# **Maths-in-Action Progress Report**

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Title of Project: Mathematics of Reinforcement Learning and its applications within Video Games

**Source Material**

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| List sources you have identified and give comments on their relevance or role in your project (report and/or public presentation). Please list in approximate order of importance.   1. Reinforcement Learning An Introduction second edition Richard S. Sutton and Andrew G. Barto   Recommended by Martin Lotz, Magnus Richardson, and YouTuber ‘AI Tango’ in an email correspondence, the first six chapters will be used as well as the thirteenth.   1. The Mathematics of Reinforcement Learning – The University of Manheim, Leif, Leo, Sara, Almut, Simon, André   These lecture notes are a more comprehensive dive behind the mathematics of RL, in particular bandits and Markov Decision Processes, and Dynamic Programming. Deep Q Learning is also discussed which is the methodology that is highlighted in the report.   1. UCL Course on RL notes by David Silver: https://www.davidsilver.uk/teaching/   Recommended by Martin Lotz, these course notes and videos break down the mathematical topics into small sections that are easily understood for learning.   1. MA3K1 Lecture Notes – Martin Lotz   Initial inspiration for the topic – Chapter 25 used. Used for initial understanding of DP, Markov Processes and Bellman Equations   1. A Markovian Decision Process – Richard Bellman Journal of mathematics and mechanics, pages 679–684, 1957.   Used for Bellman Equation topic   1. Richard Bellman. Dynamic programming. science, 153(3731):34–37, 1966.   Used for Dynamic Programming topic.   1. "Policy Gradient Methods for Reinforcement Learning with Function Approximation" by Richard S. Sutton, David A. McAllester, Satinder Singh, and Yishay Mansour   This paper explains policy gradients and theorems with proofs, providing references.   1. Spinning Up Documentation Release - Joshua Achiam   Chapter 9 is used as well as chapters relating to applications of RL in the real world.   1. Playing Atari with Deep Reinforcement Learning" by Volodymyr Mnih, Koray Kavukcuoglu, David Silver, et al.   This initial article introduces the Deep Q Learning algorithm. It also includes many references which may be useful   1. Hands on RL - Maxim Lapan   Recommended by YouTuber ‘AI Tango’, this book is used mainly to help with the coding aspect for deep q networks and some policy optimization.   1. Deep Reinforcement Learning - Aske Plaat   Used primarily for Chapter 4 about policies.   1. YouTube channel ritvikmath.   In particular the video ‘This is the Math You Need to Master Reinforcement Learning’ which explains Policy Gradient Methods is used for help creating and designing figures |

**Project Plan**

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| Give a brief plan for your report. It does not have to be very detailed and you will not be penalised if your actual report deviates from this plan. However, you should have begun to think about what your report will eventually contain. You can make reference to your sources on the previous page.  List the topics you expect to cover and maybe give some indication of the relative importance of the topics. You may, if you wish, also indicate topics that might be consider part of the theme, but that you plan not to cover in depth or at all.   * Introduction and Overview   + What is RL (Subset of AI, ML etc, differences between supervised and unsupervised learning)   + History of AI (AI Winter etc) , Pavlovian Conditioning and reward system as motivation * Mathematics used in RL – The bulk of the report, exploring theorems used   + Markov Decisioning Process (MDP)   + Bellman Equations   + Dynamic Programming   + Policy Gradients * Different Types of RL   + Explore Briefly an overview of some different RL types   + Large emphasis on deep RL – Deep Q Networks and Deep Policy Gradient Methods, Q Algorithms     - Architecture, Loss functions used, Q-Learning Algorithm with convergence properties, integration of Q-Networks with Q-Learning * Uses and Applications in the real world   + Video Games – Why it is used and also show results from Snake Game programming that is done along with the report. Include graphs relating to ho well it runs over iterations etc     - Maybe discuss transfer learning more in depth as it is used in applying video game scenarios to other applications   + Other applications – Neuroscience, Driving Cars, links to Generative AI etc * Conclusions and remarks   + Any extensions can be mentioned   + Any challenges faced and positives/negatives with techniques highlighted   + The future of RL soon and further in the future – can highlight recent reports/journals * Acknowledgments   + Lecturers who have offered advice   + YouTubers that have been contacted |

Signed: Aadam Ul Haq Date: 13/01/2024

## Attach A4 sized preview of your draft poster and submit via Moodle by 12 noon on Tuesday 16th January 2024.