TECHNISCHE UNIVERSITÄT MÜNCHEN
LEHRSTUHL FÜR INFORMATIONSTECHNISCHE REGELUNG
ORDINARIA: UNIV.-PROF. DR.-ING. SANDRA HIRCHE

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P R A C T I C A L C O U R S E
for
N.N., Mat.-Nr. XXXXXXX

Learning Stochastic Stable Systems using Sum of Squares Control Lyapunov Functions

Problem description:

Robots interacting with humans often face the difficulty to be confronted with unseen situations in their environments. A common approach in robotics is to learn skills autonomously from demonstration and observations. Point-to-point motions, also known as motion primitives, are often encoded as dynamical systems as these generalize well to unknown situations.
A key requirement for providing a save behaviour of the robot is to ensure stability of the learned dynamical systems. Different approaches based on learning control Lyapunov functions [1] e.g. using neural networks [2] or Weighted Sum of Asymmetric Quadratic Functions [1] have already shown promising results. However, sum of square techniques [3] which are well known for finding flexible Lyapunov candidates have not been investigated.
Therefore, the aim of this work is to compare sum of square candidates with existing approaches for learning control Lyapunov functions. In addition, this work extends the learning of stable system to the stochastic domain by considering uncertainties and risk-sensitive control Lyapunov functions.

Tasks:

- Literature review on learning stable dynamical systems and sum of squares techniques
- Implemention of sum of squares control Lyapunov function and comparison to existing approaches
- Extending framework to stochastic domain to consider uncertainties
- Documentation of results

Bibliography:

[1] Seyed Mohammad Khansari-Zadeh and Aude Billard. Learning control Lyapunov function to ensure stability of dynamical system-based robot reaching motions. *Robotics and Autonomous Systems*, 62(6):752–765, 2014.
[2] K. Neumann, A. Lemme, and J. J. Steil. Neural learning of stable dynamical systems based on data-driven Lyapunov candidates. In *International Conference on Intelligent Robots and Systems (IROS)*, pages 1216–1222. IEEE, November 2013.
[3] Antonis Papachristodoulou and Stephen Prajna. A tutorial on sum of squares techniques for systems analysis. In *American Control Conference (ACC)*, pages 2686–2700. IEEE, 2005.

Supervisor: M. Sc. Jonas Umlauft

(S. Hirche)
Univ.-Professor