CIS 730 Artificial Intelligence
CIS 530 Introduction to Artificial Intelligence

Fall 2013

Homework 3 of 8: Problem Set (PS3)

Games, Constraints, and Logic

Assigned: Sat 14 Sep 2013
Due: Mon 30 Sep 2013 (before midnight)

The purpose of this assignment is to exercise your basic understanding of logic programming and rule-based expert systems through a simple implementation.

This homework assignment is worth a total of 20 points (100%).
Each problem is worth 4 points (20%) for CIS 730 students and 7 points (35%) for CIS 530 students.

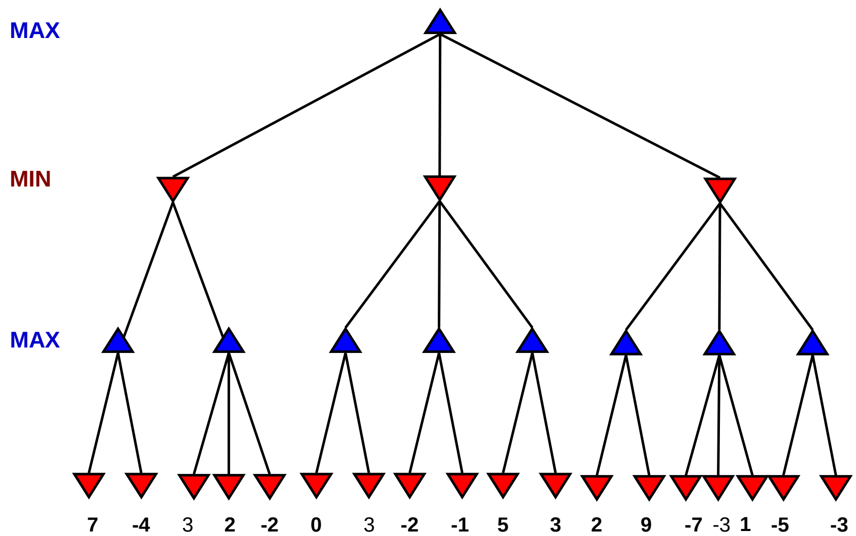
1. **(530/730) Constraint Satisfaction.** Consider the problem of coloring the following provincial map of Armenia with three colors:

a) Show how depth-first search with backtracking and no heuristics first diverges – that is, begins to differ in behavior – from DFS with the *most constrained variable / minimum remaining values (MRV)*. What improvement, if any, does MRV yield?

b) Does LCV help?

c) Does AC-3 have any effect?

2. **(530/730) Game Tree Search.** Solve the following tree using minimax and alpha-beta pruning. Mark what states are pruned (not evaluated) in the latter case.



3. **(730 only) Games.** For the TAC-SCM computer game we looked at in class, why might using a game tree (or expectiminimax tree) not be practical? What can be used instead?

Consider the following planning specification for completing a term project:

Initial State	Goal State
- Want-Project(Proj, S_0) - Topic(Proj, T) - Proposal-Option(T_i), $1 \leq i \leq n = 7$	- Complete(Project, S_{final}) - Works(Project, S_{final}) - Written(Report, S_{final}) - Documents (Report, Project) - ¬Late (Project, S_{final})

4. (530/730) Classical Planning, Situational Calculus, and the Frame Problem.

a) Give successor state axioms for Complete(P, S), Works(P, S), and Written (R, S).
b) Explain how this relates to ADD and DELETE lists in STRIPS planning.
c) Explain what axioms have postconditions Documents (R, P) and Accepted (P). You may assume there is a predicate Instructor-Permission (P) indicating that a project with special topic $T \notin \{T_1, T_2, \ldots, T_n\}$, where *n* is the number of topics to choose from (7 in fall, 2013), has been given special instructor permission.
d) Write out the following operator specifications for the specified planning problem: Propose, Implement, Write. Show your work.

5. (530/730) Hierarchical Decomposition Partial Order Planning (HD-POP). Follow the partial-order planning algorithm POP (Ch. 10, R&N 3[e], especially regression-based planning in Section 10.2.2 and GRAPHPLAN in Figure 10.9) to generate a plan using the operators:

Propose, Implement, Write

a) Define the action Prepare with postcondition Researched that is a precondition of both Implement and Write. Give a partial-order plan that takes into account this dependency. Show each partial plan and S_{need}, *c* after every POP step.
b) Refine the Implement operator down to steps Code, Test, and Collect-Results. What are the postconditions at each step? Which exact sub-operator in this hierarchical plan has Researched as a precondition and which one has the precondition of Write as a postcondition? (You must specify this postcondition as a new predicate.)

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

6. (730 only) Robust planning. Read about robust planning in Chapter 11, R&N 3[e] particularly the methodologies listed in Section 11.3, p. 415:

a) Sensorless planning
b) Conditional planning
c) Monitoring and execution
d) Continual planning

You may define new operators (**with associated pre/postconditions**) such as: Find-Partial-Code, Request-Change-of-Project

Give one concrete example of **each** of the above using the operator set you defined in problem PS3-1 above, and name one aspect of uncertainty in **each** example. (We will follow up on this in PS5.)

7. (730 only) 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[1]
http://en.wikipedia.org/wiki/Recursively_enumerable_set

Extra Credit (optional)

Draw an illustration of a graph search problem using an *admissible but not monotonic* heuristic that explores more nodes than the monotonic version induced by pathmax. Show the path found and the nodes expanded in each case.

Class Participation (required)

After going over your **Read And Explain Pairs** exercise with your assigned partner, post a short paragraph summarizing *unification* and a second containing any questions you may have on search to the KSOL discussion board for this problem set. That is, ask questions about any knowledge representation topic for which your understanding is unclear. This includes propositional logic, first-order logic, description logic, or theorem proving (forward and backward chaining, resolution strategies)

Midterm Exam Review

A review guide will be posted next Saturday (21 Sep 2013) with examples not in PS3.

Term Project Interim Reports

Submit a short interim report as specified in class the week of Mon 21 Oct 2013 and attend office hours.

[1] 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.