The key to simulated annealing's success is the "temperature" parameter, which controls the likelihood of accepting worse solutions. Initially, the temperature is high, allowing for more exploration. As the algorithm progresses, the temperature decreases, reducing the acceptance probability and allowing the search to converge towards a better solution.

3. Local Beam Search

Local beam search represents a parallelized adaptation of hill climbing, designed specifically to counteract the challenge of becoming ensnared in local optima. Instead of starting with a single initial solution, local beam search begins with multiple solutions, maintaining a fixed number (the "beam width") simultaneously. The algorithm explores the neighbors of all these solutions and selects the best solutions among them.

Initialization: Start with multiple initial solutions.

Evaluation: Evaluate the quality of each initial solution.

Neighbor Generation: Generate neighboring solutions for all the current solutions.

Selection: Choose the top solutions based on the improvement in the objective function.

Termination: Continue iterating until a termination condition is met.

Local beam search effectively avoids local optima because it maintains diversity in the solutions it explores. However, it requires more memory to store multiple solutions in memory simultaneously.

• Optimization

Optimization is the process of making something better.

Optimization refers to finding the values of inputs in such a way that we get the “best” output values.

The definition of “best” varies from problem to problem, but in mathematical terms, it refers to maximizing or minimizing one or more objective functions, by varying the input parameters.

1. Genetic Algorithm

A genetic algorithm is an adaptive heuristic search algorithm inspired by "Darwin's theory of evolution in Nature." It is used to solve optimization problems in machine learning. It is one of the important algorithms as it helps solve complex problems that would take a long time to solve.

Before understanding the Genetic algorithm, let's first understand basic terminologies to better understand this algorithm:

- Population: Population is the subset of all possible or probable solutions, which can solve the given problem.
- Chromosomes: A chromosome is one of the solutions in the population for the given problem, and the collection of genes generates a chromosome.
- Gene: A chromosome is divided into a different gene, or it is an element of the chromosome.
- Allele: Allele is the value provided to the gene within a particular chromosome.
- Fitness Function: The fitness function is used to determine the individual's fitness level in the population. It means the ability of an individual to compete with other individuals. In every iteration, individuals are evaluated based on their fitness function.
- Genetic Operators: In a genetic algorithm, the best individual mate to regenerate offspring better than parents. Here genetic operators play a role in changing the genetic composition of the next generation.
- Selection: After calculating the fitness of every existent in the population, a selection process is used to determine which of the individualities in the population will get to reproduce and produce the seed that will form the coming generation.

Types of selection styles available

1. Roulette wheel selection
2. Event selection
3. Rank- grounded selection

So, now we can define a genetic algorithm as a heuristic search algorithm to solve optimization problems. It is a subset of evolutionary algorithms, which is used in computing. A genetic algorithm uses genetic and natural selection concepts to solve optimization problems.

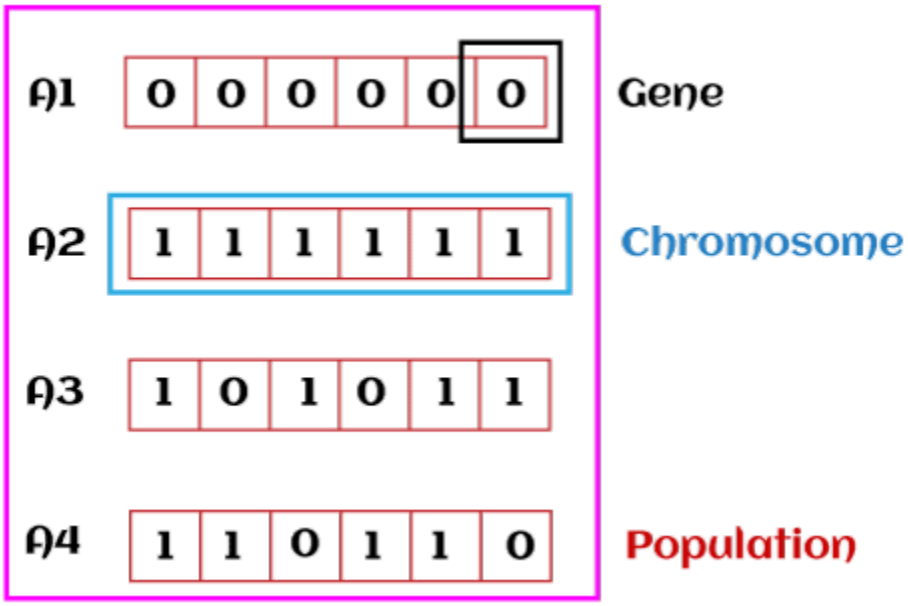
The genetic algorithm works on the evolutionary generational cycle to generate high-quality solutions. These algorithms use different operations that either enhance or replace the population to give an improved fit solution.

