Ph.D. in Information Technology
Thesis Defenses

February 27th, 2025
At 3:00 p.m.
Room BIO 1 – Building 21

Gabriele MARINI – XXXVII Cycle

FAST STIFFNESS MODULATION OF MULTICHAMBER AIR SPRING SUSPENSIONS FOR AUTOMOTIVE APPLICATIONS
Supervisor: Prof. Sergio Matteo Savaresi

Abstract:

This thesis deals with the modelling and control of multichamber air springs, that are an advanced type of variable-stiffness suspension springs for ground vehicles. Indeed, the multichamber architecture is constituted by a main elastic pneumatic chamber connected to a series of (possibly dislocated) auxiliary air supplies by means of electronically controllable valves. In this way, switching the state of the valves allows one to change the total amount of air volume subject to excitation during the ride, ultimately leading to a variation of the spring equivalent stiffness ratio. For this reason, multichamber springs represent a cost effective, safe and low energy demanding solution capable of stiffness regulation, thus motivating the main car manufacturers for the industrialization of these systems over the last decade. This work aims at providing a comprehensive overview of their functioning highlighting their potentialities in enhancing both the comfort and handling performance, by addressing the open issues still present in the scientific literature up to this day and by answering the basic industrial needs. Firstly, a novel mathematical model is developed, which accurately describes the spring behaviour during fast switching; secondly, stiffness modulation strategies are proposed. These strategies have simple, effective and interpretable formulations, are real-time implementable, and require a limited number of sensors. When available, their effectiveness is also proven experimentally. Overall, the control performance surpasses the spring passivity constraint and is able to guarantee optimality and sub-optimality over a wide series of experiments, by suitably exploiting the multichamber peculiar features arising at valve switching.

Riccardo PIERONI– XXXVII Cycle

DEVELOPMENT OF A PERCEPTION SYSTEM FOR AUTONOMOUS VEHICLES ON URBAN ROADS
Supervisor: Prof. Sergio Matteo Savaresi

Abstract:

In the past decade, there has been significant progress in the development of autonomous vehicles (AVs), driven by extensive research and industry efforts. This is because autonomous vehicles promise transformative benefits, such as reduced vehicle ownership, increased utilization, and substantial safety and environmental improvements. By potentially replacing multiple conventional vehicles, AVs can alleviate parking demand and enhance road safety through reduced traffic conflicts

and accidents. Furthermore, they contribute to environmental sustainability by optimizing traffic management and decreasing fuel consumption. Central to these advancements is the development of effective perception algorithms, which are crucial for enabling AVs to navigate complex environments safely and efficiently. These algorithms must accurately interpret data from various sensors, such as cameras, LiDAR, and radar, solving several key tasks to make real-time decisions in dynamic urban settings. Specifically, a perception system for autonomous vehicles must identify and classify various objects such as vehicles, pedestrians, cyclists, traffic signals, traffic lights and other relevant objects on the road; it must continuously track the movement of detected objects over time to predict their positions and future movements; and it must also identify the drivable areas and lane markings on the road to determine where the vehicle can safely travel. In this context, this research introduces a comprehensive perception system designed to enhance AV capabilities. The system includes an advanced camera-LiDAR neural network for real-time 3D object detection, a versatile multi-object tracking (MOT) framework that operates in both single-modality and multi-modality configurations, and an innovative algorithm for Bird's Eye View (BEV) semantic mapping. Additionally, a multi-task neural network is developed for real-time segmentation of drivable areas and road lines.

Rodrigo SENOFIENI– XXXVII Cycle

DEVELOPMENT OF VEHICLE DYNAMICS CONTROL ALGORITHMS FOR HIGH-PERFORMANCE SPORT AND RACE VEHICLES

Supervisor: Prof. Sergio Matteo Savaresi

Abstract:

Recent advances in vehicular technology and the paradigm shift towards electric and autonomous vehicles are changing the transportation world. For a small niche of vehicles, such as high-performance sports vehicles, car manufacturers are exploring new technologies to enhance vehicle dynamics performance without compromising safety and passenger comfort. To mention some of them, torque vectoring with four in-wheel independent electric motors has proven to significantly improve vehicle dynamic capabilities. Additionally, innovative actuators like the active wheel carrier, which can simultaneously adjust wheel toe and camber angle, have been shown to increase a car’s agility in all turning phases. These technologies, when applied to autonomous vehicles, particularly race cars, represent the pinnacle of innovation, showcasing advanced vehicle dynamics control. Successfully navigating challenging tracks demonstrates the precision and reliability of these systems. This progress helps build public trust in the safety and capabilities of self-driving technology. We will present four case studies applied to the aforementioned advances in vehicle dynamics control: an all-in-one torque vectoring algorithm, a novel performance-oriented regenerative brake blending for an electric hypercar, a combined rear-wheel steering and camber control for the Active Wheel Carrier actuator and concluding, a trajectory tracking control algorithm for an autonomous race car.

PhD Committee

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