**Exploration of the use and application of a learning Artificial Intelligence agent in video games.**

Is it possible to use genetic algorithms within a learning AI system to create a dynamically increasing gameplay challenge within a video game?

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Contents

[Overview 3](#_Toc31204307)

[Project rationale 3](#_Toc31204308)

[Technical Overview 3](#_Toc31204309)

[Areas of investigation 3](#_Toc31204310)

[Genetic algorithms 3](#_Toc31204311)

[Machine learning 4](#_Toc31204312)

[Saving the data of the AI at fixed generations 4](#_Toc31204313)

[Background research 4](#_Toc31204314)

[Genetic algorithms 4](#_Toc31204315)

[Machine Learning 4](#_Toc31204316)

[Literature review of sources 5](#_Toc31204317)

[Methodology 6](#_Toc31204318)

[Research ethics 6](#_Toc31204319)

[Project plan 6](#_Toc31204320)

[Deliverables 6](#_Toc31204321)

[References 7](#_Toc31204322)

# Overview

The idea behind my Final Year Project is to explore the potential uses and applications for an Artificial Intelligence (AI) system, which utilises learning through a genetic algorithm, in gaming that progressively learns and adapts to overcome certain situations that the AI agent encounters. I would go about implementing this by initially creating a system such as Snake where the first generation of snake would not know how to effectively search out food and how to avoid the fail states of the game but as the snake went through multiple generations it would adapt and improve its method of playing the game. I intend to save the state of the snake AI at a fixed number of generations and then compare that against the average of human playtesters, to see how the performance of the snake is and at what point the snake AI becomes better than a human if it does at all.

The success of my project will be determined by whether I can create an AI system that initially has little to no information on how to play the game I have created and progressively learns more information which will allow it to determine the best method to play the game. Ideally, the AI that I create will eventually perform better than all the testers however the success of the system is not dependent on this.

# Project rationale

I have chosen to undergo this project as I have not done any work in AI previously, but it is an area in the gaming industry that has always interested me. Working on a learning AI system that utilises a genetic algorithm to improve would provide me with a good technical challenge that will test my skills and allow me in the process to learn something new. Additionally, AI in some form is in most games today so it would be very beneficial to know for future employment.

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# Technical Overview

## Areas of investigation

The project will require me to know in-depth about genetic algorithms and how to program them within C++. I will also be required to know of machine learning and the different types of learning. Additionally, I will need to know how to save the AI data at fixed generations.

### Genetic algorithms

Due to the project being centred around an AI learning to play the game Snake, I want the AI to go into the game not knowing anything at the start and then as the AI progresses through generations it will have more information on the most effective way to play the game. The snake will also learn how to survive, as to not hit the confines of the play space or the body of the snake itself as well as the optimal way to search out the food which will increase the size of the snake as well as the score.

### Machine learning

The core of this project is centred around machine learning, as this is what enables AI systems to improve and learn based on experience without being programmed clearly to do so. I will need to investigate into the fundamentals of machine learning as well as the different methods of learning that I can expose the AI to.

### Saving the data of the AI at fixed generations

Since I am wanting to compare the performance of the snake at set generations against the results of human players, I want to be able to save the AI data of the snake to a file. This will allow me to boot up the game and have the snake play using a preset collection of data from the generations to visualise its performance.

## Background research

The background research that I’ve done is focused on genetic algorithms, the different types of machine learning and more importantly what machine learning is.

### Genetic algorithms

A genetic algorithm is a heuristic search method and is used to find an optimised solution to search problems based on the theory of natural selection and evolutionary biology. Genetic algorithms use the current population to create the children that make up the next generation. The algorithm will select parents in the current population who contribute their data to the children. There are multiple stopping conditions that you can use for the algorithm, such as when the algorithm reaches a set number of generations, when a time limit has passed or when the performance reaches a certain threshold.

### Machine Learning

Machine learning is an application of AI which enables systems to learn and advance based upon prior experience without being clearly programmed. It focuses on the development of programs that can access data and then use that data for their own learning.

The different machine learning types are:

* Supervised learning
  + Supervised machine learning takes what it has previously learnt and applies that to new data using labelled examples to predict future patterns and events. The AI will find patterns where we have a dataset of correct answers to learn from.
* Unsupervised learning
  + Unsupervised learning finds patterns where we don’t which may be due to the correct answer being unobservable, infeasible to obtain, or maybe there isn’t even a correct answer for a given problem.
* Semi-supervised learning (SSL)
  + Semi-supervised learning is a mix between supervised and unsupervised learning. It is used because many problems that some AI is used to solve require a balance of both approaches.
* Reinforced learning
  + Reinforcement learning is a type of dynamic programming that trains algorithms using a system of reward and punishment.

