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Artificial Intelligence Lab 8

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Genetic Algorithm Lab Manual

Introduction to Genetic Algorithms

Genetic algorithms (GAs) are optimization and search techniques inspired by the principles of genetics and natural selection. GAs are used to solve complex problems by evolving solutions over time. They are particularly useful for problems where the search space is large and traditional optimization techniques are not effective.

Key Concepts

- **Population:** A set of potential solutions to the problem.
- **Chromosomes:** Representations of the solutions in the population.
- **Genes:** Parts of a chromosome, representing specific traits or variables of the solution.
- **Fitness Function:** A function that evaluates how good a solution is.
- **Selection:** The process of choosing the best solutions to reproduce.
- **Crossover:** Combining parts of two solutions to create new offspring.
- **Mutation:** Randomly altering parts of a solution to introduce diversity.

Problem 1: Traveling Salesman Problem (TSP)

Problem Description

The Traveling Salesman Problem (TSP) is a classic optimization problem where a salesman must visit a set of cities exactly once and return to the starting city. The objective is to find the shortest possible route that visits each city and returns to the origin.

Genetic Algorithm Approach

1. **Representation:**
    - Each chromosome represents a possible tour of the cities.
    - A gene represents a city, and the sequence of genes represents the order in which the cities are visited.
2. **Fitness Function:**
    - The fitness of a tour is the inverse of its total distance. A shorter tour has a higher fitness value.
3. **Selection:**

- Use methods like roulette wheel selection or tournament selection to choose parent solutions based on their fitness.

4. **Crossover:**
    - Apply crossover techniques like ordered crossover (OX) or partially mapped crossover (PMX) to generate new offspring.
5. **Mutation:**
    - Use mutation operators such as swap mutation, where two cities in the tour are randomly selected and their positions are swapped.
6. **Algorithm Steps:**
    - Initialize a population of random tours.
    - Evaluate the fitness of each tour.
    - Select parents based on fitness.
    - Apply crossover and mutation to create a new population.
    - Repeat until a stopping criterion is met (e.g., a fixed number of generations or a satisfactory fitness level).

Necessary Details

- **Distance Matrix:** A matrix where the entry at row i and column j represents the distance between city i and city j.
- **Stopping Criteria:** Define a maximum number of generations or a convergence threshold.

Practical Implementation

Problem 1: Traveling Salesman Problem (TSP)

1. **Create a Distance Matrix:** Define the distance matrix representing the distances between cities.
2. **Initialize Population:** Generate an initial population of random tours.
3. **Evaluate Fitness:** Calculate the fitness of each tour based on the total distance.
4. **Selection, Crossover, and Mutation:** Implement the selection, crossover, and mutation operators to evolve the population.

CODE TEMPLATE:

```
# Define the distance matrix
def create_distance_matrix(num_cities):
    # Create a matrix for distances between each city
    pass

# Initialize population with random tours
def initialize_population(pop_size, num_cities):
    # Each individual is a random permutation of city indices
    pass
```

```
# Calculate total distance of a tour
def calculate_distance(tour, distance_matrix):
    # Compute the distance for the given tour
    pass

# Evaluate fitness for each tour
def evaluate_fitness(population, distance_matrix):
    # Higher fitness for shorter tours
    pass

# Select parents based on fitness
def select_parents(population, fitness):
    # Choose parents with methods like roulette or tournament selection
    pass

# Crossover to create offspring
def crossover(parent1, parent2):
    # Combine parts of parents to create new offspring
    pass

# Mutation to introduce diversity
def mutate(tour):
    # Randomly alter part of the tour
    pass

# Genetic Algorithm for TSP
def genetic_algorithm_tsp(distance_matrix, pop_size, num_generations):
    # Initialize population and evolve through generations
    pass
```