# Machine Learning for the Travelling salesman problem

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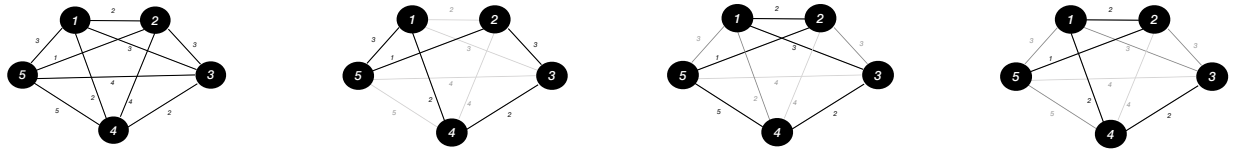
The objective of the Travelling Salesman Problem (TSP) is to find the shortest tour that visits a given set of cities. Formally, given a complete graph of $n$ vertices (the cities) with weights on arcs (the distances between cities), one wants to find the shortest Hamiltonian cycle in this graph. It is one of the most famous $\mathcal{NP}$-Hard combinatorial optimisation problems. For decades, solving the TSP has mobilised a lot of researchers and generated a lot of practical and theoretical work. Cook (2011) gives a glimpse on the works dedicated to the TSP since the late 40's. However, one difficulty that the literature of TSP still faces is the ability to determine whether an arc of a graph is a part of an optimal solution.The objective of this project is precisely to develop machine-learning approaches to answer this question.

To this extend, one has to define "features" that characterise an arc of a TSP network and use these features within an appropriate machine-learning algorithm to determine the probability that a given arc belongs to an optimal solution. The focus of this project is on the proposal of good features; one can imagine a variety of features such as: basic properties of an arc (weights, degrees...), whether an arc is selected by a constructive heuristic (nearest neighbour...), or whether an arc belongs to some graph structure (minimum spanning tree...).

An illustrative example is given in Figure 1 where one can see that arcs that appear in both a nearest neighbour solution and a minimum spanning tree solution seem likely to belong to the optimal solution of the TSP, whether arcs that appear in none are unlikely to do.




(a) A complete graph with 5 nodes

(b) An optimal TSP solution

(c) A nearest neighbour solution

(d) A minimum spanning tree solution

Figure 1: An example of two features

The vast literature on TSP and related problems should provide insights on hopefully good features; in particular there exist many efficient algorithms and solvers (Matai et al., 2010). For the learning process itself, any machine-learning algorithm can be used (logistic regression, decision trees, SVM, neural networks...). In the process, one of the critical issue will be on the constitution of a large sample of optimal TSP solutions, with the requirement to underline unavoidable limits and biases.

## References

Cook, W. J. (2011). *In pursuit of the traveling salesman.* Princeton University Press.

Matai, R., Singh, S. P., and Mittal, M. L. (2010). Traveling salesman problem: an overview of applications, formulations, and solution approaches. *Traveling salesman problem, theory and applications*, 1.