SOUTENANCE DE THÈSE

M. Stefano Masi

Soutiendra sa thèse de **doctorat** sur le sujet **:**

Safe Navigation in Complex Environments with Cooperative Perception from the Infrastructure

Unité de recherche : ***Heudiasyc – UMR CNRS 7253***

Le 5 mai 2021 à 9h, bâtiment Blaise Pascal, salle GI 42
à l'université de technologie de Compiègne et en suivant ce lien :

https://utc-fr.zoom.us/j/88687294701?pwd=VHZYaW1aWDBneDljVjFiY3NycDYvUT09

Devant le jury composé de :

Mme Huijing ZHAO, professeur, membre rapporteur
Peking University, Key Lab of Machine Perception, Chine
M. Eduardo NEBOT, professeur, membre rapporteur
University of Sydney, Field Robotics, Australie
M. Roberto SACILE, professeur, membre examinateur,
Università degli Studi di Genova, DIBRIS, Italie
M. Sio-Song LENG, chercheur, membre examinateur
Université Gustave Eiffel, Marne la Vallée
M. Javier IBANEZ-GUZMAN, ingénieur de recherche, membre examinateur
Groupe Renault, Technocentre, Guyancourt
Mme Véronique CHERFAOUI, professeur, membre examinateur,
Université de technologie de Compiègne, laboratoire Heudiasyc, Compiègne
M. Philippe XU, maître de conférences, membre examinateur,
Université de technologie de Compiègne, laboratoire Heudiasyc, Compiègne
M. Philippe BONNIFAIT, professeur, directeur de thèse,
Université de technologie de Compiègne, laboratoire Heudiasyc, Compiègne

Abstract :

Although autonomous vehicle technology has evolved significantly in recent years, the navigation of self-driving vehicles in complex scenarios is still an open issue. One of the major challenges in these conditions is safe navigation on roads open to public traffic. In such driving environments, the main issue is the interaction of the autonomous vehicle with regular traffic, as the behaviors and intentions of human-driven vehicles are hard to predict and understand.

In this PhD thesis, we propose and study an approach to ensure safe autonomous driving in such scenarios. In particular, we study how a cooperative intelligent infrastructure system can improve safety by providing detection and tracking of road users in the working frame of a High-Definition (HD) Map during the navigation into complex zones. In this work, we consider a roundabout insertion case-study.

We begin by adapting the concept of virtual platooning to roundabout crossing which allows a safe longitudinal control of the vehicle thanks to a spatial anticipation using the central polylines of the HD map. This method relies on an efficient one-dimensional formalism and is able to handle complex scenarios such as intersections and roundabouts. We consider a first situation where only cooperative autonomous vehicles are present. We use curvilinear coordinates along the HD map polylines to predict collisions at lane-level between the communicated intended trajectories of neighboring vehicles and the ego-vehicle navigation corridor. In such case, this method performs well thanks to V2V communications. To extend such a strategy to a traffic environment with manually driven vehicles that do not share their intentions through wireless communication, we need a reliable perception system with a large field of view that is able to estimate and handle uncertain information.

We propose to extend the previous strategy by using intervals to handle the uncertainty of the perception and localization systems and virtual instances to deal with the unknown intentions of other road users. We also include priority constrains during insertion maneuvers as well as multi-lane roundabouts. Moreover, we show that the method does not provide an overly cautious insertion policy, i.e., an autonomous vehicle does not wait for a long time before the insertion.

The performance of our strategy is evaluated using the SUMO simulation framework. In order to have a realistic simulation, a highly interactive vehicle flow is generated using real dynamic traffic data from the INTERACTION dataset. In particular, it is able to generate a highly adversarial traffic flow which makes it possible to appropriately quantify the performance of our method in realistic cases. We also report real tests carried out with an experimental self-driving vehicle on a test circuit on the campus of the University of Technology of Compiègne. Our results show that this approach is easy to integrate into an embedded system and that it allows roundabouts to be crossed with a high level of safety.

Thereafter, we focus on the on-board detection of road users with a 3D Lidar mounted on the roof of the vehicle. A fast method able to propagate and manage uncertainties through non-linear transformations is presented to localize objects with high integrity. This information is then combined with the HD map to keep objects that are on the drivable space of the carriageway. This method is compared with a classical propagation method that relies on linearized approximations. The performance of this approach is evaluated both in a 2D Euclidean and map-based curvilinear frameworks thanks to real data acquired at the entrance of a roundabout.

Finally, we study how to improve the performance of the perception system by adding pieces of information broadcast by an intelligent infrastructure which uses surveillance cameras mounted on street light poles. The main advantages of this approach are both to enlarge on-board perception system field of view and to improve accuracy and confidence on the detected objects which are or are moving on the roads. Such improvements are useful to improve the level of safety of autonomous vehicles in particular to perform complex insertion maneuvers as they add both redundant and complementary information.