Optimization using Real valued Genetic Algorithm

Group 14

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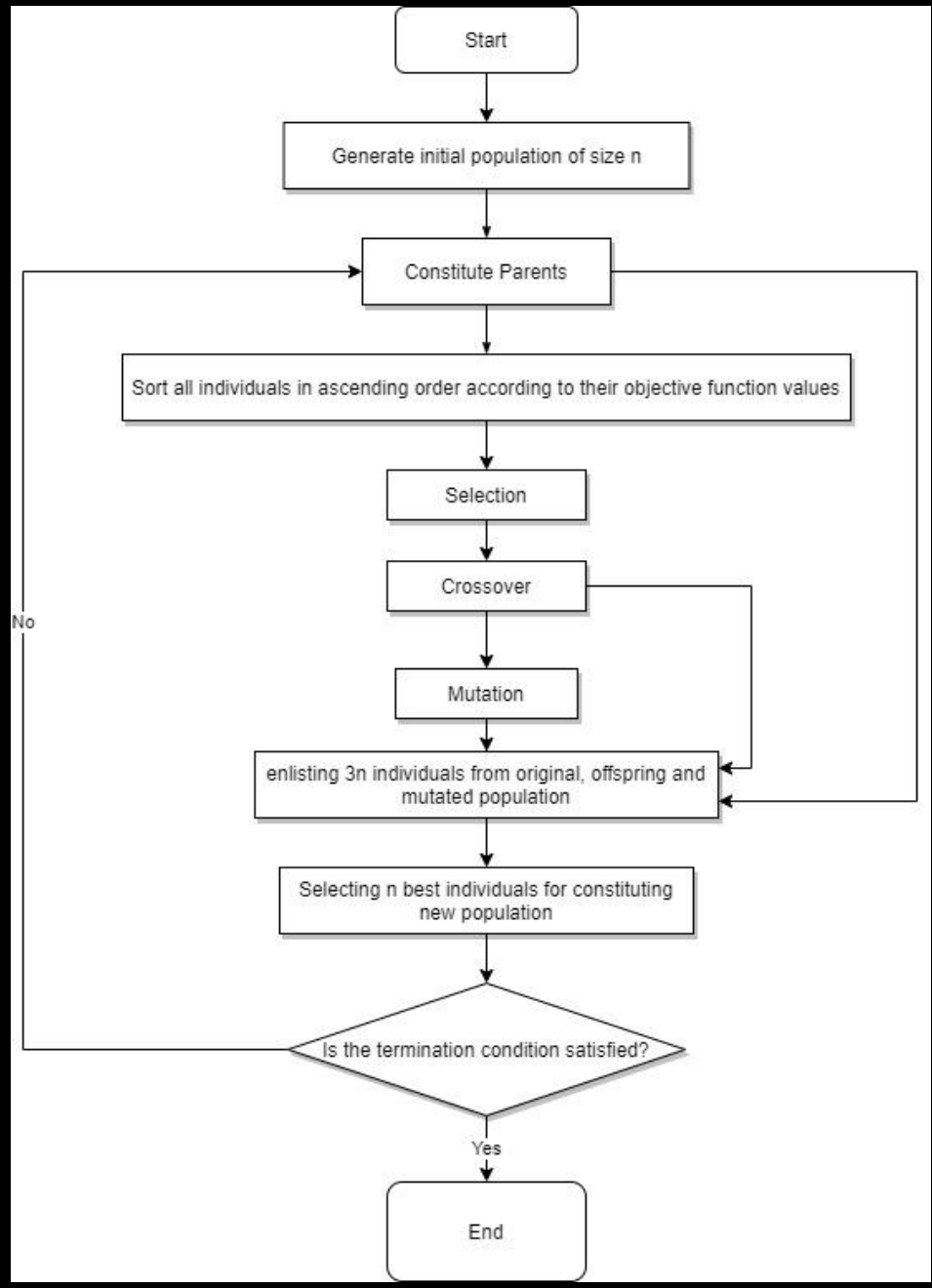
Genetic Algorithm

- It refers to the family of computational model inspired by Darwin's theory of biological Evolution(survival of the fittest)
- The idea is one of the natural selection organizing principle for optimizing individual and population of individuals
- GAs mimic the natural selection to optimize more successfully
- Problems are solved by an evolutionary process resulting in best(fittest) solution(survivor)

Flowchart


Start
Generate initial population of size n
Constitute Parents
Sort all individuals in ascending order according to their objective function values
Selection
Crossover
Mutation
enlisting 3n individuals from original, offspring and mutated population
Selecting n best individuals for constituting new population
Is the termination condition satisfied?
No
Yes
End

Selection

Sorted population according to fitness. Selected half population having best fitness values.

