**RESEARCH PROPOSAL FORM**

*(also referred to as the ‘Statement of Intent Form’, or SOI)*

***To be submitted by the researcher to the Institute Research Sub-Committee (IRC)***

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| **Research Title:**  Enhancing gameplay for Machine Learning agents in platform games using Neural Networks and Reinforcement Learning. | |
| **Institute name**  Institute of Information & Communication Technology | |
| **Course / Programme:**  B.Sc. Software Development (Hons.) | |
| **Level and year of study**  Level 6 Year 3 | |
| **Main area of study being proposed:**  The proposed research aims to explore the area of study in developing Machine Learning agents which are capable of playing platform games using Neural Networks and Reinforcement Learning. This research seeks to investigate how Neural Networks can be trained to effectively learn and navigate complex platform game environments.  This idea of applying Neural networks to games is not new, and has been applied to various other games. This ML agent would start playing from scratch without previous knowledge about the game and through repeated training it would be able to complete some levels of the game. The study seeks to demonstrate the potential for the ML agent to adapt to new game levels without the need of extensive retraining of the model. | |
| **Name of Researcher:**  Nicholas Attard | **Researcher’s I.D. Number:**  0153603L |
| **Signature of Researcher** | **Date of submission of Form**  02/06/2023 |
| **Name of Tutor (or Recommended Tutor):**  **Simon Attard** | |

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| **Personal Motivation for the Choice of Research Theme.** |
| Personal motivation for pursuing research in the field of Machine Learning and Reinforcement Learning stems from an interest in this domain and a desire to continue working in this field. The recent advancements and growing popularity of this research field have captured my attention, and inspired me to contribute to its ongoing development. Seeing the potential application of these agents to navigate game environments is motivation to further explore this field. |

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| **Outline of Key Literature and Theoretical Framework or Propositions.** |
| The application of Machine Learning (ML) to game environments is not new, in fact the first idea of ML applications in games was in 1947, applied to a game of Checkers [1]. These past few years Artificial Intelligence (AI) and ML have gained a lot of popularity which led to more research being conducted.  In many studies Reinforcement Learning (RL) has also been applied with ML in game environments. These techniques have been applied to different genres and games, some examples include, Real Time Strategy (RTS) games such as StarCraft II [2], Multiplayer Online Battle Arena (MOBA) [3] and fighting games [4], namely Dota 2 and Blade & Soul respectively. Research has also been conducted on simpler and older games like the Atari 2600 games [5] [6] and Super Mario Bros.  Many different approaches were taken to apply ML and RL to Super Mario Bros. Shu et al conducted a research where they introduced the concept for a Procedural Context Generation (PCG) including RL to form an experience-driven PCG RL framework, EDRL for short [7]. Their EDRL was used to generate an endless amount of stages for Super Mario Bros, which were then tested by RL agents to check for playability.  Liao et al made use of a Q-learning algorithm to train their agent for fifteen thousand iterations for a fixed level. The algorithm they used demonstrated fast convergence to the optimal Q-value and had a high success rate. After the training the agent was able to win 90% of the time [8].  Pedro Alves and Høiberg Eike used Double Deep Q-Networks to train their agent. They commented on the agent that was trained on Mario saying “showed promising results”, their agent was capable of making it past all the enemies but got stuck just before finishing the first level [9].  Another experimental approach of applying RL to Mario was that done by Sanyam Jain. They used the Reptile algorithm to fine tune the initial parameters for the Neural Network and compared their results to other popular RL algorithms, Proximal Policy Optimization (PPO) and Deep Q-Network (DQN). Their RAMario research was able to outperform both of these algorithms being able to travel 47% more distance and make 50% more moves [10]. |

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| **Significance of the Study.** |
| This study aims to contribute to the advancement of Machine Learning, exploring the capabilities of Neural Networks and Reinforcement Learning in gaming environments. By developing intelligent Machine Learning agents, it opens up avenues for enhancing gameplay experience for both developers and players within the gaming industry. |

