Simulated Annealing Algorithm

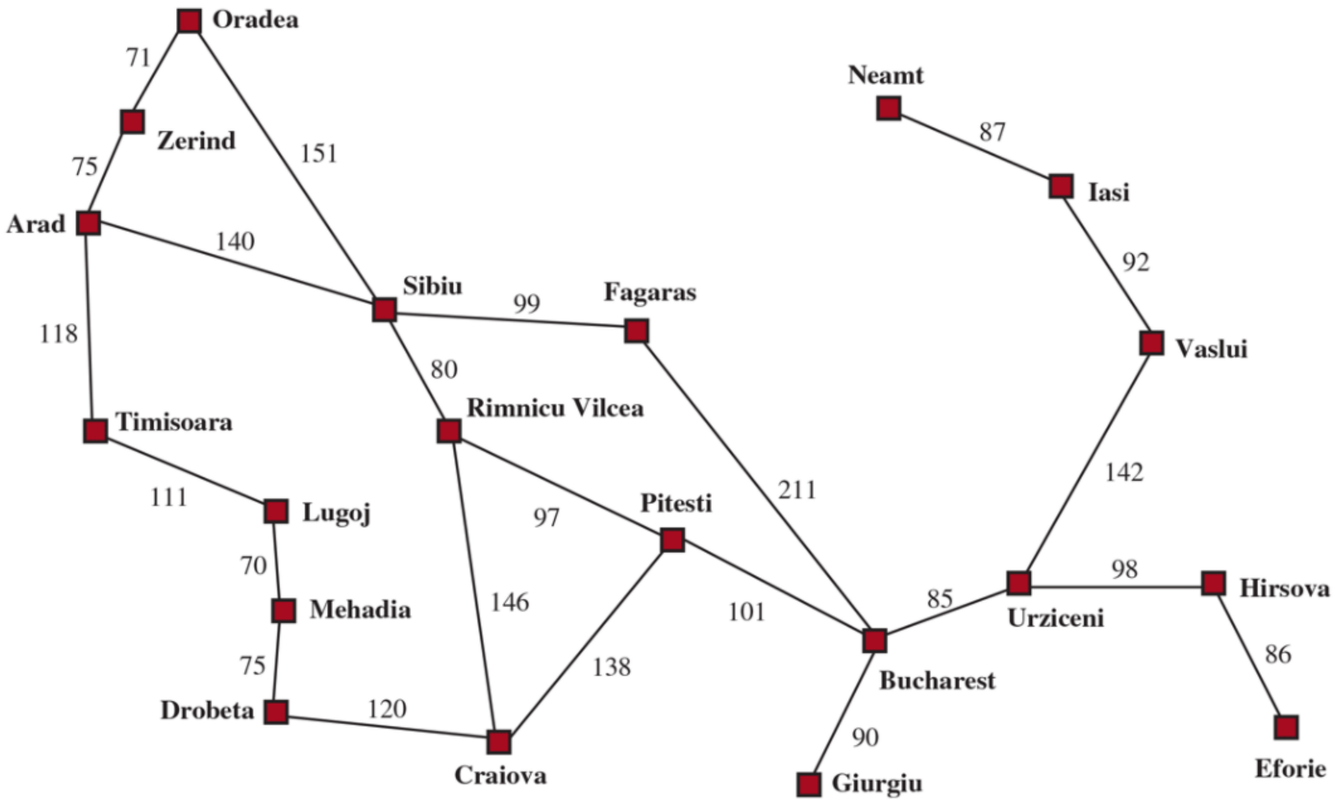
Simulated Annealing Algorithm for the Traveling Salesman Problem

Jiarui Wang, 24 August 2025

Problem

Traveling Salesman Problem

Find the shortest route visiting all cities exactly once and returning to the start.



Inspiration of Simulated Annealing

Inspired by annealing in metallurgy

Key: Slowly cooling metal allows atoms to settle in a low-energy state.

Analogy in optimisation:

- Energy = total path length
- State = one possible path
- Temperature = probability to accept worse solutions

Core Idea

- At high temperature: algorithm is flexible → can accept worse solutions.
- At low temperature: algorithm becomes greedy → focuses on better solutions.

Acception Rule:

$$P(\Delta E) = exp(-\frac{\Delta E}{T})$$

- If new path is shorter (ΔE < 0) → always accept.
- If new path is longer (ΔE > 0) → accept with some probability.

Algorithm Process

Result

Best path:

['Arad', 'Timisoara', 'Sibiu', 'Rimnicu', 'Lugoj', 'Mehadia', 'Drobeta', 'Craiova', 'Giurgiu', 'Bucharest', 'Urziceni', ‘Eforie', 'Hirsova', 'Vaslui', 'Iasi', 'Neamt', 'Pitesti', 'Fagaras', 'Oradea', ‘Zerind']

Best energy: 1747.735130908096

Conclusion

Essence of the algorithm

- Simulated Annealing = powerful heuristic for hard optimisation problems.
- Provides good (near-optimal) solutions for TSP.
- Future improvements: combine with other heuristics (e.g. Genetic Algorithms).