SOLUTION NOTES

Artificial Intelligence II 2003 Paper 8 Question 8 (SBH)

This question covers the section of the course devoted to planning algorithms.

1. Describe the *STRIPS* language for representing states, goals, and operators within a planning system. [5 marks]

   Answer:

   States are described as conjunctions of ground literals containing no functions. For example

   $$\text{at(home)} \wedge \neg\text{complete(essay)} \wedge \neg\text{have(book)}$$

   Goals are conjunctions of literals where variables are assumed existentially quantified. For example

   $$\text{at(supervision)} \wedge \text{complete(coursework)}$$

   Operators consist of a description of the action they perform, a precondition for the action to be possible consisting of a conjunction of positive literals, and an effect of the action consisting of a conjunction of literals. For example the action "complete_essay" might have precondition $\text{have(book)} \wedge \text{at(home)}$ and effect complete(essay).

2. Give a definition of a *plan*, a *consistent plan*, and a *complete plan*. [5 marks]

   Answer:

   A plan is a set $\{S_1, S_2, \ldots, S_n\}$ of steps each of which is an operator in the STRIPS language; a set of ordering constraints $S_i < S_j$ which specify that some steps must precede others; a set of variable bindings; and a set of causal links $S_i \rightarrow^c S_j$ specifying that operator S_i has an effect that satisfies precondition c of S_j.

   A complete plan is one for which all the preconditions for all the operators are achieved by a preceding step, and no other step can intervene to cancel a precondition.

   A consistent plan is one with no contradictory ordering constraints and no contradictory variable bindings.

3. Describe the *initial plan* used as a starting point by the partial-order planning algorithm. [5 marks]

   Answer:

   The initial plan contains two special steps called Start and End. These steps have no associated actions. There is one ordering constraint Start $<$ End. There are no variable bindings or causal links. Start has no preconditions and its effects describe the start state for the planning problem. End has no effects and its preconditions describe the goal of the planning problem.

4. Outline the way in which the partial-order planning algorithm constructs a plan beginning with the initial plan. Include in your answer a description of a *threat* along with an explanation of how the algorithm can attempt to remove threats by promotion or demotion. [5 marks]

   Answer:

   Start with the initial plan. At each step introduce a new operator S such that an effect of S satisfies a previously unsatisfied precondition for some other step. Backtrack when necessary.

   Say some step S in a partly constructed plan achieves a precondition c for a step S'. A threat occurs when a newly added step S'' has effect $\neg c$ and under the existing ordering constraints might be capable of canceling the precondition c by being ordered $S < S'' < S'$. The algorithm can attempt to fix this by adding an ordering constraint $S'' < S$ (demotion) or $S' < S$ (promotion).