Knowledge-Level Planning for Robot Task Planning and Human-Robot Interaction

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A robot operating in a real-world domain often needs to do so with *incomplete information* about the state of the world. A robot with the ability to *sense* the world can also gather information to generate plans with *contingencies*, allowing it to reason about the outcome of sensed data at plan time. Moreover, the type of information sensed can vary greatly between domains; for instance, domains involving object manipulation may require sensing information on object location, orientation, and distance, while domains requiring human-robot interaction may involve the sensing of social signals like gaze, facial expression, and language.

In this poster, we present some of our recent applications of high-level symbolic planning with incomplete information and sensing actions applied to the problems of task planning and interaction in robotics domains. In particular, building models of realistic domains which can be used with general-purpose planning systems often involves working with incomplete (or uncertain) perceptual information arising from real-world sensors. Furthermore, this task may be complicated by the difficulties of bridging the gap between geometric and symbolic representations: robot systems typically reason about joint angles, spatial coordinates, and continuous spaces, while many symbolic planners work with discrete representations represented in logic-like languages.

Our approach uses the PKS (Planning with Knowledge and Sensing) planner [2, 3] as the high-level reasoning and planning tool for robotics domains, which combines ideas from AI planning and knowledge representation. PKS is a general-purpose contingent planner that operates at the *knowledge level*, by reasoning about how its knowledge changes due to action. High-level actions are selected by the PKS which can construct plans with task, dialogue, or other types of actions which can be modelled by the planner. In particular, PKS can represent known and unknown information, and model sensing actions using concise but rich domain descriptions, making it well suited for structured, partially-known environments of the kind that arise in many robot scenarios. The same planner can therefore be used to provide high-level control for many types of robotic planning problems including low-level motion planning and human-robot interaction.

While PKS has been previously used in robot domains [4, 1], certain recent additions to the planner have helped improve its applicability to a wider range of robotics tasks. In this poster, we detail some of the extensions designed to improve PKS's ability to generate plans in real-world robot scenarios, by focusing on tasks such as combining high-level symbolic planning with low-level motion planning, reasoning about noisy sensors and effectors, and facilitating planner-level software integration on robot platforms. We also highlight recent work aimed to extend PKS to the representation of multiagent knowledge, and to include program-like control structures within PKS's domain representation.

Fig. 1. Example robot scenarios involving object manipulation (left) and human-robot interaction (right).

Examples are provided from a set of robot domains (see Fig. 1), which illustrate the applicability of these techniques to a broad range of robot planning applications involving incomplete knowledge, real-world geometry, and interaction. In particular, scenarios are taken from the JAMES project (http://james-project.eu/), which explored social interaction and task planning in a robot bartender domain, and recent work on the STAMINA project (http://stamina-robot.eu/), which is exploring robotic object manipulation in industrial contexts.[1]

References

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