PRIMP: PRobabilistically-Informed Motion Primitives for Efficient Affordance Learning from Demonstration (Abstract Reprint)

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Abstract

This paper proposes a learning-from-demonstration (LfD) method using probability densities on the workspaces of robot manipulators. The method, named PRobabilistically-Informed Motion Primitives (PRIMP), learns the probability distribution of the end effector trajectories in the 6D workspace that includes both positions and orientations. It is able to adapt to new situations such as novel via points with uncertainty and a change of viewing frame. The method itself is robot-agnostic, in that the learned distribution can be transferred to another robot with the adaptation to its workspace density. Workspace-STOMP, a new version of the existing STOMP motion planner, is also introduced, which can be used as a post-process to improve the performance of PRIMP and any other reachability-based LfD method. The combination of PRIMP and Workspace-STOMP can further help the robot avoid novel obstacles that are not present during the demonstration process. The proposed methods are evaluated with several sets of benchmark experiments. PRIMP runs more than 5 times faster than existing state-of-the-art methods while generalizing trajectories more than twice as close to both the demonstrations and novel desired poses. They are then combined with our labs robot imagination method that learns object affordances, illustrating the applicability to learn tool use through physical experiments.

References

Ruan, S.; Liu, W.; Wang, X.; Meng, X.; and Chirikjian, G. S. 2024. PRIMP: PRobabilistically-Informed Motion Primitives for Efficient Affordance Learning from Demonstration. *IEEE Transactions on Robotics*, 40: 2868–2887.