Boundary Observer and Controller Designs in PDEs

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Abstract

This talk presents the study of some advancements in the control theory and application, focusing on two classes of systems described by partial differential equations. Both systems are posed on 1-D bounded spatial intervals, and boundary observer and controller design problems are considered through the backstepping method.

In detail, the state-of-charge estimation problem in lithium-ion batteries is discussed firstly, i.e., the observer design. A thermal-compensated electrochemical model of lithium-ion batteries is proposed. Adding thermal dynamics serves a two-fold purpose: improving the accuracy of state-of-charge estimation and keeping track of the average temperature which is critical for battery safety management. With only one boundary measurement, the designed backstepping state observer converges exponentially to the original system. Note that the time dependency of the system coefficients makes the observer design problem nontrivial.

Then, a stabilization problem of bilayer shallow-water flows gives rise to the problem of stabilizing a general class of coupled bidirectional hyperbolic systems with spatially varying coefficients, i.e., the controller design. For the resulting closed-loop backstepping control system, finite-time stability is achieved. Disturbance rejection problem is also investigated. With regards to the systems running into control matched uncertainties and disturbances, disturbance rejection and disturbance attenuation are achieved for the closed-loop feedback system with a backstepping-based sliding mode controller and the closed-loop one with a backstepping-based active disturbance rejection controller, respectively.