Genetic Algorithm

* Explain Genetic Algorithm with its working principle.

=> Genetic Algorithm are a type of evolutionary algorithm which is inspired by the process of natural selection and genetics.

Genetic Algorithm is used as an optimization method for finding solution for solve complex problem.

Genetic Algorithm simulate the process of natural selection which means those species that can adapt to changes in their environment.

They simulate "survival of the fittest" amonge individuals of consecutive generations to solve a problem.

Each generation consists of a population of individuals and each individual represents a point in search space and possible solution.

=> Working Principle:

For Genetic Algorithm, we have to consider unconstrained optimization problem.

We have to consider the following maximization problem,

maximize $f(x)$

$$x_i^{(L)} \leq x_i \leq x_i^{(U)}$$

$$\text{for } i = 1, 2, \ldots, N$$

If we want to minimize $f(x)$,
For $f(x) > 0$,

then Objective function as

$$\text{minimize } \frac{1}{1 + f(x)}$$

If we want to minimize $f(x)$,
For $f(x) < 0$

then Objective Function as

$$\text{minimize } \{-f(x)\}$$

There are Five phase to solve the complex problem.

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

1 Initialization :

In this step, We have to generate all the set of individuals which called population.

Each individual is the solution for given problem which contains set of parameters called Genes.

2 Fitness Assignment :

Fitness Function is used to Find how fit an individual to compete with other individual.

Every individuals are evaluated based on their fitness function, which provides fitness score to each individual.

3 Selection:

This phase is used to selection of individuals for the reproduction of offstring.

All the selected individuals are arrangned in a pair of two to increase reproduction.

4 Reproduction:

In this step, the genetic algorithm uses two operators that are applied to the parent population.

5 Termination:

After reproduction step, the algorithm terminates after the threshold fitness solution is reached.

It will give final solution of problem.

* Explain Fitness Function and Reproduction in GA.

=> Fitness Function:

Fitness Function is used to get Fitness Score for every individuals.

Fitness Score shows the ability of an individual to compete with other individual.

Genetic Algorithm are used to solve ~~mi~~ maximization problem.

For solve minimization problem, we have to transformed problem into maximization problem.

Fitness Function F(x) is derived from the objective function.

Transformations required for Fitness Function.

F(x) = f(x) for maximization Problem

F(x) = 1/f(x) for minimization problem if f(x) ≠ 0

$F(x) = 1/(1+f(x))$, if $f(x) = 0$.

The Fitness Function value of the string is known as string's Fitness.

=> Reproduction:

In Reproduction, We have to use to operation.

(a) Crossover
(b) Mutation

a Crossover:

In this operation, A Crossover point is selected at random within the genes.

Then Crossover operator swaps genetic information from two parents from the current generation and create new offString.

Parent-1	1	0	1	0	1	0

1	0	1	0	1	1

offString

Parent-2	1	1	0	0	1	1

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6 Mutation:

The Mutation operator inserts random genes in the offString to maintain the diversity in the population.

This are the Types of Mutation:

- Flip bit Mutation
- Gaussian Mutation
- Exchange / Swap Mutation

offString:

A	E	C	F	D	B

Mutation String:

A	E	G	F	H	B

* Explain Operators in Genetic Algorithm.

=> There are Three operators in Genetic Algorithm.

a) Selection Operator
b) Crossover Operator
c) Mutation Operator

1 Selection Operator:

The selection operator is used to choosing individuals From the population for reproduction based on their Fitness score.

There are Three method in selection.

a) Roulette wheel Selection
b) Tournament Selection
c) Rank-based Selection

* Explain Encoding method in Genetic Algorithm.

=> There are Six Types of Encoding Method in Genetic Algorithm.

a) Binary Encoding
b) Octal Encoding
c) Hexadecimal Encoding.
d) Permutation Encoding
e) Value Encoding
F) Tree Encoding

a Binary Encoding:

In Binary Encoding, Each individuals are represents as a Binary digits 0 and 1.

