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F O R S C H U N G S P R A X I S

One-Step Backward Data Informed Reinforcement Learning for Feedback Motion Planning

Problem description:

The safe operation of autonomous agents in obstacle-filled environments requires the synthesis of motion planning and control. Most of works put emphasis either on the planning level or the control level. However, the efficient connection between these two intertwined levels is ignored. This motivates us to develop an integrated planning and control approach, in which requirements for safety (e.g., stability, input saturation, obstacles), robustness (e.g., model uncertainties, environmental disturbances), and optimality (e.g., minimum execution time and actuator effort) are all considered for practical applications.
The safe optimal motion planning is investigated from a feedback control perspective [1] in this project. This facilities us to provide provable guarantees of optimality, safety and robustness. In particular, the investigated motion planning is first formulated as an optimal regulation control problem, wherein the requirements of performance are encoded by a cost function. Then, the formulated optimization problem is solved by one-step backward data informed reinforcement learning algorithm [2]. The resulting optimal control strategy is corrected via a control barrier function [3] based safety filter to achieve safe operation in obstacle-filled environment. The effectiveness of the proposed method will be verified through numerical simulations.

Work schedule:

- Literature reading with regard to feedback motion planning, and reinforcement learning.
- Implementation and verification of the proposed method based on robot operating system (ROS) and Gazebo (python language).
- Numerical comparison with the common perception-planning-control approach.

Bibliography:

[1] Patryk Deptula, Hsi-Yuan Chen, Ryan A Licitra, Joel A Rosenfeld, and Warren E Dixon. Approximate optimal motion planning to avoid unknown moving avoidance regions. *IEEE Transactions on Robotics*, 36(2):414–430, 2019.
[2] Cong Li, Yongchao Wang, Fangzhou Liu, Qingchen Liu, and Martin Buss. Model-free incremental adaptive dynamic programming based approximate robust optimal regulation. *arXiv preprint arXiv:2105.01698*, 2021.
[3] Cong Li, Zengjie Zhang, Ahmed Nesrin, Qingchen Liu, Fangzhou Liu, and Martin Buss. Instantaneous local control barrier function: An online learning approach for collision avoidance. *arXiv preprint arXiv:2106.05341*, 2021.

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Start:
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