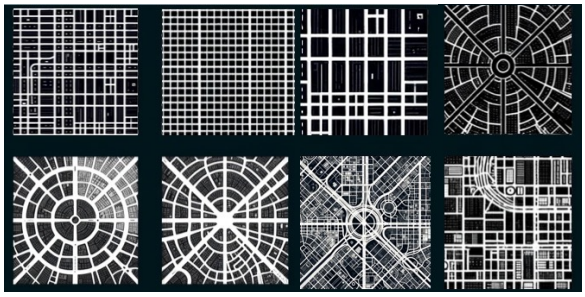
Classification of urban networks based on their topology and demand



Problem description

Cities face increasing population growth, leading to environmental problems due to congestion. Thus, there is a need for sustainable and efficient transportation systems, and the optimization of shared transportation services presents a pivotal opportunity to provide a viable alternative to private vehicles. However, the diversity in demand patterns and network topologies of different cities calls for a tailored shared mobility system rather than a universal solution for shared mobility. Finding a solution for each city is very computationally expensive and inefficient. For this reason, some researchers have aimed to classify cities and provide tailored solutions for each category. However, a systematic way to identify city categories is still elusive.

Assignment and objectives

This project aims to categorize cities into distinct typologies, considering factors such topology characteristics and demand patterns to better understand the relationship between urban form and transportation dynamics. By identifying distinct classes of urban typologies, we can tailor shared mobility systems to each class, optimizing for efficiency and sustainability.

The assignment will consist of the following:

- Conducting a literature study and select some cities for the study
- Use of OpenStreetMap to analyze urban netwroks structural characteristics.
- Identify and collect relevant transportation demand patterns from multiple cities, e.g., trip distances.
- Establishing correlations between city structure and transportation demand.
- Use of clustering techniques for network classification

Research group

Transport & Planning Department
Daily supervisor (contact for information):
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The project can be conducted as a final thesis project for the MSc Civil Engineering –Transport & Planning track or MSc in Transport Infrastructures and Logistics.

Resilience of road networks

Problem description

Recent research has shown that resilience of road networks is strongly dependent on certain parameters of the network. The relation of resilience with network parameters, such as density, number of nodes and average number of lanes was investigated, and the research showed that networks with a lower density having a higher resilience. It was also found that no conclusion could be drawn about the relation between capacity and resilience. For this research random networks were drawn. However, the networks generated had very correlated parameters. This made it difficult to find which network parameters influenced the resilience the most. It is possible to design networks differently, such that the network parameters can be better distinguished. Also, the relation between network size and resilience is still an open research topic.

Assignment

- Check recent literature on resilience and resilience metrics;
- Decide which network parameters are worth further research;
- Design and execute simulations to determine the relation between certain network parameters and resilience;
- Analyse the relation between the chosen network parameters and resilience;
- Write a thesis report (and optionally a scientific paper for an international journal).

Research group

CEG - Transport & Planning

Thesis supervisor: dr.ir. Victor Knoop

Daily supervisors: dr.ir. Irene Martínez Josemaría; dr.ir. Henk Taale (Rijkswaterstaat)

Technology, Policy and Management – Multi-Actor Systems Department

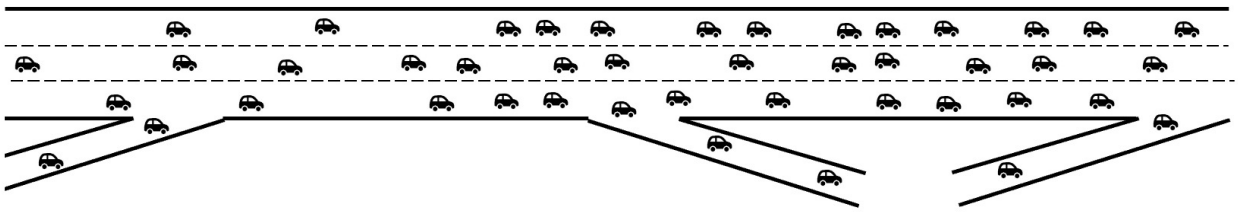
Thesis supervisor: prof.dr. Martijn Warnier

Information

This research is done in cooperation with Rijkswaterstaat, within the ITS Edulab. In ITS Edulab students analyse traffic related issues with short-term research for Rijkswaterstaat, the Dutch motorway operator. In this way, real-life, operational knowledge is connected with scientific research. ITS Edulab leads to useful, practical knowledge for Rijkswaterstaat, and interesting master projects to students.

For further information on this Master topic, please contact: h.taale@tudelft.nl

Modeling freeway traffic at corridors: comparison of microscopic, macroscopic, and network traffic flow models



Problem description

Multiple traffic flow models and simulation softwares have been developed to study the traffic dynamics that arise from the interaction of vehicles on the road. Traditional traffic flow theory describes the movement of vehicles as particles (Lagrangian coordinates) or as a stream of vehicles through a road (Eulerian coordinates). These traffic flow models can be referred to as vehicle flow models because they are focused on describing the flow of vehicles and are not particularly focused on the trip perspective of those vehicles, e.g., mode or route choice and other trip characteristics such as origin and/or destination. Based on the behavioral rules and on the representation, these traditional traffic flow models are usually classified into macroscopic (Eulerian coordinates and Macroscopic behavioral rules) or microscopic (Lagrangian coordinates and microscopic behavioral rules) flow models. The traffic dynamics on these models rely on local speeds, which can be calculated based on average local densities or the distance to the leading vehicle, respectively. Recently, there is an emerging modeling approach has been gaining interest in the research community due to its computational cost benefits. The main idea behind this approach is to treat a network as an undifferentiated unit, where trips are modeled in a relative space with respect to their destinations. These models are referred to as bathtub models. The trip flow dynamics at the network level are characterized by an average speed of the system that is calculated globally based on network-wide density. The existence of this network-wide speed-density relation at the network level has been proven to exist empirically both in urban networks and at freeway corridors.

