The Traveling Salesman Problem: How Hard is It?

15-48 EC masters' thesis project

For:	Master Students that know how to program - and are interested. If you've ever done a course in heuristics, it is a pre.
Load:	15 - 48 EC, depending on blocks (see below)
Period (approx.):	From September 2021 onward
Supervisor:	Daan van den Berg
Contact:	daan@yamasan.nl, kawarimasen0010@gmail.com
Introduction video:	https://bit.ly/3DWGFrG

About the project

The traveling salesman problem is probably the best known optimization problem. Given a number of points, find the shortest closed tour. There are many formulations of the problem, including the Euclidean version, in which the points are located on a two-dimensional map. But there are also other variants, such as ATSP, which consists of a distance matrix (possibly non-symmetrical) also.

A recent journal publication from UvA-students Sleegers, Olij and Van Horn debunked a theory that one could guess the hardness of an instance, measured in steps of a BnB-algorithm, from the distance matrix alone [1][2]. There is more to know about this.

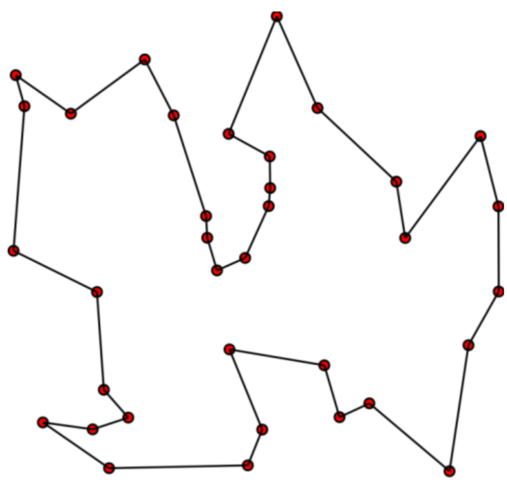

Figure 1 (source: wikipedia) Tour on a TSP-instance

Each block is about 15-18 EC's worth. You can choose blocks to your liking, though there is a strong recommendation for doing Block #1 first. Generally, we can adapt blocks as we go along, but once a block is finished, we're not going back, only forward.

Block #1
Implement Little's algorithm [3] and Zhang & Korfs [4]. Test a number of Euclidean instances, and make sure they work. Generate a set of ATSP-instances of about 30 cities, and see if there are differences in perfomance between both algorithms.

Block #2
Evolve some instances, to make them as hard as possible. There is some previous work by Van Hemert and Smith-Miles [5] and possibly others, but maybe not on ATSP. Let's evolve instances, and look at the differences. This *could* be a very large block of work, we might have to discuss how much is reasonable.

Block #3
Another very recent publication [6] from UvA suggests that for the related subset sum problem, if the number of bits remains constant, the *exact distribution of bits* seems to influence its hardness. We want to know whether this could also be the case for ATSP. Make some templates, generate some instances, and rerun the algorithms from block #1.
There must be some logic to the templates, and it is quite likely that this is only possible for ATSP, but we'll have to think about it.

Block #4
Let's evolve the templates from block #3. Quite likely, this can only be a pilot study as these operations are all computationally cumbersome. But let's give it a go anyway.

References

[1] Cheeseman, Peter C., Bob Kanefsky, and William M. Taylor. "Where the really hard problems are." IJCAI. Vol. 91. 1991.

[2] Sleegers, Joeri, et al. "Where the really hard problems aren't." Operations Research Perspectives 7 (2020): 100160. (Here it is: https://bit.ly/3DHC10O).

[3] Little, John DC, et al. "An algorithm for the traveling salesman problem." Operations research 11.6 (1963): 972-989. (a refurbished version with some typo's is available here: https://bit.ly/2YdENKJ

[4] Zhang, Weixiong, and Richard E. Korf. "A study of complexity transitions on the asymmetric traveling salesman problem." Artificial Intelligence 81.1-2 (1996): 223-239.

[5] Smith-Miles, Kate, Jano van Hemert, and Xin Yu Lim. "Understanding TSP difficulty by learning from evolved instances." International Conference on Learning and Intelligent Optimization. Springer, Berlin, Heidelberg, 2010.

[6] Daan Van Den Berg, Pieter Adriaans "Subset Sum and the Distribution of Information." IJCCI 2021: Proceedings of the 13th International Joint Conference on Computational Intelligence (to appear in November 2021; mail me for a preprint)