



Modeling and Methods in Optimization IE 305

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Meals on Wheels

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Caution

- Code won't be reading data if txt file is not well formatted
- All 3 data is sent as txt format which is in zip file with .java files
- Please beware to not put extra space for first 4 lines of txt file
- Please don't put extra line between spaces of lines
- If you want to add new customers, don't forget to update No. of customers

1. Explanation

To solve on hand problems, a simulated annealing algorithm has been generated. Initial solution has been generated randomly. For this, a random customer and a random trucks is selected. Then it's checked that if randomly selected trucks' free capacity is enough or not. If not enough this procedure restarts. Otherwise randomly selected customers is added to that trucks list and that customer is deleted from list.

This initial solution is improved by 2-opt swaps. 2 random customers are also selected here. However 1st customer is selected from randomly selected trucks route list not from whole list -2 step randomized- . 2nd customer is selected from the whole customers. Then it's proceed with checking if this swap is possible or not. Capacity of the 2 customers ex-serving trucks are controlled according to their newly replaced customers. Even If one of the trucks capacity is not enough, 2 new random customers are selected until a suitable pair of customers found.

Then it's continued with simulated annealing algorithms key steps. Newly generated solution –with translocation of 2 customers– objective value is checked with last iteration objective values (initial solution for 1st step). If it's better than last iteration objective value, iteration solution is updated with generated solution. After this, it's also checked if this generated solution is better than best solution we

had found so far. If so, we also update best solutions with this. However, if generated solution is not better than last iteration solution. We update the iteration solution to bad move with probability $1-\Delta F/T$ (T: temperature). If there happens no update generated solution is rejected and we look for different neighbor of last iteration solution. After a couple of test run on code. It's been founded that increasing T above 100 is just increments the *# of iterations* and makes no impact on *# of accepted moves*. Therefore T of the probability is decided to be 100. As for α –scalar for decreasing temperature–, it has been recorded that α being more 90% has same effect as temperature being above 100.

All of these iterations continues until 2 of these hold true at the same time;

- 5 successive generated solutions are rejected
- # of accepted moves is 2% of total iterations passed

2. Solutions

a. 31 Customers, 5 Vehicles

Data is read from *data.txt* file

Initial Random found Solution:

Truck # 1		Used Capacity: 97		Route [Depot , 20, 12, 30, 1, 19, 8, 26, 14, Depot]		Total Distance: 376.25
Truck # 2		Used Capacity: 97		Route [Depot , 7, 6, 9, 31, 27, 24, Depot]		Total Distance: 332.44
Truck # 3		Used Capacity: 48		Route [Depot , 21, 3, 5, 15, 18, Depot]		Total Distance: 348.14
Truck # 4		Used Capacity: 82		Route [Depot , 2, 11, 22, 29, 16, 10, 28, Depot]		Total Distance: 502.79
Truck # 5		Used Capacity: 86		Route [Depot , 13, 4, 23, 25, 17, Depot]		Total Distance: 447.38
Total Distance : 2006.993						

Final found Solution:

Truck # 1		Used Capacity: 95		Route [Depot , 26, 16, 30, 27, 20, 5, 25, 29, Depot]		Total Distance: 228.30
Truck # 2		Used Capacity: 63		Route [Depot , 18, 28, 23, 2, 3, 6, Depot]		Total Distance: 201.99
Truck # 3		Used Capacity: 83		Route [Depot , 12, 1, 7, 14, 24, Depot]		Total Distance: 108.81
Truck # 4		Used Capacity: 89		Route [Depot , 4, 11, 8, 9, 15, 10, 22, Depot]		Total Distance: 309.34
Truck # 5		Used Capacity: 80		Route [Depot , 13, 17, 19, 31, 21, Depot]		Total Distance: 155.73
Total Distance : 1004.172						
# of Iterations : 5000						
# of Accepted Moves : 99						

