Ph.D. in Information Technology
Thesis Defenses

February 17th, 2026
at 14:00 p.m.
Room Beta - Building 24

Giacomo DELCARO– XXXVIII Cycle

OPTIMIZATION FRAMEWORKS FOR TWIN-IN-THE-LOOP SYSTEMS IN CONTROL AND ESTIMATION
Supervisor: Prof. Sergio Matteo Savaresi

Abstract:

Accelerated by Industry 4.0, Digital Twins (DTs) are evolving from static, offline design tools into dynamic, operational assets embedded directly into the control loop. This thesis introduces Twin-in-the-Loop (TiL) systems, a framework that deploys high-fidelity, physics-based simulators in real time alongside physical systems to enhance control and estimation.
Instead of relying on simplified mathematical models, TiL systems use the full complexity of a Digital Twin to predict system states and generate control actions. The research focuses on three core architectures:

- TiL-Observer: A state observer that employs the DT as a predictive "black-box" model to estimate the full state of complex systems.
- TiL-Control: A control architecture that closes a nominal controller on a DT in parallel with the physical plant and then employs a simple compensator to ensure that the physical system tracks the optimal virtual trajectory.
- Fast Controller Optimization with Digital Twins: A controller tuning framework that employs Multi-Source Bayesian Optimization to fuse real-world measurements with data from parallel DT ensembles, leveraging virtual data to accelerate convergence toward the global optimum with minimal physical experimentation.

By effectively bridging the simulation-to-reality gap, these frameworks enhance control and estimation performance while drastically reducing the need for costly physical experiments.

Simone SPECCHIA– XXXVII Cycle

DEVELOPMENT OF LOCALIZATION AND PLANNING ALGORITHMS FOR AUTONOMOUS DRIVING BASED ON PUBLIC MAP DATABASES
Supervisor: Prof. Sergio Matteo Savaresi

The development of safe and reliable Automated Driving Systems (ADSs) represents one of the most significant challenges in the field of automotive. Thanks to advancements in sensors' technology and artificial intelligence, particularly Deep Learning, ADSs are becoming increasingly more sophisticated and complex. The widespread adoption of Autonomous Vehicles (AVs) on public roads presents several potential benefits. AV technology promises to improve safety, being human error one of the main factors in the majority of traffic accidents. AVs can also make car-sharing services more efficient, reducing the number of vehicles circulating on urban roads. This would decrease the need for parking spaces and contribute to a decrease in greenhouse emissions. Despite the potential, several challenges still limit the deployment of ADSs. One of the main factors is represented by costs, as AVs are still much more expensive than conventional vehicles. In addition, deploying AVs in new environments is a resource intensive and lenghty process, as most state-of-the-art autonomous driving algorithms rely on a dataset of custom pre-existing information. This dissertation aims at improving scalability of AV systems by proposing novel localization and planning algorithms. The proposed methods leverage publicly available databases to replace reliance on a-priori information. These solutions include the definition of a localization approach that does not require exploration of the environment prior to navigation. In addition, we propose a lateral planning method that does not rely on a high-definition map of the environment structure. Finally, we propose a method for intersection management, exploiting public maps for predicting the behaviour of other vehicles. The algorithms proposed in this dissertation have all been validated on an AV platform driving on public urban roads.

PhD Committee

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