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Travelling Salesman Problem

Biologically Inspired Computing

# Introduction

The travelling salesman problem is an optimization problem about finding the shortest route between cities around the world. I will in this report implement various optimization methods and test performance on time and result.

# Tools

I program the methods using python 3.6. The data used comes from “European\_citites.CSV”.

# Exhaustive search

## Questions

1. Question: What is the shortest route and what is the distance?

Answer: Implementing exhaustive search for 10 cities yielded following route:

***The shortest route using exhaustive search:***

*Barcelona Belgrade Istanbul Bucharest Budapest Berlin Copenhagen Hamburg Brussels Dublin Barcelona*

*The total distance is 7486.31km*

*Code execution: 3.715876340866089s*

1. Question: How long did it take the program to find it?

Answer: The code used about 3.7s when finding optimal route for 10 cities

1. Question: How long would you expect it take with all 24 cities?

Since it does not matter what the starting point is as long as the sequence of cities is the same. One can therefore do permutations

|  |  |  |  |
| --- | --- | --- | --- |
| Number of cities | Distance(km) | Time(s) | Permutations |
| 6 | 5018.81 | 0.00203 | 120 |
| 7 | 5487.89 | 0.00697 | 720 |
| 8 | 6667.49 | 0.04188 | 5040 |
| 9 | 6678.55 | 0.36299 | 40320 |
| 10 | 7486.31 | 3.54444 | 362880 |
| 11 | 8339.36 | 39.1216 | 3628800 |

(converted answer from seconds to years)

# Hill Climbing

## Questions

1. Question: How well does hill climber perform on the same first 10 cities?

Answer: Implementing hill climbing for the first 10 cities yielded:

***The shortest route:***

*Hamburg -> Copenhagen -> Berlin -> Budapest -> Bucharest -> Istanbul -> Belgrade -> Barcelona -> Dublin -> Brussels -> Hamburg ->*

*The total distance is 7486.31km*

*Code execution: 0.013934135437011719s*

However, it does not always reach global minimum,.

1. Question: Report the best and worst as well as standard deviation and mean of 20 runs. Both for 24 and 10 cities with random starting tours.

Answer:

***Performing 20 hill climbs on random sequence of 10 cities:***

*The shortest route was 7486.31km:*

*Istanbul -> Belgrade -> Barcelona -> Dublin -> Brussels -> Hamburg -> Copenhagen -> Berlin -> Budapest -> Bucharest -> Istanbul ->*

*The longest route was 9410.61km:*

*Belgrade -> Brussels -> Dublin -> Barcelona -> Istanbul -> Bucharest -> Copenhagen -> Hamburg -> Berlin -> Budapest -> Belgrade ->*

*The mean was: 7998.818500000001*

*The standard deviation was: 549.2403150215758*

*Code execution: 0.31919145584106445s*

***Performing 20 hill climbs on random sequence of 24 cities:***

*The shortest route was 13483.66km:*

*Barcelona -> Madrid -> Dublin -> London -> Brussels -> Paris -> Milan -> Munich -> Prague -> Vienna -> Budapest -> Belgrade -> Sofia -> Istanbul -> Bucharest -> Warsaw -> Berlin -> Hamburg -> Copenhagen -> Stockholm -> Saint Petersburg -> Moscow -> Kiev -> Rome -> Barcelona ->*

*The longest route was 17955.05km:*

*Saint Petersburg -> Barcelona -> Madrid -> Paris -> Brussels -> Copenhagen -> Stockholm -> Moscow -> Kiev -> Hamburg -> Dublin -> London -> Berlin -> Prague -> Munich -> Milan -> Rome -> Vienna -> Belgrade -> Sofia -> Istanbul -> Bucharest -> Budapest -> Warsaw -> Saint Petersburg ->*

*The mean was: 15190.461*

*The standard deviation was: 1045.0609307640743*

*Code execution: 1.2655680179595947s*

# Genetic Algorithm

The genetic algorithm follows simple GA structure:

|  |  |
| --- | --- |
| Initialize Population | An *x* amount of random generated routes |
| Evaluate Population (Fitness) | Total distance for each route |
| Select Parents | Based on a fitness proportionate selection  Uses windowing to scale probabilities |
| Create Offsprings | Uses partially mapped crossover between selected parents |
| Mutate Offspring | On a small selection of offsprings to keep some diversity |
| Replace population | May or may not use eliteism. If eliteism, 10% of the best of the population will join the next generation |