SMART III: Simulation and Modeling of Automated Road Transport

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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 driving automation for two application cases.

• Contribute to long-term knowledge building.
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.

• Several studies have used microscopic traffic simulation to investigate the impact caused by automated vehicles.
Microscopic modeling of automated driving

Research questions:
• How to model automated driving?
• How will the interaction between conventional and automated vehicles affect traffic systems?
Aspects to consider for modeling automated driving

A. Authorities
B. User Acceptance / User Preferences
C. Vehicle System
D. Vehicle Sensor-based Perception
E. Vehicle Connectivity
F. Physical / Digital Infrastructure

DDTs controlled by automation
Operational and Safety Constraints

DDTs controlled by human
Modes of perception

Human

Sensor-based

Connectivity (i)

Connectivity (ii)
Perception Tasks for Automated Driving: A Conceptual Model for Microscopic Traffic Simulation

- Develop a conceptual model for the perception tasks and that ensures consistency in perception and transparency about assumptions.

- Capture differences in perception performance between sensor-based perception, perception based on connectivity and human perception.
Perception for automated driving

- How is the information obtained/what are the sensing capabilities?
  - Mode of perception
  - Range – Accuracy
- Which vehicles/objects can be perceived?
- What information?
  - Position – Speed – Intentions
- When is the information obtained?
  - Frequency – Latency – Delay

Capture in a consistent way the differences between human perception, sensor-based perception and connectivity-based perception.
Change in microscopic driving model

**Current Approach**

Driving Model

- Perception
  - \( \Omega_1 \)
  - Car Following
    - \( \Psi_1, \tau_1 \)
- Perception
  - \( \Omega_2 \)
  - Lane Changing
    - \( \Psi_2, \tau_2 \)

Action

**Proposed Approach**

Driving Model

- Perception
  - \( \hat{\Omega}, \tau^p \)
  - Car Following
    - \( \Psi_1, \tau^{d_1} \)
  - Lane Changing
    - \( \Psi_2, \tau^{d_2} \)

Action, \( \tau^{ex} \)

- \( \Omega \): state variables
- \( \Psi \): submodel parameters
- \( \tau \): delay (reaction time)

Change to:

- \( \hat{\Omega} \): estimated state variables
- \( \tau \): disaggregated delay

\[
\tau = \tau^p + \tau^d + \tau^{ex}
\]
Modeling perception performance

- Accuracy -- $\epsilon$
- Delay -- $\tau$
- Range
  - Weather – Time of the day – Visibility

$$\hat{\Omega}(t) = f(\Omega, P_n)$$
$$f(\Omega, P) = \Omega(t - \tau^p_n) \pm \epsilon^\Omega_p$$

- $\Omega$ : state variables
- $\hat{\Omega}$ : estimated state variables
- $P$ : perception mode
- $\tau^p$ : perception delay
- $\epsilon$ : error
Future work

• Implement perception model in open-source traffic simulator.

• Obtain numerical results.
Thanks for your attention!

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