Ph.D. in Information Technology: Thesis Defenses

February 12th, 2018

DEIB Seminar Room "Alessandra Alario" (building 21) – 10.00 am

Fabio BUSNELLI – XXX Cycle

"Stability Control and Analysis of Two-Wheeled Vehicles Out of Plane Dynamics"

Advisor: Prof. **Sergio Savaresi**

Abstract:

In order to cope with the instability issues of the motorbike due to out of plane dynamics, a control algorithm has been developed, analysed and its efficacy has been proved through experimental test. Furthermore, the sideslip angle of the motorbike has been estimated both with a data driven and model based approach.

Tommaso COLOMBO – XXX Cycle

"Analysis and Design of Suspension Control Systems for Off-Highway Vehicles"

Advisor: Prof. **Sergio Savaresi**

Abstract:

Electronic suspension systems have been largely studied in the automotive field, for comfort and road holding improvement. In off-highway vehicles these technologies have just recently been introduced, and much research can still be done. In particular driver's comfort is of mayor interest for these vehicles' as mostly driven on rough and uneven roads, and for long working periods. This thesis deals with the analysis, design and experimental application of electronic suspension's control systems for agricultural machines. Themes regarding load leveling and semi-active suspension's control are investigated, considering cabin's and front axle's tractor's suspensions, which are the most common systems found in these vehicles.

Gianmarco RALLO – XXX Cycle

“Robustness in Data-Driven Control: Theory and Automotive Applications”

Advisor: Prof. **Sergio Savaresi**

Abstract:

The present study proposes various strategies for extending the effectiveness of direct data-driven control approaches and enhancing their robustness - which is here intended in a broad sense - with respect to real-world uncertainties. The focus of this work is on linear data-driven control in the time domain and the considered case studies concern the automotive filed, which could benefit from the application of direct approaches.

Federico ROSELLI – XXX Cycle

“Vehicle Dynamics Planning and Control for Safety and Comfort in Autonomous Cars”

Advisor: Prof. **Sergio Savaresi**

Abstract:

Autonomous driving is going to replace many of today's forms of transportation and also change the life style of most of the people. The rapid rate of technological advance is making this scenario much closer to reality; nevertheless some critical issues, mainly legal and technological, must be faced. This dissertation deals with the two main topics related to vehicle dynamics control in self-driving cars: safety and comfort. The replacement of human drivers with intelligent algorithms will wipe out many control systems developed to improve the driving experience or help the diver in the most challenging maneuvers, but will amplify the need for a comfortable and safe operation. To guarantee an acceptable level of safety, the vehicle must be able to handle critical maneuvers such as obstacle avoidance even at high speed. Two lateral controllers to track emergency maneuvers are presented: one combines the look-ahead error with the lateral shift of the CoG, the second one is based on the path curvature. Both control strategies exploit the preview of the reference trajectory, crucial in case of quick maneuvers.

Differently from most approaches in the literature, on-line optimization is not required by these controllers, simplifying real-time implementation. The algorithms are validated experimentally on a Dodge Dart equipped with by-wire interfaces and high precision GPS and on a modified RC car; good tracking performance are obtained up to the friction limits also on evasive maneuvers. A reactive planner for emergency lane change is also developed: the algorithm considers the handling limits due to road/tire friction and guarantees that the generated trajectory can be tracked by the path following controller. The last part of the dissertation focus on the possible comfort improvement due to the presence of autonomous drive sensors.

Stereo cameras can be used to detect the presence of a bump or a pothole in front of the vehicle and identify some important characteristics of the obstacle; this information is used to design a semi-active controller to optimize comfort and plan the longitudinal speed profile that better reduces the excitation.

