PS Einführung in die Bioinformatik
Project Overview

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1 Introduction

The goal is to write a program similar to Vaario's in [1]: Some simulated creatures populate the artificial world and fight for survival. Each creature has an artificial brain which processes the incoming information and controls its bahaviour. This brain is an ANN with a fixed number of neurons, input cells and output cells but the connections between them grow on a biological plausible basis.

2 External World

The external world is a bounded plane. Obstacles are spread out over the world. When a creature crashes into an obstacle or into the boundary it receives a penalty. On the other hand food is initially placed on the plane and also appears regularly. If a creature "eats" some food it gets a bonus.

3 Connection between External and Internal World

Each creature has a fixed set of sensors for food detection("Eyes") and obstacle detection("Whiskers"). The strength of a stimulus from a food detecting sensor depends on the distance and on the angle to the target food. Obstacle detection works a bit different: Each sensor has an area of influence and the strength of a stimulus depends on how much of this area is occupied by obstacles.

To move in the virtual world each creature has two wheels. Velocity and change of direction of a creature are computed based on the strength of the signals both wheels receive.

4 Internal Word

The internal world is a cube with the sensors and wheels on fixed positions. There also are several neurons and guidance cells scattered in space. From sensors and neurons axons grow guided by "chemical" gradients. Every neuron, guidance cell, and wheel produces one of several substances that may attract axons. Every axon follows exactly one substance at one time but this substance can change during growth.

After the connections have grown during development of the phenotype the "brain" is abstracted to an ANN. The length of a connection in the brain and the distance of an axon's end to a cell determine a connection weight for the ANN.

5 The ANN

Incoming stimuli are added up at neurons and if the sum does exceed a certain threshold it propagates a stimulus of a ceratin strength which is independent from the incoming stimuli. If the threshold is not exceeded the level of excitement is stored in the neuron and added to the incoming stimuli in the next cycle. (Pulse coded)

In one clock cycle information is only propageted from one cell to its direct successors. So loops in the structure of the ANN are no problem at all.

6 Genetic Coding

The following data is stored for every axon-growing cell (sensors, neurons):

- Substances which the axon follows and threashold values from which concentration on this substance is ignored.
- Connectivity parameter: the degree of "hairiness" of axons.
- Whether the axon has an excitatory or an inhibitory influence on successing neurons, wheels. (also see Appendix A)

Data for axon attracting cells (guidance cells, neurons, wheels):

- A Substance to produce and its initial concentration.

Data for free placed cells (guidance cells, neurons):

- X, Y, Z coordinates which define the position of the cell within the cube.

7 Evolution and Fitness

¿From every generation the fittest 50% are selected and may reproduce. In the mating pool pairs are selected randomly which we derive offstring from using crossover and bitflip mutation operations.

To calculate the fittest 50% we put all creatures into the same world where they compete for food. A creature has a certain amount of energy which is reduced every turn. If the creature finds some food it gets extra energy; if it bumps into an obstacle it is injured and so loses some energy. As soon as a creature's energy gets less or eqal zero it dies and so is removed from the world. If half of the population died our remaining population is the mating pool.

A To Do

How can negative connection weigths be represented in our model? (biological plausible, synapses, ...)

References

[1] Jari Vaario, Akira Onisuka and Katuso Shimohara. *Formation of Neural Structures.* Technical Paper, ATR Human Information Processing Laboratories.