\* ALGAV Sprint B Report

**Deliveries Planning using Electrical Trucks**

3DE

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Content

1. **Domain knowledge representation**

1.a. To calculate the time

1.b. To calculate the battery

1. **Optimal solution for Deliveries Planning with an electrical truck**
2. **Study of the problem**

3.a. complexity and the viability of finding the optimal

1. **Heuristics for the quick generation of solutions**

4.a. Time for deliveries in heuristic of lower time

4.b. Time for deliveries in heuristic of heavier mass

4.c. Time for deliveries in the combined heuristic

1. **Analysis of the heuristics quality**
2. **Conclusion**

6.a. Optimal solution

6.b. Heuristics

**1. Domain knowledge representation**

1.a. To calculate the total time we need 4 parts.

1. Time to go from a warehouse to the following(Including Matosinhos;the home warehouse of delivery)
2. Time to unload the delivery
3. Time to charge the battery in the warehouse(in parallel with the previous item)
4. Time to charge the batteries to avoid reaching next warehouse with less than 20%

1.b. To calculate the amount of battery we need 2 parts.

1. Considering battery condition;

When the truck goes from a warehouse to the following, amount of the battery should be left at least 20%

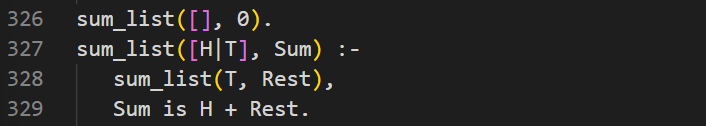
1. Considering battery condition;

During delivery, the full charging amount will be 80%

**2. Optimal solution for Deliveries Planning with an electrical truck**

**Et bilde som inneholder tekst

Automatisk generert beskrivelse**

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Automatisk generert beskrivelse**

**Et bilde som inneholder tekst, sølv, svart, skjermbilde

Automatisk generert beskrivelse**

**3. Study of the problem complexity as well as the viability of finding the optimal solution by generating all the solutions**

* Is the solution generation time (the best solution) also related to a factorial?
  + Yes
* 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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| N. of Delivery  Warehouses | N. of  solutions | List with the warehouse sequence for the deliveries | Time for the  deliveries | Time to  generate a  solution (s) (TSol) |
| 5 | 120 | [8, 1, 3, 11, 9] | 517 | 0.0442 |
| 6 | 720 | [17, 1, 3, 8, 11, 9] | 539 | 0.1160 |
| 7 | 5040 | [17, 1, 14, 3, 8, 11, 9] | 556 | 0.5265 |
| 8 | 20320 | [17, 14, 1, 12, 3, 8, 11, 9] | 581 | 4.5289 |
| 9 | 362880 | [9, 11, 8, 3, 12, 6, 14, 1, 17] | 592 | 38.2980 |
| 10 | 3628800 | [17, 1, 14, 6, 12, 3, 8, 11, 13,9] | 622 | 511.3673 |
| 11 | 39916800 | [8, 17, 2, 12, 6, 1, 14, 3, 11, 13, 19] | 652 | 4248.409 |
| 12 | 479001600 |  |  |  |
| 13 | 6227020800 |  |  |  |
| 14 | 87178291200 |  |  |  |
| 15 | 1307674368000 |  |  |  |
| 16 | 20922789888000 |  |  |  |

* + Can go on for as long as the computer is able to process the function. After 10 deliveries, the process starts to take a long time (511 seconds) and on 11 deliveries (), the time is even longer. After this, the stack limit is reached. It is possible to increase the size of the stack to allow a larger dimension list, but now the generation time is a problem. Sooner or later, the new stack limit will be reached, and then the same problem will be there.

**4. Heuristics for the quick generation of solutions**

4.a. Time for deliveries in heuristic of lower time.

First, we listed the warehouse which is the closest one to home warehouse(Matosinhos). Then, keep arranging warehouses comparing time. Starting from Matosinhos, the next one is the closest one from Matosinhos, and then the other warehouse close to the second warehouse and keep going.

EX 1) For example, 5 cities for delivery warehouses; including start and end city.

The order of warehouses will be [5, 8, 3, 11, 9, 1, 5] and time between two cities will be [29, 32, 61, 63, 181, 147].

The total time for delivery is 648 and charging point is 1.

EX 2) For example, 10 cities for delivery warehouses; including start and end city.

The order of warehouses will be [5, 17, 6, 12, 13, 11, 8, 3, 14, 1, 9, 5] and time between two cities will be [27, 82, 23, 120, 27, 59, 32, 82, 59, 185, 48].

The total time for delivery is 943 and charging points are 11 and 1.

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4.b. Time for deliveries in heuristic of heavier mass.

First, we listed the warehouse which has to be delivered the heaviest load starting from home warehouse(Matosinhos).

Then, keep arranging warehouses comparing load weight. Starting from Matosinhos, the next one is the place where has to be delivered the heaviest load from Matosinhos, and then the following warehouse has to be delivered the second heaviest load and keep going.

