Midterm Solutions

CPSC 322 Lecture 21

March 3, 2006

Midterm Grades

- Mean: 63%
- Median: 67%
- Histogram:
  - A+: 2
  - A: 3
  - A-: 7
  - B+: 4
  - B: 5
  - B-: 7
  - C+: 7
  - C: 2
  - C-: 5
  - D: 4
  - F: 15

My offer to you...

- Beat your midterm grade on the final, and I'll count your final grade as your midterm grade.

True/False

(a). DFS is complete when the graph being searched is finite.
Answer: False: the graph can still have cycles.

(b). The time complexity of a dynamic programming solution to a graph search problem is polynomial in the size of the graph.
Answer: True.

(c). Deleting values from the domains of CSP variables that prevent the constraint graph from being arc consistent can never rule out any models of the CSP.
Answer: True.

(d). Forward planning and regression planning search the same state space.
Answer: False: in forward planning states correspond to complete assignments to variables; in regression planning states correspond to partial assignments.

Short Answers – 1

(What is AI?) In class, four definitions of AI were given. It was argued that that AI should be defined as "systems that act rationally." Name two other definitions of AI that were discussed in class, and in no more than two sentences per definition, explain why the "acting rationally" definition is to be preferred.

Answer:

1. Thinking humanly: humans are not always themselves intelligent. Also, the study of how to think humanly turns into a study of humans, rather than a study of thinking.
2. Acting humanly: humans often do dumb, irrational or idiosyncratic things.
3. Thinking rationally: this requires us to characterize what rational thought is. Philosophy has been struggling with this issue for centuries.

Short Answers – 1

(Search) What node(s) is/are in the frontier of a depth-first search? Where b is the maximum branching factor and d is the maximum depth of the search, characterize the maximum size of a DFS frontier.

Answer: In a DFS, the frontier contains every child of the one single node expanded at each level of the tree. Thus, the frontier contains a maximum of bd nodes.

(Search) Can a heuristic function still be used by A* to find an optimal solution in a case where the search problem does not involve costs? Why or why not?

Answer: No, because the heuristic function is an estimate of the cost of getting from the start state to a goal state. When there are no costs, there's nothing to estimate. Note that if you answered that the heuristic function can define the number of steps to the goal, you're just supplying a cost function.

Short Answers – 2

(Search) Is the max of two admissible heuristics also admissible? Why or why not?

Answer: Yes, the max of two admissible heuristics is itself admissible, because each of the two heuristics is guaranteed to underestimate the distance from the given node to the goal, and so therefore must their max.

(CSPs) State the condition under which an arc $\langle X, r(X, \bar{Y}) \rangle$ is arc consistent.

Answer: An arc $\langle X, r(X, \bar{Y}) \rangle$ is arc consistent if for each value of X in the domain of X there is some value for $\bar{Y}$ from its domain (i.e., a value for each of the variables in $\bar{Y}$ from each of their domains) such that the constraint $r(X, \bar{Y})$ is satisfied.

Short Answers – 2

(CSPs) What is the state space of local search for a CSP?
Answer: It is the space of complete assignments to the variables of the CSP.

(CSPs) Define a plateau. Why are plateaus a problem for local search?
Answer: A plateau is a set of neighbouring states in which the scoring function is the same. It is a problem for local search because hill-climbing is impossible: many or all neighbours score the same, and so if scoring function is used as a basis for choosing neighbours, the search can cycle.

Short Answers – 3

(Planning) What is a frame rule?
Answer: It is a rule in the representation of a planning problem which specifies the conditions under which a variable maintains its value from one time step to the next.

(Planning) Explain the role of the horizon in CSP planning. How does the choice of horizon affect the behavior of the planner?
Answer: In order to represent a plan as a CSP, we need to commit to a maximal length for the plan. This length is called the horizon. If the horizon is too short, the planner will not be able to find a plan, even though the planning problem is not impossible. Having a larger horizon than necessary will make the planning problem take much longer to solve.

Short Answers – 3

(Planning) Consider a regression planner which uses STRIPS, and where the current node is given by $[X_1 = v_1, \ldots, X_n = v_n]$. Explain when an arc labeled by action A exists to another node N. (This may take more than two sentences.)

Answer: There are three conditions that must hold:

- There exists some i for which $X_i = v_i$ is on the effects list of action A
- For all j where X_j is part of the current state, $X_j = v'_j$ is not on the effects list for A with $v'_j \neq v_j$
- N is $preconditions(A) \cup \{X_k = v_k : X_k = v_k \notin effects(A)\}$ and N is consistent in that it does not assign multiple values to any one variable.

Branch and Bound

Define optimal efficiency as expanding the minimal number of nodes n for which $f(n) \neq f^*$, where f^* is the cost of the shortest path. Prove or disprove the following statement: Branch and bound search is optimally efficient. Hint: you can refer to results proven in class without re-proving them.

Answer: Branch and bound is not optimally efficient. We know that A* is optimally efficient under the definition considering the number of nodes for which $f(n) < f^*$; since A^* expands no nodes with $f(n) > f^*$, it is also optimally efficient under this definition. Thus, we just need to show that branch and bound can expand a node with $f \neq f^*$ which is not expanded by A*. Consider the situation in which the first goal node found by branch and bound does not have a cost of f^*. Since A* only finds a single goal node, it does not expand this node.

CSP Representation

Consider the problem of designing a schedule for a hockey league with eight teams. Games happen every Sunday for seven weeks in a row. Each team must play each other team once; at least three of the games must be home games and at least three must be away games. No more than two games in a row may be home games. The Vancouver team (team #1) must play its first game at home and the Toronto team (team #8) must play its last game at home. Use the following variables: $p(i,t) \in \{1,\ldots,8\}$ indicates which team is played by team i on week t; $h(i,t) \in \{0,1\}$ indicates whether team i is at home on week t. Describe the constraints needed to represent this problem as a CSP. Constraints should be specified as logical tests (i.e., you do not need to enumerate them); if you want to indicate that a constraint applies to all teams (for example), you can write "for all i `<constraint involving` i`>`".

CSP Representation

1. for all i, for all t, $p(i,t) \neq i$. ("teams never play themselves.)
2. for all i, for all $t' \neq t$, $p(i,t') \neq p(i,t)$. ("team i doesn't play the same team twice.")
3. for all i, $p(i,t) = p(p(i,t),t) = i$. ("if i plays j, then j plays i.")
4. $h(i,t) = 1 - h(p(i,t),t)$. ("if i is at home then their opponent is away, and vice versa.")
5. for all $t \in \{3, \ldots, 8\}$, if $h(i,t-1) = 1$ and $h(i,t-2) = 1$ then $h(i,t) = 0$. ("no more than two home games in a row for i.")
6. for all i, $3 \leq \sum_{k=1}^{8} h(i,k) \leq 4$. ("number of home games for i is between 3 and 4".)
7. $h_{1,1} = 1$. ("Vancouver's first game is at home")
8. $h_{8,7} = 1$. ("Toronto's last game is at home.")