Mixed Reality simulation of autonomous vehicles in urban area: from single vehicle to trafic integration.

Context :
Developing perception and control algorithms for autonomous vehicles is a hard activity which is highly time consuming especially is the développement is made solely on real experimental platforms. This time devoted to the developement is tied to several elements such as solving unexpected hardware issues, vehicle availability, weather conditions, code tweaking and its adaptation to hardware components… Besides, some experimental context are hard to reproduce especially when one want to test obstacle avoidance algorithm behaviors with mobile obstacles or when testing critical scenarios when the vehicle physical integrity is threatened. However, the real experiments can not be replaced entirely by simulation, many laboratories and companies are focusing on simulation tools for preliminary tests and development phases.
Even if huge progress has been made during the past 10 years, simulation tools are not precise enough for certain aspects of the autonomous vehicle perception/control loop. It is particularly the case for perception which requires a high level of precision in sensors multi-physics simulation. However, simulation tools allow to make the experiment reproductable. Aside to this evolution of simulation/experimentation methods for autonomous vehicles, Hardware In the Loop (HIL) methods are more and more spread. These allow to evaluate the efficiency and the behavior of real component within a well-controlled simulation environment. [1]

Goal of the PhD thesis :

The goal of this PhD thesis is to extend the HIL concept in developping a simulation solution based on mixed(hybrid) reality. This solution will thus integrate real components (sensors, vehicles…) and simulated elements (sensors, obstcacles, trafic, vehicles…). This simulation solution will be evaluated and tested on realistic scenarios involving one or several autonomous vehicles in a simplified environment and in a urban eco-system.

The work will be divided into several steps :

- Based on the simulation tools already developed by the LE2I laboratory [2], [3], [4] or some commercial solutions from partner companies [5], developing functionalities allowing the cohabitation (co-simulation) and the intersection between several vehicles with can be real or virtual.
- Testing the new functionalities on critical scenarios involving a reduced number of vehicles (hybrid real/virtual platoon of vehicles [4], obstacle avoidance algorithms evaluation with real vehicles and virtual obstacles, using real sensors on virtual vehicles, interesection management with real and virtual vehicles…)
- Improving the simulation tools so as to evaluate autonomous vehicle functions into a virtual urban eco-system in mixed reality. In this case, a study of the impact of the use of autonomous vehicle for solving the intersection blocking issues [6].

Encadrants : Abdel-Jalil Abbas Turki (MCF), Franck Gechter (MCF-HDR)

Références :

[1] **A New Approach for Fpga-Based Real-Time Simulation of Power Electronic System with No Simulation Latency in Subsystem Partitioning,** Chen LIU, Fei GAO, Rui MA, and **Franck GECHTER**. In International Journal of Electrical Power and Energy Systems, vol. 99, pp. 650-658, Elsevier, 2018. DOI: https://doi.org/10.1016/j.ijepes.2018.01.053.

[2] **Vips: a Simulator for Platoon System Evaluation,** Baudouin DAFFLON, Maxime GUERIAU, and **Franck GECHTER**. In Simulation Modelling Practice and Theory (SIMPAT), vol. 77, pp. 157-176, 2017.

[3] **Towards a Hybrid Real/virtual Simulation of Autonomous Vehicles for Critical Scenarios. Franck GECHTER**, Baudouin DAFFLON, Pablo GRUER, and Abderrafiaa KOUKAM. In Proc. of The Sixth International Conference on Advances in System Simulation (SIMUL 2014), 2014.

[4] **Virtual Intelligent Vehicle Urban Simulator: Application to Vehicle Platoon Evaluation Franck GECHTER**, Jean-Michel CONTET, Olivier LAMOTTE, Stéphane GALLAND, and Abderrafiaa KOUKAM. In Simulation Modelling Practice and Theory (SIMPAT), vol. 24, pp. 103-114, 2012. DOI: http://dx.doi.org/10.1016/j.simpat.2012.02.001.

[5] https://ipg-automotive.com/products-services/simulation-software/carmaker/