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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

Online Kinematic Teaching using Optimal Control and Gaussian Processes

Problem description:

Programming by Demonstration (PbD) [1] enhanced the application of robots in human daily environment due to more user-friendly handling. One approach to PbD is kinematic teaching: A human operator physically interacts with the robot to move the manipulator along a desired trajectory.
While common PbD approaches often are separated in a *teaching* and *execution* phase, the goal of this thesis is to achieve online learning. Thus, the robot continuously takes over responsibility when sufficient training data is gathered in the current region of the task space, or is simply recording data when in unseen situations.
Gaussian Processes [3] have gained popularity in the field of robotics for learning system dynamics. In combination with a risk-sensitive optimal controller [2], the tracking of a desired trajectory, obtained from data, is a promising approach.
From an application point of view, this thesis aims for solving the difficulty that in PbD hardly no feedback about the level of ignorance of the robot is online provided to the demonstrator. By actively supporting the demonstrator online in already seen scenarios, we hope to achieve more intuitive and faster kinematic teaching.

Tasks:

- Familiarization with concepts of risk-sensitive optimal control and Gaussian Processes
- Design concept for online teaching and run simulations in Matlab.
- Adaptation of the software for use in online kinematic teaching and conducting robot experiments

Bibliography:

[1] Aude Billard, Sylvain Calinon, RŘdiger Dillmann, and Stefan Schaal. Robot programming by demonstration. In *Springer handbook of robotics*, pages 1371–1394. Springer, 2008.
[2] Jose Ramon Medina Hernandez and Sandra Hirche. Uncertainty-dependent optimal control for robot control considering high-order cost statistics. In *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2015.
[3] CE. Rasmussen and CKI. Williams. *Gaussian Processes for Machine Learning*. Adaptive Computation and Machine Learning. MIT Press, Cambridge, MA, USA, January 2006.

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