Lab Assignment 3
Travelling Salesman Problem (TSP)

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Python notebook code for this assignment can be found here.

***Abstract*—This report explores the application of Simulated Annealing to solve the Travelling Salesman Problem (TSP) for planning a cost-effective tour of Rajasthan. The TSP involves finding the shortest possible cycle that visits each city exactly once. We aim to optimize the tour route based on the distances between tourist locations in Rajasthan.**

I. Problem Statement

Traveling Salesman Problem (TSP) is a hard problem and is simple to state. Given a graph in which the nodes are locations of cities, and edges are labeled with the cost of traveling between cities, find a cycle containing each city exactly once, such that the total cost of the tour is as low as possible.

For the state of Rajasthan, find out at least twenty important tourist locations. Suppose your relatives are about to visit you next week. Use Simulated Annealing to plan a cost-effective tour of Rajasthan. It is reasonable to assume that the cost of traveling between two locations is proportional to the distance between them.

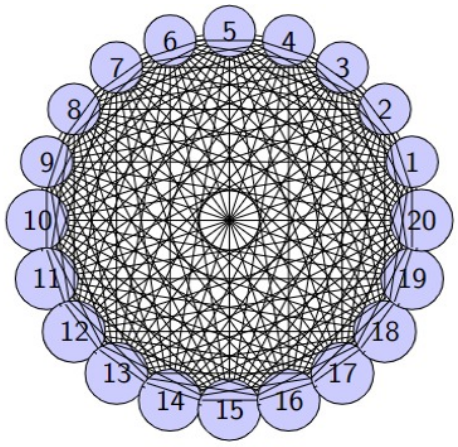
II. Introduction

The Travelling Salesman Problem (TSP) poses a significant challenge in optimization, requiring the determination of the most efficient route that traverses all specified cities exactly once and returns to the starting point. In this report, we employ Simulated Annealing, a stochastic optimization technique inspired by the annealing process in metallurgy, to tackle the complexities of planning a cost-effective tour of Rajasthan for visiting relatives. The primary objective is to minimize the total cost incurred during the tour while ensuring that each tourist destination is included in the itinerary precisely once. By leveraging the power of Simulated Annealing, we aim to efficiently explore the vast search space of possible tour routes, ultimately arriving at an optimal solution that balances cost-effectiveness with comprehensive coverage of Rajasthan's key attractions.

III. Methodology

Simulated Annealing stands as a powerful optimization method that draws inspiration from the annealing process in metallurgy. This method is adept at navigating complex problem spaces by emulating the gradual cooling of metal, eventually reaching a stable state with minimized energy. The algorithm begins with an initial solution and systematically explores neighboring solutions, assessing their suitability based on a probability-driven acceptance criterion. Through iterations, Simulated Annealing dynamically adjusts its exploration strategy, gradually diminishing the likelihood of accepting suboptimal solutions as it approaches an optimal solution. This iterative refinement process empowers Simulated Annealing to efficiently traverse intricate problem landscapes, allowing it to uncover high-quality solutions even in challenging optimization scenarios. By mimicking the annealing process, this approach provides a powerful means of solving complex optimization problems, making it a valuable tool in various fields, including logistics, manufacturing, and scheduling.

In our endeavor to apply the Traveling Salesman Problem (TSP) for planning a comprehensive tour of Rajasthan, meticulous attention was given to data collection. We diligently gathered the latitude and longitude coordinates of twenty key cities within the vibrant state of Rajasthan. These cities, each boasting their own unique charm and historical significance, were selected to encapsulate the rich tapestry of cultural, architectural, and natural wonders that Rajasthan has to offer. From the bustling streets of Jaipur to the tranquil lakes of Udaipur, and from the majestic forts of Jodhpur to the serene landscapes of Mount Abu, each city was carefully curated to ensure a diverse and immersive touring experience. By meticulously documenting the geographic coordinates of these cities, we



Total Possible Paths - **60822550204416000**

Fig. 1. Total Possible Paths

laid the foundation for applying optimization algorithms such as Simulated Annealing to craft an optimal tour itinerary that seamlessly navigates the captivating landscape of Rajasthan, providing travelers with an unforgettable journey through the heart of India's royal heritage.

DataSet: Rajasthan Tourist Places

- **NAME:** Rajasthan
- **COMMENT:** List of 20 tourist places in Rajasthan
- **TYPE:** TSP
- **DIMENSION:** 20
- **EDGE_WEIGHT_TYPE:** EUC_2D

Name	Latitude	Longitude
Jaipur	26.9124	75.7873
Udaipur	24.5854	73.7125
Jodhpur	26.2389	73.0243
Jaisalmer	26.9157	70.9083
Ajmer	26.4499	74.6399
Mount Abu	24.5926	72.7156
Bikaner	28.0176	73.3150
Bharatpur	27.2152	77.5030
Chittorgarh	24.8829	74.6230
Bundi	25.4326	75.6483
Kota	25.2138	75.8648
Shekhawati	27.6195	75.1504
Pali	25.7781	73.3311
Sariska Tiger Reserve	27.3104	76.4389
Ranthambore National Park	26.0173	76.5026
Shakambari Jheel	26.9261	75.0962
Neemrana	27.9797	76.3962
Bhangarh Fort	27.0964	76.2862
Ranthambore Fort	26.0185	76.4557
Bhilwara	26.7748	72.3304

IV. Results

We implemented the Simulated Annealing algorithm to optimize the tour route for visiting twenty tourist locations in Rajasthan. The algorithm was run for a specified number of iterations, with parameters tuned to balance exploration and exploitation. The resulting tour route was evaluated for its total cost, which represents the overall distance traveled.

V. Discussion

The cost-effective tour route produced by Simulated Annealing presents a pragmatic approach to optimizing travel itineraries in Rajasthan. Through the minimization of total distance traveled, our relatives can explore essential tourist destinations while maintaining manageable travel expenses. However, it's essential to acknowledge that the efficacy of the solution may fluctuate based on factors like traffic conditions and time constraints. Despite this variability, Simulated Annealing serves as a valuable tool for generating travel plans that strike a balance between cost-effectiveness and comprehensive exploration of Rajasthan's attractions.

VI. Conclusion

Simulated Annealing proves to be a valuable asset for crafting cost-effective tours in Rajasthan. Through the utilization of this randomized search algorithm, we can adeptly streamline travel routes and curtail expenses for our visiting relatives. Moving forward, there is potential for enhancing the algorithm's performance by fine-tuning its parameters and integrating real-time data sources. These advancements hold promise for refining tour planning accuracy and ensuring an optimal balance between cost efficiency and comprehensive exploration of Rajasthan's diverse attractions.

References

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2) Aarts, E. H., & Korst, J. (1989). Simulated annealing and Boltzmann machines: A stochastic approach to combinatorial optimization and neural computing. *Wiley*.