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Predicting Solutions for the Vehicle Routing Problem using Graph Neural Networks

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27.08.2021

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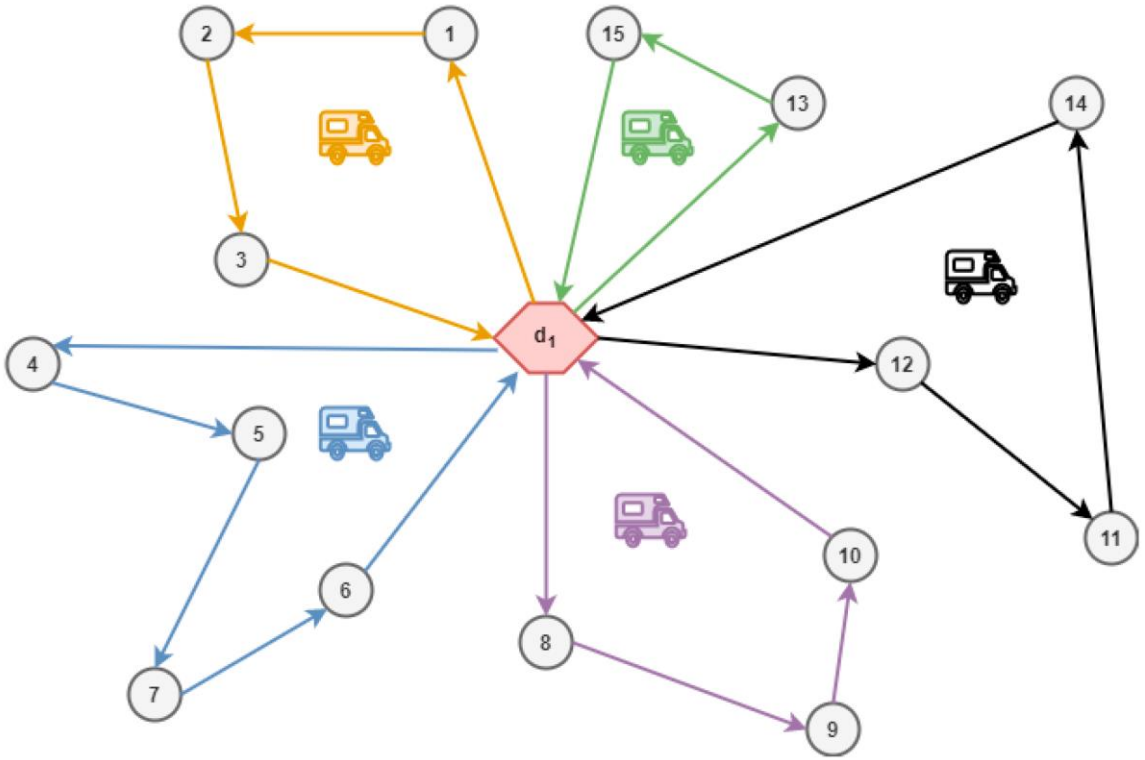
The Vehicle Routing Problem



Graph from Kovács et al. 2018

The Vehicle Routing Problem

- One of the most studied problems in combinatorial optimization
- Utilizing optimization algorithms in routing produce savings of 5% to 20% in global transportation costs (Moghdani et al. 2021)
- There are many variants of the VRP, e.g. Capacitated VRP and VRP with Time Windows

The Vehicle Routing Problem

- The VRP is an NP-hard problem, hence computation times for exact algorithms become unreasonable for large sets of customers
- Many heuristic algorithms provide good approximations within reasonable computing times (Sharma et al. 2018)
- Could the computational time and cost be further reduced with a Deep Learning model?

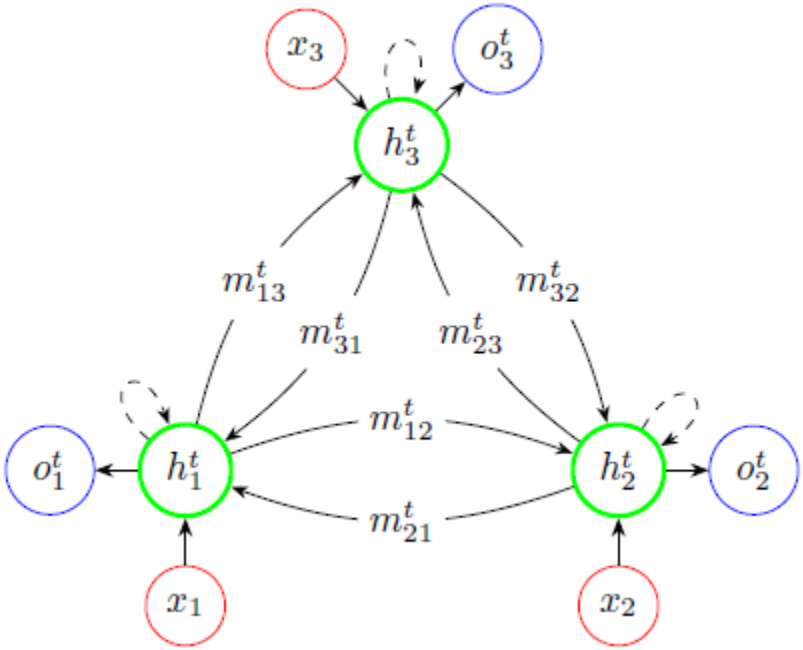
Goal of the Thesis

- The goal is to develop a graph neural network (GNN) for predicting optimal routes for the VRP
- The developed GNN will be based on the Recurrent Relational Network (RRN) architecture (Palm et al. 2018)

Related Work

- Interest in utilizing Deep Learning for solving Combinatorial Optimization problems has grown during recent years
- Most research propose hybrid models that combine Deep Learning and traditional models. For instance, learning a heuristic that is used in a local search algorithm
- A few propose end-to-end learning models that output solutions directly from input

Recurrent Relational Networks



Graph from Palm et al. 2018

Data

- Training and test data will be randomly generated instances of the VRP solved using OR-tools, a Google suite that provides powerful solvers for important optimization tasks

Constraints on the Model

- Model will be trained on fixed number of nodes
- Number of nodes will be small (n=20) in order to generate training data in a reasonable time
- Focus on developing a RRN for the vanilla VRP. If possible the model might be extended to the CVRP

Tools & Frameworks

- OR-tools
- Pytorch

Schedule

- Presentation of the topic 27.08.2021
- The RRN implemented and results obtained by end of September 2021
- Writing the thesis September-October 2021
- Presentation of results in October 2021
- Thesis ready by end of October 2021

Literature and References

- Palm et al. 2018. Recurrent Relational Networks
- Zhou et al. 2020. Graph neural networks: A review of methods and applications
- Bengio et al. 2020. Machine Learning for Combinatorial Optimization: a Methodological Tour d'Horizon
- Sharma et al. 2018. Vehicle routing problem: recent literature review of its variants
- Moghdani et al. 2021. The green vehicle routing problem: A systematic literature review
- Kovács et al. 2020. Fitness Landscape Analysis and Edge Weighting-Based Optimization of Vehicle Routing Problems