Stabilization of a hybrid system with elastic parts

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Abstract. This presentation is focused on the stabilization problem for the following system of differential equations:

$$\ddot{\theta}(t) = v, \quad t \geq 0,$$

$$\frac{\partial^2 w_i(x,t)}{\partial t^2} + c^2 \frac{\partial^4 w_i(x,t)}{\partial x^4} = \dot{\theta}^2(t) w_i(x,t) - (x+d)v, \quad x \in (0,l), \qquad (\Sigma)$$

$$w_i\Big|_{x=0} = \frac{\partial w_i}{\partial x}\Big|_{x=0} = \frac{\partial^2 w_i}{\partial x^2}\Big|_{x=l} = \frac{\partial^3 w_i}{\partial x^3}\Big|_{x=l} = 0, \; i = 1,2,...,k,$$

where $\xi(t) = \Big(\theta(t), \dot{\theta}(t), w_1(\cdot,t), w_{1t}(\cdot,t), ..., w_k(\cdot,t), w_{kt}(\cdot,t)\Big)$ is the state and $v(t) \in \mathbb{R}$ is the control. The above system describes a rotating rigid body endowed with k elastic beams. A motivation for studying the system (Σ) is the motion control for a "hybrid" spacecraft with flexible attachments: antennae, tethers, etc.

To stabilize the trivial solution of (Σ), we prove a Lyapunov-like sufficient condition for partial strong asymptotic stability which is valid for general nonlinear dynamical systems in a Banach space. This result is applied to deriving a feedback control $v = \gamma(\xi(t))$ explicitly. In addition, we prove strong (non-asymptotic) stability in the sense of Lyapunov as well as precompactness of the trajectories for the corresponding nonlinear semigroup. Some simulation results are given in conclusion.

This talk extends the approach of [2] for the case of nonlinear semigroups and the technique of [1] for the pre-compactness analysis.

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References

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