Special Session Proposal for the Polish Control Conference 2026

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Proposed Session Title: "Analytical Methods in Nonlinear Control"

Abstract:

Control theory for nonlinear dynamical systems has deep and essential links to various branches of mathematics, including differential geometry, functional analysis, linear and abstract algebra, ergodic theory, and Lyapunov methods. While conventional methods for controlling linear systems and solving linear-quadratic optimization problems rely "in silico" on efficient numerical techniques from linear algebra, the challenge of controlling essentially nonlinear mathematical models necessitates the application of abstract algebraic approaches and methods of nonlinear analysis for control design. A catalogue of such essentially nonlinear models includes, in particular, nonholonomic mechanical systems, underactuated spacecraft, nonisothermal chemical reactions, and hydrodynamical models with constrained actuation. Recent advances in computer algebra systems and the increasing computational power of microcontrollers now make it feasible to implement control algorithms for these systems using advanced techniques such as nilpotentization of nonlinear systems, construction of P. Hall bases, and generation of high-frequency control signals with prescribed properties. All these techniques rest on a solid theoretical foundation and require a preliminary stage of deriving control components from the analytic description of canonical forms and distributions for underactuated systems, a topic to be addressed within the scope of our special session.

Description:

This session aims to bring together recent advances in the analysis and control design of dynamical systems governed by nonlinear differential equations, with a focus on analytical and algebraic representations of solvability conditions for control problems in underactuated frameworks. The scope of our special session includes, but is not limited to, the following topics:

- Algebraic methods for the analysis of driftless nonlinear control-affine systems
- Control design for nonholonomic systems under higher-order controllability conditions
- Mappability of nonlinear control systems with time-invariant and time-varying vector fields onto linear and semilinear systems
- System realization problems in terms of series in non-commuting algebras
- Algorithms for constructing nilpotent and homogeneous approximations of essentially nonlinear control systems
- Extremum-seeking problems in control systems with uncertain dynamics
- Lyapunov-based controller design for nonlinear engineering models