CS 275 Project Proposal
Advanced Pac-Man simulation with Reinforcement learning

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Motivation

Our project idea comes from a famous arcade video game in 1980s called Pac-Man. The players have controls on the Pac-Man through a maze. In order to enter the next stage, the Pac-Man should eat all the pac-dots in the maze while avoiding monsters and ghosts (known as enemies). Reinforcement learning, which often used as framework for decision-making purpose, is a popular learning method for imitating animals' social behavior. Therefore, we are thinking about adding this learning ability to the original Pac-Man and simulate the game so that Pac-Man can learn from generation to generation.

Background

The advanced Pac-Man simulation will consist of many Pac-Man in a wide, dynamically changed wrap-around world. In our map there are monsters wander around, who can eat the Pac-Man and make a one-hit knockout to it. There are also obstacles and grass which serve the functionality of blocking the way and rest shelter for the Pac-Man respectively. Besides the normal pac-dots, now a new species of pac-dots which are being poisonous begin to

grow. At the very beginning, all Pac-Man can't distinguish these two species. After having a bite on the poisonous pac-dot, the Pac-Man's speed will slow down, which makes it easier for monsters to kill him. Now the mission for the Pac-Man: try to learn which pac-dot to eat so that they can avoid monsters and live longer!

Implementation

Pac-Man: Pac-Man will learn through reinforcement learning. In specific, Q-learning will be applied to its brain. If time permits, we may add other reinforcement learning method to its brain to see the difference between different learning algorithms. Pac-Man will have a visual sensor, which can be used to sense the monster, pac-dots, grass and obstacles. Though its body is of circular shape, we will assume it's rectangle (or square) for simplicity. Its motor neuron serves the movement, and it can move only in four directions: up, down, left and right.

Monster: Monster will have the same brain, visual sensor, motors as Pac-Man does. However, the body shape can be different, and we will decide later to see which gives the best collision effect.

We will mainly use pygame to develop the Pac-Man simulation. If we have extra time, we will apply PyOpenGL as well. At this moment, we have not decided yet to have a 2.5D or 3D map, but either will show the correct learning behavior for both Pac-Man and monsters.

For this project, we have three main focus. The first is Pac-Man and monsters' decision making action. We want them to exhibit correct behavior based on the Q-table constructed. The second is the Pac-Man's eating mechanism. All Pac-Man should eat normal and poisonous pac-dots blindly at first and learn to avoid poisonous pac-dot at the end. The last thing we want to observe is the Pac-Man and monster' fitness to the environment. Both are expected to behave more intelligently as the iteration increases.

Evaluation

We plan to take three different experiments:

1. Test Pac-Man's learning ability in distingiuishing normal and poisonous pac-dots
2. Test Pac-Man can rest on the grass or hide under it to avoid monsters
3. Test the learning effect for monsters, assuming all Pac-Man can learn

Presentation paper

1, Ishii, Hiroyuki, et al. "Experimental study on task teaching to real rats through interaction with a robotic rat." *International Conference on Simulation of Adaptive Behavior*. Springer Berlin Heidelberg, 2006.
2, Berthold, Oswald, and Verena V. Hafner. "Unsupervised learning of sensory primitives from optical flow fields." *International Conference on Simulation of Adaptive Behavior*. Springer International Publishing, 2014.
3, Schmickl, Thomas, and Karl Crailsheim. "An individual-based model of task selection in honeybees." *From Animals to Animats 10* (2008): 383-392.