Role Transfer for Robot Tasking

Paul Fitzpatrick

Artificial Intelligence Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

http://www.ai.mit.edu

The Problem: Robot tasking addresses how a user can induce a mechanically general-purpose robot to perform a particular operation. It is crucial for the success of tasking that the robot can acquire a sufficient characterization of the context of the task from the user to avoid having to fall back on unconstrained object recognition and segmentation, which are currently difficult to apply in practice. It is also useful if tasking is consistent with natural human behavior, which can be taken as a de facto standard for communicating about physical objects and actions.

Motivation: Robotics has proven most successful in narrowly defined domains that offer sufficient constraint to make automated perception and action tractable. The goal of this work is to take a step towards generality by developing methods for applying a robot to many different narrow domains, or tasks. This is complementary to the more common research goal of enhancing machine perception and action to deal with *wider* domains. Extending the range of application of a technology through parameterization rather than generalization has proven useful in other perceptually challenging fields such as automatic speech recognition. It has the theoretical advantage of providing a framework for factoring context into perception, and the practical advantage of creating systems that do useful work with limited technology.

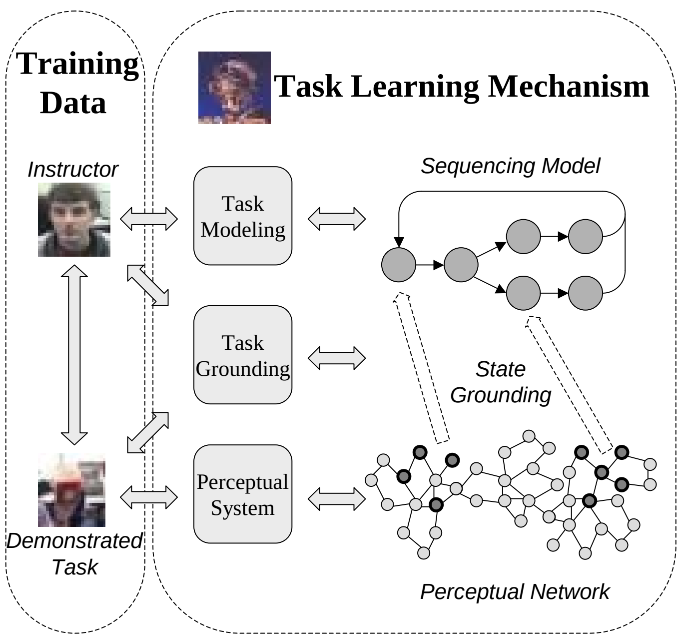

Figure 1: A summary of how tasking is implemented. The instructor demonstrates the task while providing verbal annotation. The vocal stream is used to construct a model of the task. Generic machine learning methods are then used to ground this model in the robot's perceptual network, guided by feature selection input from the human. The idea is to avoid ever presenting the robot with a hard learning problem; the learning algorithms are intended to be "decoders" allowing the human to communicate changes in representation, rather than to learn in the conventional sense.

Previous Work: Breazeal [1] has addressed many issues relevant to constructing a robot that is sufficiently socially competent to evoke natural scaffolding behavior in humans. The robot Kismet embodies this work, particularly in its ability to engage in proto-conversational turn-taking. Initial experiments in robot tasking were layered on top of Kismet's control system.

Various mixtures of programming and online training have been developed by other groups. Thrun in [3] proposes a mechanism of developing control software for embedded systems. He developed a language which, along with capturing common idioms of probabilistic reasoning, allows "gaps" to be left in programs, where values are left to be determined by function approximators such as ANNs which are trained up by examples. In a sense, this work can be seen as an attempt to widen these gaps in a manner analogous to the switch from configuration files to scripting languages in conventional computer applications.

Figure 2: Two situations within a sorting task, distinguished principally by their role within a process. An object is first presented to the robot and its color is described vocally. Then the object is moved in one direction or another based on its color, and the direction is described. Since these presentations occur within the structure of a repeated sorting task, the robot can conclude that the first situation is a decision point and the second is a deterministic response.

Approach: Figure 1 shows some details of the implementation of robot tasking. The general approach is to cast the problem of introducing the robot to a new task as an exercise in role transfer. Initially the human takes full responsibility for the task. Step by step, the robot takes over parts of the task, with the human completing the rest so that at all times the robot is presented with the full task. This is similar to a process seen in infant-caregiver interactions. It has the advantage of gracefully handling scenarios in which the human is an irreplaceable part of the task. Such cooperative tasks are likely to be very important in practice for any practical application of robot tasking, since humans will likely remain far more physically competent than robots are for some time to come.

Impact: The hope is to develop an interface that is usable by naïve users for simple instances of task invocation. More complex task induction may be more akin to programming / scripting than natural human teaching, but will still be well within the reach of "power users". Such an interface will be important for the widespread commercial deployment of robots in non-industrial settings.

Future Work: While some initial experiments in role transfer at the verbal level have been performed, this is all otherwise future work.

Research Support: Funds for this project were provided by DARPA as part of the "Natural Tasking of Robots Based on Human Interaction Cues" project under contract number DABT 63-00-C-10102, and by the Nippon Telegraph and Telephone Corporation as part of the NTT / MIT Collaboration Agreement.

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