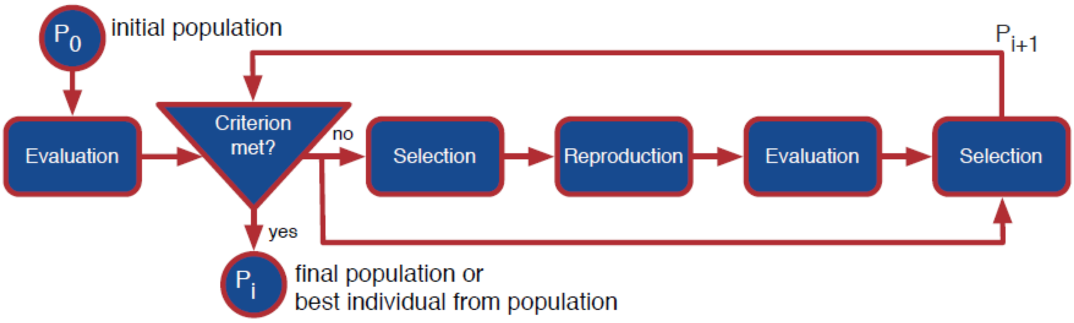
11.1 Genetic Algorithm

Genetic algorithms are usually used to identify optimal solutions to complex problems. This can clearly be easily mapped to search methods, which are aiming toward a similar goal. Genetic algorithms can thus be used to search for solutions to multi-value problems where the closeness of any attempted solution to the actual solution (**fitness**) can be readily evaluated. In short, a **population** of possible solutions (**chromosomes**) is generated, and a fitness value for each chromosome is determined. This fitness is used to determine the likelihood that a given chromosome will survive to the next generation or reproduce. Reproduction is done by applying **crossover** to two (or more) chromosomes, whereby features (**genes**) of each chromosome are combined together. Mutation is also applied, which involves making random changes to particular genes.



11.2 Lab Tasks

Exercise 11.1.

Consider the problem of maximizing the function

$$f(x) = \frac{-x^2}{10} + 3x$$

where x is allowed to vary between 0 and 31. You must perform following tasks in the code.

a. Representation of states (solutions): To solve this using a genetic algorithm, we must encode the possible values of x as chromosomes. For this problem, we will encode x as a binary integer of length 5. Thus, the chromosomes for our genetic algorithm will be sequences of 0's and 1's with a length of 5 bits, and have a range from 0 (00000) to 31 (11111).

b. Fitness function:

The fitness function for it will be:

$$f(x) = \frac{-x^2}{10} + 3x$$

To begin the algorithm, we select an initial population of 10 chromosomes at random. The resulting initial population of chromosomes is shown in Table 1. Next we take the x-value that each chromosome represents and test its fitness with the fitness function. The resulting fitness values are recorded in the third column of Table 1.

Chromosome Number	Initial Population	x-Value	Fitness Value $f(x)$	Selection Probability
1	0 1 0 1 1	11	20.9	0.1416

2	1 1 0 1 0	26	10.4	0.0705
3	0 0 0 1 0	2	5.6	0.0379
4	0 1 1 1 0	14	22.4	0.1518
5	0 1 1 0 0	12	21.6	0.1463
6	1 1 1 1 0	30	0	0
7	1 0 1 1 0	22	17.6	0.1192
8	0 1 0 0 1	9	18.9	0.1280
9	0 0 0 1 1	3	8.1	0.0549
10	1 0 0 0 1	17	22.1	0.1497

c. **Operators:**

   i. Apply cross over in every generation.

   ii. Apply mutation after every 3 generations.

d. **Termination criteria:** Your loop should stop when the value of one of your candidate's fitness functions is greater or equal to 90%.

Exercise 11.2. Travelling Salesman Problem

Suppose a TCS delivery boy has to deliver parcels from *Head Office (MM Alam Road)* to 7 different locations in Lahore *(Johar Town, Shahdara, DHA Phase 6, Wapda Town, Askari 10, Allama Iqbal Town, Mall Road)* and then return back to the *Head Office.* He wants to find the route with least travelling distance. You helped him in finding the route using *Hill Climbing Algorithm*. Now use *Genetic Algorithm* instead of *Hill Climbing* to solve this problem. Design choices should be as per class discussion. [You can construct distance matrix using google maps OR you can take random values (between 0-50) for distances between any two spots.]