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Forthcoming Papers

E. Fink and Q. Yang, Automatically selecting and using primary effects in planning: theory and experiments

The use of primary effects of operators is an effective approach to improving the efficiency of planning. The characterization of "good" primary effects, however, has remained at an informal level and there have been no algorithms for selecting primary effects of operators.

We formalize the use of primary effects in planning and present a criterion for selecting useful primary effects, which guarantees efficiency and completeness. We analyze the efficiency of planning with primary effects and the quality of the resulting plans.

We then describe a learning algorithm that automatically selects primary effects and demonstrate, both analytically and empirically, that the use of this algorithm significantly reduces planning time and does not compromise completeness.

R. Dearden and C. Boutilier, Abstraction and approximate decision-theoretic planning

Markov decision processes (MDPs) have recently been proposed as useful conceptual models for understanding decision-theoretic planning. However, the utility of the associated computational methods remains open to question: most algorithms for computing optimal policies require explicit enumeration of the state space of the planning problem. We propose an abstraction technique for MDPs that allows approximately optimal solutions to be computed quickly. Abstractions are generated automatically, using an intensional representation of the planning problem (probabilistic STRIPS rules) to determine the most relevant problem features and optimally solving a reduced problem based on these relevant features. The key features of our method are: abstractions can be generated quickly; the abstract solution can be applied directly to the original problem; and the loss of optimality can be bounded. We also describe methods by which the abstract solution can be viewed as a set of default reactions that can be improved incrementally, and used as a heuristic for search-based planning or other MDP methods. Finally, we discuss certain difficulties that point toward other forms of aggregation for MDPs.

Y. Shahar, A framework for knowledge-based temporal abstraction

A new domain-independent knowledge-based inference structure is presented, specific to the task of abstracting higher-level concepts from time-stamped data. The framework includes a model of time, parameters, events, and contexts. A formal specification of a domain's temporal abstraction knowledge supports acquisition, maintenance, reuse, and sharing of that knowledge.

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The *knowledge-based temporal abstraction method* decomposes the temporal abstraction *task* into five *subtasks*. These subtasks are solved by five domain-independent *temporal abstraction mechanisms*. The temporal abstraction mechanisms depend on four domain-specific *knowledge types*: structural, classification (functional), temporal semantic (logical), and temporal dynamic (probabilistic) knowledge. Domain values for all knowledge types are specified when a temporal abstraction system is developed.

The knowledge-based temporal abstraction method has been implemented in the *RÉSUMÉ* system, and has been evaluated in several clinical domains (protocol-based care, monitoring of children's growth, and therapy of diabetes) and in an engineering domain (monitoring of traffic control), with encouraging results.

O. Etzioni, K. Golden and D. Weld, Sound and efficient closed-world reasoning for planning

Closed-world inference—an essential component of many planning algorithms—is the process of determining that a logical sentence is false based on its absence from a knowledge base, or the inability to derive it. We describe a novel method for closed-world inference and update over the first-order theories of action used by planning algorithms such as NONLIN, TWEAK, and UCPOP. We show the method to be sound and efficient, but incomplete. In our experiments, closed-world inference consistently averaged about 2 milliseconds while updates averaged approximately 1.2 milliseconds. Furthermore, we demonstrate that incompleteness is nonproblematic in practice, since our mechanism makes over 99% of the desired inferences. We incorporated our method into the XII planner, which supports our Internet Softbot (software robot). The technique cut the number of actions executed by the Softbot by a factor of one hundred, and resulted in a corresponding speedup to XII.

G. Kondrak and P. van Beek, A theoretical evaluation of selected backtracking algorithms

In recent years, many new backtracking algorithms for solving constraint satisfaction problems have been proposed. The algorithms are usually evaluated by empirical testing. This method, however, has its limitations. Our paper adopts a different, purely theoretical approach, which is based on characterizations of the sets of search tree nodes visited by the backtracking algorithms. A notion of inconsistency between instantiations and variables is introduced, and is shown to be a useful tool for characterizing such well-known concepts as backtrack, backjump, and domain annihilation. The characterizations enable us to: (a) prove the correctness of the algorithms, and (b) partially order the algorithms according to two standard performance measures: the number of nodes visited, and the number of consistency checks performed. Among other results, we prove the correctness of Backjumping and Conflict-Directed Backjumping, and show that Forward Checking never visits more nodes than Backjumping. Our approach leads us also to propose a modification to two hybrid backtracking algorithms, Backmarking with Backjumping (BMJ) and Backmarking with Conflict-Directed Backjumping (BM-CBJ), so that they always perform fewer consistency checks than the original algorithms.

