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F O R S C H U N G S P R A X I S

A graphical tool to check the stability of non-linear dynamical systems

Problem description:

Contraction theory [1] is a novel approach to analyze the stability of dynamical systems (DS). The contraction property guarantees the convergence of each trajectory of the contracting DS to a unique reference trajectory. This reference trajectory can be a single equilibrium point or a generic path in the DS state space. Hence, it is a more general but stronger property than the asymptotic stability [2], [3].

In this Forschungspraxis work the student has to implement the graphical approach to prove contraction of dynamical system in [4]. The algorithm works in two steps. Firstly, a directed graph is constructed from the generalized Jacobian [1] of the DS to analyze. Then, if the direct graph does not contains loop, we can conclude that the DS is contracting. Moreover, given the direct graph, an algorithm has to be implemented to find the minimum number of connections to discard in order to satisfy the loop-less condition.

Work schedule:

- Literature overview on Contraction theory
- Implementation of the graphic algorithm to prove contraction in [4]
- Implementation of an algorithm to guarantee the loop-less condition.
- Development of a feed-back control law to guarantee the contraction.
- Test on dynamical systems with known stability properties

Bibliography:

[1] W. Lohmiller, J.J.E. Slotine. On contraction analysis for nonlinear systems. *Automatica*, 1998.
[2] J. Jouffroy and J.J.E. Slotine. Methodological remarks on contraction theory. *International Conference on Decision and Control*, 2004.
[3] W. Wang and J.J.E. Slotine. On partial contraction analysis for coupled nonlinear oscillators. *Biological Cybernetics*, 2005.
[4] G. Russo, M. Di Bernardo and J.J.E. Slotine. A Graphical Approach to Prove Contraction of Nonlinear Circuits and Systems. *Transactions on Circuits and Systems*, 2011.

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