b. 32 Customers, 6 Vehicles

Data is read from *data2.txt* file

Initial Random found Solution:

```
Truck # 1 | Used Capacity: 87 | Route [ Depot , 20, 12, 25, Depot] | Total Distance: 186.63
Truck # 2 | Used Capacity: 79 | Route [ Depot , 21, 30, 16, 4, 23, Depot] | Total Distance: 263.55
Truck # 3 | Used Capacity: 94 | Route [ Depot , 27, 9, 31, 26, 8, 6, 29, Depot] | Total Distance: 463.26
Truck # 4 | Used Capacity: 93 | Route [ Depot , 32, 10, 24, 7, 2, 17, Depot] | Total Distance: 220.30
Truck # 5 | Used Capacity: 89 | Route [ Depot , 3, 5, 22, 18, 19, 28, Depot] | Total Distance: 214.70
Truck # 6 | Used Capacity: 99 | Route [ Depot , 13, 11, 1, 15, 14, Depot] | Total Distance: 214.44
Total Distance : 1562.886
```

Final found Solution:

```
Truck # 1 | Used Capacity: 92 | Route [ Depot , 10, 12, 21, Depot] | Total Distance: 73.86
Truck # 2 | Used Capacity: 76 | Route [ Depot , 25, 16, 30, 27, 32, Depot] | Total Distance: 103.63
Truck # 3 | Used Capacity: 93 | Route [ Depot , 3, 9, 15, 2, 19, 7, 6, Depot] | Total Distance: 165.88
Truck # 4 | Used Capacity: 94 | Route [ Depot , 28, 31, 23, 24, 1, 18, Depot] | Total Distance: 163.52
Truck # 5 | Used Capacity: 93 | Route [ Depot , 5, 20, 29, 11, 17, 14, Depot] | Total Distance: 198.06
Truck # 6 | Used Capacity: 93 | Route [ Depot , 13, 8, 4, 26, 22, Depot] | Total Distance: 140.63
Total Distance : 845.584
# of Iterations : 3950
# of Accepted Moves : 78
```

c. 79 Customers, 10 Vehicles

Data is read from *data3.txt* file

Initial Random found Solution:

```
Truck # 1 | Used Capacity: 88 | Route [ Depot , 12, 16, 44, 7, 50, 36, 33, 78, 8, Depot] | Total Distance: 503.32
Truck # 2 | Used Capacity: 89 | Route [ Depot , 22, 31, 57, 41, 26, 55, 68, Depot] | Total Distance: 419.05
Truck # 3 | Used Capacity: 93 | Route [ Depot , 9, 69, 58, 6, 56, 53, 10, 65, Depot] | Total Distance: 672.70
Truck # 4 | Used Capacity: 91 | Route [ Depot , 25, 21, 37, 70, 75, 15, 34, 32, 47, 18, Depot] | Total Distance: 793.58
Truck # 5 | Used Capacity: 98 | Route [ Depot , 63, 27, 79, 14, 43, 1, 74, Depot] | Total Distance: 377.10
Truck # 6 | Used Capacity: 98 | Route [ Depot , 76, 28, 46, 38, 23, 40, Depot] | Total Distance: 404.56
Truck # 7 | Used Capacity: 99 | Route [ Depot , 5, 17, 2, 3, 45, Depot] | Total Distance: 298.73
Truck # 8 | Used Capacity: 93 | Route [ Depot , 11, 67, 13, 72, 35, 66, 42, 39, 51, Depot] | Total Distance: 482.35
Truck # 9 | Used Capacity: 94 | Route [ Depot , 71, 54, 29, 62, 77, 24, 73, 52, 4, 48, 60, Depot] | Total Distance: 809.96
Truck #10 | Used Capacity: 99 | Route [ Depot , 30, 20, 59, 61, 64, 49, 19, Depot] | Total Distance: 450.47
Total Distance : 5211.823
```

