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M A S T E R ' S T H E S I S
for
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Learning Stable Dynamical Systems using Contraction Theory

Problem description:

Contraction theory [1], [2] 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 trajectory in the DS state space.

In this Master Thesis work the student has to implement a control algorithm, based on the contraction theory, to guarantee the convergence of a DS represented as a mixture of Gaussian distributions (GMM/GMR). Moreover, the student is required to extend the developed algorithm to different learning approaches, such as Hidden Markov Models, Gaussian Processes and Support Vector Machines. The performance of the proposed approach will be compared with those of state-of-the-art algorithms [3].

Tasks:

- Literature overview on Contraction theory and Learning from Demonstration.
- Design of a control algorithm to guarantee the stability of a DS learned with GMM/GMR.
- Extension of the algorithm to consider different regression techniques (optional).
- Comparison with the approach in [3].

Bibliography:

[1] W. Lohmiller, J.J.E. Slotine. On contraction analysis for nonlinear systems. *Automatica*, 1998.
[2] W. Wang and J.J.E. Slotine. On partial contraction analysis for coupled nonlinear oscillators. *Biological Cybernetics*, 2005.
[3] S. M. Khansari-Zadeh and A. Billard. Learning Stable Non-Linear Dynamical Systems with Gaussian Mixture Models. *Transaction on Robotics*, 2011.

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