

# Travel time estimation using Graph Neural Networks

## Motivation

Growing urbanization leads to increasing traffic volume in urban areas. Mobility service providers aim to resolve challenges that arise due to increased traffic by developing concepts like ride-sharing or autonomous mobility-on-demand systems to provide the same extent of mobility with fewer vehicles. Herein, centrally controlled systems with online information exchange allow for intelligent dispatching of vehicles to mobility needs, which in turn depend on underlying routing optimization algorithms that work for large-scale scenarios.

As a critical part of routing optimization algorithms, travel time estimation is a challenging task as temporal and spatial interdependencies correlate with each other. Graph Neural Networks are learning algorithms able to catch such correlations and are suitable for estimating travel times under traffic conditions.

## Aims and scope of the thesis

This work focuses on a centrally-controlled fleet of self-driving vehicles that serve on-demand trip requests. When a trip request with a starting location and a destination location enters the system, two information have to be provided to the request: *How long does it take till the trip starts?* and *How long will the trip take?* The objective of this master thesis is to answer both of these questions using a Graph Neural Network. The student has to identify relevant features and dependencies influencing travel times in urban mobility systems. Moreover, it is crucial to find out how to model these spatial and temporal dependencies in a Graph Neural Network and how to train the network using data from simulation frameworks like MATSim or PTV Visum. To summarize, the work consist of the following research tasks:

1. Literature review on graph neural networks and travel time estimation
2. Formulation of a research question
3. Theoretical Problem formulation
4. Construction of a Graph Neural Network
5. Implementation and Learning of the Graph Neural Network
6. Evaluation of the travel time estimation and comparison with state-of-the-art benchmarks

## Requirements

This thesis targets students with a strong background in informatics and machine learning: Informatics, Engineering, TUM-BWL, or similar study programs. Knowledge of machine learning, optimization, and a general-purpose programming language (e.g., Python (TensorFlow, PyTorch), C++) is required. Knowledge of Graph Neural Networks and simulation programs like MATSim is advantageous. The thesis should be written in English.

## Related Research

- Wu, Z., Pan, S., Chen, F., Long, G., Zhang, C., & Yu, P. S. (2021). A Comprehensive Survey on Graph Neural Networks. *IEEE Transactions on Neural Networks and Learning Systems*, 32(1), 4–24.
- Wang, D., Zhang, J., Cao, W., Li, J., & Zheng, Y. (2018). When will you arrive? Estimating travel time based on deep neural networks. *32nd AAAI Conference on Artificial Intelligence, AAAI 2018*, 2500–2507.
- Lange, O., & Perez, L. (2020). Traffic prediction with advanced Graph Neural Networks. <https://deepmind.com/blog/article/traffic-prediction-with-advanced-graph-neural-networks>

**Begin:** as soon as possible

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**Co-advisor:** Dr. Gerhard Hiermann

**Application:** See <https://www.professors.wi.tum.de/osm/education/masters-thesis/>