It basically involves five phases to solve the complex optimization problems, which are given as below:

1. Initialization
2. Fitness Assignment
3. Selection
4. Reproduction
5. Termination

1. Initialization

The process of a genetic algorithm starts by generating the set of individuals, which is called population. Here each individual is the solution for the given problem. An individual contains or is characterized by a set of parameters called Genes. Genes are combined into a string and generate chromosomes, which is the solution to the problem. One of the most popular techniques for initialization is the use of random binary strings.



2. Fitness Assignment

Fitness function is used to determine how fit an individual is? It means the ability of an individual to compete with other individuals. In every iteration, individuals are evaluated based on their fitness function. The fitness function provides a fitness score to each individual. This score further determines the probability of being selected for reproduction. The high the fitness score, the more chances of getting selected for reproduction.

3. Selection

The selection phase involves the selection of individuals for the reproduction of offspring. All the selected individuals are then arranged in a pair of two to increase reproduction. Then these individuals transfer their genes to the next generation.

There are three types of Selection methods available, which are:

Roulette wheel selection

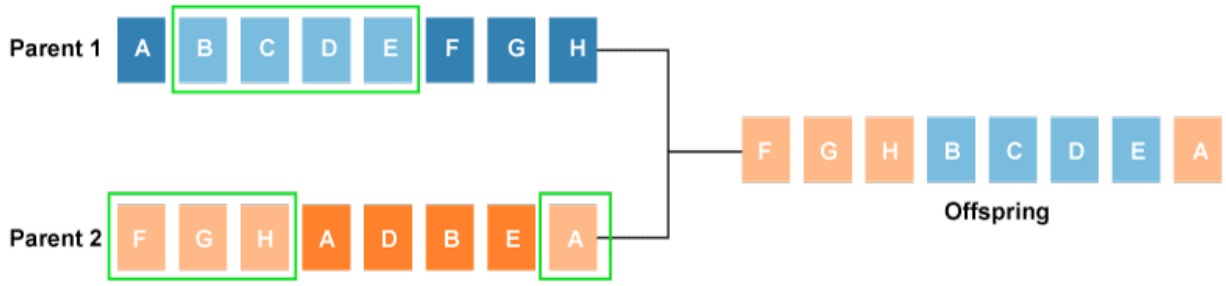
Tournament selection

Rank-based selection

4. Reproduction

After the selection process, the creation of a child occurs in the reproduction step. In this step, the genetic algorithm uses two variation operators that are applied to the parent population. The two operators involved in the reproduction phase are given below:

Crossover: The crossover plays a most significant role in the reproduction phase of the genetic algorithm. In this process, a crossover point is selected at random within the genes. Then the crossover operator swaps genetic information of two parents from the current generation to produce a new individual representing the offspring.



The genes of parents are exchanged among themselves until the crossover point is met. These newly generated offspring are added to the population. This process is also called crossover.

