Stabilization of Chemical and Biochemical Networks

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Abstract:

Biochemical networks consist of highly interconnected dynamic systems of chemical reaction networks interacting with the environment through mass and energy flows. The abstract representation of living cells as networks is becoming appreciated in these last years by the biochemistry research community as a useful tool to unravel biological complexity, whereas the application of the theory of dynamical systems to the study of biochemical pathways is at the basis for the so called metabolic control analysis [1], [2].
Under certain conditions, biochemical networks are shown to exhibit complex nonlinear behaviour, such as multistationarity, sustained oscillations or even deterministic chaos which origin is still not always well understood. In order to elucidate the origins of these phenomena and to design a stabilizing control configuration, the approach proposed in this contribution is based on the following idea: by defining the appropriate interconnections between the network and the environment through the appropriate input/output configurations, the systems evolution can be driven to the desired response. In addition, the stabilization of a particular steady state, or a given sustained oscillation (limit cycle) requires the combination of suitable observers to reconstruct the entire state of the system from a given set of measurements (concentrations) and robust controllers.
The mathematical model of biochemical networks under study consist of systems of nonlinear ODEs with a characteristic algebraic structure imposed by physical laws [3]. On one hand, the kinetic mechanisms is of mass action law type and on the other hand, the system must obey the mass conservation principle. In this contribution, we take advantage of these underlying structure to state observability and controllability conditions which, in combination with efficient nonlinear control schemes, will be employed to enforce stabilization of chemical and biochemical networks.

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