Waste collection with EVs: A preliminary report

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Introduction: switching to EVs

We need to make heavy-duty trucks environmentally sustainable because they contribute significantly to carbon emissions despite their small overall quantity. As regards waste collection:

Which are the **optimal routes** for electric garbage trucks?

We focus on litter bins, as it is easy to estimate their weight, and their collection involves small trucks (cheaper to electrify).

E-VRP waste collection

Problem: given a depot (the start and end point), and a set of bins, we want to find the optimal (minimal duration) set of routes, for a fleet of electric vehicles, to collect all the trash from bins.

Besides classical extensions (maximum battery capacity...), we

- add charging stations of three types, assuming non-linear charging functions and partial recharge policies [1],
- consider the effect of load on energy consumption.

We wrote a mixed-integer linear programming (**MILP**) optimization model without using binary variables to describe the charging process. Furthermore, we developed constraints to select the feasible charging stations for each couple of nodes.

We want to fill the gap of research into exact algorithms.

Real Instances

It is hard to generate instances that resemble reality. Furthermore, they could prevent us from providing ready-to-deploy solutions.

- We generate 50 instances from open data.
- We use unsupervised learning techniques on the road layout data to remove arcs without reducing the quality of solutions.

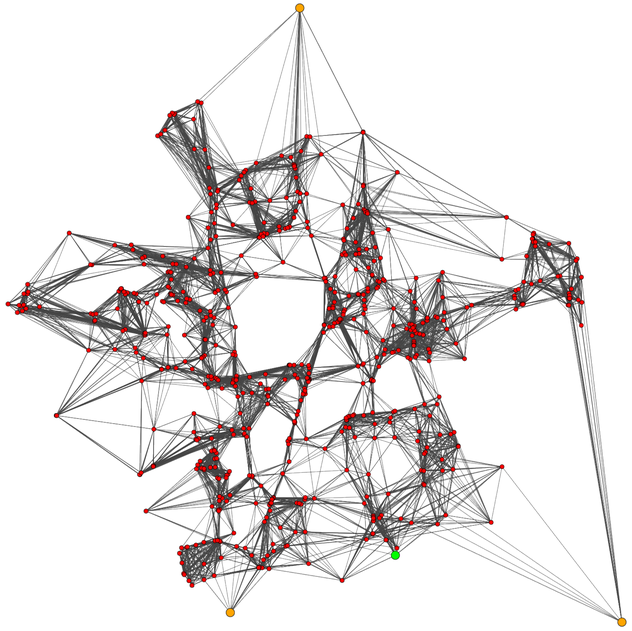

Figure 1: One of the instances generated from open data.

Constraint Programming (CP) + AI

We want to construct a reliable, resilient, fast , and free solver.

- Stochastic methods are fast and efficient but slow to adapt, as they use a lot of procedural programming to describe the problem.
- A Constraint Programming (CP) model is easy to modify, but the search based on propagation and backtracking is too slow for large instances.

We plan to use the Ant Colony Optimization metaheuristic (stochastic search) within a CP framework. The former is a form of reinforcement learning.

CMSA: learning to boost the exact algorithm

As we want to solve large instances, we plan to combine a custom randomized greedy algorithm and our model in the Construct, Merge, Solve & Adapt algorithmic framework [2], which is a learning-based optimization method.

Extend the model

We will extend the model to meet operational requirements:

- Drivers' rest breaks.
- Landfills are not in the same place as the depots and let only heavy-duty trucks in to avoid traffic congestion.

Furthermore, we will rewrite our model as an orienteering problem to exploit all the advantages of smart bins (data on fill levels).

Goals

- The formulation of a new general optimization problem for waste collection with EVs.
- The creation of instances from open data.
- The definition of exact algorithms and hybrid techniques (AI + optimization algorithms) for the general problem.
- We will do an extended analysis of the operation cost increase due to electric trucks.

References

[1] Alejandro Montoya, Christelle Guéret, Jorge E Mendoza, and Juan G Villegas. The electric vehicle routing problem with nonlinear charging function. *Transportation Research Part B: Methodological*, 103:87–110, 2017.

[2] Christian Blum, Pedro Pinacho, Manuel López-Ibáñez, and José A Lozano. Construct, merge, solve & adapt a new general algorithm for combinatorial optimization. *Computers & Operations Research*, 68:75–88, 2016.