Traveling Salesman Problem with Time Windows applied to liberal professions

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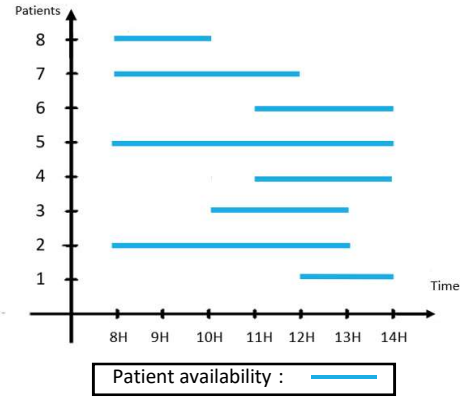
Motivation

In a morning, liberal nurses usually work 6 hours straight, see 25 to 30 patients and drives about 150km. Optimizing their route to reduce transportations between each patients may help them to reduce this number.

This problem is known as the Traveling Salesman Problem with Time Windows and we will propose here an implementation of an exact solution.

A simplified morning of a liberal nurse



Methodology

Loop with the next time interval

Extract different intervals from all patients' availability schedule

Compute new sequences based on:
- Patients available on this time interval
- Sequences done at the previous iteration

For each sequence :
- Compute time needed
- Remove similar[1] or impossible[2] sequences

Return of the shortest path and the complete time of the journey

1 : Similar sequences deletion

Consider the 2 following sequences :
1 : [A, B, C, D], time needed : 5 2 : [A, C, B, D], time needed : 7
The 2 sequences start by, finish by and visit the same patients. We can remove the 2), as it is longer.

2: Impossible sequences deletion

The impossible cases are the cases where the nurse arrives too early at the patients house, too late, or where a patient hasn't been treated before the maximum interval of the patient (so it is too late to meet him).

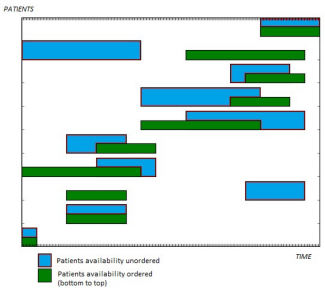
Tests

Execution time depending on the number of patients and patients' average disponibility

Patients' Average Disponibility over the period of time

Number of patients \	16%	33%	50%	66%	83%	100%
5	0.28 ms	0.33 ms	0.80 ms	1.4 ms	2.5 ms	3.4 ms
6	0.30 ms	0.46 ms	0.87 ms	1.6 ms	2.7 ms	4.6 ms
7	0.32 ms	2.0 ms	44 ms	1.7 s	9 s	10.3 s
8	0.32 ms	2.3 ms	0.5 s	3.27 s	4 min	7 min
9	0.33 ms	2.6 ms	0.9 s	32 min	X	X
10	0.36 ms	2.7 ms	2.7 s	X	X	X

- « X » means the time to compute is higher than 1 hour.
- Results shown are the mean of 10 computations.
- Removing similar sequences accounts for 95% of our program execution time.



Example of a solution

Conclusion

This algorithm :
- Gives the best solution of the best schedule to follow, not an approached one;
- Only asks for the needed distances;
- Has a too long execution time for it to be usable on real nurses' journey, but might work for other liberals'.

Perspectives

Future improvements possible :
- Optimize the implementation of the « removing similar sequences » function that currently accounts for roughly 95% of our computation time;
- Deal with cases where patients have discontinuous availability, i.e. are available during 2 or more different periods of time

Bibliographic References:

1. *An Exact Algorithm for the Time Constrained TSP* by Edward K. Baker (1983)