constructive lyapunov methods for stability analysis of dynamical systems

lecturers

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objective

In real-life applications it is of utmost importance to guarantee safe operation of a system for a desired operating range. To this end, stability and domain of attraction are useful concepts. This course will provide a theoretical basis for Lyapunov stability theory for discrete-time nonlinear systems and contractive set theory for discrete-time homogeneous systems, respectively. In both Lyapunov and set theoretical frameworks, the classical theorems and algorithms will be worked out and new, less conservative finite-time theorems and algorithms will be presented. The notions of Minkowski function and proper C-set will be used to establish equivalence between Lyapunov functions and contractive sets for homogeneous systems. Numerical algorithms for constructing Lyapunov functions and contractive sets will be worked out for the following types of discrete-time system dynamics: linear, switched linear with arbitrary switching and switched linear with state-dependent switching and rule-dependent switching. All developed methods will be illustrated on several examples.

contents

Lecture 1 Lyapunov stability theory: KL stability, Lyapunov functions, Lyapunov's theorem, finite-time Lyapunov functions, converse Lyapunov theorem, domain of attraction.

Lecture 2 Contractive set theory: proper C-sets, Minkowski functions, contractive sets, finite-time contractive sets, equivalence of Minkowski Lyapunov functions and contractive proper C-sets.

Lecture 3 Switched linear dynamics: Construction of piecewise quadratic and piecewise linear Lyapunov functions, construction of finite-time Lyapunov functions.

Lecture 4 Switched linear dynamics: Construction of contractive proper C-sets by forward and backward set-iterates, construction of finite-time contractive proper C-sets.

lecture notes

A selection of articles will be recommended for reading for each lecture along with the lecture handouts.

prerequisites

Linear algebra, Continuous functions, Basic knowledge of Lyapunov stability theory and Systems theory, Convex optimization, Matlab MPT Toolbox. A set of appendices that contain a compact summary of prerequisite knowledge will be

available for download.

homework assignments

The participants will be asked to complete a composite homework assignment.