UNIVERSITÄT ZU LÜBECK
INSTITUTE FOR ROBOTICS
AND COGNITIVE SYSTEMS

Humanoid Robotics
Summer term 2018
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Exercise sheet 4 - Planning and Learning

Please prepare the following exercises for the upcoming tutorial.

Task 1: Path Planning

a) Explain the RRT algorithm presented in [LaValle, 1998]!

b) Explain the RRT* algorithm presented in [Karaman and Frazzoli, 2011] and state the difference between RRT and RRT*!

c) Explain the STOMP algorithm presented in [Kalakrishnan et al., 2011]!

Hint: You can use sketches and pseudo-code in order to explain the above algorithms.

Task 2: Reinforcement Learning

a) Explain the general idea of Reinforcement Learning and draw a short diagram in which you sketch the different subareas for Reinforcement Learning!

b) Use the Reinforcement Learning approach which you can find in [Rückert et al., 2013, page 4-7] in order to steer the pendulum depicted in Figure 1 to $\varphi = \pi$. The parameters are given with

$$l = 1, \qquad m = 1, \qquad g = 9.81, \qquad u_{\max} = 5, \tag{1}$$

where $u_{\max}$ is the maximum possible torque which can be applied.

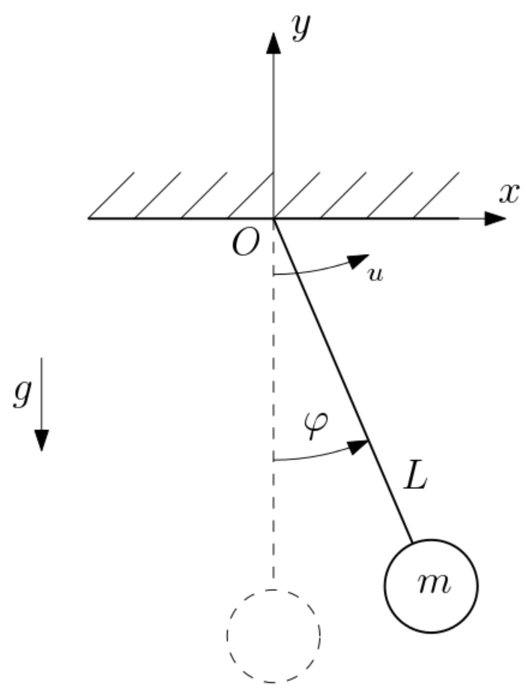

Figure 1 Pendulum with Torque

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Graded Assignment 04: Path Planning and Reinforcement Learning

In this assignment you have to steer a differential drive driven robot through a labyrinth. Therefore you have to first find an optimal way through the labyrinth using the above introduced planning algorithms and second steer the robot along the determined trajectory using the above presented RL approach combined with a simple PD-Controller. You will find the labyrinth stored as rectangulars as well as a kinematic model for the differential drive here.
In order to pass the assignment you have to write a Matlab code which steers the robot through the laybrinth starting from the initial pose $p_0 = [0, 0, \pi/4]$ and ending at the position $[4, 4]$. The Matlab code has to be executable using a main file. You have to give a presentation in order to show your results. Therefore you have a maximum of 8 minutes. We recommend Powerpoint for the presentation slides. The maximum number of points reachable is 24.

The submission deadline for this assignment is July 10, 2018, 10am. Please send your submission (Matlab files + presentation slides) as a Zip data named RO5300_TeamNumber to Nils.Rottmann@rob.uni-luebeck.de with the subject RO5300_TeamNumber. Other submissions will not be considered.

The presentations will take place at July 11, 2018, during our exercise session. The order of the presentations will be as follows:

- 10:15 - 10:25: Group 1
- 10:25 - 10:35: Group 2
- 10:35 - 11:45: Group 3
- 10:45 - 10:55: Group 4
- 11:00 - 11:10: Group 5
- 11:10 - 11:20: Group 6
- 11:20 - 11:30: Group 7
- 11:40 - 11:50: Group 9

If you have any problems with the assignment feel free to get in touch. You will find me in Building 64, Room 85.

Literatur

[Kalakrishnan et al., 2011] Kalakrishnan, M., Chitta, S., Theodorou, E., Pastor, P., and Schaal, S. (2011). STOMP: Stochastic Trajectory Optimization for Motion Planning. In *International Conference on Robotics and Automation (ICRA), 2011*, pages 4569–4574. IEEE.

[Karaman and Frazzoli, 2011] Karaman, S. and Frazzoli, E. (2011). Sampling-based Algorithms for Optimal Motion Planning. *The International Journal of Robotics Research*, 30(7):846–894.

[LaValle, 1998] LaValle, S. M. (1998). Rapidly-exploring Random Trees: A new Tool for Path Planning.

[Rückert et al., 2013] Rückert, E. A., Neumann, G., Toussaint, M., and Maass, W. (2013). Learned graphical models for probabilistic planning provide a new class of movement primitives. *Frontiers in computational neuroscience*, 6:97.