Genetic Algorithm

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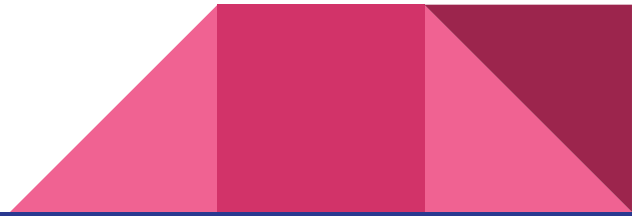
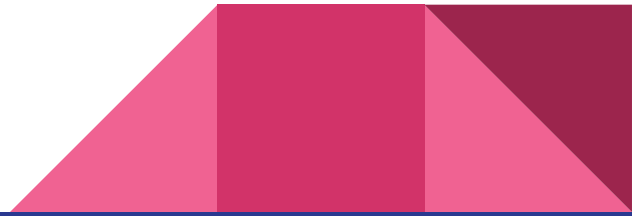
Introduction

- Provides effective and efficient solution to Machine Learning and Optimization problems
- Follows a biological approach that is why it is named as such.
- Widely used in Business, Scientific and Engineering field.

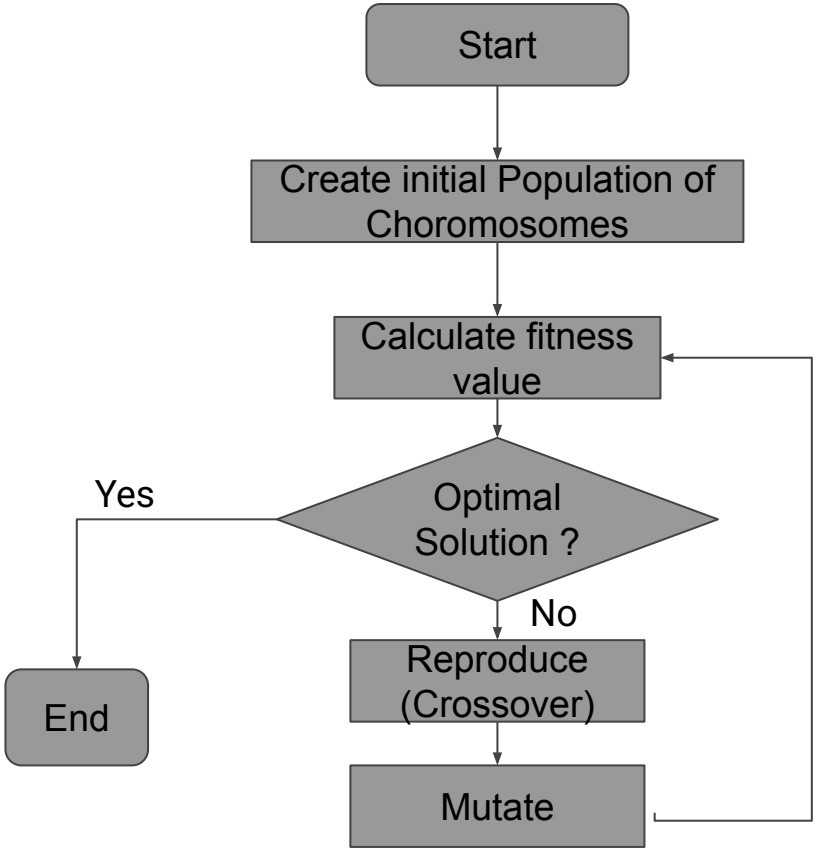


Terminology

- Chromosome/Gene
- Population
- Fitness Function
- Crossover
- Mutate
- Offspring



Flowchart


Start
Create initial Population of Choromosomes
Calculate fitness value
Optimal Solution ?
Yes
No
End
Reproduce (Crossover)
Mutate

