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March 9, 2016

B A C H E L O R T H E S I S / M A S T E R T H E S I S

Learning and Control for Stochastic Stable Systems

Problem description:

Robots interacting with humans face the difficulty to react to unseen events in their environment which occurs in many real-world applications. One approach is to make the robot acquire skills autonomously from observation and generalization. This idea initiated research at the intersection between machine learning and control.
An open remaining challenge is to guarantee certain desired behaviour of such self-learning robots, such as stability or good tracking performance [2]. First approaches in [1] have shown promising results, but use deterministic models which don't capture the stochastic nature of the human demonstration. To take advantage of the full potential of the underlying machine learning techniques a stochastic modelling is required.
This work aims to learn stable dynamics from observations based on probabilistic models. It enables robots to generate guaranteed converging trajectory by choosing from a distribution of trajectories. Additionally, knowledge about the similarity to the observation can be used for the risk-quantification of movements and the stochastic models allow risk-sensitive controller design [3].

Tasks:

- Literature review on stochastic stability and learning of stable dynamics
- Developing of a learning/control scheme for stable stochastic systems.
- Simulate and evaluate trajectory generation based on stochastic dynamics.

Bibliography:

[1] Seyed Mohammad Khansari-Zadeh and Aude Billard. Learning stable nonlinear dynamical systems with gaussian mixture models. *IEEE Transactions on Robotics*, 27(5):943–957, 2011.
[2] Harold Joseph Kushner. *Introduction to stochastic control*. Holt, Rinehart and Winston New York, 1971.
[3] J.R. Medina and S. Hirche. Uncertainty-dependent optimal control for robot control considering high-order cost statistics. In *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pages 3995–4002, Sept 2015.

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Delivery:	xx.xx.xxxx

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