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Desenho de Algoritmos
Programming Project II

Routing Algorithm for Ocean Shipping and Urban Deliveries

2LEIC03
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INTRODUCTION AND IMPLEMENTATION

In this second programming project we had two goals, first we had to implement a basic exhaustive approach for the classic routing problem using the TSP abstraction, therefore learning first hand that although such an approach can find optimal solutions, its applicability is restricted to very small graphs. Second, refine your critical thinking
skills, by developing and analysing a set of approximate solutions to the TSP.

We were asked to design efficient algorithms to find optimal routes for vehicles in generic shipping and delivery scenarios, from urban deliveries to ocean shipping. As the TSP is intractable, there are no known efficient algorithms to solve it, so in order to find a solutions to this problems we tested a variety of algorithms and some were only feasible when the size of the graph were relatively low.

To eficiently address TSP-based problems the group devolped approximation algorithms based on heuristics so we could it handle larger graphs.

The algorithms used in this project other than **Backtracking** and **Triangular Approximation** were **Greedy 2-opt** and **Nearest Neighbour** algorithms.

Backtracking - O(N!)

- Shipping
    - Elapsed Time: 1,64492x10^-1s
    - Optimal distance to be travelled: 79,2m
- Stadiums
    - Elapsed Time: 1,12205x10^+1s
    - Optimal distance to be travelled: 341m
- Tourism
    - Elapsed Time: 9.2147^-05s
    - Optimal distance to be travelled: 2600m

Triangular Approximation (MST) - O(N^2 log N)

- Shipping
  - Elapsed Time: 2,78014x10^-4s
  - Optimal distance to be travelled: 90,3m
- Stadiums
  - Elapsed Time: 4,65522x10^-4s
  - Optimal distance to be travelled: 391,4m
- Tourism
  - Elapsed Time: 1,47461x10^-4s
  - Optimal distance to be travelled: 2600m
- Fully Connected 900 Nodes Graph
  - Elapsed Time: 1,6s
  - Optimal distance to be travelled: 2096580,6m

*GREEDY 2-OPT (O(V^3) - O(V*E) construction of the greedy tour + O(V^3) applying 2-opt)*

- Stadiums
  - Elapsed Time: 2,9x10^-4s
  - Optimal distance to be travelled: 348,6m
  - Approximation ratio: 2,2%
- Fully Connected 900 Nodes Graph
  - Elapsed Time: 9,983x10^+1s
  - Optimal distance to be travelled: 1657470m

*NEAREST NEIGHBOUR - (O(V*E)*

- Stadiums
    - Elapsed Time: 9,8x10^-5s
    - Optimal distance to be travelled: 461,1m
    - Approximation ratio: 22%
- Fully Connected 900 Nodes Graph
    - Elapsed Time: 3,9x10^-2s
    - Optimal distance to be travelled: 188948,8m

CONCLUSIONS

Backtracking ensures an optimal solution but with high computational cost **(O(N!))**. It is suitable for small problem instances where the exact optimal solution is important.

On the other hand, the **Triangular Approximation** method offers an efficient, near-optimal solution with significantly lesser computation time **(O(N^2 log N))**.

It may not always give the exact optimal path but guarantees a solution within twice the optimal length under triangular inequality. It is ideal for larger instances where computational efficiency is crucial.

For example in Tourism, the smallest graph, achieved an optimal solution of 2600m in just 9.2147e-05s using the Backtracking algorithm, and even it does demonstrate its efficiency for smaller problems, the approximation achieved the same solution but it took longer for it to finish.

CONCLUSIONS

We also found that using the **Greedy 2opt** e **Nearest Neighbour** alghorithms may not be suitable to find the best solution even when they can be the most efficient.

The **Backtracking** algorithm was also used to compare with our own algorithms to try and understand how much much distance and accuracy we're willing to give up on in order to be more efficient.