatively new to video games and hence have less research and techniques to implement them into video games.

This is largely due to the performance requirements of these artificial intelligence compared to AD-HOC techniques.

There is the issue of balancing a neurological network. Balancing issues can arise from an intelligence, new players could have a hard time adapting to a smart learning computer, players can easily find a way to abuse the training data. These are just some of the issues from a development standpoint (Boser, Sackinger, Bromley, LeCun, & Jackel, 1992)

Another reason is simply that AD-HOC AI is easier to implement, neurological networks require training and data to be built and that comes with its own issues (Yannakakis & Togelius, 2018). Simple games like Pac-man (Namco, 1980) would not benefit in any way from a neurological network.

For the purpose of this study the effectiveness of neurological networks for small simple games is void this is due to the obvious ease that an AD-HOC AI can be created for these games within a much quicker timer then a neural network. The study is focusing more on larger games with more complex inputs as these are the games that most modern developers are creating and it would be a better test to put a learning AI in a game with multiple data inputs and unpredictable variables to truly test the system.

## 2.3 Neural Networks current capabilities within video games

Neurological networks do exist in video games. Forza Horizon 4 (Turn 10 Studios, Playground Games, 2018) uses them for its driver profiles to adapt dynamically to players techniques and create more dynamic AI for their game (Forza Support, 2019). Alpha star is a modded ai system for Star craft 2 (Blizzard Entertainment, 2010), Alpha star (DeepMind, 2019) is a Deep Mind AI that learns from its matches and training data and is currently battling the professionals of the game.

Neurological networks are very rare as of 2019 in the video game industry. With the only two examples being those above. However, their capabilities for games is evident. Machine learning AI has picked up games such as chess and are very effective competitors at the game (IBM, 1997). Using this knowledge Learning AIs on a base level should be effective at strategy games, specifically playing the commander of the forces. This is because they have all the information and learn from their mistakes often completing actions in a logical order and taking routes that players would not consider. Most strategy games have some computer opponents anyway which are adequate at the game so the systems should work with a learning AI behind them, as Alpha Star (DeepMind, 2019) proves within Star Craft 2 (Blizzard Entertainment, 2010).

Neurological networks are evidently capable of being the commander, which is one component of the game, however the true test of their effectiveness would be to look at agents. Agents must process information every frame and decide their actions using ad-hoc techniques which have a set outcome, I.E. Agent sees enemy, agent shoots enemy, enemy dies, agent carries on. Those steps have been programmed out for the ad-hoc AI, but a learning AI would have to learn how to do all that (Yannakakis & Togelius, 2018). In theory the most effective way to create the learning AI would have a hybrid of the two systems. The learning AI chooses what actions it conducts, and the AD-hoc programming will complete that action.

## 2.4 Main Differences between AI and Neural Networks

The biggest and most notable draw back of a neural network is the time and resources needed for it. Hypothetically it will take one day just to train it to walk around the map, whereas the AD-HOC has already got all those systems created for it. Simply put the ad-hoc ai is cheaper and more effective to have in a video game, the game can have more agents. Training the AI requires data and input as well as time to fix any learning issues. (Yannakakis & Togelius, 2018)

Continuing this learning AIS still need to be researched for video games, they are still a relatively new technology. AD-HOC systems already have the performance, research and industry standards. Learning AI is currently only in one game in a relatively small way and it was required for them to have a server farm to run that system. (Buckland, 2011)

However, the main advantage of neural networks is the realistic nature of them, while they require allot of training behind them, they are far more complex and capable of completing tasks that ad-hoc are not due to limitations. Neural networks can expand as much as the developers allow it to and in theory could be as competent as the players in the video games. There could be a chance that these agents are used in multiplayers games to fill in the numbers that way lower player count does not impact the players enjoyment on the game.

## 2.5 Current Issues with Artificial intelligence in modern games

Artificial intelligence in games can be complex beasts which can be hard to maintain and often have bugs, even triple A titles like outer wilds had bugs with the AI getting stuck or shooting at targets that the player wouldn’t otherwise know existed. Most issues with the current AI systems are the AI can get stuck within doors, or walls with small gaps, which players can get through but the AI struggles to. The AI can also have supernatural ability to see the player, even when they would not be spotted by another player.

The biggest issue with Artificial Intelligence is within its ability to adapt for players mistakes or personalities. The players can do unknown actions and the AI would either not respond or bug out and get stuck in loops.

In video games like Arma 3 ( Bohemia Interactive, 2013) the Artificial intelligence has a reputation for having god like eyesight and can see through objects. The AI also detects people from behind even when they are making no noise, this often makes stealth in the game difficult without modifications improving the AI.

AD-HOC also has a smaller issue with only being able to perform set tasks. If the AI needs to perform a new task or do something different it will need to be told to do that. This results in the AI only being as dynamic as it is programmed to be, while it can have responses to stimuli and actions upon that, if it hasn’t been programmed to complete that task or respond to that set of inputs it won’t do anything.

