Assignment : 01

Topic : Genetic Algorithm on the Traveling Salesman Problem (TSP) explanation and analysis.

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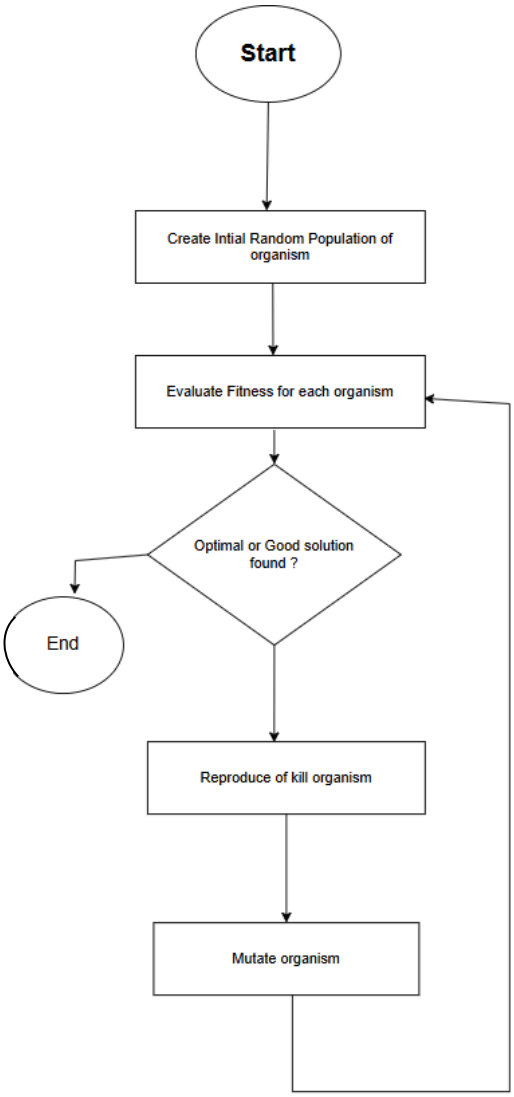
Introduction : . Genetic Algorithm is a search heuristic based on natural selection . Genetic Algorithm provides efficient ,effective techniques for machine learning applications. It is used for search optimization.

Travelling Salesman Problem(TSP) is a optimization problem in which a salesman visit each city once before returning to the starting location while reducing overall trip distance.If the number of citites grows,it gets increasingly difficult to solve optimally.

Flowchart of Genetic Algorithm : Flow chart made from **Draw.Io** software.



Genetic Algorithm for TSP :

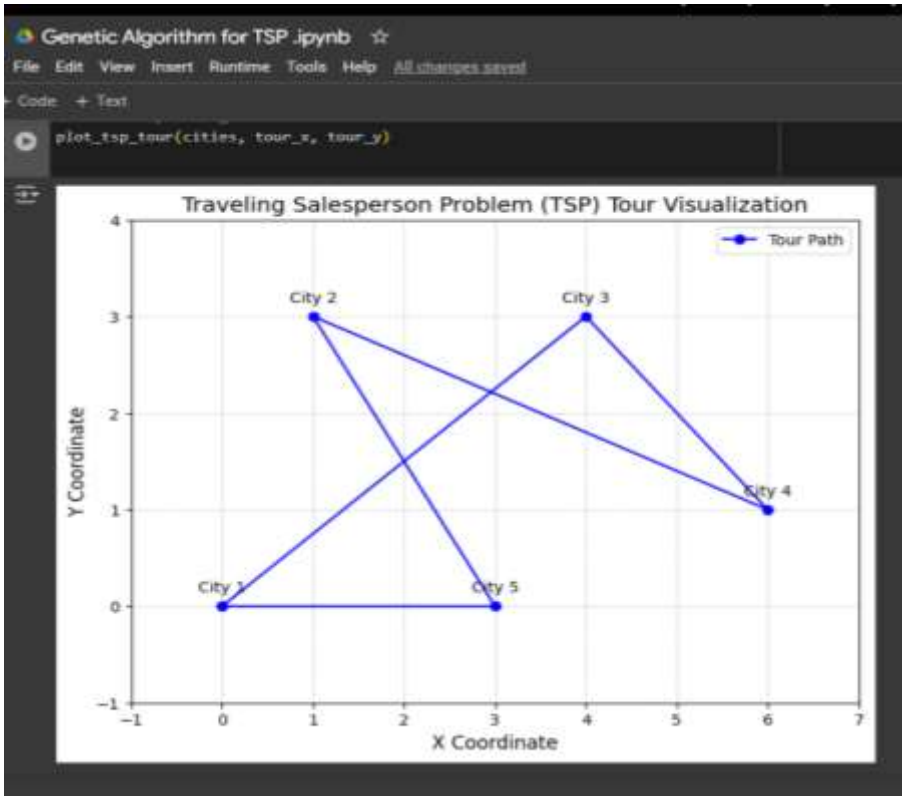
Algorithm Steps :

1. Initialize: Generate an initial population of random tours.
2. Evaluate: Calculate the fitness of each chromosome.
3. Selection: Select parent chromosomes based on their fitness.
4. Crossover: Perform crossover to produce offspring.
5. Mutation: Apply mutation to offspring.
6. Replacement: Form a new population by replacing some or all of the old population with offspring.
7. Termination: Repeat steps 2-6 until a stopping criterion is met (a fixed number of generations or a satisfactory fitness level).

