**Investigating AI approaches and how they challenge resolutions: State AI vs Machine Learning**

This document will explain the aims and objectives of the project, my motivation behind choosing this topic and what problems I aim to solve. It will also summarise the work I will undertake to achieve the objectives.

**Motivation and Rational**

The context

Machine learning is core subsection of Artificial Intelligence, and it is used in many different sectors, from education, to healthcare, to entertainment. These machines are trained to carry out and respond to complex tasks using data from previous instructions, with the aim that they will eventually be able to carry out tasks individually and make decisions themselves. Over time, these machines can come to almost mimic human behaviour and therefore are a popular addition to video games as opponents.

The problem

There are many different AI types and algorithms, and they can change the behaviour generated by the AI agent. Simple AI’s can be used to move non-player characters (NPC) by using state machines or decision tress for example, whereas more complex AI can act as an enemy or even a player using machine learning techniques such as Reinforcement learning. I would like to explore whether the more intricate AI approaches have a better outcome over using State AI in a simple game of Hardpoint. Training the machine learned AI is time and resource consuming and this will presumably affect the outcomes as well and I would like to include this discussion on the “trade-offs” in this project.

The rationale

In this project I plan to investigate how different AI approaches can change the outcome of a hardpoint game and examine the learned behaviour of the AI units over time. This will be done by studying the wins/losses of a State AI team against an AI team that is being taught using deep reinforcement learning and imitation learning. Further aims of the project will be to explore the behaviours generated by the machine taught AI and how it compares to different “human” gameplay styles. For example, answering the questions: are the agents aggressive in their attacks, or more defensive? Do they “camp”? and so on.

**Aims and Objectives**

The overall aim of the project is to investigate how different AI approaches can change the outcome of a hardpoint game and examine the learned behaviour of the AI units over time.

Objectives

1. Explore and research different AI approaches and how they are implemented, focusing on Unity
2. Understand the limitations and risks of bias algorithms in machine learning and how these could affect the outcome of the study
3. Develop a prototype that can host AI units and run a Hardpoint game which can be watched and observed. The prototype should focus on simplicity for its interface to ensure it is easily viewable and understandable
4. Develop a State AI agent that can successfully complete a game of Hardpoint with no human interaction
5. Develop and train an AI agent using deep reinforcement learning and imitation learning to complete a game of Hardpoint
6. Gather and evaluate the outcome of a Hardpoint game when the two AI agents are played against each other multiple times
7. Gather, evaluate, and discuss the behavioural patterns developed by the two AI agent types over time by observing and recording the changes
8. Assess the effectiveness of training the AI by looking at the trade-off between training time and accuracy of the trained model

**Background**

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| **Ref** | **Resource Name** | **Info** |
| [1] | Computer Science: Abstraction to Implementation | Description  This paper describes finite state machines with example scenarios.  Reason  I will be developing an AI team that uses finite state machines so this paper will help increase my knowledge on these types of machines and how to implement them successfully. |
| [2] | Unity - Manual: Inner Workings of the Navigation System | Description  This article explains the inner working of the Unity navigation components, such as the algorithms used and how they work.  Reason  The Unity navigation component tools will be helpful throughout my project and will be used in different places. For example, the NavMesh will be used for the State AI movement. Therefore, it is important that I understand what is happening in the background to ensure I can compare AI approaches effectively. |
| [3] | Deep Reinforcement Learning for Navigation in AAA Video Games - Ubisoft Montréal | Description  This article explores the limitations of using a NavMesh for more complex maps and character movements – such as wall running, reaching rooftops, etc. It highlights that NavMesh becomes impractical after a certain point and compromises must be made. Instead, they explore using Deep RL for navigation.  Reason  This study explores additional point to point navigation techniques that AI agents can be trained in which I also will need to explore and apply to the machine learned AI agents within this project. They study explains the success rates which will help me to know the expectations set on my own work. |
| [4] | How to Prevent Bias in Machine Learning | Description  This article goes on to explain how machine learned agents can exhibit bias behaviours based on the data inputted by the creator  Reason  Bias is likely to occur in my own work, however the aim is to study the behaviour generated. This article will help me to know how to reduce this bias and also how to notice this in the results to ensure that the outcomes are as fair as possible |
| [5] | Future-proofing Video Game Agents with Reinforced Learning and Unity ML-Agents | Description  This study was focused on the Unity machine learning tools and explored how successful an agent built using these tools and deep reinforcement learning could be and if it could be incorporated into games.  Reason  This project is heavily focused on Unity and its tools as well. This study highlights the success rates and limitations throughout the study that I can use to help avoid similar situations. |
| [6] | Artificial Intelligence - Pacman Capture The Flag | Description  This study looked at building an AI that would play a pacman game. It focused on the design choices made to make the AI more efficient such as using different pathfinding techniques.  Reason  This study has implemented different strategies and highlighted the limitations for each one within the game scenario. This has been helpful in pointing out issues that my own AI could run into. |
| [7] | Capture the Flag: the emergence of complex cooperative agents | Description  This study is looked at different AI approaches to a capture the flag game and how the AI agents cooperated with their team members  Reason  This study is similar to what this project is focusing on and this will be helpful to have a guide on what can be achieved and what has not yet been achieved. It will be a great point for comparison. |

**Work Plan**

Timeline

Description automatically generatedThis project will last for 3.5 months, with the first 3 months dedicated to developing the project. The remaining time will be for solidifying and writing up my findings.

