Name: Jigar Siddhpura **SAPID:** 60004200155

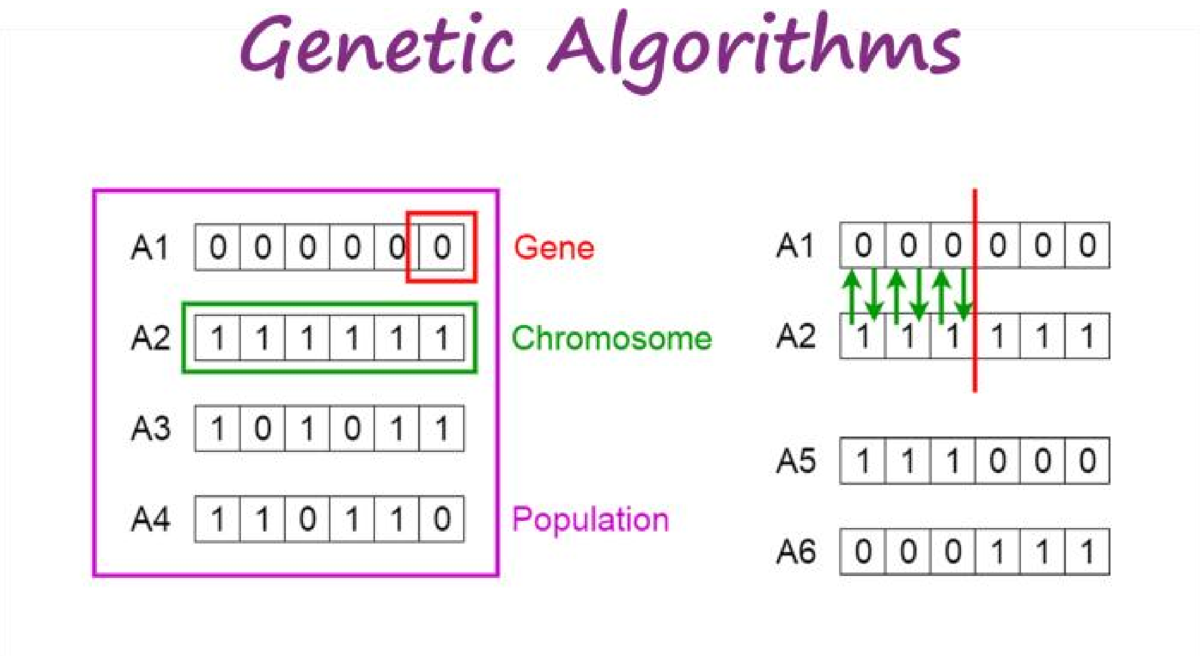
DIV: C/C2 **Branch:** Computer Engineering

AI EXPERIMENT 5 - Genetic Algorithm

Aim: To study and implement Genetic Algorithm

Theory:

A genetic algorithm is a search heuristic that is inspired by Charles Darwin'stheory of natural evolution. This algorithm reflects the process of natural selection where the fittest individuals are selected for reproduction in order toproduce offspring of the next generation.



Five phases are considered in a genetic algorithm.

1. Initial population
2. Fitness function
3. Selection
4. Crossover
5. Mutation

Initial Population

The process begins with a set of individuals which is called a Population. Eachindividual is a solution to the problem you want to solve.An individual is characterized by a set of parameters (variables) known as Genes. Genes are joined into a string to form a Chromosome (solution).

Fitness Function

The fitness function determines how fit an individual is (the ability of an individual to compete with other individuals). It gives a fitness score to each individual. The probability that an individual will be selected for reproduction isbased on its fitness score.

Selection

The idea of selection phase is to select the fittest individuals and let them pass their genes to the next generation.Two pairs of individuals (parents) are selectedbased on their fitness scores. Individuals with high fitness have more chance to be selected for reproduction.

Crossover

Crossover is the most significant phase in a genetic algorithm. For each pair ofparents to be mated, a crossover point is chosen at random from within the genes.

Mutation

In certain new offspring formed, some of their genes can be subjected to
a mutation with a low random probability. This implies that some of the bits inthe bit string can be flipped.

