Recent Developments on Robust Regulation of Infinite-Dimensional Systems

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In this paper the robust regulation problem for a distributed parameter system

$$\dot{x} = Ax + Bu + F_s v, \qquad y = Cx + Du + F_m v,$$

with an infinite-dimensional exosystem

$$\dot{v} = Sv,$$

is discussed. The infinite-dimensional feedback controller is of the form

$$\dot{z} = \mathcal{G}_1 z + \mathcal{G}_2 e, \qquad u = Kz.$$

All the spaces involved are infinite-dimensional. The purpose of the feedback controller is to stabilize the closed loop system and to asymptotically track the reference and perturbation signal generated by the exosystem, despite perturbations in the system's parameters.

The famous Internal Model Principle states that a robust feedback controller must contain a copy of the dynamics of the exosystem. Therefore it is difficult or impossible to stabilize the closed loop system exponentially. Instead polynomial, strong, or weak stability must be considered.

The infinite-dimensional Internal Model Principle can be formulated in various ways, in the time and frequency domains. In this presentation the different definitions are presented and their relations will be clarified. The frequency domain formulation is based on a new ring of stable transfer functions.

The theory of finite-dimensional robust controllers was developed independently by Wonham and Francis and at the same time by Davison. Wonham's approach was based on geometric theory while Davison introduced a combination of servo-compensator and stabilizing compensator. This decomposition also holds for infinite-dimensional systems and two approaches are shown to be similar by the formalism used in the presentation.

The presentation reviews and combines the recent results of T. Hämäläinen, L. Paunonen. P. Laakkonen and S. Pohjolainen.

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