G. DeJong and S. Bennett, Permissive planning: extending classical planning to uncertain task domains

Uncertainty, inherent in most real-world domains, can cause failure of apparently sound classical plans. On the other hand, reasoning with representations that explicitly reflect uncertainty can engender significant, even prohibitive, additional computational costs. This paper contributes a novel approach to planning in uncertain domains. The approach is an extension of classical planning. Machine learning is employed to adjust *planner bias* in response to execution failures. Thus, the classical planner is conditioned towards producing plans that tend to work when executed in the world.

The planner's representations are simple and crisp; uncertainty is represented and reasoned about only during learning. The user-supplied domain theory is left intact. The operator definitions and the planner's projection ability remain as the domain expert intended them. Some structuring of the planner's *bias space* is required. But with suitable structuring the approach scales well. The learning converges using no more than a polynomial number of examples. The system then probabilistically guarantees that either the plans produced will achieve their goal when executed or that adequate planning is not possible with the domain theory provided. An implemented robotic system is described.

J. Lobo and C. Uzcátegui, Abductive consequence relations

In this paper we present a systematic study of abductive consequence relations. We show that a monotone abductive consequence relation satisfies the properties of a cumulative monotonic system as defined by Kraus, Lehmann and Magidor when the disjunction of all abductive explanations is the explanation used to justify the observations. We also show that, in general, for this class of abductive consequence relations the Or rule does not hold. We present an example that shows that when there are preferences between different abductive explanations monotonicity does not hold. We show that non-monotonic abductive systems preserve a partial version of rational monotonicity and in fact are very similar to rational relations. We also present semantic characterizations of both monotonic and non-monotonic abductive systems in terms of cumulative models as defined by Kraus, Lehmann and Magidor.

M. Thielscher, Ramification and causality

In formal systems for reasoning about actions, the ramification problem denotes the problem of handling indirect effects. These effects are not explicitly represented in action specifications but follow from general laws describing dependencies among components of the world state. An adequate treatment of indirect effects requires a suitably weakened version of the general law of persistence. It also requires a method to avoid unintuitive changes suggested by the aforementioned dependency laws. We propose a solution to the ramification problem that uses directed relations between two single effects, stating the circumstances under which the occurrence of the first *causes* the second. We argue for the necessity of an approach based on causality by elaborating the limitations of common paradigms employed to handle ramifications—the principle of categorization and the policy of minimal change. Our abstract solution is realized on the basis of a particular action calculus, namely, the fluent calculus.

T.G. Dietterich, R.H. Lathrop and T. Lozano-Pérez, Solving the multiple-instance problem with axis-parallel rectangles

The multiple instance problem arises in tasks where the training examples are ambiguous: a single example object may have many alternative feature vectors (instances) that describe it, and yet only one of those feature vectors may be responsible for the observed classification of the object. This paper describes and compares three kinds of algorithms that learn axis-parallel rectangles to solve the multiple-instance problem. Algorithms that ignore the multiple instance problem perform very poorly. An algorithm that directly confronts the multiple instance problem (by attempting to identify which feature vectors are responsible for the observed classifications) performs best, giving 89% correct predictions on a musk-odor prediction task. The paper also illustrates the use of artificial data to debug and compare these algorithms.

A. Darwiche and J. Pearl, On the logic of iterated belief revision

We show in this paper that the AGM postulates are too weak to ensure the rational preservation of conditional beliefs during belief revision, thus permitting improper responses to sequences of observations. We remedy this weakness by proposing four additional postulates, which are sound relative to a qualitative version of probabilistic conditioning. Finally, we establish a model-based representation theorem which characterizes the proposed postulates and constrains, in turns, the way in which entrenchment orderings may be transformed under iterated belief revisions.

A. Chella, M. Frixione and S. Gaglio, A cognitive architecture for artificial vision

A new *cognitive* architecture for artificial vision is proposed. The architecture, aimed at an autonomous intelligent system, is cognitive in the sense that several cognitive hypotheses have been postulated as guidelines for its design. The first one is the existence of a *conceptual* representation level between the *subsymbolic* level, that processes sensory data, and the *linguistic* level, that describes scenes by means of a high-level language. The conceptual level plays the role of the interpretation domain for the symbols at the linguistic levels. A second cognitive hypothesis concerns the active role of a *focus of attention* mechanism in the link between the conceptual and the linguistic level: the exploration process of the perceived scene is driven by linguistic and associative expectations. This link is modeled as a time-delay attractor neural network. Results are reported obtained by an experimental implementation of the architecture.

T. Eiter, Semantics and complexity of abduction from default theories

G.A.W. Vreeswijk, Abstract argumentation systems

P. Baumgartner, U. Furbach and F. Stolzenburg, Computing answers with model elimination