I have developed a Gantt chart to help plan and organise the progress to be made throughout this project. The chart highlights the key tasks that need to be completed in a weekly format. It shows when a task should be started and finished with the darker colours representing main tasks to be done and the lighter colours representing background tasks that should be constantly occurring over a long period of time. For example, the research into similar topics and the tools/skills needed should continue even whilst implementation is happening.

Whilst it is not fully clear from the diagram, I will be using the Agile Development methodology during the implementation stages as there are clear cut objectives to achieve during this time, but they don’t have to be dependant on each other – making this strategy favourable over the Waterfall methodology.

Overview

The chart shows that I will start with a research phase. I will research into the different types of AI approaches and other studies/articles that have done similar topics to further my understand for this project. Also during this stage, I will be continually improving my skills needed for the implementation stages. I will be using online resources surrounding the Unity Physics Engine and the Unity Machine Learning Agents to become more knowledgeable about how to use them to ensure I can provide the best quality outcome of this study. As seen by the chart, research will begin early, but it will continue throughout the project. This will help to achieve objectives 1 and 2 by the end of the project.

The implementation and testing stage work alongside each other and will be the most intense part of the project. Due to this project using the Agile Development methodology it is expected that testing will occurring throughout the implementation stages and in more depth at the end of each sprint which is 2 weeks long. During Sprint1, I will cover objectives 3 and 4 by building the initial map level and implementing the State AI within Unity. By the end of the sprint, the State AI agents should be able to play the game without any human interaction. Sprint2 will partially cover objective 5 as training the AI will take time – with Sprint3 completing this objective. An additional part of the testing would be to record the development of the machine learned AI as this is part of objectives 6, 7 and 8. This will occur continuously and will monitor the behaviour of the AI from the very beginning.

I have also included on the Gantt chart the other deliverables that that will occur during this project. This is to remind myself that they are to do as well as also ensure I know to take them and the time they will take into consideration when working. These include items such as the poster and dissertation.

Risks and Contingencies

This project will be using the Agile Development methodology for the implementation with each sprint introducing the next AI type. Sprint1 and Sprint2 are two weeks long but there comes the risk that work will not be completed within the sprint for a range of possible reasons, and this will cause a knock-on effect in the upcoming sprints.

In addition, the most significant risk for this project, is that the sprints I have planned extend into and through April which is the holidays. Whilst I plan to continue the implementation during this time, home life and other responsibilities expected of me may interfere with this and may result in delays. To help manage this, Sprint3 is significantly bigger than Sprint1 and Sprint2 but with the same amount of work planned for this stage. This will help to accommodate for any interference during the sprint as well as allowing for work not completed in previous sprints to be now completed before the deadlines.

**References**

**[1]** Keller, R., 2001. *Computer Science: Abstraction to Implementation*. [ebook] Available at: <Robert M. Keller “Computer Science: Abstraction to Implementation” (2001) https://www.cs.hmc.edu/~keller/cs60book/12%20Finite-State%20Machines.pdf> [Accessed 11 March 2022].

**[2]** Technologies, U., 2022. *Unity - Manual: Inner Workings of the Navigation System*. [online] Docs.unity3d.com. Available at: <https://docs.unity3d.com/Manual/nav-InnerWorkings.html> [Accessed 11 March 2022].

**[3]** Ubisoft Montréal. 2020. *Deep Reinforcement Learning for Navigation in AAA Video Games - Ubisoft Montréal*. [online] Available at: <https://montreal.ubisoft.com/en/deep-reinforcement-learning-for-navigation-in-aaa-video-games/> [Accessed 11 March 2022].

**[4]** Shadowen, N., 2018. *How to Prevent Bias in Machine Learning*. [online] Medium. Available at: <https://becominghuman.ai/how-to-prevent-bias-in-machine learning-fbd9adf1198> [Accessed 11 March 2022].

**[5]** Andersson, P., 2021. *Future-proofing Video Game Agents with Reinforced Learning and Unity ML-Agents*. [ebook] Available at: <https://www.diva-portal.org/smash/get/diva2:1605238/FULLTEXT01.pdf> [Accessed 11 March 2022].

**[6]** Sharma, A., 2020. *Artificial Intelligence - Pacman Capture The Flag*. [online] Creed's Log Book. Available at: <https://abhinavcreed13.github.io/projects/ai-team-pacamon/> [Accessed 11 March 2022].

**[7]** Jaderberg, M., Czarnecki, W., Dunning, I., Graepel, T. and Marris, L., 2019. *Capture the Flag: the emergence of complex cooperative agents*. [online] Deepmind. Available at: <https://deepmind.com/blog/article/capture-the-flag-science> [Accessed 11 March 2022].