Before sorting

After sorting

Selected the half population having the best fitness values

Arithmetic Crossover

In real coded GA, a crossover can be defined as follows:
if $x_1 = (x_{11}, x_{12}, \dots, x_{1n})$ and $x_2 = (x_{21}, x_{22}, \dots, x_{2n})$ denote two parents and $y_1 = (y_{11}, y_{12}, \dots, y_{1n})$ and $y_2 = (y_{21}, y_{22}, \dots, y_{2n})$ denote the offsprings, then the offsprings are arithmetically represented by

$$y_{1i} = \alpha_i x_{1i} + (1- \alpha_i) x_{2i}$$

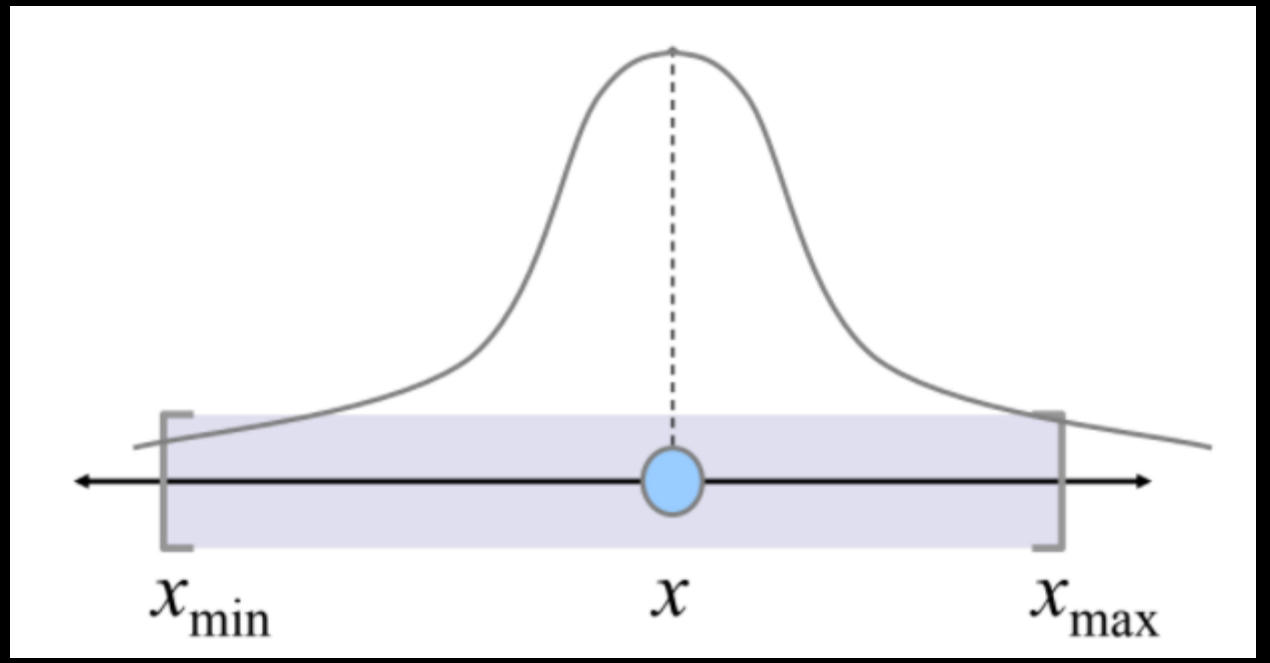
$$y_{2i} = (1- \alpha_i) x_{1i} + \alpha_i x_{2i}$$

where α_i are random numbers in [0, 1]

Normally Distributed Mutation

Perturb the gene value using a zero-mean Gaussian distribution

$$x^{new} = x + N(0, \sigma)$$



Sphere Problem

The problem used in this algorithm is

$$\min f(x) = \sum_{i=1}^{n} x_i^2$$

Selection

- Roulette Wheel Selection Method
- The Tournament Selection Method

Roulette Wheel Selection Method

The cumulative sum of the goodness values is calculated. A random number is then generated between the minimum and the maximum of the cumulative sum. The point where the random number intercepts the cumulative sum curve determines the parent.

