Project Proposal

By Grant Merrill

# Scripture

Abraham 3:19 “And the Lord said unto me: These two facts do exist, that there are two spirits, one being more intelligent than the other; there shall be another more intelligent than they; I am the Lord thy God, I am more intelligent than they all.”

No matter how intelligent our artificial intelligent agents become, we will always be more intelligent. No matter how intelligent we become, the Lord our God will always be more intelligent.

# Abstract

The focus of this project is developing the Neuroevolution of Augmenting Topologies (NEAT) algorithm and understanding its usefulness. The NEAT algorithm will be described more fully in the Background section. The application of this project is using the NEAT algorithm in order to beat the original Super Mario Bros for the Nintendo Entertainment System.

# Background

### Definitions

* Nintendo Entertainment System (NES): A home gaming console made by Nintendo
* NeuroEvolution of Agumenting Topologies (NEAT): A method that enables the auto generation of neural networks.
* Neural Network: An algorithm that tries to emulate how the brain learns.
* Genetic Algorithm: An algorithm that emulates the process of natural selection in order to solve the given problem
* Machine Learning: A subfield of computer science that attempts to teach machines how to learn from a given set of inputs and possible rules or “winning” scenarios.
* Artificial Intelligence: The intelligence shown by machines.

### Why a Topic of Interest

Artificial intelligence and machine learning are very interesting to me. The idea that you can create a system that can learn and develop a method of solving a problem you give it is an incredible feat. Many of the problems that needed to be solved in today’s society cannot not be solved with a simple sequential program. However, we can teach a machine to learn from a complex set of inputs and tell it what is desired or simply to give possible solutions to these sets of inputs. This is a very powerful tool. I want to delve more into this subject so I can be a part of solving these solutions. The application is a fun way to expand my understanding and knowledge of this subject and show, visually, how powerful this kind of methodology actually is.

### Prior work by others

The information of these prior works can all be found in the References section.

SethBling, a YouTuber, took the NEAT method and applied to his own program called MarI/O. This program primarily tries to beat different levels in Super Mario Bros. and Super Mario World. SethBling had a lot of success with this method. The approach he took is a similar approach that I will be taking to solve this problem. [1]

Kenneth O. Stanley and Risto Miikkulainen were the inspiration to SethBling and now the inspiration to me. They developed the method of NEAT “which outperforms the best fixed-topology method on a challenging benchmark reinforcement learning task.” [2] It uses neuroevolution in order to accomplish this. They also state that “NEAT is also an important contribution to GAs because it shows how it is possible for evolution to both optimize and complexify solutions simultaneously, offering the possibility of evolving increasingly complex solutions over generations, and strengthening the analogy with biological evolution.” [2]

Dr. Tom Murphy developed a program that attempts to automate the gameplay of video games. It uses the bits of the game to see whether or not the player (which is the machine) is winning. It does this by seeing if certain bits are going up or not. This method is very interesting and presents some interesting concepts and ideas to think about. However, it does have its flaws. In certain games, it tends to pause a lot, thinking that pausing helps win the game. Since it is only looking the bits and not the actual game, it falls into this kind of trap. [3]

The idea of evolving the neural network topology, using neural networks, and using genetic algorithms is not new to the world of gaming. Mat Buckland and André LaMothe wrote the textbook titled: “AI Techniques for Game Programming.” In this textbook, they discuss all three of these concepts and how they apply to game programming. [4]

Stuart Russell and Peter Norvig helped write “Artifical Intelligence a Modern Approach.” This textbook discusses AI in great detail. Specifically for this project, it discusses the advances made in genetic algorithms and evolutionary learning. [5]

Stephen Marsland wrote “Machine Learning an Algorithmic Perspective” which goes into great detail of how the different algorithms that will used work. [6]

### Prior work by me

This project will deal with neural networks and genetic algorithms. I have developed and designed my own neural networks. I have learned how they work and what they try to accomplish. I have learned a bit about genetic algorithms as well. However, I have never dealt with a genetic algorithm at this level before. Nor have I had to develop a method to auto generate neural networks. I have learned and developed AI before, however, this was always in a known environment. I have never had to develop a system that doesn’t know anything about its environment before.