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| **Hypotheses and/or Research Question/s** |
| By making use of Neural Networks and Reinforcement Learning a Machine Learning agent would be capable of completing levels in the platform game Super Mario Bros.   * Can the ML agents benefit by using Curriculum Learning to train on simpler levels before progressing to more difficult stages and completing them in a short period of time? * Can Transfer Learning approaches be utilised to enable ML agents to complete more complex and unseen levels after being trained on simpler levels of the game? * How can the Neural Network be optimized to train the ML agent to successfully complete levels, considering the immanent challenges of the game? * What is the impact of different reward functions on the final time achieved by the ML agent? |

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| **Target Participants and Research Methods for Data Collection and Analysis** |
| The primary method of collecting data would be from simulating the Super Mario Bros game environment and allowing the ML agent to interact with it. During gameplay data logging can be used to gather relevant information such as, agent’s observations and chosen actions. This data would be the training dataset for the Neural Network.  Reinforcement Learning algorithms would be used to iteratively collect data though interactions with the game environment and updating the neural network’s parameters.  Statistical analysis techniques such as analysis of variance and regression analysis will be employed to analyise quantitatively the collected data and evaluate the ML agent’s performance between different generations. |

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| **Anticipated Contributions of the Study.** |
| This study aims to act as review on existing research when applying Neural Networks and Reinforcement Learning to game environments and contribute to the already existing knowledge base of ML agents in platform games.  As well as being an alternative approach in implementation this research aims to contribute new ideas to the strong and popular AI game research community. |

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| **Dissertation Project Plan.** |
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| **Ethical Considerations.**  **Refer to *guidance points below. You are also additionally required to read MCAST Document 074 ‘Research Ethics Policy and Procedure’ that is available on the College website***  *Research shall be conducted in such a manner so as to avoid any psychological and physical harm to humans and animals and financial damage to organizations:*   1. *Only the supervisor and examiners will have access to any data gathered.* 2. *Participants will remain free to withdraw from the study at any time without having to provide any reason. In the case of withdrawal, all the records and information collection will be deleted.* 3. *The participant, who is the sole proprietor of the data provided, is granting that such data would be processed for this study purposes only.* 4. *The data collection process will be a transparent process.* 5. *All transcriptions and/or electronic recordings reflecting the data collected, once exhausted, are to be deleted* 6. *Confidentiality, anonymity and data protection procedures are to be ethically abided by.* 7. *The researcher would provide a soft copy of the study to the participant, if required.* |
| *Enter details here regarding possibility of issues regarding confidential personal data:*  This section is not applicable since no personal data will be collected or used. |
| *Enter details here regarding possibility of physical harm:*  This section is not applicable because no participants will be taking part in this study. |
| *Enter details here regarding possibility of moral harm:*  This section is not applicable because no participants will be taking part in this study. |
| *Enter details here regarding possibility of business harm:*  This section is not applicable since no businesses are involved. |

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| *Please see* ***Annex 1*** *for a sample Participant Information Letter and* ***Annex 2*** *for a sample Participant Consent Form. Student is to submit a copy of the proposed Participant Information Letter and Participant Consent Form where applicable. Both documents should be attached to the end of the SOI that is being submitted by the student.* |

