Planning for Conjunctive Goals

David Chapman

notes by Lise Getoor

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1 Overview

TWEAK A (neat) sound and complete partial order planner

Modal Truth Criterion A necessary and sufficient condition for correctness of a partial plan.

2 TWEAK

TWEAK is a constraint posting planner. There are two types of constraints that can be posted:

temporal constraints require that one step is before another

codesignation constraints requirements that a variable that appears in a pre or postcondition must (not) be bound to a specific constant.

TWEAK constructs a partial plan. The partial plan could be completed in many different ways. We say "necessarily p" if p is true in all completions of a plan, and "possibly p" if p is true in some of the completions of the plan.

Two possibly codesignating propositions can be made to necessarily codesignate by constraining all the corresponding elements of their contents to codesignate, i.e. unification. Two possibly noncodesignating propositions can be made to necessarily not codesignate by choosing some tuple index and adding a noncodesignation constraint to the elements.

TWEAK represets states of the world with situations, which are sets of propositions. A plan has an initial situation and a final situation. Associated with each step in the plan is its input situation, which is the set of propositions that are true in the world just before it is executed, and its output situation, which is the set of propositions that are true in the world just after it is executed.

A step can be executed only if all its preconditions are true in its input situation. In this case, the output situation is just the input situation minus any propositions denied by the step, plus any propositions asserted by the step.

Modal Truth Criterion: A proposition p is necessarily true in a situation s iff two conditions hold: There is a situation t equal or necessarily previous to s in which p is necessarily asserted; and for every step C possibly before s and every proposition q possibly codesignating with p which C denied, there is a step W necessarily between C and s which asserts r, a proposition such that r and p codesignate whenever p and q codesignate. The criterion for possible truth is exactly analogous, with all the modalities switched.

The MTC can be checked in time poly in the number of steps in the plan; the body of the criterion can be verified for each of the n^3 triples $< t, C, W >$ with a fixed set of calls to the poly-time constraint-maintenance module.

TWEAK uses dependency-directed breadth-first search.

Dependency-directed backtracking is more efficient than chronological backtracking only if the search space is nearly decomposable into independent subparts.

Correctness/Completeness Theorem: If TWEAK, given a problem, terminates claiming a solution, the plan it produces does in fact solve the problem. If TWEAK returns signaling failure or does not halt, no solution exists.

First Undecidability Theorem: Any Turing machine with its input can be encoded as a planning problem in the TWEAK representation. Therefore, planning is undecidable, and no upper bound can be put on the amount of time required to solve a problem.

Note this is weak because it assumes infinite # of constants. If there are a finite # then problem can be decidable (Latombe). Actually just shows that the size of the shortest plan to solve a problem may be arbitrarily large, rather than that the process of planning itself is complex.

Sussman Anomaly Example

3 Representation

Action

TWEAK does not allow condition effects or actions that have side-effects.

Intractability Theorem: The problem of determining whether a proposition is necessarily true in a nonlinear plan whose action representation is sufficiently strong to represent conditional actions, dependency of effects on input situations, or derived side-effects is NP-hard.

Weld: This made many planning researchers believe that least commitment planning would not scale to expressive action languages (eg those that allow conditional effects). The flaw is that while determining the MTC for these extended action representations is NP-hard, all a planner needs to do is *ensure* the MTC.

Second Undecidability Theorem Planning is undecidable even with a finite initial situation if the action representation is extended to represent actions whose effects are a function of their situation.

planning cliches: intermediate techniques that are neither completely general, nor completely domain-specific.

Time

He thinks that nonlinear planning is potentially exponentially more efficient than linear planning.

Action with temporal intervals. Vere, DEVISER. McDermott. Allen.

Codesignation Constraints

Tweak can only do = and <>, can't restrict range like Molgen and SIPE can.