Final found Solution:

```
Truck # 1 | Used Capacity: 98 | Route [ Depot , 70, 72, 50, 32, 4, 45, 22, 58, 66, Depot] | Total Distance: 213.64
Truck # 2 | Used Capacity: 92 | Route [ Depot , 38, 54, 9, 69, 56, 55, 76, Depot] | Total Distance: 260.75
Truck # 3 | Used Capacity: 94 | Route [ Depot , 1, 10, 52, 28, 27, 60, 53, 67, Depot] | Total Distance: 213.38
Truck # 4 | Used Capacity: 99 | Route [ Depot , 78, 68, 61, 57, 75, 19, 43, 16, 8, 30, Depot] | Total Distance: 281.72
Truck # 5 | Used Capacity: 96 | Route [ Depot , 34, 37, 2, 48, 71, 7, 21, Depot] | Total Distance: 210.55
Truck # 6 | Used Capacity: 85 | Route [ Depot , 49, 73, 36, 42, 13, 40, Depot] | Total Distance: 94.25
Truck # 7 | Used Capacity: 88 | Route [ Depot , 74, 12, 23, 11, 63, Depot] | Total Distance: 152.69
Truck # 8 | Used Capacity: 94 | Route [ Depot , 62, 59, 20, 26, 35, 65, 47, 64, 3, Depot] | Total Distance: 271.43
Truck # 9 | Used Capacity: 97 | Route [ Depot , 77, 39, 46, 25, 41, 15, 33, 31, 17, 29, 51, Depot] | Total Distance: 204.51
Truck #10 | Used Capacity: 99 | Route [ Depot , 44, 5, 6, 24, 79, 18, 14, Depot] | Total Distance: 211.60
Total Distance : 2114.525
# of Iterations : 9950
# of Accepted Moves : 198
```

Initial Random found Solution:

Truck # 1	Used Capacity: 95	Route [Depot , 70, 36, 17, 53, 63, 6, Depot]	Total Distance: 287.11
Truck # 2	Used Capacity: 92	Route [Depot , 20, 73, 24, 25, 15, 45, 5, 48, 51, Depot]	Total Distance: 563.51
Truck # 3	Used Capacity: 94	Route [Depot , 58, 27, 31, 13, 14, 3, 23, 30, 10, 8, Depot]	Total Distance: 502.75
Truck # 4	Used Capacity: 98	Route [Depot , 60, 42, 59, 76, 68, 33, 65, 55, Depot]	Total Distance: 486.25
Truck # 5	Used Capacity: 97	Route [Depot , 12, 61, 64, 56, 46, 26, 49, 67, 21, Depot]	Total Distance: 465.05
Truck # 6	Used Capacity: 97	Route [Depot , 29, 35, 4, 71, 19, 43, 62, 22, 69, Depot]	Total Distance: 739.92
Truck # 7	Used Capacity: 97	Route [Depot , 1, 41, 11, 2, 54, 32, 47, 66, Depot]	Total Distance: 467.38
Truck # 8	Used Capacity: 79	Route [Depot , 57, 79, 77, 52, 18, Depot]	Total Distance: 387.43
Truck # 9	Used Capacity: 98	Route [Depot , 50, 72, 37, 44, 7, 74, 39, Depot]	Total Distance: 325.47
Truck #10	Used Capacity: 95	Route [Depot , 16, 38, 28, 40, 34, 78, 9, 75, Depot]	Total Distance: 626.51
Total Distance :			4851.381

Final found Solution:

Truck # 1	Used Capacity: 99	Route [Depot , 42, 77, 60, 74, 62, 1, Depot]	Total Distance: 145.25
Truck # 2	Used Capacity: 90	Route [Depot , 49, 73, 31, 27, 5, 44, 12, 3, 51, Depot]	Total Distance: 173.33
Truck # 3	Used Capacity: 71	Route [Depot , 36, 70, 54, 33, 15, 19, 75, 20, 72, 76, Depot]	Total Distance: 269.03
Truck # 4	Used Capacity: 98	Route [Depot , 40, 21, 29, 17, 46, 25, 41, 64, Depot]	Total Distance: 199.71
Truck # 5	Used Capacity: 100	Route [Depot , 13, 11, 8, 78, 59, 6, 24, 14, 10, Depot]	Total Distance: 252.12
Truck # 6	Used Capacity: 100	Route [Depot , 39, 26, 35, 65, 69, 56, 9, 32, 38, Depot]	Total Distance: 296.72
Truck # 7	Used Capacity: 98	Route [Depot , 7, 71, 52, 2, 37, 34, 67, 66, Depot]	Total Distance: 223.60
Truck # 8	Used Capacity: 99	Route [Depot , 48, 18, 79, 28, 63, Depot]	Total Distance: 190.10
Truck # 9	Used Capacity: 98	Route [Depot , 53, 55, 47, 57, 61, 30, 23, Depot]	Total Distance: 246.30
Truck #10	Used Capacity: 89	Route [Depot , 58, 50, 68, 43, 16, 4, 22, 45, Depot]	Total Distance: 364.86
Total Distance :			2361.025
# of Iterations :			11500
# of Accepted Moves :			229

