AAAI 94: Decision-Theoretic Planning

Position Paper

Iain Buchanan
Department of Computer Science
University of Strathclyde
Glasgow UK

Decision Theory, Planning and Constraint Satisfaction

Among recent work at Strathclyde has been a set of projects in AI techniques for scheduling; a major portion of that is described in the 3 doctoral theses produced by Prosser, Burke, and Berry, and subsequent publications. Much of this has a distributed flavour, and includes a novel architectural paradigm for distributed problem-solving. This was amongst the earliest work to address solution repair (as well as construction) and did so with an elegant and economical approach. Part of that work, and other recent/on-going research, is concerned with focus during search and other aspects of search control. As a high-level technical (rather than applications) view of our work, I would say it is concerned with computational paradigms for (distributed/co-operative) search on basically combinatorial problems.

There are similarities between the AI/decision theory elements of the symposium and aspects our our scheduling-driven work. The two most significant are described below.

Firstly, in both cases there is a concern with the processes and features needed to achieve goals within a search process. Thus there are concerns over the need for adaptive or reactive behaviour within the search process, or indeed following it, in the case where solution/plan maintenance over time is required. In the combinatorial search area, as practised in AI, there have been numerous paradigms and experiments with them on test problems, though there is as yet little by way of extended, rigourous, comparative experimental work, and the nature of the problem sets is sometimes of questionable value. In support of this, we note that at least some of the delegates at IJCAI93 were vocal in their support of the opportunities here, and critical of what has been achieved so far.

Secondly, there are complications and uncertainties due to problems of representation, mainly associated with measurement. The quantification issues may be with respect to the quality of solutions achieved or be associated with control issues in the solution process itself. Both measurement and its use are thus important. Although perhaps using different terms in describing this work, the notions of desirability, likelihood, trade-offs, criteria and conflicting objectives are all to be found here.

Much of the work above can be described in terms of constraint satisfaction problems (CSPs). Of the work in this area, comparatively little has concerned itself with the meta-level issues of guiding search through (absolute) measurement; rather the concentration has been at the algorithmic level and with guiding search through plausible rules or constraints, sometimes founded on local or surrogate measures. In constraint satisfaction problems there is now a move to introduce measures, even if only of a relative type, which could be embedded in meta-level control strategies. The recent work of Prosser and Smith (following that of Cheeseman, Kanefsky and Taylor on graph colouring) is the beginning of a quantitative assessment of problem (search) difficulty. The analyses, based on problem features which are sometimes expressed in terms of likelihoods - such as the probability that a constraint exists between a pair of variables in a constraint satisfaction problem - are both simple and supported, at least in part, by experimental evidence.

In terms of taking further the CSP work and examining relationships with the decision theory and planning worlds, there are a number of open questions. Included in this set are extensions of the analyses of Prosser/Smith to more asymmetric and less uniform problem classes, the use of more sophisticated parameters to describe these classes, and an investigation of the potential relationships between planning problems and CSPs, especially if the latter turn out to have measurable qualities which can be used in meta-level control.

Success in more sophisticated analysis may well rest on alternative analytic tools, especially those which can provide a handle onto the tree search cum problem decomposition approach. This may well involve relating measures across the problem-subproblem interface, which fits well with traditional methods in decision theory but is so far relatively unexplored in CSP terms.

Associated with all of this is the determination and exploitation of data such as the (expected) value of information, or the value of computation. While these are well-known concepts in decision theory, so far they only feature in a relatively low key way in the CSP world, and usually are known by different names.

In summary, there is an opportunity for a rich interaction between the decision theory/planning community and other workers with an interest in apparently distinct areas of modelling and problem-solving.

References

P Cheeseman, B Kanefsky and W M Taylor, "Where the Really Hard Problems Are", Proc IJCAI91, pp331-337, 1991.

P T Prosser, "An Empirical Study of Phase Transitions in Binary Constraint Satisfaction Problems", Technical Report AISL-49-93, Dept of Computer Science, University of Strathclyde, Glasgow UK, December 1993.

B M Smith, "The Phase Transition in Constraint Satisfaction Problems: A Closer Look at the Mushy Region", Research Report 93.41, School of Computer Studies, University of Leeds, 1993.