PhD proposal – Université de Lorraine

Projected dynamical systems for constrained integral control

Supervisors

Romain Postoyan (CNRS, Université de Lorraine, CRAN, France)

Pietro Lorenzetti (CNRS, Université de Lorraine, CRAN, France)

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CRAN, UMR CNRS 7039: 2 Avenue de la Forêt de Haye, 54516 Vandœuvre-lès-Nancy, France

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Themes & Objectives

A major question in engineering applications is to design a control action such that the output of a physical system is able to track a desired reference, while rejecting unwanted disturbances. When the desired reference is constant, this problem is referred to as **set-point tracking** problem, and it arises naturally in numerous engineering applications. This is the case, e.g., if we want to operate a power converter (physical system) at constant power (desired reference) to mention an example.

It is well-known that an **integral control** action is needed to robustly solve the set-point tracking problem. For instance, sufficient conditions for linear time-invariant systems can be found in [2,9]. For nonlinear systems, the theory is not as developed. However, when the plant possesses an equilibrium point and its steady-state input-output map is well defined, low-gain integral control methods can be used [3,11], relying on singular perturbation theory [5]. Yet, when applying these techniques in practice, **input constraints** must be taken into account.

For instance, in the presence of actuator saturation, the actual plant input may differ from the controller output. When this happens, the plant is not driven by the controller and, as a result, the states of the controller are wrongly updated causing long transients, oscillations, and even instability. This phenomenon is called controller windup [4]. Various anti-windup techniques have been proposed, resulting in a vast literature [4,12]. However, despite the effectiveness of these strategies, they primarily focus on linear plants with nonlinear actuators.

A different approach for constrained integral control of nonlinear systems has been recently proposed in [7,8]. The idea is to use tools from **projected dynamical systems** [1,10] to constrain the state of the integrator in a closed and convex set, where safety constraints are guaranteed. By doing this, the set-point tracking problem can be solved and safety constraints (including anti-windup guarantees) are enforced altogether. We call this new class of controllers projected integral controllers. As shown in [7,8], projected integral controllers find a wide range of applications in power systems, e.g., for the constrained output power regulation in grid-connected synchronverters [6].

The methods developed in [7,8] are extremely promising in applications, yet the theory is still in its early stages. The objective of this thesis is to extend the results from [7,8], further investigating projected integral controllers**.** These results will be applied to the control of power converters.

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Profile

Candidates must have a M.Sc. (or an equivalent degree) in one of the following: control engineering, applied mathematics, electrical engineering. Please, do not hesitate to contact Romain Postoyan (romain.postoyan@univ-lorraine.fr) and Pietro Lorenzetti (pietro.lorenzetti@univ-lorraine.fr) for related questions.