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M A S T E R ' S T H E S I S
for
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Robot's Compliance Adaptation through Reinforcement Learning

Problem description:

In many tasks controlling only the robot position is insufficient to achieve the goals of the task. These are typically tasks that involve contact or require a specific response to physical perturbations. The ability to adapt the impedance to different task requirements and stochastic disturbances increases the performances, versatility and robustness of the robot.

In this Master Thesis work the student has to implement a Reinforcement Learning (RL) based algorithm to learn a variable joint stiffness while the robot is executing a task as in [2], [3]. The main idea is to project the contributions of these variable stiffness terms into the Null Space of the robot Jacobian. In this way the Cartesian Space impedance (learned, for example, as in [1]) remains unchanged while the robot can react to the disturbances.

Tasks:

- Literature overview on Impedance Control and Reinforcement Learning
- Learning the Cartesian stiffness (Learning from Demonstrations, Kinaesthetic teaching, ...)
- Learning the Joint stiffness through RL and projection in the Null Space
- Experimental evaluation on a KUKA LWR4+

Bibliography:

[1] K. Kronander and A. Billard. Online Learning of Varying Stiffness Through Physical Human-Robot Interaction. in *International Conference on Robotic and Automation (ICRA)*, 2012.

[2] P. Kormushev, S. Calinon and D.G. Caldwell. Robot Motor Skill Coordination with EM-based Reinforcement Learning. in *Proceedings of the IEEE/RSJ Intl Conf. on Intelligent Robots and Systems (IROS)*, 2010.

[3] J. Buchli, F. Stulp, E. Theodorou and S. Schaal Learning variable impedance control. in *The International Journal of Robotics Research* vol. 30, no. 5, pp. 556-573, 2011.

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