Master's thesis project

Analysis and modelling of drivers' responses to lane change scenarios extracted from Naturalistic Driving Data (NDD) to support the design of automated driving

Research project title Analysis and modelling of drivers' responses to lane change scenarios extracted from Naturalistic Driving Data (NDD) to support the design of automated driving
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Keywords Driver behaviour; automated driving; driver models; glance behaviour
Mandatory requirements • Proficiency with Matlab or other programming languages and good analytical skills • Fluency in English • Good statistics skills *Optional requirements* • Basic knowledge about driver behaviour analysis and driver behaviour modelling
Workplace This is a joint research project to be performed partly at Chalmers University of Technology (Crash Analysis and Prevention group, division of Vehicle Safety) and partly at AB Volvo
Learning objectives • Formulate hypotheses about driver behaviour • Analyse and interpret data collected during Naturalistic Driving Studies (NDS) • Understand how to model driver behaviour using Naturalistic Driving Data • Evaluate impact on the design of automated driving
Highlight • Work with a relevant research topic undergoing intense study (automated driving) and with automotive industry (AB Volvo)

Number of students	Scholarship provided
2	Yes, at completion of Master's thesis

Background

In January 2016, the Swedish automotive industry (AB Volvo, Volvo Car Corporation and Autoliv) in collaboration with universities / research institutes (Chalmers and VTI) started the project *Quantitative Driver Behaviour Modelling for Active Safety Assessment Expansion* (QUADRAE). The aim of the project is to **develop and validate models of driver behaviour** that are needed in current and future simulation tools for virtual testing of active safety and automation. Within the overall project, an important sub-task is the **modelling of drivers' behaviour in safety-critical events during semi-automated driving** and this project contributes to this sub-task.

Objective

Previous driving simulator as well as naturalistic driving studies showed that, in rear-end unexpected emergency situations, drivers react to the situation kinematics (Bianchi Piccinini, 2018; Engström and Markkula, 2018; Markkula et al., 2016). For rear-end scenarios, the kimematics of the situation translates into patterns of optical flow through the optical expansion of the lead vehicle's width on the

retina of the following driver: notably, the looming (τ) – calculated as the optical angle subtended by the lead vehicle, θ, divided by the angular rate of expansion, θ – provides an estimation of the time-to-collision (Lee 1976). The looming has been included as a decisional variable in models describing drivers' reactions to rear-end unexpected emergency situations, assuming that drivers react to unexpected looming rather than to looming per se.

The lane change manoeuvre of a Principal Other Vehicle (POV) in front of the Subject Vehicle (SV)[1] represents a driving scenario in which the SV driver is exposed to looming due to the POV appearing in the visual field of the SV. However, the looming accumulation in the lane change scenario would be different from the rear-end scenario since, initially, the POV is not in the visual field of the SV. Then, the model describing the SV driver's response to the lane change of the POV will also be different from the model developed for rear-end critical scenarios.

This Master thesis work aims to model SV drivers' responses to lane changes of the POV (especially, trucks but also cars), by using Naturalisitic Driving Data (NDD), available at the division of Vehicle Safety. The results of the study will be used to develop models that will support the design of automated lane changes of truck drivers, within the QUADRAE project.

Research project work

The students will filter, annotate and analyse Naturalistic Driving Data extracted from different datasets (SHRP2, UDRIVE and EuroFOT) to assess several variables (e.g. SV drivers' evasive maneuver, type of vehicle changing lane; POV overlap with respect to SV; time headway between SV and POV; SV driver's looming) during critical and non-critical lane changes performed by the POV. The information extracted from the NDD will be used to develop driver models describing the drivers responses to the critical and non-critical lane changes. The detailed plan of the research project includes the following steps:

1. Review the literature about models of driver behaviour.
2. Filter the Naturalistic Driving Data to extract events for the scenario under analysis (lane change).
3. Annotate and look into the Naturalistic Driving Data to extract the relevant variables
4. Analyse the extracted data to find relations between the extracted variables
5. Develop driver models describing drivers' responses of the SV driver to lane changes performed by the POV.
6. Write the final thesis report.

References

Bianchi Piccinini, G., Lehtonen, E., Forcolin, F., Engström, J., Albers, D., Markkula, G., Johan Lodin, J., Sandin, J. (2018). How do drivers respond to silent automation failures? Driving simulator study and comparison of computational driver braking models. Manuscript in preparation

Engström J., & Markkula G. (2018). Kinematics-dependent braking responses in rear-end emergencies: experimental results and a simulation model. Manuscript in preparation

Lee, D.N. (1976). A theory of visual control of braking based on information about time-to-collision. *Perception*, 5, 437–459.

Markkula, G., Engström, J., Lodin, J., Bärgman, J., & Victor, T. (2016). A farewell to brake reaction times? Kinematics-dependent brake response in naturalistic rear-end emergencies. *Accident Analysis & Prevention*, 95, 209-226.

[1] SV is used in the document to name the instrumented vehicle in the Naturalistic Driving Data, while the POV is the vehicle changing lane in front of the SV