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S C I E N T I F I C S E M I N A R
for
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Learning on Manifolds for Stable Dynamical System

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 concept initiated research at the intersection between machine learning and system identification for control.
An open remaining challenge is to guarantee desired behaviour of such self-learning robots like stability, which strongly depends on the underlying model. Learning under stability constraints has e.g. been investigated in [3]. An alternative idea is to restrict the learning to a limited class of models which all guarantee the desired behaviour. This constraint learning is better known as learning on a manifold [1]. For learning linear models, positive definiteness of the system matrix is the decisive criteria for stability. Therefore, a special focus of this scientific seminar is put on learning on the manifold of positive definite matrices [2]. The goal is to summarize and classify the existing approaches in this field and transfer their application to learning stable dynamical systems.

- Literature review on learning on manifolds in general
- Identify methods for learning positive definite matrices and their application to system identification
- Summary and documentation of results

Bibliography:

[1] Mikhail Belkin. *Problems of Learning on Manifolds*. PhD thesis, The University of Chicago, 2003.
[2] Sadeep Jayasumana, Richard Hartley, Mathieu Salzmann, Hongdong Li, and Mehrtash Harandi. Kernel methods on the Riemannian manifold of symmetric positive definite matrices. In *Conference on Computer Vision and Pattern Recognition*, pages 73–80, 2013.
[3] 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.

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