CSE/ECE 848 Introduction to Evolutionary Computation

Module 3 - Lecture 12 - Part 1

Differential Evolution: The Algorithm

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Introduction

- Recent arrival: First publication in 1995:
  - R. Storn and K. Price, “Differential Evolution - A Simple and Efficient Adaptive Scheme for Global Optimization over Continuous Spaces,” Tech. Report, International Computer Science Institute (Berkeley), 1995.
- No convergence proof
- But found to be more efficient than GA or SA (1997 paper)

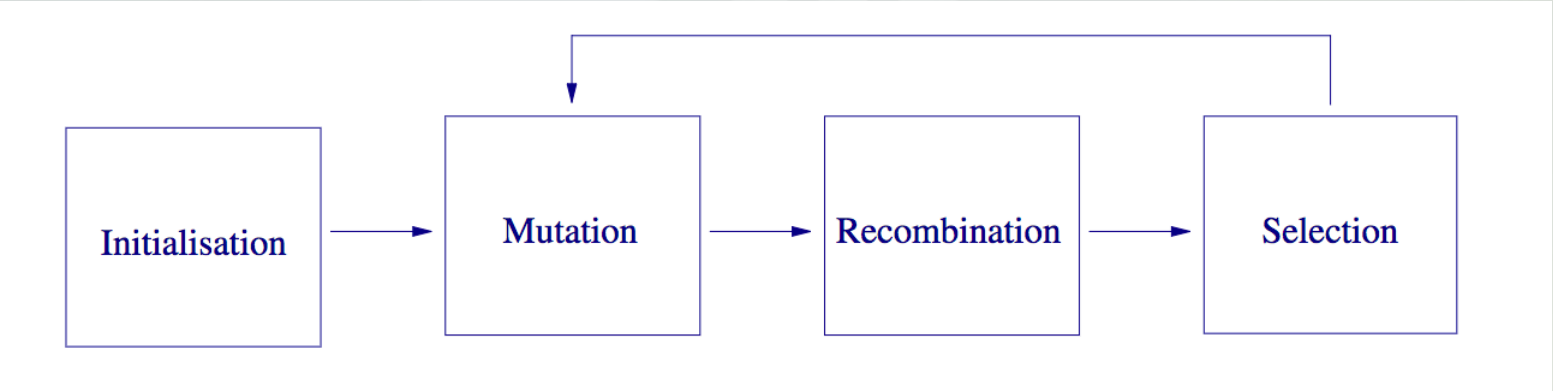
General Features

- Evolutionary approach
- Population-based
- Stochastic
- Derivative-free
- Real-value variables

Distance Vector

- Makes use of distance between individuals
- Mean decreases during iterations
- Mean decreases as population increases (more density in search space)
- Important: Distribution of the population, rather than parameters for stepsize etc.
- Central Limit Theorem: "Under certain conditions, the arithmetic mean of independent random variables will be approximately normally distributed, regardless of the underlying distribution."
- Normal distribution has only mean and std dev as parameters

Main Steps of DE



- Mutation uses other individuals! It is thus more like a perturbation, not entirely random, but dependent on the population
- Recombination mixes with successful individuals
- Selection is greedy (as in small tournaments)

Initialisation

- Define upper (U) and lower (L) bounds on your variables

$$x_j^L \leq x_j \quad \leq x_j^U$$

- Randomly (uniform) select from the interval $[x_j^L, x_j^U]$

Mutation

- Define a donor vector v by selecting 3 individuals from the population
- F is the mutation or perturbation factor controlling the rate of evolution

$r1, r2, r3 \in \{1, 2, \cdots, NP\}$

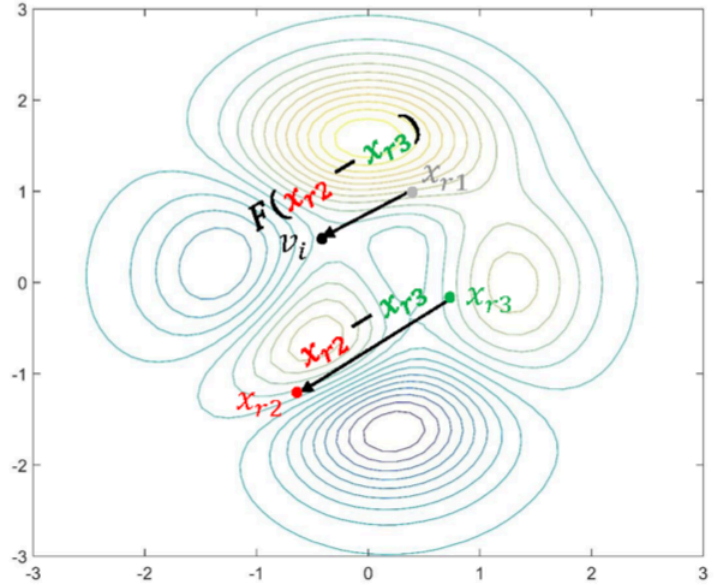
Donor vector:

