Proposal of Master 2 Internship

Development and Implementation of Robust Estimation Algorithms for Intelligent Vehicles

Supervision

Laboratory CRIStAL UMR CNRS 9189, École Centrale de Lille, Lille, France

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Application deadline: Applications are evaluated on an ongoing basis and the position is closed when the right candidate is found.

Context and Objectives

Ensuring safety and comfort is paramount in the development of advanced driver assistance systems (ADAS) for intelligent vehicles. The effectiveness and stability of vehicle control systems depend significantly on real-time data related to various vehicle states and unknown inputs, such as the sideslip angle and tire-road forces. Acquiring precise knowledge of these variables enhances feedback control performance and the ability to predict real-time tire-road friction and potential vehicle trajectories, playing a crucial role in improving ADAS control performance. Unfortunately, obtaining accurate information about the vehicle's sideslip angle and tire-road forces in mass-produced vehicles is challenging due to high costs and practical limitations. Hence, it is essential to explore alternative methodologies, such as observation or estimation, to effectively determine these vehicle variables. To address this challenge, the internship aims to develop advanced estimation algorithms, i.e., virtual sensors, for intelligent vehicles, with a focus on their integration and validation on instrumented experimental platforms (Renault Zoé-PRETIL from CRIStAL, SHERPA driving simulator from LAMIH, INSA-LAMIH autonomous vehicle).

Planned works

The works to be carried out during this internship are as follows.

- Construct a nonlinear vehicle model in the Matlab/Simulink platform. This simulation model will be used for numerical validations of the developed estimation algorithms.
- Propose different robust model-based algorithms to estimate crucial vehicle variables, such as sideslip angle, tire-road forces, and faults in vehicle actuators/sensors. These estimation algorithms should be effective under various operating conditions, such as uncertain parameters, unknown inputs/faults, and road conditions.
- Evaluate the performance of the proposed estimation algorithms under various driving conditions. Two main validation steps are planned. First, the estimation algorithms will be validated on simplified vehicle models used for synthesis purposes. Second, the validation will be performed on one of our dedicated experimental platforms, as shown in Fig. 1.

Renault Zoé-PRETIL from CRIStAL

SHERPA Hybrid Simulator for Automotive Studies

Equipped Autonomous Vehicle at LAMIH

Transalley technopole test track Valenciennes

Fig. 1. Experimental facilities from CRIStAL and LAMIH laboratories.

Administrative information

- Remuneration in accordance to French standard internship's pay (about 640 euros/month).
- Laboratories: CRIStAL CNRS UMR 9189 (Lille) & LAMIH CNRS UMR 8201 (Valenciennes).
- Starting date: **As early as possible**.
- Duration: 6 months.

Application

Applicants must have a background in systems and controls, applied mathematics, or a related subject, with a strong theoretical foundation and an interest in Control Engineering/Automatic Control. The candidate must demonstrate a keen interest in engaging in innovative, high-profile research. Some experience using Matlab/Simulink and/or conducting experimental validations in previous projects during their academic training would be appreciated. Fluency in English is required (French is not necessary). Interested applicants are encouraged to contact us for further details.

Formal applications should be submitted with a CV, a brief statement of motivation and research interests, and with names and email addresses of at least two referees in a single PDF file to: sara.ifqir@centralelille.fr and tnguyen@uphf.fr

Some related references

Rajesh Rajamani. *Vehicle Dynamics and Control*. Springer Science & Business Media, 2011.

Sara Ifqir, Dalil Ichalal, Naima Oufroukh, Said Mammar, "Robust Interval Observer for Switched Systems with Unknown Inputs: Application to Vehicle Dynamics Estimation", *European Journal of Control*, vol. 44, pp. 3-14, 2018.

Anh-Tu Nguyen, Thierry-Marie Guerra, Chouki Sentouh, Hui Zhang, "Unknown Input Observers for Simultaneous Estimation of Vehicle Dynamics and Driver Torque: Theoretical Design and Hardware Experiments", *IEEE/ASME Transactions on Mechatronics*, vol. 24, iss. 6, pp. 2508-2518, 2019. [PDF]