

Computer Games Development

Project Report

Year IV

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# Acknowledgements

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Oisin Cawley, who acted as my supervisor, providing advice and helping keep track of my progress throughout this project.

I’d also like to thank my fellow students for providing me advice whenever I encountered a problem.

Use this template when writing your research report. As a rule of thumb, the report should be of the order of 10 pages (about 250 words/page).

# Project Abstract

The purpose of my project is to investigate and compare the advantages and disadvantages of two different training mechanisms of Artificial Neural Networks (ANN) in the context of interacting with a game world: Backpropagation and Reinforcement Learning respectively.

An ANN is a computational model designed to mimic a human brain. It uses a collection of nodes interconnecting using various patterns to create a facsimile of the neurons in the human brain. In order to do this, we train the ANN. There are various methods to do so. We could use supervised learning where we provide the ANN with training pairs, Unsupervised where we don’t, and reinforcement learning where the ANN learns from the feedback it gets from the environment.

During this investigation I will look at Backpropagation as a method of supervised Learning and Q Learning as a method of Reinforcement Learning. I will be looking at the accuracy of the choices made by the ANN after each method, as well as the time and resources used during training. I will also be looking at how human like are the choices made by the ANN. This should give a comprehensive insight into which of the two methods would work best in a game environment.

# Project Introduction and Research Question

I’ve chosen to investigate and compare two training methods for artificial neural networks within the context of a game: Backpropagation and Reinforcement Learning respectively. What sparked this interest was the AI of the Alien in Alien: Isolation. Throughout the game, the developers managed to simulate the feeling of the Alien getting smarter and learning the players playstyle. In reality, this was achieved using 2 different AI and the Alien’s own behaviour tree which was unlocked as the player made their way through the game. In practice this could result in a player who would often hide in lockers having to change their tactics in order to combat the Alien.

I then learned about ANNs and how they actually can learn. Then that made me begin to think about the uses of ANNs in games development in general. For example, one could train an ANN with the purposes of playtesting, generating a model that mimics players in order to spot any bugs or problems a player could encounter. Alternatively, in a gameplay environment, what about creating an enemy that runs off of an ANN that learns and improves as the game goes on, either through the player’s input or the game environment itself. What kind of gameplay experiences could someone craft for the player with an enemy that adjusts to the players choice of playstyle, and what choices could the player make to navigate this. to that end, I chose to investigate two methods of training an ANN and weighting the pros and cons of the two methods to try and see which of the two would be better suited for interacting with a game environment.

# Literature Review

Replace this text with an appropriate Literature Review.

The literature review places your research in context. You aren’t the first person to investigate or research a particular topic. Present a short literature review with the following goals:

* Give the reader a good overview of the key concepts;
* Describe the most relevant work (in your own words) that other people have done in this area;
* Use proper academic writing with references.
* Show how the existing work influenced your project.

During the course of the project, I had read two works published regarding AI and ANNs: “Reinforcement Learning” 2nd Edition by Richard S. Sutton and Andrew G. Barto, as well as “Artificial Intelligence A Modern Approach” 3rd Edition by Stuart Russel and Peter Norvig.

“Reinforcement Learning”, as the name implies, went over Reinforcement Learning; it focuses on core online learning algorithms, with the more mathematical material set off in shaded boxes. Part I covers as much of reinforcement learning as possible without going beyond the tabular case for which exact solutions can be found. Many algorithms presented in this part are new to the second edition, including UCB, Expected Sarsa, and Double Learning. Part II extends these ideas to function approximation, with new sections on such topics as artificial neural networks and the Fourier basis, and offers expanded treatment of off-policy learning and policy-gradient methods. Part III has new chapters on reinforcement learning's relationships to psychology and neuroscience, as well as an updated case-studies chapter including AlphaGo and AlphaGo Zero, Atari game playing, and IBM Watson's wagering strategy. The final chapter discusses the future societal impacts of reinforcement learning.

I found that Part 2 most relevant to my work, particularly the section on Nonlinear Function Approximation: Artificial Neural Networks. It starts off by showing and explaining the inner works of a feedforward ANN. It also goes on to compare Backpropagation to Reinforcement Learning. The authors spoke about how “The backpropagation algorithm can produce good results for shallow networks having 1 or 2 hidden layers, but it may not work well for deeper ANNs.” This in particular made me wonder about the limitations of the two methods, and helped me form the basis of the game I’d use for testing and experimentation. Originally, I had envisioned making a simplified version of Megaman 3 and have the ANN actually play through a dumbed down version of a level from the game. But after reading this section, I decided it’s be best to reel the scope of the game as a whole to better compare the two methods as something too complex may result in unfair results. Likewise, as a result of bringing the scope back down, the use of a Deep Q Learning method began to seem overly complex for the game as it was, so I opted to drop the Deep Learning aspect and use a simpler Q Learning method.

“Artificial Intelligence A Modern Approach” On the other hand took a more general look at AI as a whole, having 6 sections, each covering a different topic: Part I introduced AI in general as well as the concept of Intelligent Agents interacting with an environment. Part II introduced problem solving, the idea of having AI or Intelligent Agents solving problems in their environments, including ones encountered in a game environment. Part III Spoke about knowledge, reasoning and planning, in which we design agents that can form representations of a complex world, use a process of inference to derive new representations about the world, and use these new representations to deduce what to do. Part IV then expanded on this by introducing uncertainty or nondeterminism to the AI, and how they make decisions when unexpected or unplanned situations crop up. Part V is of particular interest to me as it introduces the concept of AI learning and improving their behaviour, but we’ll circle back to this. Finally, Part VI talks about Communicating, perceiving and acting; how the Ai could communicate to a person, or perceive information.

As I mentioned, Part V was of particular importance to my work, as it discussed how we can design AI to learn. The subsection on reinforcement learning greatly influenced my work on the project as it dived into the concepts passive or active learning, as well as applications of reinforcement learning. In passive learning, the agent’s policy, a function that returns a feasible action for a problem, is fixed. This means when a certain state is met, it will always execute a certain action. On the other hand, an active agent must decide what actions to take. An example of active learning is Q learning. This section even goes on to explain more about Q learning, discussing how, as it pays no attention to a policy, it can be more flexible than some other algorithms such as the SARSA(State-Action-Reward-State-Action) algorithm. From what I gathered, the freedom with which the Q Learning algorithm approaches exploration, I felt it could lead to more interesting emergent gameplay as it tries to use the best Q value in any situation. As a result, this work helped solidify my choice on using the Q Learning algorithm as a means of Reinforcement Learning.

# Evaluation and Discussion

Replace this text with Results and Discussion.

Describe the results using diagrams such as graphs etc. as appropriate, and discuss what the results mean.

Example: Results indicate that once the threshold gets over a certain point it significantly reduces player performance and player experience

**Project Milestones**

Replace this text with Project Milestones.

Key project milestone dates and measurement on schedule, was project schedule adhered to, effectively planned for delivery on-time or ahead of schedule if appropriate.

**Major Technical Achievements**

What are your major technical achievements?

**Project Review**

What went right? What went wrong? What (if anything) is still outstanding/missing (i.e., still left to do)? If starting again, how would you approach this project differently? What advice would you have for someone attempting a similar project in the future? Were your technology choices the right or wrong ones? If you chose the wrong technology, provide justifications for why you think this. What were the implications of your technology choices?

# Conclusions

summarise your work and findings.

**Future Work**

Indicate what might be some next steps to try (if a student next year was going to undertake a project in this area what might be an interesting thing for him/her to examine?).

# References

# Appendices

Replace this text with Appendices.

This might include ethics application and other relevant material e.g. copy of any questionnaires used.