EX 1) For example, 6 cities for delivery warehouses; including start and end city.

The order of delivery city will be [5, 17, 11, 1, 9, 8, 3, 5] and each load weight will be [310, 300, 200, 150, 120, 100].

If add the truck weight, accumulating the weight of the loads to the previous list([310, 300, 200, 150, 120, 100]), then it would be [8680, 8370, 8070, 7870, 7720, 7600, 7500].

The total time for delivery is 807 and charging points are 1 and 3.

EX 2) For example, 11 cities for delivery warehouses; including start and end city.

The order of delivery city will be [5, 13, 2, 17, 11, 14, 6, 1, 12, 9, 8, 3, 5] and each load weight will be [390, 380, 310, 300, 270, 220, 200, 180, 150, 120, 100].

If add the truck weight, accumulating the weight of the loads to the previous list([390, 380, 310, 300, 270, 220, 200, 180, 150, 120, 100]), then it would be [10120, 9730, 9350, 9040, 8740, 8470, 8250, 8050, 7870, 7720, 7600, 7500].

The total time for delivery is 1048 and charging points are 11 and 12.

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4.c. Time for deliveries in the combined heuristic.

We combined lower time and heavier mass function for heuristics solution.

Before, listing the warehouses we have to make sure about weighting of time and load weight. Lower time and heavier mass is the most important consideration in heuristics solution.

So, the Formula is ‘X = Time \* (1 / Load\_Weight)‘.

Time means time between two cities, Load\_Weight means the mass which has to be delivered to specific warehouse.

So, we listed the warehouse which has the smallest X value, following the first one and keep going.

EX 1) For example, 5 cities for delivery warehouses; including start and end city.

The order of delivery city will be [5, 11, 8, 9, 3, 1, 5] and each X value will be [0.177, 0.242, 0.320, 0.480, 0.705].

The total time for delivery is 619 and charging point is 3.

EX 2) For example, 7 cities for delivery warehouses; including start and end city.

The order of delivery city will be [5, 17, 11, 8, 9, 14, 3, 1, 5] and each X value will be [0.087, 0.177, 0.242, 0.320, 0.389, 0.480, 0.705].

The total time for delivery is 904 and charging points are 9 and 3.

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**5. Analysis of the heuristics quality**

|  |  |  |
| --- | --- | --- |
| N. of Delivery  Warehouses | Optimal solution | Time for Deliveries  In Optimal Solution |
| 5 | [8, 1, 3, 11, 9] | 517 |
| 6 | [17, 1, 3, 8, 11, 9] | 539 |
| 7 | [17, 1, 14, 3, 8, 11, 9] | 556 |
| 8 | [17, 14, 1, 12, 3, 8, 11, 9] | 581 |
| 9 | [9, 11, 8, 3, 12, 6, 14, 1, 17] | 592 |
| 10 | [17, 1, 14, 6, 12, 3, 8, 11, 13,9] | 622 |
| 11 | [8, 17, 2, 12, 6, 1, 14, 3, 11, 13, 19] | 652 |
| 12 |  |  |
| 13 |  |  |
| 14 |  |  |
| 15 |  |  |
| 16 |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| N. of Delivery  Warehouses | 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 | 648 | 764 | 619 | [11, 8, 9, 3, 1] |
| 6 | 675 | 807 | 722 | [17, 8, 3, 11, 9, 1] |
| 7 | 751 | 819 | 904 | [17, 8, 3, 11, 9, 14, 1] |
| 8 | 766 | 822 | 927 | [17, 8, 3, 11, 9, 12, 14, 1] |
| 9 | 675 | 859 | 948 | [17, 6, 12, 14, 1, 3, 8, 11, 9] |
| 10 | 943 | 973 | 988 | [17, 6, 12, 13, 11, 8, 3, 14, 1, 9] |
| 11 | 865 | 1048 | 1103 | [17, 2, 3, 8, 11, 13, 9, 12, 6, 14, 1] |
| 12 |  |  |  |  |
| 13 |  |  |  |  |
| 14 |  |  |  |  |
| 15 |  |  |  |  |
| 16 |  |  |  |  |

**6. Conclusion**

6.a. Optimal solution

In conclusion, comparing to Heuristics, Optimal solution is actually much better solution in the part of real delivery time. As you can see previous table, time for delivery is similar both Optimal solution and Heuristics up to 10 warehouses. However, 11 warehouses and more, the gap of time for delivery is being doubled. But, there is following problem. Time to generate a solution(TSol) is getting much longer, as many as cities are added. So, we cannot get an Optimal solution with 12 cities and more.

There are some problems with the calculation of the time in the part about the battery charging.

6.b. Heuristics

In conclusion, using Heuristics is very useful method for getting a solution in short time. It is much easier to access comparing to Optimal solution. However, more and more the problem getting complex, Heuristics is getting far from Optimal solution. Therefore, with less complexity problem, it can be said that Heuristics is good solution.