Karlsruhe Institute of Technology

Autonome Lernende Roboter (ALR)

Prof. Gerhard Neumann

Project Type

- [x] Master Thesis
- [ ] Bachelor Thesis
- [ ] Research Project

Supervisors

Niklas Freymuth

niklas.freymuth@kit.edu

Philipp Kiesling

philipp.kiesling@kit.edu

Difficulty

Algorithmic

Math

Application

Swarm RL for Solving the Inventory Routing Problem in Cooperation with an AI-Startup

Description

In contemporary supply chains, inefficiencies in tour planning and scheduling result in elevated costs and carbon emissions. To combat these issues, logistics companies utilise both scheduling and routing algorithms. However, in many scenarios, such as inventory replenishment or waste collection, scheduling and vehicle routing problems (VRP) are deeply interlinked, with the VRP outcome directly influencing scheduling strategies.
SOTA approaches mainly segregate the problem into distinct scheduling and VRP tasks, which are subsequently solved using (non-)linear programming or heuristics. This separation, however, induces suboptimal outcomes, given that the primary objective of scheduling optimization is inextricably linked to the efficiency of the resultant routing, which is determined independently. [1, 2]

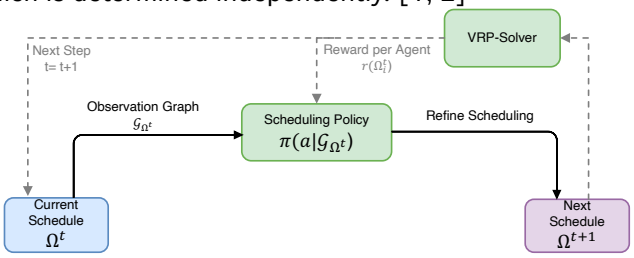

Figure 1: Illustration adapted from [3] to illustrate the learning process

This thesis proposes the integration of scheduling and VRP through the application of Reinforcement Learning (RL). Specifically, it explores the potential of Swarm RL for the dynamic generation of optimized schedules that inform VRP solutions. An RL agent will be developed to create schedules that are subsequently used as input to the VRP, which is the basis of the associated rewards. This thesis will be developed in cooperation with an AI startup from Karlsruhe, which provides simulated and real-world data environments. Specifically, the goal is to explore the application of GNN-based Swarm RL as performed in [3]. The model treats each customer within the network as a distinct agent in a larger swarm system. At every step, agents assess their need for inventory replenishment. This decision is informed by their local view and through interactions with neighbouring agents, facilitated by message-passing or attention mechanisms.

Tasks

The tasks in this project will involve:

- Literature Review: Acquire a comprehensive understanding of multi-Agent RL and conventional approaches to the Problem.
- Implementation of the RL-agent: Refine and implement the suggested approach.
- Tests on Synthetic and Real-world Data Test your approach first on smaller, synthetic instances and later on a dataset with >200 customers.

References

[1] Claudia Archetti, Natashia Boland, and M Grazia Speranza. A matheuristic for the multivehicle inventory routing problem. 2017.

[2] Meysam Mahjoob et al. A modified adaptive genetic algorithm for multi-product multi-period inventory routing problem. 2022.

[3] Niklas Freymuth, Philipp Dahlinger, Tobias Würth, Simon Reisch, Luise Kärger, and Gerhard Neumann. Swarm reinforcement learning for adaptive mesh refinement. 2023.