Stability of large scale nonlinear systems

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Abstract

In many modern applications like communication networks, interacting agents, biological systems, logistics networks, teleoperation etc. the dynamics of important quantities (called states) can be modeled by interconnected dynamical systems, for example written as systems of differential equations. Usually this dynamics is nonlinear and subject to such effects as time delays, impulsive actions, switching between different dynamics modes, unpredictable disturbances and other uncertainties. Moreover such systems of equations can be of large scale and their dynamics is also affected by the interaction properties of subsystems.

Vitally important properties of such dynamical systems are stability and robustness, that assure their proper performance. This course is devoted to studying modern mathematical tools that allow to investigate stability of nonlinear dynamical systems with input signals. We will learn about recent theories developed during last 10-20 years in the framework of Input-to-State Stability theory, which is a rather recent extension of the well known Lyapunov stability theory. The main parts of this course are as follows.

1. Introduction to the Input-to-State Stability theory:

Definitions, examples, different characterizations, relation to Lyapunov stability theory.

2. Modeling of interconnections and the small-gain theory:

Stability conditions will be developed and discussed. Geometric interpretations will be discussed, examples will be considered.

3. Numerical tools to check stability:

Verification of stability conditions turns out to be a nontrivial problem in sense of numerical computations. In particular in case of large scale interconnections efficient numerical tools are necessary. A numerical approach to verify stability will be considered at the end of this course.