Deterministic construction heuristics for the time-dependent travelling salesman problem

Maximilian T. Zimmermann[1], Fayçal A. Touzout[2], Anne-Laure Ladier[3], Khaled Hadj-Hamou[3]

[1] Karlsruhe Institute of Technology, D-76131 Karlsruhe, Germany
ufrsb@student.kit.edu

[2] Univ. Grenoble Alpes, CNRS, Grenoble INP, G-SCOP, F-38000 Grenoble, France
faycal-atik.touzout@grenoble-inp.fr

[3] Univ. Lyon, INSA Lyon, DISP, EA 4570, F-69100 Villeurbanne, France
{anne-laure.ladier,khaled.hadj-hamou}@insa-lyon.fr

Mots-clés : *time-dependent travelling salesman problem, construction heuristics, Savings*

1 Introduction

The objective of the *time-dependent travelling salesman problem* (TSP) is to find the Hamiltonian cycle with the optimal objective value in a given time-dependent graph. The TD-TSP has different applications, such as the transportation sector. Because solving the TDTSP is complex for real-life sized problems, scholars turn to *construction heuristics* or also called *constructive heuristics* that start with an empty solution and run until a feasible solution is obtained. If no randomness is involved in their procedure, they are called deterministic.

While compilations and comparisons of construction heuristics exist for the TSP, they are not available for the TD-TSP. We fill this gap by evaluating five deterministic construction heuristics on four benchmarks considering the objective value.

2 Algorithms

Five different deterministic construction heuristics are adapted to the TDTSP. First Fit operates by up counting the index numbers of the vertices. Nearest Neighbour starts with the depot and always connects the closest vertex. The third algorithm Cheapest Insertion does always add the vertex with the smallest increase to the cycle. Savings connects in the first step all vertices to the depot and takes afterwards repeatedly shortcuts. For Christofides, not the algorithm, but the benchmark is adapted. It uses a minimum spanning tree and a minimum weight perfect matching for the calculations.

3 Benchmarks

The heuristics are compared on four different benchmarks from Melgarejo et al. [4], Rifki et al. [5], Cordeau et al. [3] and TSPLIBs [1, 2]. TAB.1 presents the characteristics of all benchmarks, including the number of vertices, number of times steps, duration of the times steps, the time horizon, the creation and the number of instances.

4 Results

A merged illustration of the results is presented in FIG.1. There the average relative gap of all benchmarks is shown depending on the number of vertices. For the benchmarks of [4], [3]

Name	Melgarejo et al.	Rifki et al.	Cordeau et al.	TSPLIBs
Number of vertices	10 - 100	11 - 61	15 - 40	29 - 194
Number of time steps	130	1 - 120	3	1
Duration time steps	6 min	6 min - 12 h	variable	-
Time horizon	6 am - 7 pm	7 am - 7 pm	-	-
Creation	real traffic	real traffic	artificial	artificial
Number of instances	220	900	180	9

TAB. 1 – Summary of the featured benchmarks [4, 5, 3, 1, 2]

and [1, 2] Savings ranked first ahead of Christofides, Cheapest Insertion, Nearest Neighbour and First Fit. The ranking changed for [5] with regard to Christofides and Cheapest Insertion, which have been interchanged.

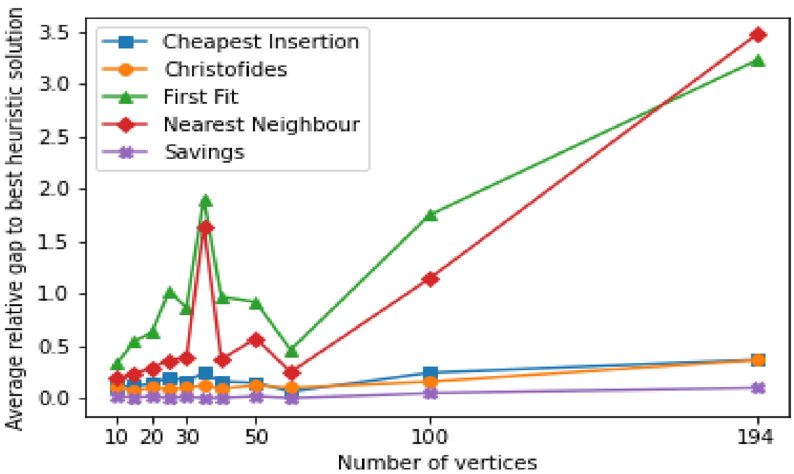

FIG. 1 – Ranking of the construction heuristics on the considered benchmarks

Overall, the ranking was surprisingly similar between all benchmarks and even on average equal on three out of four benchmarks. Also, it was unexpected that the rankings do not intersect regarding different numbers of vertices on three out of four benchmarks. The computational tests show that the modified Savings algorithm outperforms all other heuristics significantly with a low average, standard deviation, minimum and maximum gap of the relative gap to the upper bound.

Références

[1] TSPLIB Symmetric Traveling Salesman Problem Instances, Zuse Institute Berlin, http ://elib.zib.de/pub/mp-testdata/tsp/tsplib/tsp/, (visited on 2021/11/17)

[2] TSPLIB National Traveling Salesman Problems, University Waterloo, https ://www.math.uwaterloo.ca/tsp/world/countries.html, (visited on 2021/11/17)

[3] Jean-François Cordeau, Gianpaolo Ghiani and Emanuela Guerriero, Analysis and Branch-and-Cut Algorithm for the Time-Dependent Travelling Salesman Problem, 2014

[4] Melgarejo, Penélope Aguiar and Laborie, Philippe and Solnon, Christine, A Time-Dependent No-Overlap Constraint : Application to Urban Delivery Problems, 2015

[5] On the impact of spatio-temporal granularity of traffic conditions on the quality of pickup and delivery optimal tours, Rifki, Omar and Chiabaut, Nicolas and Solnon, Christine, 2020