Epistemic planning for single- and multi-agent systems

In this paper, we investigate the use of event models for automated planning. Event models are the action defining structures used to define a semantics for dynamic epistemic logic. Using event models, two issues in planning can be addressed: Partial observability of the environment and knowledge. In planning, partial observability gives rise to an uncertainty about the world. For single-agent domains, this uncertainty can come from incomplete knowledge of the starting situation and from the nondeterminism of actions. In multi-agent domains, an additional uncertainty arises from the fact that other agents can act in the world, causing changes that are not instigated by the agent itself. For an agent to successfully construct and execute plans in an uncertain environment, the most widely used formalism in the literature on automated planning is "belief states": sets of different alternatives for the current state of the world. Epistemic logic is a significantly more expressive and theoretically better founded method for representing knowledge and ignorance about the world. Further, epistemic logic allows for planning according to the knowledge (and iterated knowledge) of other agents, allowing the specification of a more complex class of planning domains, than those simply concerned with simple facts about the world. We show how to model multi-agent planning problems using Kripke-models for representing world states, and event models for representing actions. Our mechanism makes use of slight modifications to these concepts, in order to model the internal view of agents, rather than that of an external observer. We define a type of planning domain called epistemic planning domains, a generalisation of classical planning domains, and show how epistemic planning can successfully deal with partial observability, nondeterminism, knowledge and multiple agents. Finally, we show epistemic planning to be decidable in the single-agent case, but only semi-decidable in the multi-agent case.