Ph.D. in Information Technology:

Thesis Defenses May 27th, 2021 online by Teams – at 09.00

Riccardo Desimini – XXXIII cycle

Advisor: Prof.ssa Maria Prandini

PhD Thesis Title: **Hybrid systems: computational approaches to verification and control**

Abstract:

Hybrid systems are a class of dynamical systems characterized by interleaved continuous and discrete dynamics, which allows to model complex systems characterized by intertwined physical and logical components encountered in various application domains. This has motivated researchers from different communities (computer science, control, mathematics) to investigate analysis and design problems for hybrid systems.

In this thesis, we address formal verification and control design for hybrid systems. The goal is to adopt a unifying modelling framework and develop a toolkit of set-based computational methods based on reachability and invariant analysis for determining if a given hybrid system can satisfy some property related to its state evolution and operate in a safe and/or efficient way. We consider the case when the system evolution is affected by input variables that can be either disturbances or control inputs: if no control input is present, we are addressing a verification problem, whereas if some control input is available, we are solving a control problem trying to enforce a certain behavior, despite the presence of disturbances.

We adopt as modelling framework the class of discrete time PieceWise Affine (PWA) dynamical systems, which are hybrid systems characterized by a polyhedral partition of the continuous state space and a set of affine dynamics, each one associated with an element of the partition representing the discrete component of the state. Indeed, PWA systems have powerful modeling capabilities since they are equivalent to various classes of hybrid systems characterized by an affine continuous dynamics, and can also be adopted as an abstraction of the nonlinear smooth dynamics governing the continuous state evolution in a (nonlinear) hybrid system.

The developed toolkit of computational methods for verification and control of PWA systems is inspired by existing approaches in the literature on reachability analysis, reach set representation and reduction, invariant set computation, model abstraction, and further extend and combine them within a comprehensive framework, including also the parameter varying case, thus enhancing the applicability of the model-based approach to PWA systems verification and control.

Davide Todeschini – XXXIII cycle

Advisor: Prof. Giulio Panzani

PhD Thesis Title: **Design and control of actuators for modern vehicles**

Abstract:

The drive-by-wire paradigm of modern vehicles led to the replacement of traditional mechanical actuators with electronically controlled ones. In this thesis, some specific cases have been analyzed, where the peculiar nature of the actuator and its application call for a deeper study. In particular, new tuning methods and actuator design procedures have been investigated and developed to improve the efficiency and comfort of modern mobility. The design and the control of such actuators reveal some challenges and opportunities for performance improvements. More in detail, the

control challenges that these actuators pose can arise from different needs. Some of them are so strongly entangled with the vehicle and the related control strategies, that both the actuator design and the control problem must be addressed at the same time. On the contrary, some others are independent from the actual application and their goal is to track some variables as fast and as precisely as possible, no matter the vehicle control logic that generated the reference. For these actuators the development of a control strategy is an almost solved problem while one scientifically relevant challenge, is the automatic and data-driven calibration of such strategies. Moreover, other actuators consider innovative architectures that substitute the traditional ones, opening the way for different vehicle control strategy paradigms, with respect to traditional ones.