Constraint-based Methods for Human-aware Planning

av

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Abstract


As more robots and sensors are deployed in work and home environments, there is a growing need for these devices to act with some degree of autonomy to fulfill their purpose. Automated planning can be used to synthesize plans of action that achieve this. The main challenge addressed in this thesis is to consider how the automated planning problem changes when considered in the context of environments that are populated by humans. Humans have their own plans, and automatically generated plans should not interfere with these. We refer to this as social acceptability. Opportunities for proactive behavior often arise during execution. The planner should be able to identify these opportunities and proactively plan accordingly. Both social acceptability and proactivity require the planner to identify relevant situations from available information. We refer to this capability as context-awareness, and it may require complex inferences based on observed human activities. Finally, planning may have to consider cooperation with humans to reach common goals or to enable robots and humans to support one another.

This thesis analyzes the requirements that emerge from human-aware planning — what it takes to make automated planning socially acceptable, proactive, context aware, and to make it support cooperation with humans. We formally state the human-aware planning problem, and propose a planning and execution framework for human-aware planning that is based on constraint reasoning and flaw-resolution techniques, and which fulfills the identified requirements. This approach is modular and extendable: new types of constraints can be added and solvers can be exchanged and re-arranged. This allows us to address the identified requirements for human-aware planning. In particular, we introduce Interaction Constraints (ICs) for this purpose, and propose patterns of ICs for social acceptability, proactivity, and context-awareness. We also consider cooperative plans in which certain actions are assigned to humans and the implications that this has. We evaluate the proposed methods and patterns on a series of use cases, as well as a variety of domains including a real-world robotic system. We evaluate the proposed methods and patterns on a series of use cases, as well as a variety of domains including a real-world robotic system. We introduce Interaction Constraints (ICs) for this purpose, and propose patterns of ICs for social acceptability, proactivity, and context-awareness. We also consider cooperative plans in which certain actions are assigned to humans and the implications that this has. We evaluate the proposed methods and patterns on a series of use cases, as well as a variety of domains including a real-world robotic system.

Keywords: Task Planning, Constraint-based Planning, Human-aware Planning

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