Genetic Algorithms

Rui Mendes

Introduction

Characteristics

- Inspired in living systems
- Borrow ideas from evolution

Examples

- Genetic Algorithms
- Genetic Programming

Genetic Algorithm

- Optimization algorithm
- Inspired in natural selection
- Uses a population of individuals
- Each individual encodes a solution
- There are three operators:
  1. Selection
  2. Crossover
  3. Mutation

Encoding

- Process that represents a solution in a given alphabet
- There are several encodings, e.g.:
  - binary
  - integer
  - real numbers
  - permutations
- Usually, they are linear sequences of values (chromossomes composed of genes)

Creating new solutions

- The genetic operators for creating new solutions are:
  - Recombination or Crossover
  - Mutation

Crossover

- Combines several solutions
- Usually, it takes two parents and creates two offspring
- Usual methods:
  - One point crossover
  - Two point crossover
  - Uniform crossover

One point crossover

- A cutting point is randomly selected
- Each solution takes a part from each parent

Parents

$010|110$

$011|101$

Offspring

$010|101$

$011|110$

Two point crossover

- Two cutting points are randomly selected
- The central parts are exchanged

Parents

$10|11|0$
$01|10|1$

Offspring

$10|10|0$
$01|11|1$

Uniform crossover

- The value of the first parent is randomly copied to one of the offspring
- The value of the second parent is copied to the other one

Parents

10110
01101

Offspring

00100
11111

Mutation

- A position is randomly selected inside the string
- The value is randomly selected among the possible values

Before

10110

After

10010

Fitness

- Quantifies the quality of a solution
- It is usually a *floating point number*
- In order to compare the quality of two solutions, one simply has to compare the fitness values

Selection

- Process for choosing which individuals will generate offspring or will be copied into the new population
- It usually selects individuals:
  - According to their fitness;
  - By partial or total ordering of the solutions
  - By stochastic choice of the individuals according to their fitness

Fitness proportionate selection

- The probability of selecting an individual is proportional to their fitness
- If it is a maximization problem, the probability of selecting an individual is $p_i = \frac{f_i}{\sum_i f_i}$

Genetic Algorithm outline

1. Initialize the population
2. While not finished
    1. Choose individuals
    2. Apply genetic operators
    3. Insert offspring into the next population