Code :

```
import random

gene = ['000000','111111','101011','110110']

def selection(gene):
    x = [int(x,2) for x in gene]
    fx = [int(x)*int(x) for x in x]
    fx_sum = sum(fx)
    fx_avg = fx_sum//len(fx)
    excepted_count = [round((i/fx_avg),4) for i in fx]
    actual_count = [round(i) for i in excepted_count]
    mate_pool = []
    for i,j in zip(actual_count,gene):
        if i:
            for c in range(i):
                mate_pool.append(j)
   return x,fx, fx_sum,fx_avg,excepted_count,actual_count,mate_pool

def generate_mate(size,mate_element_size):
    if size % 2 != 0:
        return -1

    available_positions = list(range(size))
    random.shuffle(available_positions)

    mate = [-1] * size
    crossover =[-1] * size

    for i in range(size):
        if mate[i] == -1:
            j = random.choice(available_positions)
            while mate[j] != -1 or j == i:
                j = random.choice(available_positions)
            mate[i] = j
            mate[j] = i
            available_positions.remove(i)
            available_positions.remove(j)
    for i in mate:
        if crossover.count(-1) != 0:
            crossover[i] = crossover[mate[i]] = random.randint(1,mate_element_size-1)
    return mate,crossover

def crossover(mate_pool):
    mate, crossover_points = generate_mate(len(mate_pool),len(mate_pool[0]))
    new_poplu = [-1]*len(mate_pool)
    for i in mate:
        new_poplu[i] = mate_pool[i][:crossover_points[i]] + mate_pool[mate[i]][crossover_points[i]:]

    x = [int(x,2) for x in new_poplu]
    fx = [int(x)*int(x) for x in x]


    return mate_pool,new_poplu,mate,crossover_points,x, fx


def GA(gene,iter,n):
    if iter == 0:
        return

    x,fx, fx_sum,fx_avg,excepted_count,actual_count,mate_pool = selection(gene)
```

```python
    if sum(actual_count)!=len(gene):
        print("Error dont know what to do at this situation ")

        return
    print(f"\n-------------------------------------------------- GENERATION {n} --------------------------------------------------")
    print("Initial Population\tX Value\t\tFitness Value( f(x) )\tProbability(Expected Count)\tActual Count")
    print(f"-----------------------------------------------------------------------------------------------------------------")
    for i in range(len(gene)):
        print(f"{gene[i]}\t\t\t{x[i]}\t\t{fx[i]}\t\t\t{excepted_count[i]}\t\t\t\t{actual_count[i]}")
    mate_pool,new_poplu,mate,crossover_points,x, fx = crossover(mate_pool)
    print(f"\n------------------------------------------------ New Population {n} ------------------------------------------------")
    print("Mate Pool\tMate\t\tCrossover Points\tNew Population\t\tx value\t\tf(x)")
    print(f"-----------------------------------------------------------------------------------------------------------------")
    for i in range(len(gene)):
        print(f"{mate_pool[i]}\t\t{mate[i]}\t\t{crossover_points[i]}\t\t\t{new_poplu[i]}\t\t\t{x[i]}\t\t{fx[i]}")

    GA(new_poplu,iter-1,n+1)

GA(gene,4,0)
```

Output :

```
-------------------------------------------------- GENERATION 0 --------------------------------------------------
Initial Population      X Value         Fitness Value( f(x) )   Probability(Expected Count)     Actual Count
-------------------------------------------------------------------------------------------------------------------
000000                  0               0                       0.0                             0
111111                  63              3969                    1.8181                          2
101011                  43              1849                    0.847                           1
110110                  54              2916                    1.3358                          1

------------------------------------------------ New Population 0 ------------------------------------------------
Mate Pool       Mate            Crossover Points        New Population          x value         f(x)
-------------------------------------------------------------------------------------------------------------------
111111          3               5                       111110                  62              3844
111111          2               5                       111111                  63              3969
101011          1               5                       101011                  43              1849
110110          0               5                       110111                  55              3025

-------------------------------------------------- GENERATION 1 --------------------------------------------------
Initial Population      X Value         Fitness Value( f(x) )   Probability(Expected Count)     Actual Count
-------------------------------------------------------------------------------------------------------------------
111110                  62              3844                    1.2122                          1
111111                  63              3969                    1.2517                          1
101011                  43              1849                    0.5831                          1
110111                  55              3025                    0.954                           1

------------------------------------------------ New Population 1 ------------------------------------------------
Mate Pool       Mate            Crossover Points        New Population          x value         f(x)
-------------------------------------------------------------------------------------------------------------------
111110          3               1                       110111                  55              3025
111111          2               4                       111111                  63              3969
101011          1               4                       101011                  43              1849
110111          0               1                       111110                  62              3844

-------------------------------------------------- GENERATION 2 --------------------------------------------------
Initial Population      X Value         Fitness Value( f(x) )   Probability(Expected Count)     Actual Count
-------------------------------------------------------------------------------------------------------------------
110111                  55              3025                    0.954                           1
111111                  63              3969                    1.2517                          1
101011                  43              1849                    0.5831                          1
111110                  62              3844                    1.2122                          1

------------------------------------------------ New Population 2 ------------------------------------------------
Mate Pool       Mate            Crossover Points        New Population          x value         f(x)
-------------------------------------------------------------------------------------------------------------------
110111          1               4                       110111                  55              3025
111111          0               4                       111111                  63              3969
101011          3               5                       101010                  42              1764
111110          2               5                       111111                  63              3969

-------------------------------------------------- GENERATION 3 --------------------------------------------------
Initial Population      X Value         Fitness Value( f(x) )   Probability(Expected Count)     Actual Count
-------------------------------------------------------------------------------------------------------------------
110111                  55              3025                    0.951                           1
111111                  63              3969                    1.2477                          1
101010                  42              1764                    0.5545                          1
111111                  63              3969                    1.2477                          1

------------------------------------------------ New Population 3 ------------------------------------------------
Mate Pool       Mate            Crossover Points        New Population          x value         f(x)
-------------------------------------------------------------------------------------------------------------------
110111          3               3                       110111                  55              3025
111111          2               2                       111010                  58              3364
101010          1               2                       101111                  47              2209
111111          0               3                       111111                  63              3969
PS D:\SEM 5\AI\EXPERIMENTS>
```

Conclusion :

Thus we successfully studied and applied Genetic Algorithm