CIS 730 Artificial Intelligence
CIS 530 Principles of Artificial Intelligence
Fall 2007

Homework 5 of 10: Problem Set (PS5)
Constraints and Logic, Part III:
Decidability, Situational Calculus, and First-Order Planning

Assigned: Wed 10 Oct 2007
Due: Wed 17 Oct 2007 (before midnight)

The purpose of this assignment is to exercise your basic understanding of probabilistic reasoning and apply these concepts to constructing basic graphical models.

This homework assignment is worth a total of 20 points.
Each problem is worth 4 points for CIS 730 students and 7 points for CIS 530 students.
Upload a copy of your solution (scanned or typed) to your K-State drop box before the due date.

Consider the following planning specification

Initial State	Goal State
- At(Home, S_0) - Have($50, S_0) - In-Account(Commerce-Bank, $200, S_0) - Sells(Varney's, *AIMA-2e*) - Costs(Varney's, *AIMA-2e*, $114)[1]	- At(Home, S_{final}) - Have(*AIMA-2e*, S_{final})

1. **(530/730) Classical Planning, Situational Calculus, and the Frame Problem.**

   a) Give a successor state axiom for Have(*AIMA-2e*, S).
   b) Explain how this relates to ADD and DELETE lists in STRIPS planning.
   c) Give an example of the *representational frame problem* in this case.
   d) Write out a set of operator specifications for the specified planning problem. In particular, describe the actions Buy, Go, and Withdraw. Show your work.

2. **(530/730) Partial Order Planning (POP).** Follow the partial-order planning algorithm POP (Ch. 11, R&N 2e) to generate a plan.

   a) Show each partial plan and S_{need}, c after every POP step.
   b) Show how the plan ordering is generated. If a threat arises, show how it is resolved.

   Draw the final plan and show how all preconditions are met starting with the initial state.

3. **(730 only) Robust planning.** Read about robust planning in Chapter 12, R&N 2e, particularly the methodologies listed in Section 12.3, p. 431:

   a) Sensorless planning
   b) Conditional planning

[1] Based on Fall, 2007 prices, retrieved from http://www.shopvarneys.com (http://snipurl.com/1rzpe).
Public service announcement: comparative prices can be found using *MySimon* (http://snipurl.com/1rzpn) and *Textbooks.com* (http://snipurl.com/1rzpm).

c) Monitoring and execution
d) Continual planning

Give one concrete example of **each** of the above using the operator set you defined in problem PS5-1 above, and name one aspect of uncertainty in **each** example. (We will follow up on this in PS7.)

4. (530/730) Decidability.

a) Explain in your own words how Cantor's diagonal argument can be used to demonstrate that $L_{SAT} \in$ co-RE (i.e., it is not recursive enumerable).
b) Then show what this tells us about the other three languages, L_{VALID} and the complementary languages L_{SAT}^{C} and L_{VALID}^{C}.

References:
http://en.wikipedia.org/wiki/Cantor%27s_diagonal_argument
http://snipurl.com/1rzpz - Gödel's First Incompleteness Theorem[2]
http://en.wikipedia.org/wiki/Recursively_enumerable_set

5. (730 only) HTN planning.

a) Develop an HTN specification for Visit-ATM which results in the agent having available cash up to the account balance plus the previous amount
b) Refine the specification by giving an operator for going to the ATM, logging in, and withdrawing cash. What external and internal preconditions does this have?

Class participation (required). Suppose that in PS5-1 and PS5-2, we only have time to go to the ATM once. Explain in your own words how this can be represented using a *threat* and results in a Sussman Anomaly-like problem for non-POP systems. **Hint**: as AIMA indicates, the Sussman Anomaly is a classical problem endemic to non-POP

See the Wikipedia entry on the Sussman Anomaly and Kurt van Lehn's notes:

http://en.wikipedia.org/wiki/Sussman_Anomaly
http://www.pitt.edu/~vanlehn/FoundationsOfAI00/planning3.htm

Post your answer to CIS730-L, along with any questions you have about first-order logic, description logics, unification, resolution theorem proving situational calculus, and the frame problem.

Coming Up Next

Machine Problem 6 (due Fri 26 Oct 2007) – Constraints and Logic, Part IV: More Clausal Form and Prolog with Applications to Planning

Problem Set 7 (due Fri 02 Nov 2007) – Artificial Neural Networks and Probabilistic Reasoning

Machine Problem 8 (due Fri 09 Nov 2007) – Probabilistic Reasoning

Problem Set 9 (due Fri 16 Nov 2007) – Machine Learning

Machine Problem 10 (due Fri 30 Nov 2007) – Term Project Experiment

[2] According to this theorem, the statement that "S $\notin L_{SAT}$" is either true (meaning that L_{SAT} is inconsistent) or false (meaning that it is incomplete). A corollary of this is that if we supposed that $L_{SAT} \in$ RE, we derive a contradiction either way.