A Practical Comparison of Three Robot Learning from Demonstration Algorithms

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Overview

Existing evaluations of robot learning from demonstration have focused exclusively on algorithmic performance and not on usability factors. In this work we present findings from a comparative user study in which we asked non-experts to evaluate three distinctively different robot learning from demonstration algorithms -- Behavior Networks, Interactive Reinforcement Learning, and Confidence Based Autonomy.

DBUG Domain

- **31 users – 21 male and 10 female ages ranging from 18 to 35**
- **asked to train Nao humanoid robot to pickup moving HEXBUG toys**
- **10 minutes given to each per algorithm**
- **Robot able to track X, Y location of the bugs**
- **Pick-up, wait, and sweep actions**

The DBUG experimental setup

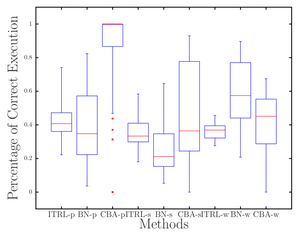
Goals

- **Highlight the algorithmic assumptions violated by users**
- **Provide guidance for future algorithm designs**

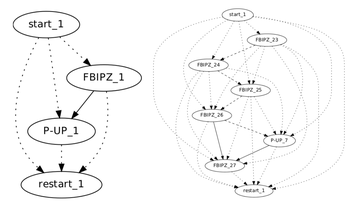
Algorithms

- **Interactive Reinforcement Learning [1]**
  - RL with human given rewards
  - Taught through on-screen +/- input
- **Confidence Based Autonomy [2]**
  - Confidence based classifier
  - Taught through on-screen action selections
- **Behavior Networks [3]**
  - Planning-based policy learning
  - Taught through physical guidance

Summary Results

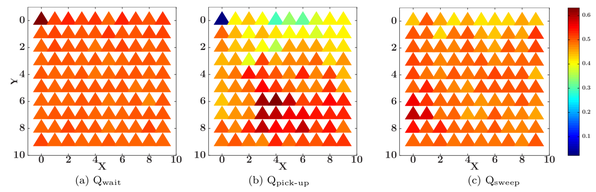


User Performance



Expert vs. User Behavior Networks

Average Int-RL Q-Values



	Mismatch w/ Algorithmic Assumptions	Usability
Int-RL		•Slow learning rate prevented entire task from being learned •Not seeing immediate results, users changed their behavior to try other strategies
CBA	•Ineffective state space sampling for classification •Delayed correction led to mismatch between states and labels	•Strong policy learning performance •Delays between actions perceived as "lag"
BNets	•User attempts to demonstrate multiple actions simultaneously •Frequent unintended action dependencies	•Kinesthetic teaching well received •Tendency to improve robot behavior through overcomplicated plans

"How quickly did the robot learn the task?"

	Very-Slowly	Slowly	Quickly
Int-RL	11	16	4
CBA	3	9	19
BNets	8	11	12

"How well did the robot learn the task?"

	Not-at-All	Not-Well	Well	Very-Well
Int-RL	4	9	17	1
CBA	1	4	17	9
BNets	4	17	9	1

References

[1] A. L. Thomaz and C. Breazeal. Adding guidance to interactive reinforcement learning. In the Twentieth Conference on Artificial Intelligence (AAAI), 2006.
[2] S. Chernova and M. Veloso. Interactive policy learning through confidence-based autonomy. Journal Artificial Intelligence Research (JAIR), pages 1-25, 2009.
[3] M. N. Nicolescu and M. J. Matarić. Natural methods for robot task learning: instructive demonstrations, generalization and practice. Autonomous Agents and Multiagent Systems (AAMAS), pages 241-248, New York, NY, USA, 2003. ACM.