PhD Committee:

Prof. **Matteo Corno**, DEIB – Politecnico di Milano

Prof. **Javier Cuadrado Aranda**, University of La Coruna

Prof. **Patrick Gruber**, University of Surrey

DEIB Conference Room "Emilio Gatti" (building 20) - 10.00 am

Soufiane MEDDOURI – XXIX Cycle

"Robust Control of Autonomous System for Wind Electrical Generators"

Advisor: Prof. **Luca Ferrarini**

Abstract:

Wind energy applications are the most important and promising solutions against global warming, which however show natural fluctuations of the main source. This PhD project aims to study and improve the performance of a wind energy conversion system in stand-alone operation, proposing different advanced control techniques with storage system for the electric power improvement and ancillary services contribution.

Alexander Josef POLLOK – XXX Cycle

"Modelling and Control of Aircraft Environmental Control Systems"

Advisor: Prof. **Francesco Casella**

Abstract:

The development, modelling and control of aircraft energy systems was developed further on the following aspects. A dynamic simulation model including the Engine Bleed Air system (EBAS), the air conditioning pack, the ducting system, the cabin dynamics and the recirculation system was created in the equation-based object-oriented modelling language (EOOML) Modelica. It was found that Helmholtz resonance effects do not contribute to the occurrence of limit cycle oscillations (LCO). EBAS were modelled in detail, predicting LCO in aircraft environmental control systems. A control strategy was developed which is able to reduce those oscillations significantly. A new architecture for cabin temperature control was developed, enabling an unlimited number of temperature control zones. This is in contrast to conventional architectures, which were limited to a small number of zones. For simulation studies at early stages of a development cycle, a class of virtual controllers was identified that shows good tracking performance without any tuning effort. Several experiments were performed to make dependable statements about the usability of EOOML

Xinglong ZHANG – XXX Cycle

Hierarchical and Multilayer Control Structures Based on MPC for Large-Scale Systems

Advisor: Prof. Riccardo Scattolini

Abstract:

Over the last decades, the complexity of systems is continuously increasing due to economic reasons and technological advances. It is known that the centralized Model Predictive Control (MPC) solutions for such large-scale systems might result in unacceptable control performance due to various factors, such as high dimension of the system, computation efficiency and communication bandwidth. Moreover, centralized controllers are not scalable and difficult to maintain. For these reasons, in the last twenty years, decentralized and distributed MPC algorithms have been developed with a number of local problems solved in parallel to achieve global or local objectives. An alternative to decentralized and distributed control consists in the use of hierarchical control structures based on MPC. This approach is very powerful especially for control of systems with separable fast and slow dynamics, for the coordination of subsystems and when it is required to consider different objectives in the long term and regulation problems in the short term. This work addresses the theoretical development of hierarchical and multilayer control algorithms based on MPC for large-scale systems. We first develop a two-layer control structure for the coordination of independent linear dynamic systems with input and joint output constraints. At the higher layer, a reduced order dynamic model of the system's components is used to state and solve an economic MPC algorithm in a long time scale. At the lower layer, decentralized MPC controllers, one for each subsystem, are implemented in a shorter time scale and according to a shrinking horizon strategy to compensate for the model inaccuracies at the high level.

A second line of research is focused on a fully scalable hierarchical control scheme for coordination of similar independent systems with joint output and input constraints. Differently from the previous approach, a scalable low-dimensional model mapping the common input to the collective output is used at the high layer, this model is easily determined from the impulse responses of the subsystems. This approach allows to modify the system configuration with time varying weights, in terms of the contribution provided by any subsystem to the overall system performance, and to implement plug-and-play operations. Finally, we extend the hierarchical control structure to large-scale interconnected systems. At the higher layer, a robust centralized MPC algorithm based on a reduced order dynamic model optimizes a long-term performance index, while at the lower layer local MPC regulators, are designed for the full order models of the subsystems to refine the control action computed at the higher layer. The recursive feasibility and convergence properties of the proposed algorithms are proven and several simulation examples are reported to show their effectiveness.

PhD Committee:

Prof. **Patrizio Colaneri**, DEIB – Politecnico di Milano

Prof. **Alessandro Beghi**, Università di Padova

Prof. **Luigi Glielmo**, Università del Sannio