Sujet de stage au laboratoire Heudiasyc UMR 7253 :

Titre/Title	Model-based and machine-learning-based hybrid state observer applied to vehicle dynamics
Encadrant(s) / Supervisor(s)	Alessandro Correa Victorino (principal supervisor) Bruno Barbosa
Descriptif du sujet/ Project description	**Context** This master's project concerns the problem related to the development of state observers applied to the estimation of parameters and variables of vehicle dynamics that cannot be measured in a conventional way. The development of new diagnostic algorithms for driving behavior and driving assistance remains an important subject for automotive manufacturers. Indeed, equipping recent cars (or in the near future autonomous vehicles) with intelligent systems capable of automatically detecting a malfunction or anticipating an imminent accident will constitute a major development. These algorithms are based on dynamic parameters, such as tire-road interaction forces, drift angle or grip. The majority of these variables cannot be measured directly, so they must be estimated by state observation algorithms. In general, probabilistic methods, such as the extended Kalman filter, are used for the estimation of these parameters based on predefined state models (white-box models). These methods have significant limitations due to the uncertain parameters of the vehicle model on which they are based. Other methods are also used to estimate these variables, such as those called "black-box models", based on machine learning. However, their independence from a physical model makes the output of these estimators unpredictable in certain situations since dynamical data of a system only convey dynamic information over a limited operating range, and the identification of black-box models (or data-driven models) with good performance over a wider operating range is very unlikely. To overcome such a shortcoming, estimation methods that are more robust should be used, such as those that mix physical models and artificial intelligence (AI) techniques. These hybrid models are called “grey-box models” and they are part of the Scientific Machine learning research area. **Objectives and methodology** The work of the internship to be carried out consists in implementing algorithms for the estimation of dynamic variables of the vehicle by hybrid methods: based on physical models and those based on machine learning. It is expected that the use of prior information from the system dynamics will help to identify proper models that can be implemented in real time. The first step will consist in establishing a bibliographic study of vehicle dynamics, and especially the handling of methods for estimating vehicle

	dynamics based on physical models already developed in the Heudiasyc laboratory. The student will also study the application of machine learning methods applied to state observation problems and their association with methods based on mathematical models. Special attention will be given to techniques based on Neural Networks and NARX (Nonlinear AutoRegressive with eXogenous inputs) models in order to include prior information about the vehicle dynamics during the identification (training) process. The student will develop an estimation algorithm for this hybrid identification approach and validate it on Matlab/Python. In this project, we will limit the study to the lateral dynamics of the vehicle. So, to estimate the side slip angle and lateral forces developed on the tire-road interaction point. An initial methodology developed in previous projects will serve as a base for this project. The student will validate his/her developments on the simulation and experimental facilities at the Heudiasyc laboratory. Contact: • Alessandro Corrêa Victorino (alessandro.victorino@hds.utc.fr) • Bruno Barbosa (bruno.barbosa@hds.utc.fr)
Pré-requis / Skills	The candidate must have knowledge of programming (especially Matlab, Python and C).
Possibilité de poursuite en thèse/ Possibility of continuing in PhD	YES