SMART - Simulation and Modeling of Automated Road Transport

CTR-day 2021

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Upcoming Mobility
Automated Vehicles

Traffic performance
• Changes in travel behavior
• Interaction between automated and non-automated vehicles
• Smaller vehicles, increased heterogeneity

Public Transport
• MaaS
• Smaller public transport vehicles
• Demand-driven services
• New transport solutions

Urban design / City planning
• Redistribution of space
• Parking spaces

Technology for integration of multimodal mobility
• Service platforms
• Cloud-based infrastructure
The purpose of the SMART project

- Identify the limitations of current traffic models to include automated vehicles
- Further develop current traffic models to enable analysis of traffic systems including automated vehicles
- Evaluate the effects on traffic systems due to vehicle automation for two application cases
- Contribute to long-term knowledge building
SMART consists of two doctoral projects

Public Transport

Traffic simulation of fleets with automated vehicles

- David Leffler
- Wilco Burghout
- Erik Jenelius
- Oded Cats

- New public transport solutions
  - Real-time control strategies
  - Automated vehicles in flexible feed traffic
- Modeling and effects of multimodal public transport systems
  - Effects of competing versus cooperating fixed and flexible public transport systems
  - Modeling of traveler behavior

Microscopic traffic simulation of automated vehicles

- Ivan Postigo
- Johan Olstam
- Clas Rydergren

- Traffic effects of mixed traffic
  - Transition to automated roads
  - Heterogeneity of automated vehicles
- Modeling of automated driving
  - Differences in perception and reaction
  - Compliance to real-time control strategies
  - Effects of digital infrastructure
Microscopic Modeling of Automated Vehicles

Research questions:

• How to model automated driving?

• How will the interaction between conventional and automated vehicles affect traffic systems?
Background

- Traffic simulation is an important tool used for traffic analysis.
- Microscopic traffic simulation models describe the movements and interactions of all individual vehicles or travelers.
- Typical use of microsimulations is to investigate how changes in the infrastructure impact the traffic flow.
- With the introduction of automated vehicles, there is a change on the vehicle population.
- Several studies have used microscopic traffic simulation to investigate the impact caused by automated vehicles.
Aspects to consider for modeling automated driving

**Automated Driving Context**
- Authorities
- User acceptance / User preferences
- Vehicle System
  - Sensor-based perception
  - Connectivity
  - Physical / Digital Infrastructure

**Operational and safety constraints**

**Automated driving**

**Fallback to conventional driving**
Effects on Traffic Performance due to heterogeneity of Automated Vehicles

A first study was done based on microscopic traffic simulations:

- Over time AVs will become more advanced and improve their driving capabilities and,
- Different generations of AVs will coexist on the roads → AV heterogeneity.
Modeling Perception for Automated Driving

Automated Driving Context

- Sensor-based perception
- Connectivity
- Physical / Digital Infrastructure

- Which vehicles/objects can be perceived?
- What type of information?
  - Position
  - Speed
  - Intentions (route, desired lanes, desired speed)
  - ...
- When is the information obtained?
  - Frequency
  - Latency
- How is the information obtained/what are the sensing capabilities?
- Focus on the developing a generic model of perception including quality, range and latency.
- Capture in a consistent way the key differences between human perception, sensor based perception and connectivity based perception.
Automated vehicles in public transit

- Automated transit services integrated with traditional public transit services
- Limited real-life data and experience of such systems

**Our focus:**
- Real-time control of fixed transit
- Flexible feeder services

Source: UITP (2017)
BusMezzo

- **Transit simulation** model with extensions

- **Agent-based**, models individual passenger’s route and mode choices
  - within-day (short-term adaptation)
  - day-to-day (learned from experiences)

- Extended with functionalities to model **demand-responsive** services and alternative assignment strategies
On-demand feeder to fixed case study

Case description:
• Simulate replacement of branches with shared on-demand vehicles
• Passenger and operator costs for collection direction (on-demand branch to fixed corridor)

Proposed contribution:
• Demonstrate flexible transit simulation framework to evaluate a ‘real-life’ scenario
• Conceptualize and experiment with evaluation metrics for collaborative on-demand feeder to fixed transit systems

Based off of the paper:

Stockholm bus lines 176 & 177
Branches to/from Solbacka/Skärvik (Ekerö) that merge into a common corridor toward Mörby C through Solna
Scenario variations

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<thead>
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<th>Scenario</th>
<th>Fixed fleet</th>
<th>DRT fleet</th>
<th>DRT capacity</th>
<th>Algorithm</th>
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Measured effects:
- Passenger level-of-service per OD category
  - Branch-to-branch, Branch-to-corridor, Corridor-to-corridor
- VKT, Fleet utilization
Main takeaways

- **Shortening and simplifying** the **fixed** service while maintaining the same frequency **improves LoS** for travelers on the **corridor**
- The effects of **rebalancing** are **positive for the largest fleet** of smaller vehicles, however can also have **negative effects for smaller fleets** (in this case mainly for transferring travelers)
- **Median waiting times improve** for all DRT scenarios, however it is difficult to compete with the fixed service without transfers in terms of **reliability and equity of waiting times**
Future work

- Work potentially benefits operators, planners, policy-makers: experiment with different conditions, to improve planning these types of services prior to implementation
- Next steps are to further integrate the flexible transit framework with the day-to-day learning framework of BusMezzo

Modeling traveler behavior for multimodal trips:
- Walking
- Fixed transit
- Flexible transit
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