Some recent results on boundary control of infinite dimensional port-Hamiltonian systems on 1-D spatial domains

The talk deals with the control of a large class of partial differential equations (PDEs) actuated at the boundary of a one dimensional spatial domain. This class of PDEs can be represented as boundary controlled port-Hamiltonian systems (PHS). First we shall comment the conditions for which a strictly-input passive linear finite dimensional controller exponentially stabilizes PHS actuated at the boundary of a 1-D spatial domain. This follows since the controller imposes exponential dissipation of the total energy. Then the conditions for existence of solutions and stability, asymptotic and exponential, of PHS subject to nonlinear dynamic boundary actuation are given. The consideration of such class of control systems is motivated by the use of actuators and sensors with nonlinear behavior in many engineering applications. These nonlinearities are usually associated to large deformations or the use of smart materials such as piezo actuators and memory shape alloys. Including them in the controller model results in passive dynamic controllers with nonlinear potential energy function and/or nonlinear damping forces. These results have been used for control synthesis and for the stability analysis of complex systems modeled by sets of coupled PDE's and ODE's.

Finally we shall talk about the energy shaping of 1-D linear boundary controlled PHS. The energy-Casimir method is first proposed to deal with power preserving systems. It is shown how to use finite dimensional dynamic boundary controllers and closed-loop structural invariants to partially shape the closed-loop energy function and how such controller finally reduces to a state feedback. When dissipative PHS are considered, the Casimir functions do not exist anymore, because of the dissipation obstacle, and the immersion/reduction method via a dynamic controller and invariants cannot be applied. It is then shown how to use the same ideas and state functions to shape the closed-loop energy function of dissipative systems through direct state feedback i.e. without relying on a dynamic controller and a reduction step.

The general theory is illustrated along the talk through an application example.

References

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