PhD Thesis in Automatic Control
ANR INFIDHEM

Observer based control of distributed Port Hamiltonian systems

Directed by: Yann Le Gorrec, Professor, yann.le.gorrec@ens2m.fr,
Hector Ramirez, Associate professor, hector.ramirez@femto-st.fr

Institute/Department: FEMTO-ST/AS2M, 24 rue A. Savary 25000 Besançon, FRANCE, Tel: +33381577287, Web: http://www.femto-st.fr

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Start of the Thesis: September/October 2017.
Duration: 3 years.
Salary: 1500 Euros net/month.
Location: AS2M/FEMTO-ST, Besançon, France.

Interested candidates are invited to contact us for further information (please join a CV).

Detailed description: The modeling of physical systems based on the representation of intrinsic energy exchanges between different energetic domains allows a modular description of their eventually complex dynamic behaviour. In this context, the port-Hamiltonian framework represents a powerful modeling and control tool. Port-Hamiltonian systems link the physical energy of a system and its dynamic behaviour through the definition of a geometric structure, named Dirac structure. This geometric structure, which arises in the modeling step, is instrumental for the stability analysis and the control design. In the case of non-linear or distributed parameter systems, the structure is not only instrumental, but also fundamental to study the solutions in a systematic manner. Even though the formalism is not new [1], it has only been extended to distributed parameter systems in 2002 [2]. The complete parametrization of linear distributed port Hamiltonian systems controlled at the boundaries over 1D spatial domains, as well as the study of the existence of solutions and stability properties, can be found in [3, 4, 5]. These results have recently motivated the extension of passivity based control techniques to infinite dimensional port-Hamiltonian systems controlled at the boundaries [6, 7, 8] and with distributed control [9, 10]. In all cases these control design techniques have been developed based on state feedbacks.

The aim of the thesis is to extend these approaches to observer based boundary control of distributed parameter port Hamiltonian systems. The observer design problem for infinite-dimensional linear and non-linear port Hamiltonian systems will first be addressed. This in order to achieve real-time reconstruction of the spatial-temporal state evolution from measurement data collected from sensors located at the boundaries or within the spatial domain. The use of observers for control design will then be investigated. First backstepping and its combination with IDA-PBC (cf [8]) will be generalized and extended to state observer design. Then recent results proposed in [11] will be employed to futher improve and extend the observer based design to larger clases of systems. Extended Luenberger concepts [12] will also be investigated. The real time implementation of both the controller and the observer will be considered using appropriate reduction schemes and evaluating the performance in terms of tracking error and robustness. The approaches will be applied for the smart boundary control of a vibroacoustic system by active foam actuation [13].

Working context : The Ph.D. takes place in the frame of the French-German ANR-DFG sponsored research project INFIDHEM (http://websites.isae.fr/infidhem/). The research activities will be developed at the AS2M department in FEMTO-ST, Besançon, France (http://www.femto-st.fr/) in collaboration with foreign researchers involved in the aforementioned project (University of Kiel, Germany, University of Twente, The Netherland, University of Bologne, Italy). The candidate is expected to submit research papers to high level conferences and journals, as well as actively participate in local and international seminars, workshops and conferences.

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