Backstepping observer design for PDEs: estimating the state of linearized KdV equations and state-of-charge of Li-ion batteries

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Abstract

This talk presents some advancements in the backstepping control theory and application for partial differential equation (PDE)-modeled physical systems, focusing on the observer designs. The backstepping method is introduced firstly, followed by an example on the observer design for parabolic PDEs. Then, observer design problems are studied for a water management system and an energy management system, respectively. The first one is a linear Korteweg-de Vries system with possible anti-diffusion, which models the shallow water flow along a narrow channel. The key challenge comes from the third order spatial derivative in the PDE, for which we managed to derive the existence of the backstepping transformation based on an induction process. The second one is state-of-charge estimation of lithium-ion batteries modeled by a coupled ordinary differential equations (ODE)-PDE system. Some of the system coefficients are time-varying, resulting in time dependency of some coefficients in the kernel function system of the backstepping transformation. This further introduces difficulties in showing well-posedness of the latter system, for which reasonable regularity assumptions need to be imposed on the current input of batteries. The PDEs in both cases are posed on 1-D bounded spatial intervals, and the PDE states are unmeasurable over the interval except at one boundary. Both the designed backstepping-based state observers converge exponentially to the original systems.