Deep learning

Deep learning, also known as Deep Neural Learning or Deep Neural Network, is a specialised form of machine learning that imitates the workings of the human brain in processing data and creating patterns for use in decision making. This type of machine learning has been used to create AI that are able to beat the top percentage of players in some video games, such examples include the Starcraft 2 Deepmind AI and the Super Smash Bros SmashBot AI.

## Literature review of sources

1. Hou, N.C., Hong, N.S., On, C.K. and Teo, J. (2011). Infinite Mario Bross AI using Genetic Algorithm. 2011 IEEE Conference on Sustainable Utilization and Development in Engineering and Technology (STUDENT). [online] Available at: <https://ieeexplore.ieee.org/abstract/document/6089330> [Accessed 29 Jan. 2020].
2. ‌Verma, M.A. and McOwan, P.W. (2020). An adaptive methodology for synthesising Mobile Phone Games using Genetic Algorithms. 2005 IEEE Congress on Evolutionary Computation. [online] Available at: <https://ieeexplore.ieee.org/abstract/document/1554774> [Accessed 29 Jan. 2020].
3. ‌Sorenson, N. and Pasquier, P. (2010). Towards a Generic Framework for Automated Video Game Level Creation. Applications of Evolutionary Computation, pp.131–140. Available at: <https://link.springer.com/chapter/10.1007/978-3-642-12239-2_14> [Accessed 29 Jan. 2020].
4. Mitchell, M. (1998). An introduction to genetic algorithms. Cambridge, Mass. ; London: Mit. <https://books.google.co.uk/books?hl=en&lr=&id=0eznlz0TF-IC&oi=fnd&pg=PP9&dq=+An+Introduction+to+Genetic+Algorithms&ots=shpJ92ZaRd&sig=oVDGt5-JYpFHOLbxXY29nzjsaik&redir_esc=y#v=onepage&q=An%20Introduction%20to%20Genetic%20Algorithms&f=false>
5. González-Pardo, A., Palero, F. and Camacho, D. (2015). An empirical study on collective intelligence algorithms for video games problem-solving. Repositorio.uam.es. [online] Available at: <https://repositorio.uam.es/handle/10486/674486> [Accessed 29 Jan. 2020].
6. Mourato, F., dos Santos, M.P. and Birra, F. (2011). Automatic level generation for platform videogames using genetic algorithms. Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology - ACE ’11. Available at: <https://dl.acm.org/doi/abs/10.1145/2071423.2071433> [Accessed 29 Jan. 2020].
7. Deepmind. (2019). AlphaStar: Mastering the Real-Time Strategy Game StarCraft II. [online] Available at: <https://deepmind.com/blog/article/alphastar-mastering-real-time-strategy-game-starcraft-ii>.
8. Revell, T. (2019). AI beats professional players at Super Smash Bros. video game. [online] New Scientist. Available at: <https://www.newscientist.com/article/2122452-ai-beats-professional-players-at-super-smash-bros-video-game/> [Accessed 29 Jan. 2020].
9. Certes. (2018). Types of Artificial Intelligence: A Detailed Guide - Certes. [online] Available at: <https://certes.co.uk/types-of-artificial-intelligence-a-detailed-guide/>. [Accessed 29 Jan. 2020].

## Methodology

Waterfall vs agile

Combination

<https://reqtest.com/agile-blog/agile-waterfall-hybrid-methodology-2/>

Main tasks I expect to complete etc.

Source Control

When working on this project I will be using Source control to keep backups and a changelog of all the features I have added, this will allow me to keep to my schedule and plan future sprints depending on the work that I have already done. I will be using GitHub as I have used it the past two years and it’s the only form of source control that I know how to use comfortably and provides me with multiple backups and the ability to access my work from any machine if I were to forget my hard drive. Source control is good because it allows for every change to always be available to roll back to, so if I get a project breaking error/bug I can always roll back my work to a build that wasn’t broken and try fix the mistakes I have made.

Collecting Results

I would like to do some testing and collect some feedback on the different methods that I create, I

would like to test my methods on a group of users and collect their opinions on which method

worked better and which methods they preferred to use.

## Research ethics

At some point during of the course of my project, I will require people to come and play the game so that I can record data on their performance. However, due to the nature of including others in this research, I will be required to obtain consent from the participants that they are happy to take part in this research and that they are aware that their data will be stored to ensure the results are genuine. If I am going to use any premade libraries or graphics programs to visualise the game, I will need to ensure that I adhere to copyright or any licensing that there may be.

# Project plan

Steps/stages

Gantt chart

Be realistic.

Probably something here about when I plan to work on this module and what days I intend to work on my other module.

* Create basic snake game:
  + Create snake.
  + Implement win/lose states.
  + Implement score system.
  + Collision detection.
  + Create fruit object.
  + Random fruit spawn locations.
  + Align everything with a grid.
* Research genetic learning algorithm
* Implementation of the genetic learning algorithm
* Save the data set for the snake at an equal number of generations.
* Create game testing form
* Playtest and record results
* Tabulate results against snake performance

# Deliverables

Evaluation of the performance of the AI

Generation selection.