**List of Key References:**

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| [1] - A. L. Samuel. “Some Studies in Machine Learning Using the Game of Checkers”.  IBM Journal of Research and Development 3:3, 1959, pp. 210–229.  [2] - Vinyals, O., Ewalds, T., Bartunov, S., Georgiev, P., Vezhnevets, A.S., Yeo, M., Makhzani, A., Küttler, H., Agapiou, J., Schrittwieser, J. and Quan, J., 2017. Starcraft ii: A new challenge for reinforcement learning. arXiv preprint arXiv:1708.04782.  [3] - Berner, C., Brockman, G., Chan, B., Cheung, V., Dębiak, P., Dennison, C., Farhi, D., Fischer, Q., Hashme, S., Hesse, C. and Józefowicz, R., 2019. Dota 2 with large scale deep reinforcement learning. arXiv preprint arXiv:1912.06680.  [4] - Oh, I., Rho, S., Moon, S., Son, S., Lee, H. and Chung, J., 2021. Creating pro-level AI for a real-time fighting game using deep reinforcement learning. IEEE Transactions on Games, 14(2), pp.212-220.  [5] - Mnih, V., Kavukcuoglu, K., Silver, D., Graves, A., Antonoglou, I., Wierstra, D. and Riedmiller, M., 2013. Playing atari with deep reinforcement learning. arXiv preprint arXiv:1312.5602.  [6] - Kaiser, L., Babaeizadeh, M., Milos, P., Osinski, B., Campbell, R.H., Czechowski, K., Erhan, D., Finn, C., Kozakowski, P., Levine, S. and Mohiuddin, A., 2019. Model-based reinforcement learning for atari. arXiv preprint arXiv:1903.00374.  [7] - Shu, T., Liu, J. and Yannakakis, G.N., 2021, August. Experience-driven PCG via reinforcement learning: A Super Mario Bros study. In 2021 IEEE Conference on Games (CoG) (pp. 1-9). IEEE.  [8] - Liao, Y., Yi, K. and Yang, Z., 2012. Cs229 final report reinforcement learning to play mario. Technical report, Stanford University.  [9] - Alves, P. and Eike, A.H., Reinforcement Learning With PyBoy.  [10] - Jain, S., 2023. RAMario: Experimental Approach to Reptile Algorithm--Reinforcement Learning for Mario. arXiv preprint arXiv:2305.09655. |

***This section is to be filled in by the representative of the Institute Research Sub-Committee (IRC) prior to forwarding of this Form to the ‘MCAST Research Ethics Committee’ for final ethics approval:***

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| ***Nature of Ethical Consideration*** | ***Outcome (Tick)*** | ***Comments/Advice*** |
| All ethical issues have been adequately tackled. |  |  |
| Possibility of issues regarding misuse of data or some form of harm. |  |  |

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| **Details of Representative to the Institute Research Sub-Committee.** | |
| Name | Signature |
| Designation | Date |

**Annex 1: Participant Information Letter**

***Sample:*** 

**Title of Research: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

You are being invited to take part in a research study. Before you decide to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

**What is the purpose of the study?**

This research is being undertaken on…

**Why have I been chosen?**

You have been chosen because…

**Do I have to take part?**

It is up to you to decide whether or not your take part. If you decide to take part you will be given this information sheet to keep and be asked to sign a corresponding consent form.

**What will happen to me if I take part?**

You will then be given a questionnaire on.../your data will be used…/your image will be used…

**What are the possible disadvantages and risks of taking part?**

There are no disadvantages or risks foreseen in taking part in the study.

**What are the possible benefits of taking part?**

By taking part you will be contributing to the development of a set of recommendations for…

**What if something goes wrong?**

If you wish to complain or have any concerns about any aspect of the way in which you have been approached or treated during the course of this study, please contact…(researcher is to give his/her MCAST email as a contact)

**Will my details be kept confidential?**

All information which is collected about you during the course of the research will be kept strictly confidential so that only the researcher carrying out the research will have access to such information and will not be shared with any other individuals. Participants should note that data/images collected from this project may be retained and published in an anonymized form. By agreeing to participate in this project, you are consenting to the retention and publication of data.

**What will happen to the results of the research study?**

The results will be written up into a dissertation for my final project of my Bachelor…

**Who is organizing the research?**

The research is conducted as part of a degree in …

**Who may I contact for further information?**

If you would like more information about the research before you decide…(researcher is to give his/her MCAST email as a contact)

*Thank you for your interest in this research…*

**Annex 2: Participant (or Guardian) Consent Form**

***Sample:*** 

**Title of Research: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Name of Researcher: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

# Please initial box

1. I confirm that I have read and understand the Information Letter

for the above study and have had the opportunity to ask questions.

1. I understand that my/my charge’s participation is voluntary and that I/my charge am/are free to withdraw at any time without giving any reason.

3. I agree to allow my daughter/son/charge to take part in the above study.

*(Statement 3 is to be included only when guardians/parents are involved in giving consent)*

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Name of Participant/

Guardian Date Signature

Researcher Date Signature

*1 for participant; 1 for researcher*