Binary Encoding is straightforward and efficient for problems.

Ex. Integer 9 : Equivalent of 9 Binary is : 1001

2	9	Reminder
2	4	1 ^
2	2	0 | Binary Number = 1001
	1	0

↷

Binary Substring $S_i = \sum_{n=0}^{n_i - 1} 2^k S_k$

b Octal Encoding:

Octal encoding represents individuals using octal digits 0 to 7.

Each octal digit corresponds to a group of three binary digits.

Ex. 542

8	542	Reminder
8	67	6
8	8	3
	1	0

Octal Number: 1036

Binary Substring,

$$S_i = \sum_{k=0}^{k_{ni}-1} 8^k S_k$$

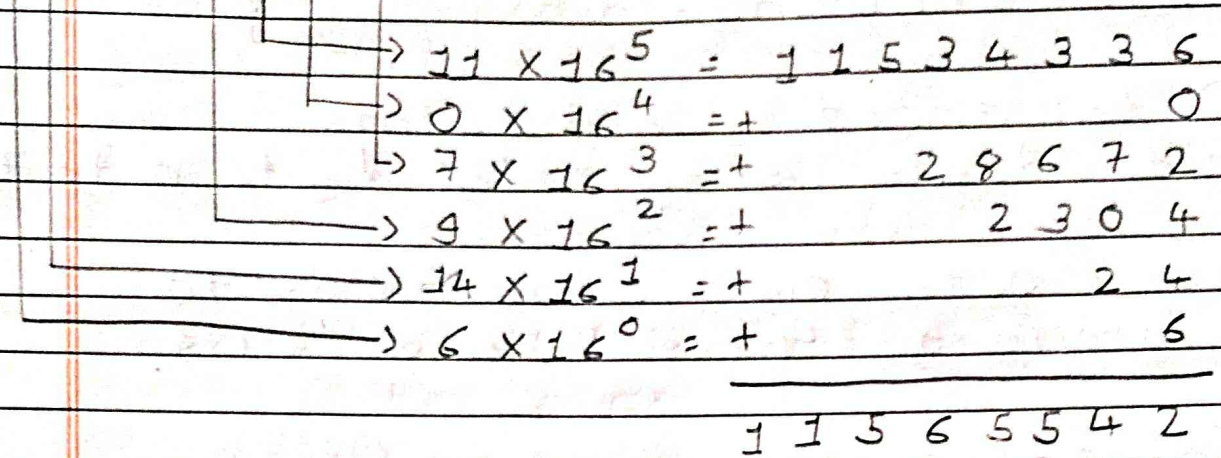
c Hexadecimal Encoding:

Hexadecimal encoding uses hexadecimal digits (0-9, A-F) to represent individual.

Each Hexadecimal digit corresponds to a group of four binary digits.

Hexadecimal String $S_i = \sum_{k=0}^{k=ni-1} 16^k S_k$

Ex. B 0 7 9 E 6



d Permutation Encoding:

Permutation Encoding is used to represent solution for problems involving permutation.

In Permutation Encoding, Each individual represent a possible ordering.

Individual A: 1 5 3 2 4 7 9 8 6

e Value Encoding

Value Encoding is used to represent solutions as values rather than binary string or permutation.

Each individual directly represents numerical or categorical values.

Individual A 7.23 5.32 0.45 2.02

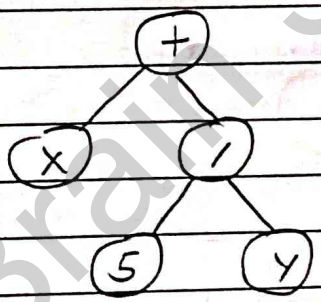
Individual B abdjetiapdxy...

Individual C (Back), (Right), (Forward), (Left)

F Tree Encoding:

Tree Encoding is used to represent the solutions as hierachical structures such as trees or graphs.

Ex. + x(/5y)



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