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Evolving an Intelligent Ms. Pac-Man Agent Under Partially Observable Conditions

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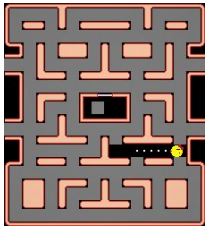
Introduction

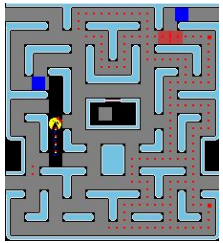
Ms. Pac-Man is a well known video game that has also been used extensively as a testbed for artificial intelligence research over the past two decades [1]. There have been many successful artificial agents built using a wide variety of techniques. However, past research has been confined to the standard, fully observable version of the domain. Restricting Ms. Pac-Man's view makes the game partially observable and more challenging. Ms. Pac-Man can only see down halls. The solution to this domain presented in this work is an agent that extends a previous approach using MM-NEAT [2], an algorithm for evolving agents using artificial neural networks.

Ms. Pac-Man

Ms. Pac-Man consists of four mazes full of pills. To earn points, she must move over and thus consume the pills. However, she must also avoid the four ghosts that roam the mazes. If a ghost catches her, she loses a life. Aiding the player are four special power pills located in the corners of each maze. Eating these pills allows the player to eat the ghosts which temporarily disables them and earns points.



Modeling the Maze



To address the challenge of partial observability, the agent constructs a model of the game state based on observations. There are two models: a perfect model of pill locations and a probabilistic model of ghost locations. The pill model allows the agent to see pills outside of her view. The ghost model allows Ms. Pac-Man to track probable ghost locations and whether they are threatening or edible. Such knowledge allows the agent to pursue and capture edible ghosts.

Method/Experiments

This research used MM-NEAT [2] to evolve neural network controllers for a Ms. Pac-Man agent. MM-NEAT evolves agents that have multiple behavioral modules to exhibit different behaviors in different situations. MM-NEAT extends the highly influential NEAT [3] algorithm, which simulates the evolution of networks by allowing the best performing networks to produce offspring with a small chance for mutation and crossover.

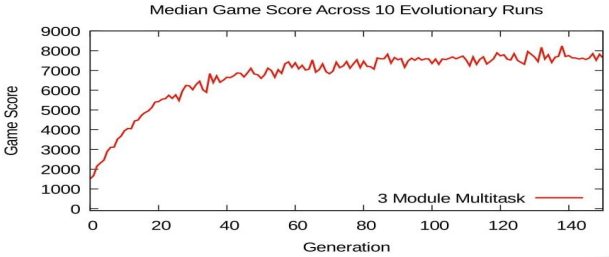
The agent evaluates sensor readings for each possible movement direction. These inputs are passed through the evolved network to calculate a preference for moving in each direction. The direction with the highest preference is the one that Ms. Pac-Man moves in.

The agent has three output modules. These allow the agent to exhibit different behaviors in different situations. Ms. Pac-Man has modules for:

- seeing no ghosts
- seeing only edible ghosts
- seeing any threat ghost (edible may also be present)

Results

The agent demonstrated two important behaviors for playing Ms. Pac-Man: fleeing ghosts and pursuing edible ghosts to eat them. Across 10 runs, performance reached a median score of about 8000 points, which is impressive in this challenging variant of the game.



Discussion

This agent (Squillyprice01) won first place in the Ms. Pac-Man track of the 2018 Ms. Pac-Man vs. Ghosts competition. To calculate scores, agents played twenty games against each of the Ghost controllers submitted to the competition, two of which were provided by the competition. The average of these scores is the agent's overall score. Below are the competition results (note that all starter agents were provided by the competition):

Agent	Average Score
Squillyprice01	7736.63
GiangCao	7516.63
thunder	6733.13
PacMaas	6275
Starter PacMan	5865.5
StarterPacManOneJunction	1134.25
StarterNNPacMan	535
user76	120

References

[1] P. Rohlfshagen, J. Liu, D. Perez-Liebana, S. M. Lucas. 2017. Pac-Man Conquers Academia: Two Decades of Research Using a Classic Arcade Game. *IEEE Transactions on Games.*

[2] J. Schrum, R. Miikkulainen. 2014. Discovering Multimodal Behavior in Ms. Pac-Man through Evolution of Modular Neural Networks. *Genetic and Evolutionary Computation Conference.*

[3] K. O. Stanley, R. Miikkulainen. 2002. Evolving Neural Networks through Augmenting Topologies. Evolutionary Computation.