$$v_i = x_{r1} + F(x_{r2} - x_{r3})$$

$$F \in [0, 2]$$

In practice:

$$F \in [0.5, 1]$$



Recombination

- Incorporates existing successful solutions by mixing a current solution and a donor to build an offspring (trial vector):
- Select one individual from the population (target vector), and mix it with a probability CR with one of the donors (mutated individuals)

$$u_{i,j} = \begin{cases} v_{i,j} & j \in J \\ x_{i,j} & otherwise \end{cases}$$

$i \in \{1, 2, \cdots, NP\}$

$j \in \{1, 2, \cdots, D\}$

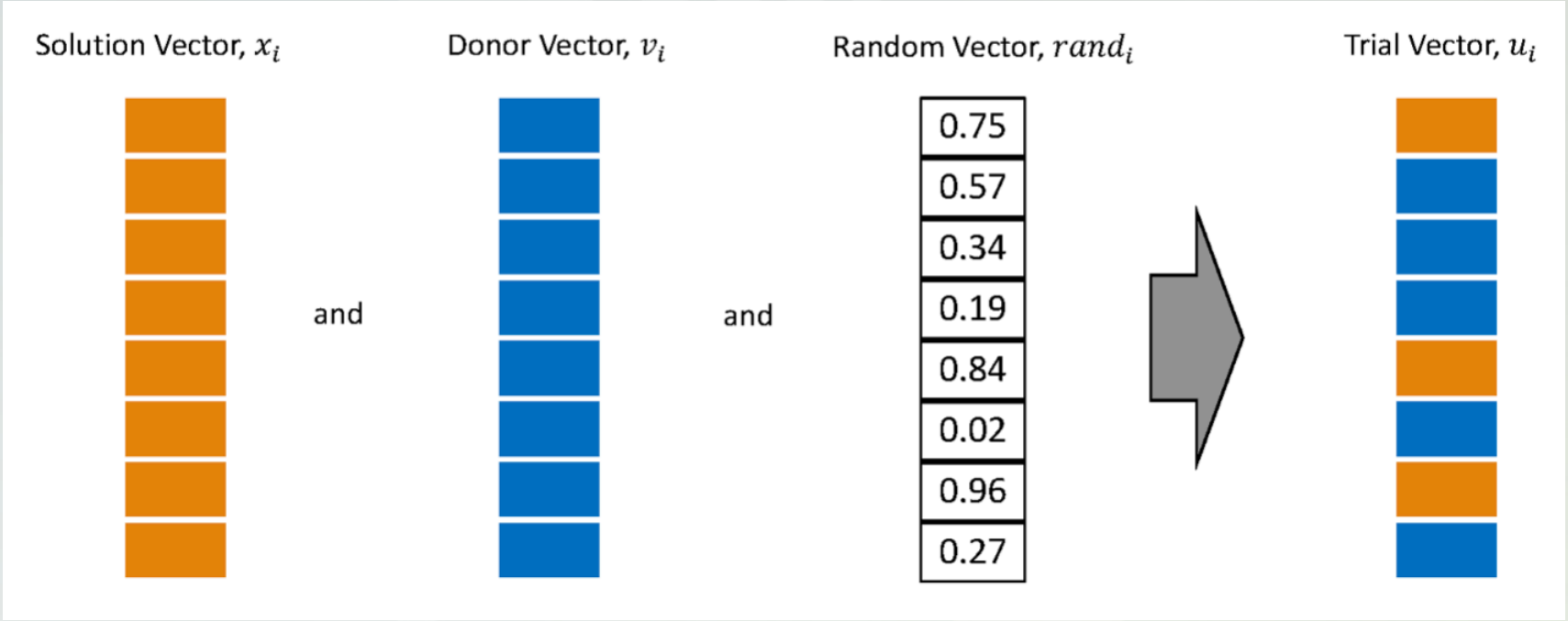
$rand_{i,j} \sim U[0, 1]$

two-point modulo (Exponential Crossover)

Randomly choose j_0
Add j_0 to J
for $j = 1$ *to* D
    if $rand_j \leq CR$
        add j to J
    end
end

At least one allele is from donor

Example Recombination with CR=0.7



Parent 1 x Parent 2 Uniform xover Offspring

Selection

- Compare target vector (current solution) with the offspring (recombined trial vector) and select the better one!

$$x_i^{k+1} = \begin{cases} u_i^k & f(u_i^k) \leq f(x_i^k) \\ x_i^k & otherwise \end{cases}$$

- Greedy, as only one of them survives, tournament size is 2
- (μ+λ) strategy also possible, with μ=λ=NP

The DE Algorithm

Initialization: # Population, # Generations, F and CR

    Evaluate the fitness values of all population individuals

while the terminate criteria is not met

    Pick individuals from the population

    Building a donor vector for each

    Making a trial vector using the parent and the donor

    Evaluate the fitness values of new individuals (children)

    Replace the child with the parent if it is better

end while