Initial Random found Solution:

Truck # 1	Used Capacity: 86	Route [Depot , 77, 38, 51, 59, 23, 41, 44, Depot]	Total Distance: 309.71
Truck # 2	Used Capacity: 99	Route [Depot , 50, 60, 27, 25, 24, 32, 40, 74, 35, 29, Depot]	Total Distance: 611.27
Truck # 3	Used Capacity: 99	Route [Depot , 76, 55, 78, 30, 58, 56, 19, 42, 46, Depot]	Total Distance: 533.59
Truck # 4	Used Capacity: 99	Route [Depot , 6, 72, 48, 2, 1, 11, 34, 70, Depot]	Total Distance: 480.73
Truck # 5	Used Capacity: 90	Route [Depot , 71, 63, 7, 36, 10, 68, Depot]	Total Distance: 346.48
Truck # 6	Used Capacity: 99	Route [Depot , 20, 21, 9, 61, 14, 79, Depot]	Total Distance: 481.44
Truck # 7	Used Capacity: 98	Route [Depot , 37, 49, 31, 8, 3, 54, 33, 47, 67, 62, 69, Depot]	Total Distance: 732.66
Truck # 8	Used Capacity: 98	Route [Depot , 28, 39, 15, 17, 18, 65, 26, 43, Depot]	Total Distance: 498.82
Truck # 9	Used Capacity: 85	Route [Depot , 5, 52, 16, 73, 64, 45, 57, Depot]	Total Distance: 516.57
Truck #10	Used Capacity: 89	Route [Depot , 66, 13, 4, 75, 22, 12, 53, Depot]	Total Distance: 448.24
Total Distance :			4959.516

Final found Solution:

Truck # 1	Used Capacity: 100	Route [Depot , 1, 29, 25, 20, 75, 61, 5, Depot]	Total Distance: 225.27
Truck # 2	Used Capacity: 96	Route [Depot , 66, 70, 76, 54, 9, 33, 15, 55, 41, 46, Depot]	Total Distance: 241.27
Truck # 3	Used Capacity: 78	Route [Depot , 74, 56, 69, 47, 19, 57, 26, 35, 65, Depot]	Total Distance: 307.65
Truck # 4	Used Capacity: 99	Route [Depot , 51, 77, 11, 28, 79, 34, 2, 71, Depot]	Total Distance: 228.04
Truck # 5	Used Capacity: 85	Route [Depot , 49, 13, 42, 53, 36, 73, Depot]	Total Distance: 101.72
Truck # 6	Used Capacity: 98	Route [Depot , 7, 62, 6, 30, 44, 12, Depot]	Total Distance: 160.68
Truck # 7	Used Capacity: 91	Route [Depot , 24, 37, 8, 43, 16, 68, 78, 64, 58, 38, 67, Depot]	Total Distance: 283.59
Truck # 8	Used Capacity: 98	Route [Depot , 21, 10, 14, 48, 18, 52, 63, 40, Depot]	Total Distance: 193.18
Truck # 9	Used Capacity: 98	Route [Depot , 3, 50, 72, 22, 4, 45, 32, Depot]	Total Distance: 235.98
Truck #10	Used Capacity: 99	Route [Depot , 23, 27, 59, 31, 17, 39, 60, Depot]	Total Distance: 168.88
Total Distance :			2146.253
# of Iterations :			12050
# of Accepted Moves :			240