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Stability and Stabilisation of Time-varying Systems, Focus on Formation and Consensus Control

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Abstract

Time-varying systems appear in diverse engineering disciplines, such as Robotics and Electrical Engineering; notably in the context of tracking control, but also in set-point stabilisation problems of autonomous (nonholonomic) vehicles, for which smooth set-point controllers must be time-varying.

While for many physical systems, intuitive model-based control designs that exploit structual properties, such as passivity, are often eficacious, the formal stability analysis of such systems via Lyapunov's direct method is complex because the closed-loop dynamics is time-varying and energy-based Lyapunov functions are often non-strict (their derivative is negative semidefinite).

In this course we will study alternative methods to that of Lyapunov's and which do not rely on constructing strict Lyapunov functions. We will learn many easy-to-apply statements for systems with particular structures, such as passive systems and cascades. Such structures may often be constructed via the control design. In particular, passivity-based model-reference adaptive control will be properly revisited.

We will see how these powerful simple statements may be used to establish strong properties of stability and robustness for networked systems, notably in scenarii of consensus and formation control of multi-agent vehicles.

Outline of the course

- Revision of the fundamentals
  (uniform stability, robustness, theorems by Lyapunov, Barbashin-Krasovskii)
- Passivity-based control and analysis of passivity-based controlled systems
  (tracking control of mechanical systems)
- On persistency of excitation
  (Passivity-based adaptive control, stabilisation and tracking control of nonholonomic vehicles)
- Cascaded nonlinear time-varying systems
  (Consensus over directed graphs, separation principle for nonlinear systems)
- Formation control, consensus and tracking, of multi-agent vehicles

See also: https://l2s.centralesupelec.fr/en/u/loria-antonio/