A Brief Introduction to Distributed Planning

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September 2017

1 Introduction

The issues inherent in multi-agent systems are appealing to me in general, as I spend most of my time at work working on a distributed multi-agent text classifying system. In many ways, we can interpret neural networks as being a way of programatticaly dealing with multi-agent systems. This led me to look for overviews of multi-agent approaches in order to solve planning problems. The challenges inherent in multi-agent systems stem from the need to support the interleaving of actions in order to guarantee completeness, as was pointed out by Allen Brown (Sussman, 1975). This challenge is only exacerbated when we the agents are also decentralized, with no main finalizing agent to aggregate the results. Furthermore, a given agent in a distributed multi-agent system isn't only concerned with the question of how to interleave its actions with those of its companions, but it must also deal with the possibiliy that each agent might view a different subset of the problem space, if only partial observability can be guaranteed.[1]

2 Developments

One of the first works to start branching heavily from previous approaches is to combine distributed multi-agent approaches with CSP problem solving approaches. In Nissim et al.'s work[2] they expand on Brafman & Domshlak's work of applying CSPs to multi-agent planning problems[3]. They note that despite the theoretical completeness of Brafman & Domshlak's approach (as most CSP solution mechanisms often resort to some search based approach, they can guarantee completeness and optimality via-BFS), the requirement of their DisCSP creates nonbinary constraints on otherwise independent agents.[2]

They use two mechanisms by which to separate variable definiton. The first is to separate the agent-specific notion of **Action Variables**, which correspond to the actions internally available to the agent, **Time Variables**, which provide ordered sequences of times when an action may be performed, and **Requirement Variables**, which provide a mechanism by which external agents can satisfy the requirements for a given action. The second distinction is to extend the role of each agent in their internal planning. Rather than limiting themselves to their internally determined cootdination points (as per[3]), they utilize all private and public actions, in an "ignore preconditions"-like approach to distributed multi-agent planning. This in turn determines their internal ordering of the aforementioned variables, and is refined in an action-first order as other agens report conflicts in the planning.

Another novel idea in the realm of distributed multi-agent planning is the identification of heuristics which are additive across agents yet retain their admissibility, i.e. they do not overestimate the cost of attaining a goal state.[4] Specifically, these works focus on multi-agent cost-partitioning, wherein the cost of actions must be non-negative, and less than, or equal to, the actual cost of a given action. This allows some information transfer between agents, while retaining relatively strong measures of privacy (although the article's authors do indicate some vagueness around weak and strong variable privacy).[4] This idea appears to still require robust testing, but preliminary findings would appear to show promise in its applicability to various scenarious (although it appears to be very sensitive to the given heuristic.

References

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[3] Ronen I. Brafman & Carmel Domshlak *From One to Many: Planning for Loosely Coupled Multi-Agent Systems* Bun-Gurion University, Israel 2008 @ https://www.aaai.org/Papers/ICAPS/2008/ICAPS08-004.pdf

[4] Michal Stolba & Antonin Komenda Department of Computer Science, Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic @ http://icaps16.icaps-conference.org/proceedings/dmap16.pdf#page=92