Evolution of Recurrent Neural Networks to Control Autonomous Life Agents

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Abstract

Studies of artificial life (alife) attempt to simulate simple living beings. On the other hand, autonomous agents researchers are interested in building agents that are able to complete a particular task without supervision. In this research, these two areas of artificial intelligence are combined into what we call "Autonomous Life Agent" (ALA). ALA is an artificial agent that is sent to some environment in which to live without any supervision or any predefined behaviour rules. The primary goal of the agent is to learn how to survive in its artificial environment. We utilize a recurrent neural network (RNN) to determine the agent's actions. A novel ALA Training System is developed that evolves RNN topology and link weights simultaneously using genetic algorithms.

1 GENERAL DESCRIPTION

ALA has a number of internal variables such as energy and maintenance levels. Each variable is reduced as the agent acts in the environment by a user-controlled rate. The agent dies when one of the variables becomes negative. Therefore, to remain alive, the agent has to periodically increment the values of the internal variables by visiting specific cells in the world that correspond to each variable. This increment is analogous to acquiring energy from energy cells and receiving maintenance in home cells. There are three types of cells: empty cells that are passive, wall cells that are fatal, and active cells that increment internal variables. Active cells have a time delay before they can be active again after being used.

This task involves hidden system states. Some information about the world is not available to the agent as input. For instance, at any time, the agent can sense only the immediately surrounding cells and the current cell. Thus, the agent has to explore the world and encode its information in the agent's brain. Furthermore, some data is not available to the agent at all such as the time delay of the active cells. The agent must automatically discover this information by observing the visible system states.

2 APPROACH

The ALA Training System consists of five components: (1) agent, (2) genome, (3) population, (4) world, and (5) genetic engine. The internal structure of the agent is a three-layer RNN where each layer is fully connected with the next layer. Some of the nodes in the hidden layer have recurrent links. The genome completely defines an agent by specifying its topology definition and the link weights. The genome uses numerical encoding. The population uses tournament selection to select genomes for reproduction. The world evaluates agents by measuring how long they can survive in the environment. If an agent can live up to the maximum age then it is considered a solution and the evolution terminates.

3 EXPERIMENTAL RESULTS

We are able to evolve agents that can live a 10x10 world with 3 active cells. The agents start their life span from a random cell and are evolved on two distinct but similar environments. The agents are also able to live in unseen environment that is similar to the training environment. These agents have few hidden neurons (1-3) and some of them do not have any recurrent links.

4 CONCLUSION

The training system is robust, flexible, fully configurable, and efficient. The contribution of this research extends beyond building training and simulation environment. It leads to discovering that few nodes in the hidden layer of the RNN are sufficient to control ALAs in non-trivial world definitions. Furthermore, this research showed through empirical experiments that recurrent links do not enhance the capabilities of neural networks in controlling autonomous agents in this problem definition.