Assignment

The assignment will consist of:

- Literature study on microscopic and macroscopic flow models and on bathtub models
- Develop code(s) to compare traffic dynamics for different traffic models on a freeway corridor with multiple on- and off-ramps
- Compare computational cost and accuracy between models

Background

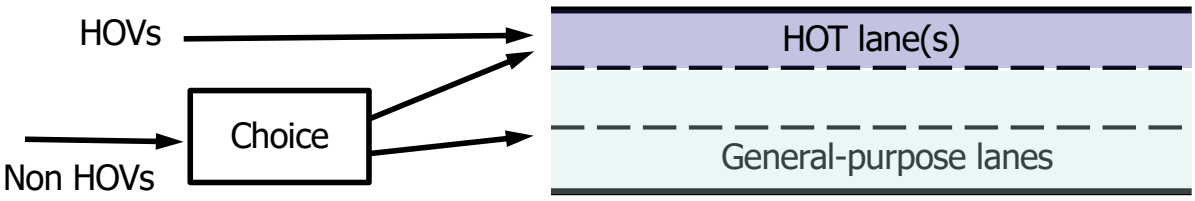
A student who has interest in traffic flow simulation and wants to elevate their programming skills.

Research group

The project can be conducted as final thesis project for MSc Civil Engineering –Transport & Planning track or MSc in Transport Infrastructures and Logistics.

Daily supervisor (contact for any information): Dr. Ir. Irene Martínez (I.MartinezJosemaria@tudelft.nl)

Lane choice behavior modeling on high-occupancy-toll (HOT) lanes



Problem description

Dedicated lanes for high-occupancy-vehicles (HOVs, where there are 3+ persons in a vehicle) are usually underutilized. To take advantage of the available unused capacity in these lanes, HOT lanes allow vehicles that do not meet the minimum occupancy requirement to pay a toll to travel in the underutilized lane. This management strategy improves the system performance without significantly influencing the travel time of HOVs. The operator should determine the dynamic toll for SOVs based on the demand to ensure that the HOT lane is never congested while also not being underutilized. Moreover, there is an increasing interest to make the toll collection a distance-based pricing strategy.

However, the lane choice for HOT lanes is not systematically studied in the literature. Because drivers can choose to travel in the HOT lanes only for a portion of their trip, the path alternatives have significant overlap, therefore, simple discrete choice models like the logit model can not be applied due to the correlation between alternatives. Moreover, the choice of drivers will also depend on the congestion level in the general-purpose lanes as well as on the HOT lanes, the value of time of the driver, and the his/her personal characteristics.

Assignment

This project consists in developing a stated choice experiment to develop a model for the decision of which lane to take, for how long, and when.

The assignment will consist of the following:
- Conducting a literature study of lane choice models
- Develop an experimental design in terms of variables and their levels as well as context variables
- Design a stated preference survey with alternatives and calibrate different model structures
- Analyze the results and produce meaningful insights from the research

Research group

Transport & Planning Department
Committee:
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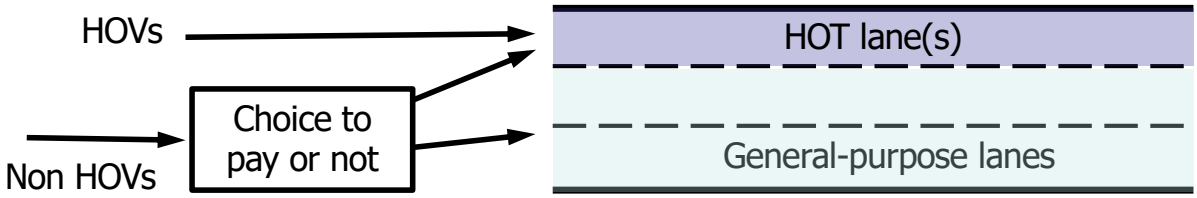
The project can be conducted as a final thesis project for the MSc Civil Engineering – Traffic and Transport Engineering track or MSc in Transport Infrastructures and Logistics.

Fair and dynamic HOT lane pricing based on expected travel time



Problem description

Single-occupancy vehicles (SOVs) are charged to use the high occupancy toll (HOT) lanes, while high-occupancy-vehicles (HOVs) can drive in them at no cost. The pricing scheme for HOT lanes has been extensively studied at local bottlenecks or at the network level through computationally expensive simulations. However, most of the dynamic pricing strategies are reactive in nature and may lead to unfair pricing. Leveraging vehicle-to-infrastructure communication, we can rely on a more personalized toll, which is not only time but also distance-dependent.

This thesis aims to develop a fair and dynamic HOT lane pricing strategy for freeway corridors with multiple bottlenecks. The proposed tolling scheme will account for the expected travel time of users based on day-to-day information or near-future demand predictions, ensuring a more equitable distribution of toll rates. The research will leverage Vickrey's bathtub model or agent-based bathtub model to evaluate the equity and efficiency of traffic control. The findings of this study will contribute to the advancement of equitable transportation policies and congestion management strategies.

Assignment

The assignment will consist of:
- Literature study of HOT lane pricing
- Introduce one or multiple dynamic tolling scheme that considers the expected travel time
- Introduce one or multiple dynamic tolling scheme that accounts for the overall expected externalities caused by each vehicle (marginal pricing)
- Simulations to evaluate the impact on efficiency and equity of the proposed strategies

Research group

The project can be conducted as final thesis project for MSc Civil Engineering –Transport & Planning track or MSc in Transport Infrastructures and Logistics.

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