Ph.D. in Information Technology
Thesis Defenses

April 6th, 2023
at 16:00
Room "Alpha" and online by Teams

Luca Franceschetti – XXXV Cycle
Applications of Augmented Reality to ADAS
Supervisor: Prof. **Matteo Corno**

Abstract:

This research presents the design and validation of a vehicular Head-Mounted Augmented Reality system for applications on advanced driver assistance systems (ADAS). Augmented Reality (AR) is an interactive experience where real objects are "augmented" through computer-generated virtual graphics and head-mounted displays (HMD).
Nowadays, AR is used only in small and static environments, like rooms or laboratories, where standard Simultaneous Localization and Mapping Algorithms (SLAM) are precise and robust. These algorithms do not work properly in wide and moving environments, like vehicles travelling on the road.
Currently, ADAS help drivers avoid collisions, warning them of potential hazards through misleading abstract symbols on the vehicle dashboard or distracting alert sounds, still without giving any information about the position/location of the danger.
With the integration of AR, ADAS could show warnings directly overlaid on the real dangers, reducing reaction time, distraction and uncertainty in understanding the type of hazard. AR can considerably improve the driving experience by increasing the driver situational awareness.
Since AR devices employ see-through Head Mounted Displays, high accuracy head tracking is essential to give the driver a good sense of immersion. The proposed solution, tested in different scenarios and on different vehicles (both with open and closed cockpit), is based on tracking of passive markers, stereoscopic detection of the road, IMU compensation with sensor fusion algorithm, GPS localisation and deep learning approaches on depth sensors measures.

Alberto LUCCHINI – XXXV Cycle
Advanced Vehicle Dynamics Control for High-Performance Self-Driving Cars
Supervisor: Prof. **Sergio Matteo Savaresi**

Abstract:

Autonomous racing represents the ideal scenario to boost autonomous driving development and testing, as it pushes the limits of technology through competition, while remaining confined to a controlled and regulated environment. In recent years, self-driving competitions such as Indy Autonomous Challenge, Roborace and Formula Driverless are becoming popular. In this context, several challenges arise, requiring more advanced and performant control systems for sports and racecars and resulting in novel solutions for vehicle dynamics control at the limits of handling.

In this thesis, we focus on the development and experimental validation of feedback control systems for high-performance vehicles in sport driving conditions, including strongly model-based control techniques such as Model Predictive Control. The research is based on the traditional architecture with steering and throttle/brake control inputs, with an extended high-speed experimental validation on a full-scale racecar. Besides that, we explore the potentialities of alternative architectures that are common in the world of high-performance vehicles. We focus on torque vectoring (for electric and hybrid vehicles with multiple electric motors) and four-wheel-steering. Despite these latter applications are limited to the simulation environment, attention is placed on the limitation of computational complexity for potential real-time implementation on low-power hardware.

In the development of the control strategies, it is fundamental to deal with several side aspects of vehicle dynamics control. In particular, we cover the design of hardware-in-the-loop simulation tools that help to reduce costs and development time, while improving safety in the testing phase. Another focal point is the development and experimental validation of localization and state estimation algorithms, whose output is fundamental to maximize the performance of the control system in sport driving conditions. In particular, we propose an alghoritm for the sensor fusion of measurements from inertial and Global Positioning Satellite System units based on an Extended Kalman Filter. Three-dimensional track modeling and trajectory optimization for lap-time minimization are also part of the research. Specifically, we compare the results obtained with the employment of two models of the vehicle dynamics in the three-dimensional space with different levels of accuracy and complexity.

PhD Committee
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Prof. **Milos Zefran**, University of Illinois at Chicago
Prof. **Paolo Falcone**, Università degli studi di Modena e Reggio Emilia