Types of crossover styles available:

- ➔ One point crossover
- ➔ Two-point crossover
- ➔ Livery crossover
- ➔ Inheritable Algorithms crossover

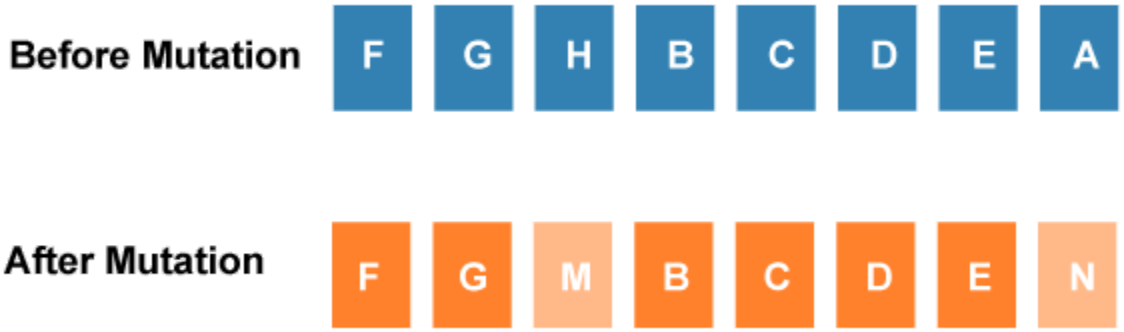
Mutation

The mutation operator inserts random genes in the offspring (new child) to maintain the diversity in the population. It can be done by flipping some bits in the chromosomes.

Mutation helps in solving the issue of premature convergence and enhances diversification. The below image shows the mutation process:

Types of mutation styles available,

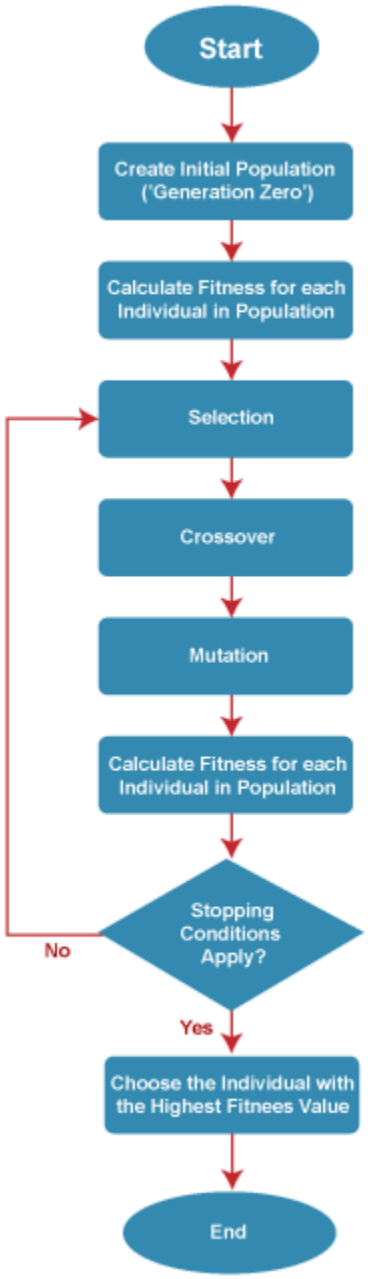
- ➔ Flip bit mutation
- ➔ Gaussian mutation
- ➔ Exchange/Swap mutation



5. Termination

After the reproduction phase, a stopping criterion is applied as a base for termination. The algorithm terminates after the threshold fitness solution is reached. It will identify the final solution as the best solution in the population.

General Workflow of a Simple Genetic Algorithm



Advantages of Genetic Algorithm

- The parallel capabilities of genetic algorithms are best.

- ➢ It helps in optimizing various problems such as discrete functions, multi-objective problems, and continuous functions.
- ➢ It provides a solution for a problem that improves over time.
- ➢ A genetic algorithm does not need derivative information.

Limitations of Genetic Algorithms

- ➢ Genetic algorithms are not efficient algorithms for solving simple problems.
- ➢ It does not guarantee the quality of the final solution to a problem.
- ➢ Repetitive calculation of fitness values may generate some computational challenges.