Evolving Motor Techniques for Artificial Life

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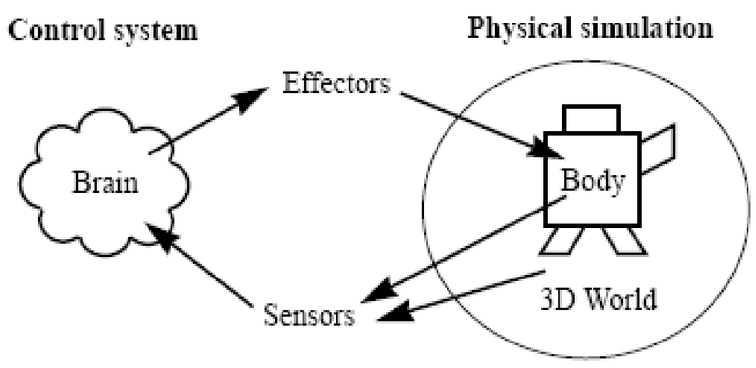
Abstract

This project simulates evolving virtual creatures in a 3D environment, based on ideas proposed by Karl Sims in his research paper "Evolving Virtual Creatures." Creatures' movements are calculated via an internal neuron system which produces effector output values. Generations of creatures are evaluated based on specific fitness tests and the most successful instances are used in the next generation. This eventually allows for the evolution of sophisticated motor skills and unique movement techniques. Creatures should also have the ability to evolve physically to allow for more sophisticated movement with the addition of specialized body parts.

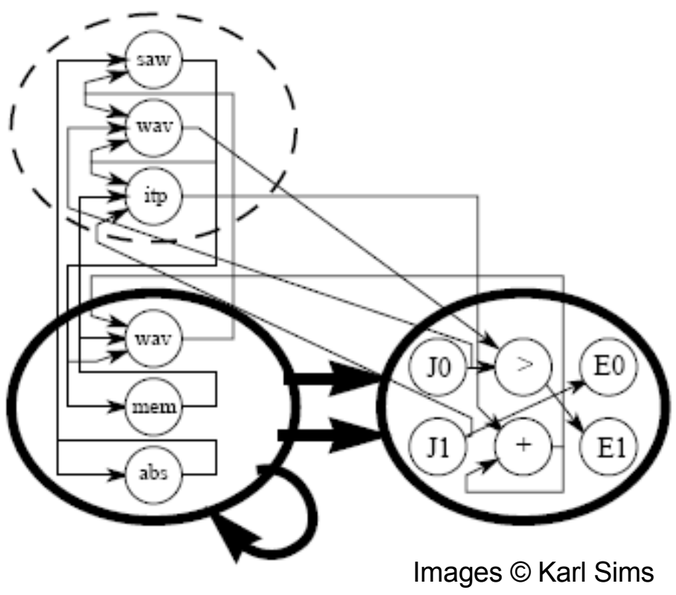
Background

This project is based on research proposed in Karl Sims' paper "Evolving Virtual Creatures." His paper introduces the idea of virtual creatures compared with various fitness evaluation functions to simulate creatures specialized to walk, swim, jump, and follow. He proposes a simulation that can create an infinite number of unique possible creatures with interesting movement strategies.

Sims' uses a system of sensors (inputs), neurons (modifiers), and effectors (outputs). Input data is taken from joint-angle sensors, are passed through and modified by neurons, and then applied as forces to the creature's joints.



In this image, the relation between the creature and its environment are show. The sensors measure data about how the environment and the creature interact, this data is modified by neurons in the “brain,” and the effector values influence the creature's next interaction.

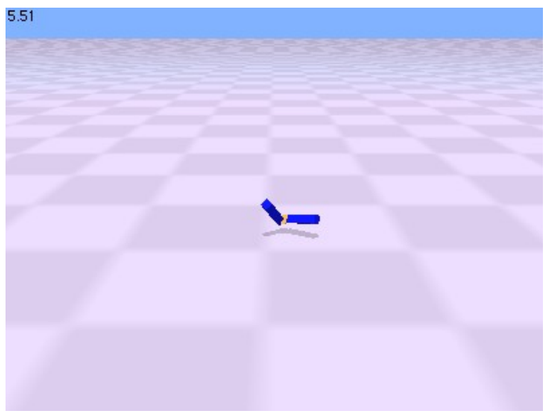


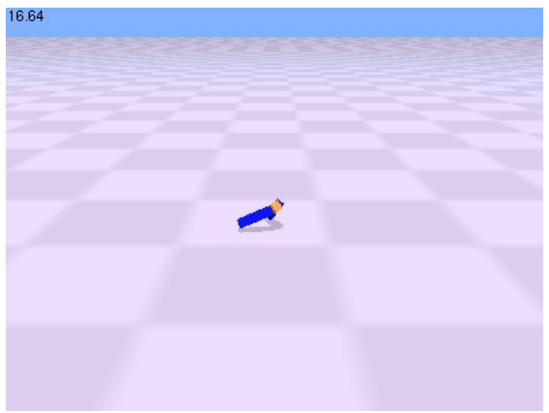
This diagram shows the flow of sensor data through the neurons and into the output. J0 and J1 are input joint-angle values. They travel through the different neurons (circles marked with saw, >, abs, etcetera) and reach E0 and E1, the effectors.

Images © Karl Sims

Development

For my project, I plan to incorporate Sims' control structure with genes passed on from the past generation. The simulation begins with ten creatures, all of which are controlled by neuron-modified values. This will produce creatures that move randomly.





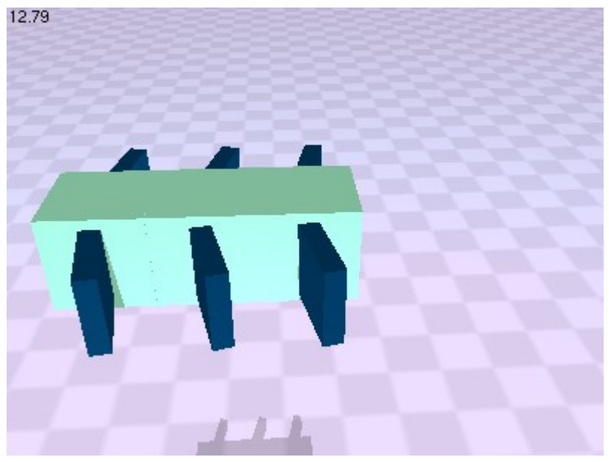
A creature controlled by neuron modification of sensor inputs.

These creatures will move randomly for a given amount of time, and then their fitness level is measured. For example, how far a creature goes in that time would be a good measure of walking fitness. The two instances that receive the highest fitness values are selected, and their velocity arrays are averaged together. This new creature is added to the next generation, and the creatures that did not pass the fitness test are replaced by new, neuron-controlled organisms.

Expected Results

My final goal is to create a simulation that can create a unique variety of creatures with advanced motor techniques. I expect that several different methods for movement will be possible because of the inclusion of neuron-controlled creatures in each generation. The use of genes from the past generation is what will allow for evolution.

I'd also like to implement a method for generating specialized creatures. This should be fairly simple with the use of fitness tests. In order to create creatures that are specialized for swimming or following, different fitness tests would be used in order to develop creatures with the best traits for these specialties.



Example of a swimming creature not created through evolution. It's environment does not have gravity in order to simulate water, and has simulated drag.