# Description

Using the NEAT method, I will develop a program that will learn how to play Super Mario Bros. and attempt to beat the game. For complete accuracy, I want to be able to beat at least one level of Super Mario Bros. If I happen to beat more, then this is considered beyond what I want.

# Scope

This project is about the application of the NEAT method. This will include the use of genetic algorithms and neural networks. This will include the use of video game emulation. This project is not focusing on beating games in their entirety. Nor is it focusing on multiple games. Super Mario Bros. is the only game this project will focus on and this project’s goal is to beat one level of Super Mario Bros. If it is successfully in beating that one level, it will move onto other levels.

# Tasks and Schedule

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Start Date | Stop Date | Hours Estimation |
| Requirements Spec | May 31st, 2016 | June 7th, 2016 | 12 |
| Learn Lua sufficiently | May 31st, 2016 | - | 40 |
| Create test programs for NEAT concepts | June 12th, 2016 | June 18th, 2016 | 12 |
| Move Mario using code only | June 19th, 2016 | June 25th, 2016 | 12 |
| Design the project | June 26th, 2016 | July 2nd, 2016 | 30 |
| Develop the genetic algorithm | July 3rd, 2016 | July 9th, 2016 | 20 |
| Develop the auto generation of neural networks | July 10th, 2016 | July 16th, 2016 | 20 |
| Manage the inputs and Mario’s outputs and test | July 17th, 2016 | July 23rd, 2016 | 12 |
| Choose a level to test on and begin testing (if successful, move onto other levels. If adjustments need to be made, make them) | July 24th, 2016 | August 13th, 2016 | 40 |

# Applicability

As stated before, I do have experience with neural networks and some experience with genetic algorithms. However, I do not have any experience or prior knowledge of the NEAT method. To reiterate this method, this allows an evolution of neural networks by way of genetic algorithms. This concept is to take a genetic algorithm with a set of inputs and let neural networks be created to try and find a solution to the problem at hand. This concept is new to me and the application of it is a completely new idea. This is exclusive from simple neural networks and genetic algorithms because the focus of the NEAT method is not the neural networks nor is it the genetic algorithm. It is a different algorithm that uses these concepts to assist the evolution of neural networks.

# Required Resources

All items on this list are free to use.

* NES emulator - BizHawk emulator <https://github.com/TASVideos/BizHawk>
* Super Mario Bros. ROM for playing on an emulator
* Lua programming language<http://www.lua.org/>

# References

[1] Original inspiration for the idea: <https://www.youtube.com/watch?v=qv6UVOQ0F44>

[2] Kenneth O. Stanley and Risto Miikkulainen, Evolving Neural Networks through Augmenting Topologies. This paper describes the NEAT method: <http://nn.cs.utexas.edu/downloads/papers/stanley.ec02.pdf>

[3] Dr. Tom Murphy, The First Level of Super Mario Bros. is Easy with Lexicographic Orderings and Time Travel ...after that it gets a little tricky. Paper and YouTube video explanation of a method to automatic NES video gameplay: <http://www.cs.cmu.edu/~tom7/mario/mario.pdf> <https://www.youtube.com/watch?v=xOCurBYI_gY>

[4] Mat Buckland and André LaMothe, AI Techniques for Game Programming. This describes neural networks and genetic algorithms in more detail: <http://www.cs.uni.edu/~schafer/4620/readings/Ai%20Techniques%20For%20Game%20Programming.pdf>

[5] Stuart Russell and Peter Norvig, Artifical Intelligence a Modern Approach. This textbook is a great resource on AI. For my purposes I will be looking at the sections that discuss genetic algorithms and neural networks.

[6] Stephen Marsland, Machine Learning an Algorithmic Perspective. This is a great resource for neural networks and evolutionary learning.