Adaptive extremum seeking control

Keywords : Extremum seeking; Real-time optimisation; Control.

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Abstract – This research activity deals with the design of control schemes that also allow to reach unknown optimal set-points. In the class of real-time optimization schemes, adaptive extremum seeking controllers are designed by using Lyapunov based theory in order to guarantee convergence to the unknown optimal setpoints.

Most control schemes documented in the literature are developed for the regulation to known set points or the tracking of known reference trajectories. In many applications, however, the control objective is to optimize an objective function that can be a function of unknown parameters, or to select the desired states to keep a performance function at its extremum value. The objective is then to perform real-time optimization. Extremum seeking is a possible option for doing so. The task of extremum seeking is indeed to find the operating setpoints that maximize or minimize an objective function. The main feature of adaptive extremum seeking control is that the design is a Lyapunov-based one that allows to provide guarantees of convergence to the unknown setpoints.

Two approaches can be followed in adaptive extremum seeking control : perturbation-based methods and model-based methods. Figure 1 shows a schematic view of the perturbation-based methods.

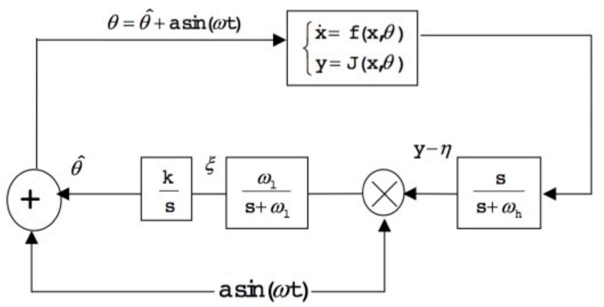

Figure 1: Schematic view of the perturbation-based extremum seeking control approach.

Different research progresses have been made in both types of approaches [2]. In perturbation-based extremum seeking control, several designs have been provided [4] [6] including one synthesis within the standard framework of a classical PI (Proportional-Integral) regulator [5]. In the model-based approach, several case studies corresponding to different real-time optimization issues have been considered, e.g.

- Continuous bioreactor with one microbial growth reaction with unknown and known (Monod, Haldane) kinetics model structure [2][11]
- Fedbatch bioreactor with unknown [10] and known (Haldane) kinetics model structure
- Non-isothermal chemical reactors (Figure 2) [8]
- Tubular reactor with distributed heat exchanger [9], as well as with distributed feed [1]
- Cascade bioreactors with distributed feed
- Pulp and paper : paper machine (wet-end) [3]
- Drug delivery for medical treatment of patients [7]
- ABS car braking system

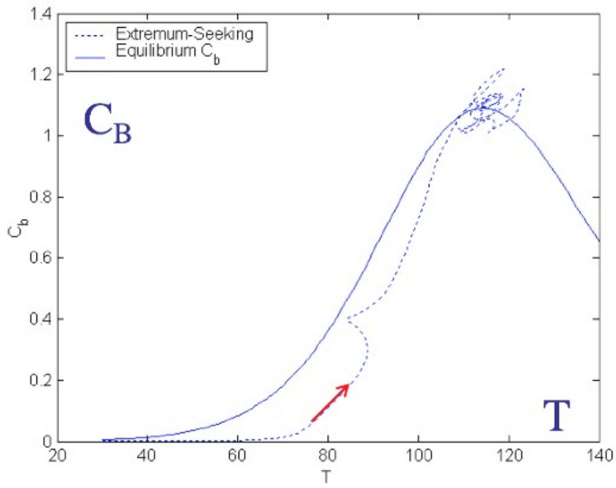

Figure 2: Extremum seeking control applied to the optimization of the production of an intermediate product in a chemical reactor.

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