$$p(i) = \frac{f(i)}{\sum_{j=1}^{n} f(j)}$$

The Tournament Selection Method

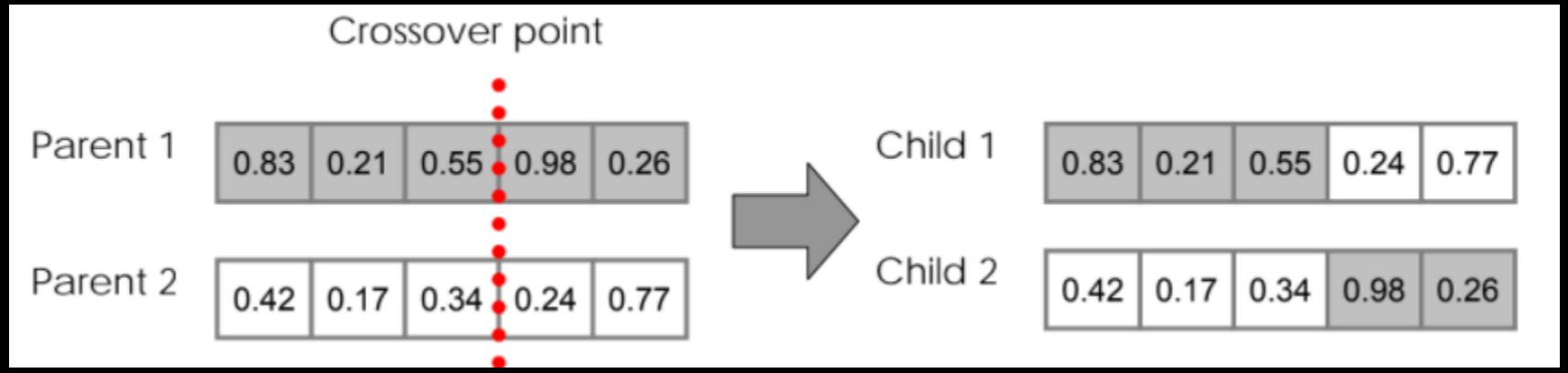
A certain number of chromosomes are selected randomly to participate in a “tournament”. The chromosome with the highest (lowest) goodness value is the winner and is selected as a parent.

$$\text{p(i)} = \begin{cases} \frac{C(k-1,n-1)}{C(k,n)} & if\ i \in [1, n-k-1] \\ 0 & if\ i \in [n-k, n] \end{cases}$$

Crossover

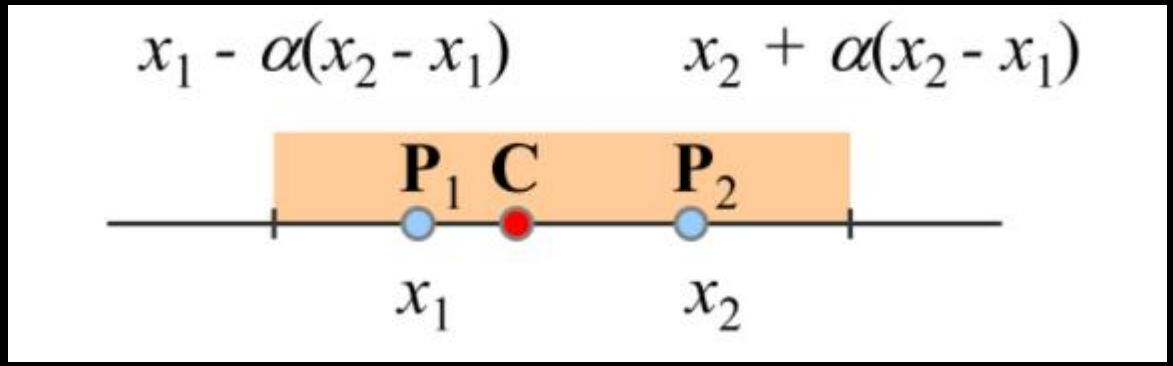
- Single-Point Crossover
- The Blend-α crossover operator

Single-Point Crossover



The Blend-α crossover operator

- Given the two parents x1 and x2 where x1< x2, the blend crossover randomly selects a child in the range [x1-α(x2-x1), x2+α(x2-x1)]



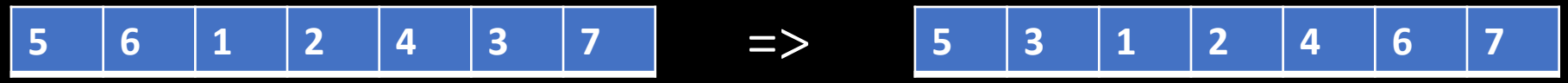
- It is often suggested that a good choice of α is 0.5.

Mutation

- Swap Mutation
- Scramble Mutation

Swap Mutation

In swap mutation, we select two positions on the chromosome at random, and interchange the values. This is common in permutation based encodings.



Scramble Mutation

Scramble mutation is also popular with permutation representations. In this, from the entire chromosome, a subset of genes is chosen and their values are scrambled or shuffled randomly.

Conclusion

- Population is problem specific ,Larger the population better will be the result, moreover a population of 300 has given good results.
- Crossover probability should be high.
- Mutation probability should be low(in some/our case a probability of 60% gave good results).
- The algorithm give good result for spherical function.

Strength and Weakness

Strength

- Code is generalized, so can be applied to any function.

Weakness

- Function can converge to any point other than minima when during iterations, minima goes out of domain of population.

Libraries used

- Pandas
- Numpy

Improvement Analysis of Real-Coded Genetic Algorithm

An improved real-coded genetic algorithm (IRCGA) is proposed to solve constrained optimization problems.

- A sorting grouping selection method is given with the advantage of easy realization and not needing to calculate the fitness value.
- A heuristic normal distribution crossover (HNDX) operator is proposed. It can guarantee the cross-generated off springs to locate closer to the better one among the two parents.
- In IRCGA, substitution operation is added after the crossover operation so that the population does not have the same individuals, and the diversity of the population is rich.