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M A S T E R T H E S I S
for
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Kinesthetic Teaching of End-Effector and Null-Space Motion Primitives with Learned Task Priorities

Problem description:

Kinesthetic teaching, i.e. the manual guidance of the robot towards the task execution, is a natural and intuitive way to teach new skills [1]. When the robot is redundant, one should consider how the redundant degrees-of-freedom (DoF) can be used in a fruitful manner. In [2], an approach is proposed for kinesthetic teaching of null-space motion primitives. The approach in [2] considers fixed task priorities during the execution, i.e., the user has to pre-define end-effector and null-space tasks.

In this Master Thesis work the student has to overcome the limitations of the work in [2] by considering variable task priorities. Variable task priorities will be learned by optimizing a suitable cost function [3]. The learning approach has also to take into account eventual constraints in the task demonstrations. To this end, the student has to implement an approach to automatically extract constraints from the given demonstrations. These constraints will be explicitly considered in the algorithm which learns the variable task priorities.

Tasks:

- Literature overview on variable impedance control and learning task priorities.
- Implementation of an approach to learn variable task priorities.
- Evaluation on a KUKA LWR IV+ 7 DoF manipulator and a NAO humanoid robot.

Bibliography:

[1] D. Lee and C. Ott. Incremental Kinesthetic Teaching of Motion Primitives Using the Motion Refinement Tube, in *Autonomous Robots*, 2011.
[2] M. Saveriano, S. An and D. Lee. Incremental Kinesthetic Teaching of End-Effector and Null-Space Motion Primitives, in *International Conference on Robotics and Automation*, 2015.
[3] V. Modugno, G. Neumann, E. Rueckert, G. Oriolo, J. Peters and S. Ivaldi. Learning soft task priorities for control of redundant robots, in *Int. Conf. on Robotics and Automation*, 2016.
[4] S. Calinon, F. Guenter and A. Billard. On Learning, Representing, and Generalizing a Task in a Humanoid Robot, in *Transactions on Systems, Man, and Cybernetics, Part B*, 2007.

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