Lecture
Evolutionary Strategies

CIS 412 Artificial Intelligence
Umass, Dartmouth

Evolutionary computation

Evolutionary approach

The evolutionary approach is based on computational models of natural selection and genetics. We call them evolutionary computation, an umbrella term that combines **genetic algorithms**, **evolution strategies** and **genetic programming**.

Evolution strategies

- Another approach to simulating natural evolution was proposed in Germany in the early 1960s. Unlike genetic algorithms, this approach − called an **evolution strategy** − was designed to solve technical optimization problems.

Evolution strategies

- In 1963 two students of the Technical University of Berlin, **Ingo Rechenberg** and **Hans-Paul Schwefel**, were working on the search for the optimal shapes of bodies in a flow. They decided to try random changes in the parameters defining the shape following the example of natural mutation. As a result, the evolution strategy was born.
- Evolution strategies were developed as an alternative to the engineer's intuition.
- Unlike GAs, evolution strategies use only a mutation operator.

Basic evolution strategy

- In its simplest form, termed as a (1+1)- evolution strategy, one parent generates one offspring per generation by applying *normally distributed* mutation. The (1+1)-evolution strategy can be implemented as follows:
- Step 1 - Choose the number of parameters *N* to represent the problem, and then determine a feasible range for each parameter:

$$\{x_{1min},\ x_{1max}\},\ \{x_{2min},\ x_{2max}\},\ \ldots,\ \{x_{Nmin},\ x_{Nmax}\}$$

Define a standard deviation for each parameter and the function to be optimized.

Basic evolution strategy

- Step 2 - Randomly select an initial value for each parameter from the respective feasible range. The set of these parameters will constitute the initial population of parent parameters:

$$x_1, x_2, \ldots, x_N$$

- Step 3 - Calculate the solution associated with the parent parameters:

$$X = f(x_1, x_2, \ldots, x_N)$$

Basic evolution strategy

- Step 4 - Create a new (offspring) parameter by adding a normally distributed random variable *a* with mean zero and pre-selected deviation δ to each parent parameter:

$$x_i' = x_i + a(0,\ \delta) \quad i = 1, 2, \ldots, N$$

- Normally distributed mutations with mean zero reflect the natural process of evolution (smaller changes occur more frequently than larger ones).
- Step 5 - Calculate the solution associated with the offspring parameters:

$$X' = f\left(x_1', x_2', \ldots, x_N'\right)$$

Basic evolution strategy

- Step 6 - Compare the solution associated with the offspring parameters with the one associated with the parent parameters. If the solution for the offspring is better than that for the parents, replace the parent population with the offspring population. Otherwise, keep the parent parameters.
- Step 7 - Go to Step 4, and repeat the process until a satisfactory solution is reached, or a specified number of generations is considered.

Evolution strategy

- An evolution strategy reflects the nature of a chromosome.
- A single gene may simultaneously affect several characteristics of the living organism.
- On the other hand, a single characteristic of an individual may be determined by the simultaneous interactions of several genes.
- The natural selection acts on a collection of genes,not on a single gene in isolation.