1. Representation

Chromosome: Let , For TSP, a chromosome represents a possible tour (sequence of cities). For example, a chromosome for a tour of 5 cities might be represented as [1, 3, 4, 2, 5] .

Gene: Each gene in the chromosome represents a city.



Output Analysis

1. **Tour Plot:**
    - Displays a path connecting cities as per the chromosome [1, 3, 4, 2, 5].
    - Cities are annotated for clarity.
    - Includes the calculated total distance in the legend.
2. **Fitness Calculation:**
    - Fitness is calculated as the total distance of the tour. A shorter distance indicates a better solution.

CODE FOR THE PLOT :

```
import matplotlib.pyplot as plt

cities = {
    1: (0, 0),
    2: (1, 3),
    3: (4, 3),
    4: (6, 1),
    5: (3, 0)
}


chromosome = [1, 3, 4, 2, 5]

def get_tour_coordinates(cities, chromosome):
    x_coords = [cities[city][0] for city in chromosome]
    y_coords = [cities[city][1] for city in chromosome]
    # Close the tour by returning to the starting city
    x_coords.append(x_coords[0])
    y_coords.append(y_coords[0])
    return x_coords, y_coords

tour_x, tour_y = get_tour_coordinates(cities, chromosome)


def plot_tsp_tour(cities, tour_x, tour_y):
    plt.figure(figsize=(8, 6))
    plt.plot(tour_x, tour_y, marker='o', linestyle='-', color='blue',
label='Tour Path')
    plt.title('Traveling Salesperson Problem (TSP) Tour Visualization',
fontsize=14)
    plt.xlabel('X Coordinate', fontsize=12)
```

```
    plt.ylabel('Y Coordinate', fontsize=12)
    plt.grid(visible=True, linestyle='--', alpha=0.6)


    for city, (x, y) in cities.items():
        plt.annotate(f'City {city}', (x, y), textcoords="offset
points", xytext=(0, 10), ha='center', fontsize=10)

    plt.legend()
    plt.xlim(min(tour_x) - 1, max(tour_x) + 1)
    plt.ylim(min(tour_y) - 1, max(tour_y) + 1)
    plt.show()
plot_tsp_tour(cities, tour_x, tour_y)
```

2. Initial Population

Population: A set of chromosomes (tours). The initial population is generated randomly.

Population Size: The number of chromosomes in the population. A larger population size increases diversity but also computational cost.

3. Fitness Function

Fitness: The fitness of a chromosome is typically the inverse of the total travel distance of the tour. The goal is to maximize fitness (minimize travel distance).

Fitness= 1 / Total Distance

4. Selection

Selection: The process of selecting parent chromosomes for reproduction. Common methods include:

Roulette Wheel Selection: Chromosomes are selected based on their fitness proportion.

Tournament Selection: A subset of chromosomes is chosen randomly, and the best one is selected.

5. Crossover

Crossover (Recombination): Combines two parent chromosomes to produce offspring. Common crossover methods for TSP include:

Order Crossover (OX): A segment of one parent is copied to the offspring, and the remaining cities are filled in the order they appear in the other parent.

Partially Mapped Crossover (PMX): Segments are exchanged between parents, and conflicts are resolved by mapping.

6. Mutation

Mutation: Introduces diversity by randomly altering genes in a chromosome. Common mutation methods for TSP include:

Swap Mutation: Two cities in the tour are swapped.

Inversion Mutation: A segment of the tour is reversed.

7. Replacement

Replacement**: The process of forming a new population. Common strategies include:

Elitism: The best chromosomes are carried over to the next generation.

Generational Replacement: The entire population is replaced by offspring.

Analysis :

Advantages :

- Scalability: GAs work pretty well on large and complex search spaces.
- Flexibility: GAs can be adapted to various types of optimization problems.
- Search: It performs a global search & has lesser chances of being trapped into local optima.

Disadvantages :

- Computational Cost: GAs are expensive to compute, in particular for large populations and generations.
- Parameter Sensitivity: The performance of Gas depends upon parameters such as population size, crossover rate, and mutation rate.
- Convergence: GAs may converge to a near-optimal solution rather than the exact optimal solution.
- Diversity: Maintaining diversity in the population is crucial to avoid premature convergence.

Conclusion : The use of a Genetic Algorithm to solve the Traveling Salesman Problem provides a robust and flexible approach toward near-optimal solutions of complex optimization problems. Even though GAs cannot guarantee the optimal solution, they are very effective in exploring large search spaces and provide good approximations within reasonable computational time.

References : Include references to academic papers, books, and online resources(youtube) that provide more detailed information on GAs and TSP.