Self-Organizing Map (SOM) Approach for the Traveling Salesman Problem (TSP)

Introduction to SOM

The Self-Organizing Map (SOM) is a type of artificial neural network that uses unsupervised learning to map high-dimensional input data to a lower-dimensional space while preserving the topological relationships of the data. In the context of the Traveling Salesman Problem (TSP), SOM can be adapted to approximate the shortest route through a set of cities by learning the spatial relationships between them.

Initialization

The SOM approach begins with the initialization of city coordinates and SOM nodes:

- **City Coordinates:** Random coordinates are assigned to each city on a 2D plane. These coordinates serve as the input data for the SOM.
- **SOM Nodes:** A set of neurons, referred to as SOM nodes, are initialized with random positions within the same 2D space. These nodes will adapt their positions during the training process to better represent the cities.

Training Process

The training process involves iteratively adjusting the positions of the SOM nodes to minimize the distance between each node and its corresponding city. The key steps in the training process are as follows:

1. **Random City Selection:** In each iteration, a city is randomly selected as the input.
2. **Winner Neuron Identification:** The SOM identifies the neuron closest to the selected city, known as the winner neuron.
3. **Neuron Adjustment:** The winner neuron and its neighboring neurons are adjusted to move closer to the selected city. This adjustment is governed by a neighborhood function and a learning rate, both of which decay over time to ensure convergence.

4. **Parameter Decay:** The learning rate and neighborhood radius are gradually reduced to allow the SOM to converge to a stable solution.

Adaptation to TSP

After sufficient training, the SOM nodes approximate the spatial relationships between the cities. The sequence of these nodes can then be used to determine an approximate solution to the TSP. The final tour is extracted by tracing through the SOM nodes, ensuring that each city is visited exactly once before returning to the starting city.

Challenges

- **Parameter Tuning:** The learning rate and neighborhood radius need careful tuning to ensure the SOM converges to a reasonable solution. Too high a learning rate can cause instability, while too low can slow convergence.
- **Suboptimal Convergence:** The SOM approach may not always find the optimal solution, especially for larger instances of the TSP. It provides an approximate solution, which may be suboptimal.
- **Complexity:** The SOM approach involves iterative training, which can be computationally intensive, particularly for larger datasets.

Route and Approximate Total Distance

After training the SOM, the algorithm provides an approximate solution to the TSP. The output includes the sequence of cities in the tour. The approximate total distance can be calculated by summing the distances between consecutive cities in the tour using the given adjacency matrix.

Example Output:

SOM Tour: City1 → City2 → City3 → City4 → City5 → City6 → City7 → City1