PhD thesis proposal

Human driver modeling and Adaptive Shared Lateral Control for Automated Vehicles.

Supervisors
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Start Date: October 2023
Fund request 3 years:
Contrat doctoral du Ministère de l'Education Nationale, de l'Enseignement Supérieur, de la Recherche et de l'Innovation (MESRI)
Work Organisation: mainly in Grenoble, short periods in Valenciennes for thesis progress assessment and experimental validations

Potential international collaborations: SZTAKI (Budapest, Hungary), ITESM (Monterrey, Mexico)

HOW TO APPLY:
- CV with contact details
- Bachelor and master transcripts (including list of courses with corresponding grades) for all the university years
- A summary of (or an e-link to) your master thesis
- Name and email of two references

CONTEXT

Intelligent and automated vehicles are at the heart of the societal concerns of tomorrow's transport. Equipped with numerous sensors and actuators, these vehicles will enhance road safety, streamline traffic, make transportation more accessible to people with disabilities and older people, and participate in the development of new modes of transport.

A lot of studies are dedicated today to the interaction between the driver and the vehicle, and in particular to the shared control between both the driver and the controller. This study takes part of this framework and concerns the contribution of advanced control methodologies to participate in the technological development of automated vehicles, in order to enhance their capabilities and efficiency.

OBJECTIVES

Autonomous vehicles for the transport of people are intimately connected to the driver in the sense that, even if we are able to achieve full autonomy, a human (driver or passenger) will always remain within the vehicle. This raises an important issue regarding the acceptability of the control algorithms for vehicle passengers, with respect to how passengers on board feel "the reaction of the vehicle". An example concerns the driver's action in the event of critical situations: the driver has a reaction time (due to his own understanding of the situation) and can, in a non-negligible time, continue to generate actions on vehicles inconsistent with the situation encountered.

The main objective of the thesis is to propose a control architecture where the driver performances is taken into account in the whole scheme to adapt the assistance level to it. This will include to develop some algorithms/observers for fault estimation and the coordination with the control scheme, merged into a Fault Tolerant Control scheme. The thesis will be in the continuity of current works at both teams [11-12].

METHODOLOGY

In this thesis control methods will be addressed using robust control approaches for Linear Parameter Varying (LPV) Systems to account for variations in environmental conditions (road condition, curvature, ...), nonlinearities of the vehicle, but also the driver's real-time driving activity and performance.

It will include to develop

- LPV models for drivers (to account for a large number of drivers), together with vehicle dynamics
- LPV observers to estimate unmeasured variables and to evaluate the driver performance
- LPV controllers coordinated to the driver state

MAIN TAKS AND SCHEDULE

1. Literature Review (state of the art) on:
    a. control architectures for automated vehicles
    b. driver model's architectures to understand and to consider the interaction between the two systems in the control design.
    c. LPV control theory: modelling, analysis and control

2. Modelling.
   Simplified driver modeling and vehicle interaction: If it is important to have information about the external environment (infrastructure), performing an effective driving task requires knowledge of the driver's behavior.
   New driver models will be proposed, adapted from existing ones, to better fit with vehicle models. The LPV framework is an intuitive solution for that objective.
   To have a better tool for modeling a complex system such as a vehicle, and because of the variable nature of the information available, it is proposed to have a structured model that takes into account the interactions between the internal dynamics of the vehicle, the external road information of the current infrastructure and the physiological state of the driver.

3. Observer and Control design.

Some estimation algorithms will be proposed to evaluate the driver state. To this aim, LPV observers will be proposed, and compare to other classical Fault Detection/Estimation algorithm

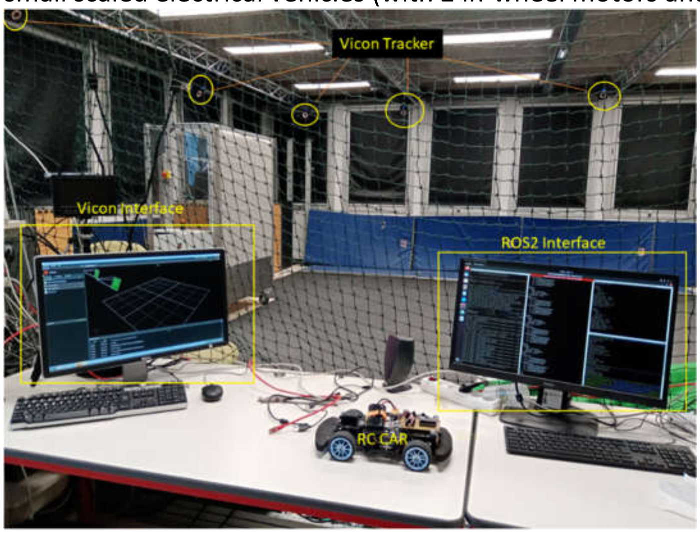
The control algorithms will be proposed, being adaptive and flexible, able to combine driver information and vehicle information to provide a shared control architecture where intelligent decisions of vehicles are made considering the status of the driver. The proposed control design should allow the driver to effectively share control authority with the automated driving system and minimize conflicts at the steering wheel while ensuring robustness and safety.

4. Validation

Performance assessment (in simulation and experimental tests) of the proposed algorithms for several driving situations of an automated vehicle using :

a. Realistic simulations based on full car vehicle models available at GIPSA-lab
b. Real platforms as the DS7 and SHERPA one in LAMIH (real experimental automated vehicle prototype and interactive dynamic car driving simulator with a real car)


c. small scaled electrical vehicles (with 2 in-wheel motors and a steering actuator)



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