

Genetic Algorithms and Artificial Life

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Introduction

Genetic Algorithms (GAs) are adaptive heuristic search algorithm based on the evolutionary ideas of natural selection and genetics.

GA's are a subclass of Evolutionary Computing

GA's are based on Darwin's theory of evolution

Introduction

- ◆ Offspring are similar to their parent, so each new generation has organism that are similar to the fit members of the previous generation.
- ◆ GA starts with a set of one or more individuals and applies selection and reproduction operators to "evolve" an individual that is successful.

History

- ◆ In 1950s and 1960s evolutionary computing evolved. Idea of Evolution could be used as an optimization tool.
- ◆ In late 1960s, Rechenberg introduced "evolution strategies".
- ◆ In 1960s, Fogel, Owens, and Walsh developed "evolutionary programming".
- ◆ GA's were created by John Holland in the mid-70's

Simple form of GAs

1. Start with a randomly generated population of chromosomes.
2. Calculate the fitness of each chromosome in the population.
3. Apply selection and genetic operators to the population to create a new population.
4. Go to step 2.

Applications

- ◆ Optimization : Circuit design, job shop scheduling etc.
- ◆ Automatic Programming : cellular automata, sorting network etc.
- ◆ Machine and robot learning
- ◆ Economic models : Bidding strategies etc.
- ◆ Immune system models

Applications

- ◆ Ecological models : biological arms races, resource flow in ecologies etc.
- ◆ Population genetics models
- ◆ Interactions between evolution and learning
- ◆ Models of social systems : evolution of cooperation, trail-following behaviors in ants etc.

How to Apply?

GA simply searches directly in the space of individuals with the goal of finding one that maximizes the fitness function.

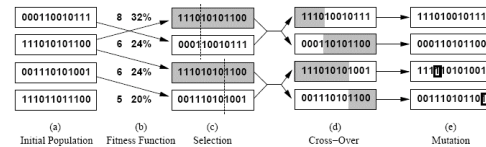
Before apply the GA, we need the answer:

1. What is the fitness function?
2. How is an individuals represented?
3. How are individuals selected?
4. How do individuals reproduce?

GAs Functions

- ◆ Population :set of individuals
- ◆ Fitness Function: Function which takes an individual as input and returns a real number as output.
- ◆ Selection
- ◆ Cross-over
- ◆ Mutation

Example



Interactions Between Learning and Evolutions

Baldwin Effect is that if learning helps survival, then organism best able to learn will have the most offspring and increase the frequency of the genes responsible in learning.

1. Hinton and Nowlan's simple model
2. Evolutionary reinforcement learning

Simple Model

- ◆ GA plays evolution role in neural network learning algorithm.
- ◆ Each individual is a neural network with 20 potential connections.
- ◆ Three connections : Present, absent, learnable (1, 0, ?)
- ◆ Problem is find the single correct set of connections
- ◆ To summarize, learning allows genetically code partial solutions to get partial credit.

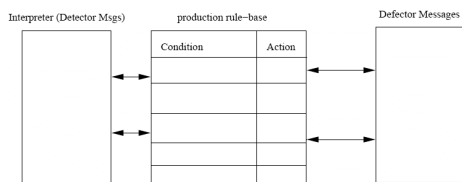
Reinforcement Learning

- ◆ Ackley and Littman, agents randomly moves on a 2-D lattice, encountering food, hiding places, etc.
- ◆ Each agent possesses two feed-forward neural network: One maps the agent state at time t , another one maps agents state in time t with this action.
- ◆ The weights on the action network change over the agent's lifetime according to a reinforcement learning algorithm.

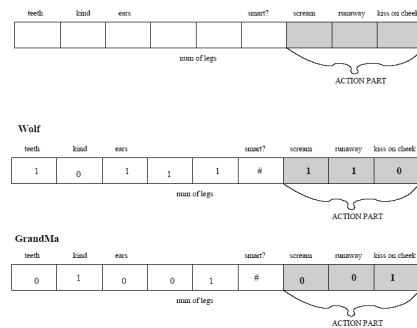
Classifier Systems

- ◆ Parallel machine (like NN)
- ◆ Three layers:
 - Performance system
 - Bucket Brigade learning
 - Genetic operators

Classifier System



Example



Prisoner's Dilemma (PD)

You and a friend have committed a crime and have been caught. You are being held in separate cells. You are both offered a deal but have to decide what to do :

- ◆ If you confess and your partner denies taking part in the crime, you go free and your partner goes to prison for five years.
- ◆ If your partner confesses and you deny, you go to prison for five years and your partner goes free.
- ◆ If you both confess you will serve four years each.
- ◆ If you both deny taking part in the crime, you both go to prison for two years.

Conclusion

- ◆ Denker remark: "neural networks are the second best way of doing just about anything"
- ◆ Extended with "and genetic algorithms are the third"
- ◆ GA has large application areas especially in search, optimization and learning problems.