## 2.6 Industry Problems with Neural networks

Neural networks are rarely incorporated within the video game industry due to problems with the technology. The first and most substantial problem is resources needed to create a neural network currently there are multiple methods to creating a neural network (Yannakakis & Togelius, 2018), this will lead to unnecessary developer research into what method they need to use. Adding to this problem with resources is the time and data needed to teach the learning AI, hypothetically each node takes 500ms of a CPU and requires 1 day to train the data for that node, the more nodes added the bigger and more expensive the AI gets on the CPU. (Yannakakis & Togelius, 2018)

The second problem with the method is the current fact that video games can incorporate dynamic AI which can be realistic and immersive without the need for learning algorithms. Games like Heat Signature (Suspicious Developments, 2017) and Outer Worlds (Obsidian Entertainment, Virtuos, 2019) already have dynamic and realistic AI responses with little issues. Developers can create gold standard AI without the amount of time it takes to create the learning AI and with the added benefit of industry standards, documentation and resources on creating a better AI. AD-HOC AI within the industry is more preferable as it is easier to implement and does not require as many resources to create it.

Even though there are processes like reinforced learning a minor issue with neural networks is not being able to guarantee what a learning AI profile does if it gets shot at there is no guaranteed way it will seek cover if its brain decides to run at the player and stab them. This can lead to issues with the AI, while this does create dynamic gameplay, such as unpredictable behaviour and often doing the wrong action at the wrong time.

# Chapter 3: Methodology

## 3.1 Time Management

To manage the time, I have chosen the Kanban method. Kanban is a method of time management for just in time manufacturing. The work is put on a board which tracks tasks needed for the artefact and essay in the stages of the development cycle. Stages are not set in stone. This is effective for the project as a certain task may suddenly need to be developed or an idea was no longer viable.

As Kanban is less structured then other methodologies there are no deadlines, working to deadlines has always been more effective for me. This avoids the pushing stuff tasks aside because they do not have a deadline and leaving it to last minute.

To manage my time effectively I have chosen to keep a tight week development cycle. If a system has taken to long it gets pushed to the stretch goal region that way I can focus on the core systems of the project.

The artefact will need to be complete within 3 months to gather primary research, this requires me to have an altered Kanban system and run the project like an extended game jam having prototype systems instead of clean created code.

## 3.2 Analysing the artefact

To analyse the artefact, I have split it into two areas: Primary research of how a group of players interact with the game and primary research of how effective the learning AI is.

For the group it will be a focus group of 20 players, from any background possible, the focus group will complete a blind test on two games. I choose to do a blind test as it is a more effective way of gathering data (Haverford College, 2015). The blind variable for these tests will be which game has the learning AI and which game has the AD-HOC. The players will get a chance to play both games for 30 minutes, the only difference will be the AI. After each session with the game the players will be given a survey to fill out asking them quantitate and qualitative questions to gather data. After this it will be revealed as to which AI was the learning and they will have one final game with the learning ai, after this taking a final survey.

To measure how effective the development of a learning AI was I am going took at two areas. The performance of the learning AI and the development process of creating a learning AI. The performance will look at CPU, GPU, RAM AND DISK usage using unities profiler in test cases with both the learning AI and the AD-HOC AI seeing if the learning AI takes to many resources. The next is to look back at the development through GitHub pushes, project diary and notes as to how the process of creating a game for a learning AI went.

## 3.3 Software

Due to past knowledge and its ease of access to prototypes I have chosen to use Unity (Unity Technologies, 2019) for the project. The ad-hoc AI is going to be created using pre-created AI systems from either Unity (Unity Technologies, 2019) or online resources. Unity (Unity Technologies, 2019) is effective at creating the systems I need due to the nature of the component system it allows me to easily create the world and systems I want for the artefact and also allows me to create more dynamic gameplay in a quicker nature then unreal. It is also easier to develop for and to debug in making ideal for a project of 3 months.

# Chapter 4: Coronavirus update

# Chapter 5: Creating the Learning AI

## 5.1 SERE

SERE is a game based on the United Kingdom Special Forces selection process, the game aims to simulate this process of evasion. The learning AI will be trained to be the people searching for the players. The AI will get input from dogs, helicopters, thermal cameras and more to help them in their search. The learning AI will learn and use searching patterns to find the players within an area and their objective is to capture the players. The players must reach an extraction point without being caught by the AI. The world is procedurally generated which adds challenge both to the AI and players, the world is roughly 10km squared and can have various biomes and areas in it including jungle, woodland, rivers, desert, urban, fields and more.

## 5.2 Designing a game for an AI that learns

## 5.3 Building the AI

## 5.4 Training the AI

## 5.5 Testing the AI

## 5.6 Initial analysis of the effectiveness

## 5.7 Performance

# Chapter 6: Results & Findings

## 6.1 Group 1

## 6.2 Group 2

## 6.3 Performance Results

## 6.4 How much did the AI learn

## 6.5 Application of Learning AI in video games

* Hive mind and strategy games / Commanders
* Standard AI agents that learn
* NPCS
* Puzzle making
* Other
  + Asset creation
  + Level generation
  + Auto translating voices and text for multiplayer games

## 6.5 AI Profiling Results

# Chapter 7: Discussion

# Chapter 8: Conclusion

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# Appendences