Support to Sprint B of Practical Work of ALGAV Goods Delivery Planning with Electric Trucks

Curricular Unit: Advanced Algorithms

Programme: Computer Engineering (ISEP)

Let’s now consider a 2nd exemple of deliveries

%entrega(<idEntrega>,<data>,<massaEntrefa>,<armazemEntrega>,<tempoColoc>,<tempoRet>)

```
entrega(4439, 20221205, 200, 1, 8, 10).
entrega(4438, 20221205, 150, 9, 7, 9).
entrega(4445, 20221205, 100, 3, 5, 7).
entrega(4443, 20221205, 120, 8, 6, 8).
entrega(4449, 20221205, 300, 11, 15, 20).
entrega(4398, 20221205, 310, 17, 16, 20).
entrega(4432, 20221205, 270, 14, 14, 18).
entrega(4437, 20221205, 180, 12, 9, 11).
entrega(4451, 20221205, 220, 6, 9, 12).
entrega(4452, 20221205, 390, 13, 21, 26).
entrega(4444, 20221205, 380, 2, 20, 25).
entrega(4455, 20221205, 280, 7, 14, 19).
entrega(4399, 20221205, 260, 15, 13, 18).
entrega(4454, 20221205, 350, 10, 18, 22).
entrega(4446, 20221205, 260, 4, 14, 17).
entrega(4456, 20221205, 330, 16, 17, 21).
```

The first five deliveries, in the entregas_ex2.pl correspond to the same as entregas_ex1.pt, and the later 11 deliveries are inserted so that there is one for each warehouse

The goal is to start with the first 5 and build a framework making the inclusion one by one of another delivery (6 deliveries,7 deliveries,…, 16 deliveries) and analyze the evolution of the generation time of the best solution

The idea is to see how far we can go using this approach

Feasibility and Complexity study

N. of Delivery Warehouses	N. of solutions	List with the warehouse sequence for the deliveries	Time for the deliveries	Time to generate a solution (TSol)
5	120			
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

Time to generate a solution(TSol)

%...

```
%...
get_time(Ti),
%... Parte do codigo para a geracao da melhor solucao
get_time(Tf),
TSol is Tf-Ti,
%...
```

Complexity Study

- In the study of complexity, we will verify how the developed method behaves depending on the dimension of the problem
- We have already seen that the number of solutions is related to a factorial of the number of deliveries (Ndeliveries!)
- Is the solution generation time (the best solution) also related to a factorial?
- How far can we go? How long can we wait to generate the best solution? This also depends on how far in advance the delivery set is defined
- In any case, there is always a dimension from which it is not feasible to opt for a method that manages all the solutions and guarantees that the best one is obtained
- It is advisable to make this discussion in the report
- In this situation we should use heuristics

Heuristics

Most known Heuristic – Travelling Salesman Problem (TSP) Heuristic

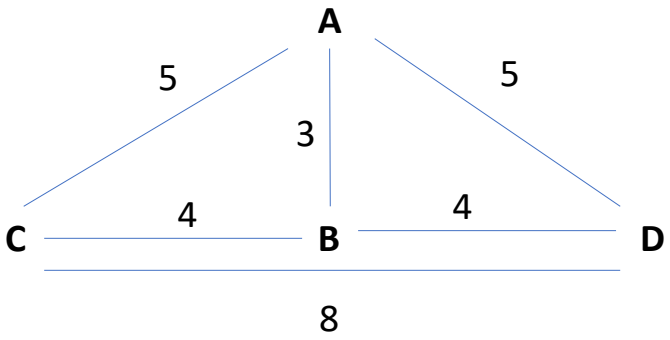
- There is a set of cities, all connected 2 by 2

- The aim is that, departing from one city, a traveling salesman visits all the cities and returns to the city of departure without passing through the other cities more than once

- For N cities we have (N-1)! solutions
  - For example, for 4 cities, A, B, C and D we have the following 3!=6 solutions: ABCDA; ABDCA; ACBDA; ACDBA; ADBCA e ADCBA
  - Fort 11 cities we have 10!=3628800 solutions
  - Thus, according the dimension increases, soon or later it will not be possible to generate all solutions to choose the better

- TSP Heuristic: the next city to visit is, among those that have not yet been visited, the one that is closest

Heuristics



However the heuristic does not guarantee the better solution

ABCDA -> 3+4+8+5 = 20 <- TSP Heuristic

ABDCA -> 3+4+8+5 = 20

ACBDA -> 5+4+4+5 = 18 <- better solution

ACDBA -> 5+8+4+3 = 20

ADBCA -> 5+4+4+5 = 18

ADCBA -> 5+8+4+3 = 20

- Heuristics do not guarantee the best solution, but they guarantee a quick solution.
- The heuristic will be better the more often it is able to generate solutions close to the best solution
- In the example we have in the ALGAV work, 3 heuristics will be targeted:
  - One that chooses to go to the nearest warehouse (distance) where delivery has not yet been made; alternatively, it could be to go to the warehouse to which we arrive in the shortest time in which delivery has not yet been made
  - One that chooses to go to the warehouse where the heavier mass of the delivery is released
  - One that combines distance with mass or, alternatively, time with mass

- Note that in the distance (or time) heuristic we want to go to the next smaller step, while for the mass delivery heuristic we want to go to the next larger step. The 3rd heuristic combines these two aspects (recall point c) of the 7/Feb/2022 exam)
- To compare the performance of the 3 heuristics, a new table must be built that, in addition to indicating the delivery time for the optimal solution, also indicates the delivery times of the solutions generated by the 3 heuristics (this will be done up to the dimension in which it is possible) . Conclusions should be drawn as to the quality of the heuristics. Note that more examples should be used(for example, from entegas_ex3.pt)

Adequation of Heuristics Study

N. of Delivery Warehouses	Optimal solution	Time for Deliveries in Optimal Solution	Time for Deliveries in Heuristic of lower time or distance	Time for Deliveries in Heuristic of heavier mass	Time for Deliveries in The Combined Heuristic	Better solution by the 3 heuristics
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						

- When it makes sense to use heuritics?
  - Note that if we are in a problem of reduced dimension, where the solution obtained by the generator of all solutions is feasible, then it does not make sense to use the heuristics (the previous table was only constructed to try to gain sensitivity to the quality of the 3 heuristics)
  - From a given dimension of the problem, the generation of all solutions to choose the best one is no longer feasible, at that time it is interesting to apply the 3 heuristics and choose the one that causes the shortest time for deliveries

During Sprint B, we will not be concerned with the fact that the total time for deliveries has a high value (and may even exceed 1 day), nor will issues such as lunch/dinner break for the driver or mandatory stops by law after some driving time