Main Tasks

- Parents Selection

Choose best parents based on fitness function

- Crossover

One point

1100|1100
1010|1010

11001010
10101100

Two point

11|0011|00
10|1010|10

11101000
10001110

- Mutate

11100111 → 11100101

Example 1

Q1. Find the maximum value for the given function f(x) = x^2. The domain of x is [0,31]

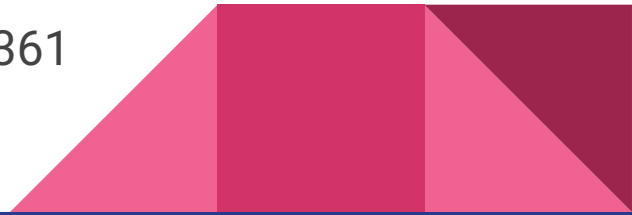
Ans:

Step 1: Generate initial population.

01101(13), 11000(24), 01000(8), 10011(19)

Step 2: Calculate the fitness score

13 -> 169, 24 -> 576, 8 -> 64, 19 -> 361



Example 1

Step 3: Select Parents

$$p_i = f_i / \sum_i f_i \quad \text{for } i = 1,2,\ldots n$$

String No	Chromosome	X value	Fitness Score (f_i)	p_i
1	01101	13	169	0.14
2	11000	24	**576**	**0.49**
3	01000	8	64	0.06
4	10011	19	361	0.31
SUM			**1170**	1

Example 1

Step 4: Crossover

String No	Mating Pool	Crossover point	Offspring	X value	Fitness Score (f_i)
1	0110|1	3	01100	12	144
2	1100|0	3	11001	25	625
2	11|000	1	11011	27	729
4	10|011	1	10000	16	256
SUM					**1754**

Example 1

Step 5: Mutate

String No	Offspring	Mutation Point	Offspring (After mutation)	X value	Fitness Score (f_i)
1	01100	0	11100	26	676
2	11001	N/A	11001	25	625
2	11011	N/A	11011	27	729
4	10000	2	10100	18	324
SUM					**2354**

Example 2

Q2. Based on the information below try to maximize the value of the 0/1 knapsack problem when the size of your knapsack is 12Kg.

Item	Weight	Value
A	5 Kg	$12
B	3 Kg	$5
C	7 Kg	$10
D	2 Kg	$7

Example 2

Step 1: Generate Population.

Assume each position of a 4 bit string as an item. 0 Presents not selecting an item while 1 presents selecting an item.

0 1 1 0, 1 0 0 0, 1 1 1 1, 0 0 1 1

Step 2: Calculate the fitness score

0 1 1 0 -> 10Kg - $10

1 0 0 0 -> 2Kg - $7

1 1 1 1 -> 17Kg - $34

0 0 1 1 -> 9Kg - $17

Example 2

Step 3: Select Parents

$$p_i = f_i / \sum_i f_i \quad \text{for } i = 1,2,\ldots n$$

String No	Chromosome	Weight	Fitness Score (f_i)	p_i
1	0110	10	15	0.38
2	1000	2	7	0.18
3	1111	17	34	N/A
4	0011	9	**17**	**0.44**
SUM			39	1

Example 2

Step 4: Crossover

String No	Mating Pool	Crossover point	Offspring	Weights	Fitness Score (f_i)
1	0|110	0	0110	10	15
4	0|011	0	0011	9	17
2	100|0	2	1001	5	12
4	001|1	2	0010	7	10
SUM					**54**

Example 2

Step 5: Mutate

String No	Offspring	Mutation Point	Offspring (After mutation)	Weights	Fitness Score (f_i)
1	0110	0	1110	15	27
4	0011	3	0010	7	10
2	1001	1	1101	10	24
4	0010	0	1010	12	22
SUM					**56**

Homework

Q1. You are to produce the following string “I_LOVE_AI” using the following characters “ABC...Z_” (27 in total). Use GA to produce this string. Each chromosome is to be of 9 characters. Fitness function can be the distance between each character.