Dissertations

Semantically Grounded Learning from Unstructured Demonstrations

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Date of Award
9-2013

Document Type
Open Access Dissertation

Degree Name
Doctor of Philosophy (PhD)

Degree Program
Computer Science

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Keywords
Bayesian nonparametrics, Learning from demonstration, PR2, Robotics

Subject Categories
Computer Sciences | Robotics

Abstract
Robots exhibit flexible behavior largely in proportion to their degree of semantic knowledge about the world. Such knowledge is often meticulously hand-coded for a narrow class of tasks, limiting the scope of possible robot competencies. Thus, the primary limiting factor of robot capabilities is often not the physical attributes of the robot, but the limited time and skill of expert programmers. One way to deal with the vast number of situations and environments that robots face outside the laboratory is to provide users with simple methods for programming robots that do not require the skill of an expert.

For this reason, learning from demonstration (LfD) has become a popular alternative to traditional robot programming methods, aiming to provide a natural mechanism for quickly teaching robots. By simply showing a robot how to perform a task, users can easily demonstrate new tasks as needed, without any special knowledge about the robot. Unfortunately, LfD often yields little semantic knowledge about the world, and thus lacks robust generalization capabilities, especially for complex, multi-step tasks.

To address this shortcoming of LfD, we present a series of algorithms that draw from recent advances in Bayesian nonparametric statistics and control theory to automatically detect and leverage repeated structure at multiple levels of abstraction in demonstration data. The discovery of repeated structure provides critical insights into task invariants, features of importance, high-level task structure, and appropriate skills for the task. This culminates in the discovery of semantically meaningful skills that are flexible and reusable, providing robust generalization and transfer in complex, multi-step robotic tasks. These algorithms are tested and evaluated using a PR2 mobile manipulator, showing success on several complex real-world tasks, such as furniture assembly.