Introduction to Differential Evolution

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Differential Evolution

It is a stochastic, population-based optimization algorithm for solving nonlinear optimization problem

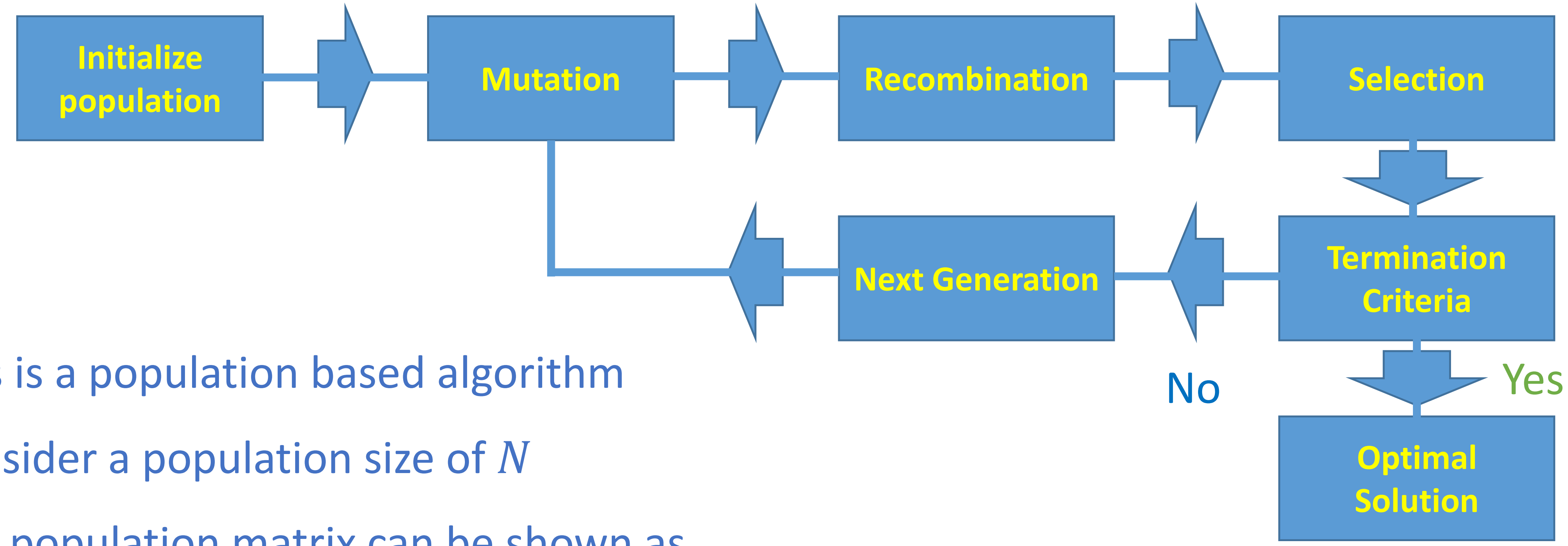
The algorithm was introduced by Storn and Price in 1996

Consider an optimization problem

Minimize $f(X)$

Where $X = [x_1, x_2, x_3, \ldots, x_D]$, D is the number of variables

Evolutionary algorithms



This is a population based algorithm

Consider a population size of N

The population matrix can be shown as

$$x_{n,i}^{g} = [x_{n,1}^{g}, x_{n,2}^{g}, x_{n,3}^{g}, \dots, x_{n,D}^{g}]$$

Where, g is the Generation and $n = 1,2,3, \dots N$

Initial population

Initial population is generated randomly between upper lower and upper bound

$$x_{n,i} = x^{L}_{n,i} + rand(\quad) * (x^{U}_{n,i} - x^{L}_{n,i}) \qquad i = 1,2,3,\dots D \;\; and \quad n = 1,2,3,\dots N$$

Where x_i^L is the lower bound of the variable x_i

Where x_i^U is the upper bound of the variable x_i

Mutation

From each parameter vector, select three other vectors x_{r1n}^{g}, x_{r2n}^{g} and x_{r3n}^{g} randomly.

Add the weighted difference of two of the vectors to the third

$$v_n^{g+1} = x_{r1n}^{g} + F\left(x_{r2n}^{g} - x_{r3n}^{g}\right) \qquad n = 1,2,3, \dots N$$

v_n^{g+1} is called donor vector

F is generally taken between 0 and 1

Recombination

A trial vector $u_{n,i}^{g+1}$ is developed from the target vector, $x_{n,i}^{g}$, and the donor vector, $v_{n,i}^{g+1}$

$$u_{n,i}^{g+1} = \begin{cases} v_{n,i}^{g+1} & if\ rand() \leq C_p\ or\ i = I_{rand} \\ x_{n,i}^{g} & if\ rand() > C_p\ and\ i \neq I_{rand} \end{cases} \qquad \begin{matrix} i = 1,2,3,\ldots D\ \ and \\ n = 1,2,3,\ldots N \end{matrix}$$

I_{rand} is a integer random number between [1,D]

C_p is the recombination probability

Selection

The target vector $x_{n,i}^{g}$ is compared with the trial vector $u_{n,i}^{g+1}$ and the one with the lowest function value is selected for the next generation

$$x_n^{g+1} = \begin{cases} u_{n,i}^{g+1} & if\ f\left(u_n^{g+1}\right) < f\left(x_n^{g}\right) \\ x_n^{g} & Otherwise \end{cases}$$

$$n = 1,2,3, \ldots N$$

THANKS