Master Project

Solving Dynamic Vehicle Routing Problems using Inverse Optimization

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Context

In recent years, at-home delivery has taken a giant leap. It is therefore in the best interest of delivery companies to make delivering as efficient as possible. For this, the 'EURO Meets NeurIPS 2022 Vehicle Routing Competition' was created, in order to spur researchers to find more efficient algorithms for last mile deliveries. In this project we will join this competition retroactively to see if we can improve on the performance of the contestants.

In the Vehicle Routing Problem (VRP), parcels must be delivered to customers from a central depot with delivery vehicles. These packages must each be delivered within a certain time window. The objective is to minimize the total distance travelled by the vehicles. In the dynamic variant of the VRP (the DVRP), new delivery requests pop up over time that must be shipped the same day. It is not known in advance when those new requests are made. This means the routing algorithm must anticipate these requests in order to find optimal routes. The state of the art heuristic algorithms are good at finding near-optimal routes for the VRP, but struggle with the anticipation necessary for the DVRP. The state of the art machine learning algorithms are good at anticipating, but not good at finding efficient routes. In this thesis project we will try to combine both types of algorithms such that each algorithm plays to its strengths.

The machine learning algorithm of interest to this master thesis is Inverse Optimization (IO), which is a form of Supervised Learning. In Supervised Learning, there is a black box that, given an input gives a certain output. We don't know how the black box creates the output from the input, but we do have a data set of such input-output pairs. With this data, we will attempt to learn the behaviour of the black box. The way we do this is by choosing a parameterized function, and compare its input and output with the black box data. Then by optimization, we will try to tune our parameters in order to get as close as possible to the input-output data of the black box. in IO, we make the extra assumption that the black box is an optimization problem itself. The output of the box is the optimizer of an unknown optimization problem. The Supervised Learning scheme will try to learn this optimization problem. In the DVRP, the black box is an actual optimization scheme, so it is natural to use IO as this form of Supervised Learning. To the best of our knowledge, this has not been done before. The main goal of this project is to reformulate the DVRP as an IO problem and combine this with the state-of-the-art heuristic methods to see if this brings improvement to the performance.

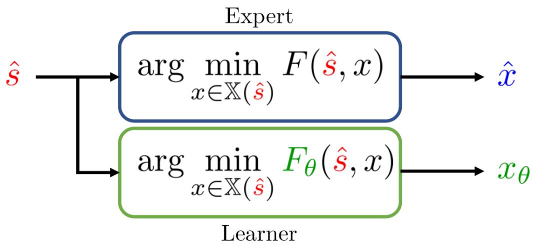

Figure 1: In the IO problem, we tune the parameter θ to minimize the difference between the output $\hat{x}$ of the unknown optimization problem and the output of x_θ of our parameterized optimization problem.

Project tasks

The project can roughly be divided into the following parts:

1. Perform a literature research on Inverse Optimization and the Vehicle Routing Problem.
2. Reformulate the Dynamic VRP as an IO problem.
3. Develop an algorithm that solves the DVRP by combining the IO reformulation with state of the art heuristic methods for the static VRP.
4. Implement the algorithm using real world data from the 'EURO Meets NeurIPS 2022 Vehicle Routing Competition' and compare the performance to that of the contestants of this competition.