# References

1. Hou, N.C., Hong, N.S., On, C.K. and Teo, J. (2011). Infinite Mario Bross AI using Genetic Algorithm. 2011 IEEE Conference on Sustainable Utilization and Development in Engineering and Technology (STUDENT). [online] Available at: <https://ieeexplore.ieee.org/abstract/document/6089330> [Accessed 29 Jan. 2020].
2. ‌Verma, M.A. and McOwan, P.W. (2020). An adaptive methodology for synthesising Mobile Phone Games using Genetic Algorithms. 2005 IEEE Congress on Evolutionary Computation. [online] Available at: <https://ieeexplore.ieee.org/abstract/document/1554774> [Accessed 29 Jan. 2020].
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4. Mitchell, M. (1998). An introduction to genetic algorithms. Cambridge, Mass. ; London: Mit. <https://books.google.co.uk/books?hl=en&lr=&id=0eznlz0TF-IC&oi=fnd&pg=PP9&dq=+An+Introduction+to+Genetic+Algorithms&ots=shpJ92ZaRd&sig=oVDGt5-JYpFHOLbxXY29nzjsaik&redir_esc=y#v=onepage&q=An%20Introduction%20to%20Genetic%20Algorithms&f=false>
5. González-Pardo, A., Palero, F. and Camacho, D. (2015). An empirical study on collective intelligence algorithms for video games problem-solving. Repositorio.uam.es. [online] Available at: <https://repositorio.uam.es/handle/10486/674486> [Accessed 29 Jan. 2020].
6. Mourato, F., dos Santos, M.P. and Birra, F. (2011). Automatic level generation for platform videogames using genetic algorithms. Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology - ACE ’11. Available at: <https://dl.acm.org/doi/abs/10.1145/2071423.2071433> [Accessed 29 Jan. 2020].
7. Deepmind. (2019). AlphaStar: Mastering the Real-Time Strategy Game StarCraft II. [online] Available at: <https://deepmind.com/blog/article/alphastar-mastering-real-time-strategy-game-starcraft-ii>.
8. Revell, T. (2019). AI beats professional players at Super Smash Bros. video game. [online] New Scientist. Available at: <https://www.newscientist.com/article/2122452-ai-beats-professional-players-at-super-smash-bros-video-game/> [Accessed 29 Jan. 2020].
9. Certes. (2018). Types of Artificial Intelligence: A Detailed Guide - Certes. [online] Available at: <https://certes.co.uk/types-of-artificial-intelligence-a-detailed-guide/>. [Accessed 29 Jan. 2020].

~~6. Literature review: At this stage we are not expecting a full literature review but you should give details of 2 books, 2 academic journal articles or conference papers and 3 websites that will be useful to your project. You should cite them correctly in your text (Harvard style) and give the full reference details in a reference section at the end of your project specification (see section 11 for further details). All of them should be up-to-date (i.e. less than 6 years old, unless you can clearly explain why it is important to include an older reference) and there should be clear justification for including each reference.~~

7. Methodology: Discuss the main tasks that you expect to do in your project. For instance, you might decide that you need to collect some data in order to understand users’ views. In this case think of the type of data you will collect i.e. quantitative or qualitative and how you will be collecting them e.g. questionnaire, interviews. Also, you might want to briefly discuss your initial thoughts in respect of what development methodology you might use, e.g. re waterfall versus iterative development. Your methodology need not be fully formed at this stage but you should provide evidence that you have clearly thought about this area and have proposed some appropriate and sensible approaches and considered the benefits and potential drawbacks.

9. Project Plan: Provide a project plan which highlights the main phases of your project process and define deadline / completion dates for each phase. It should be detailed enough to be of some help to you, but not so detailed that it becomes difficult to follow. Your plan should also include details of time you will be spending on other modules, including any hand-ins, you can get this information about the modules running from the intranet (https://unity3.tees.ac.uk/schools/015/Pages/Students/Assessment.aspx#icasubmissions –> Assessment Calendars –> Final Year). You may also be able to see details of the assessments for some modules and if this is available you should incorporate this into your plan as well. Don’t forget to factor in your “me” time and any work, family or sports commitments you might have.

10. Project Deliverable(s): Provide a brief description of what you will create for your project’s ‘product’. It could be an IT product such as a web site or application, a design document or report for a business client (or potential interested group), or a poster to present a new model or research outcomes.

11. References: Give full reference details for all works cited, using Pears, R. and Shields, G. (2016). Cite them right: the essential referencing guide. 10th edn. Basingstoke: Palgrave Macmillan. Copies of this text are available in the Library and online via: <https://www.citethemrightonline.com/>