

CS 540: Introduction to Artificial Intelligence

Midterm Exam: 7:15-9:15 pm, October 22, 2014
Room 1240 CS Building

CLOSED BOOK
(one sheet of notes and a calculator allowed)

Write your answers on these pages and show your work. If you feel that a question is not fully specified, state any assumptions you need to make in order to solve the problem. You may use the backs of these sheets for scratch work.

Write your name on this page and initial all other pages of this exam (in case a page comes loose during grading). Make sure your exam contains *seven* problems on *nine* pages.

Name _____

Student ID _____

<u>Problem</u>	<u>Score</u>	<u>Max Score</u>
1	_____	20
2	_____	15
3	_____	12
4	_____	14
5	_____	20
6	_____	9
7	_____	10
TOTAL	_____	100

Problem 1 – Decision Trees (20 points)

Assume that you are given the set of labeled *training examples* below, where each feature has three possible values *a*, *b*, or *c*. You choose to learn a decision tree and select “-” as the default output if there are ties.

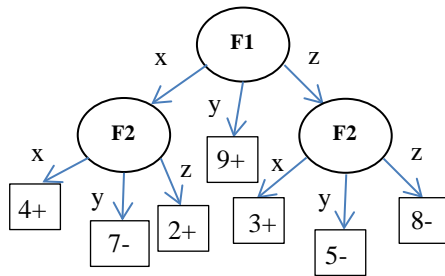
<i>F1</i>	<i>F2</i>	<i>Output</i>
<i>b</i>	<i>b</i>	+
<i>b</i>	<i>c</i>	+
<i>c</i>	<i>a</i>	+
<i>c</i>	<i>b</i>	-
<i>b</i>	<i>a</i>	-
<i>c</i>	<i>c</i>	-

- a) What score would the *information gain* calculation assign to each of the features?
Be sure to show all your work (use the back of this or the previous sheet if needed).

- b) Which feature would be chosen as the root of the decision tree being built? _____
 (Break ties in favor of *F1* over *F2*.)

Initials: _____

- c) Consider the following learned tree and TUNE set. The numbers in the leaves represent the number of TRAIN examples reaching that leaf.



<u>F1</u>	<u>F2</u>	<u>Output</u>
y	x	+
z	y	+
x	z	+
y	z	-
z	z	-

Using the decision-tree pruning algorithm presented in class, draw and score all the possible pruned versions of the above learned tree and circle the best tree found after the first cycle of the pruning algorithm.

- d) Circle the search strategy used when creating a decision tree that fits the TRAIN set.
- i) A* ii) breadth-first search iii) depth-first search iv) hill climbing
- e) Circle the search strategy used when pruning the learned tree using the TUNE set.
- i) A* ii) breadth-first search iii) depth-first search iv) hill climbing

Problem 2 – Search (15 points)

Consider the search space below, where S is the start node and $G1$ and $G2$ satisfy the goal test. Arcs are labeled with the cost of traversing them and the estimated cost to a goal is reported inside nodes.

For each of the following search strategies, indicate which goal state is reached (if any) and list, *in order*, all the states *popped off of the OPEN list*. When all else is equal, nodes should be removed from OPEN in alphabetical order.

You can show your work (for cases of partial credit), using the notation presented in class, on the back of the previous page.

Best-first search (using $f=h$)

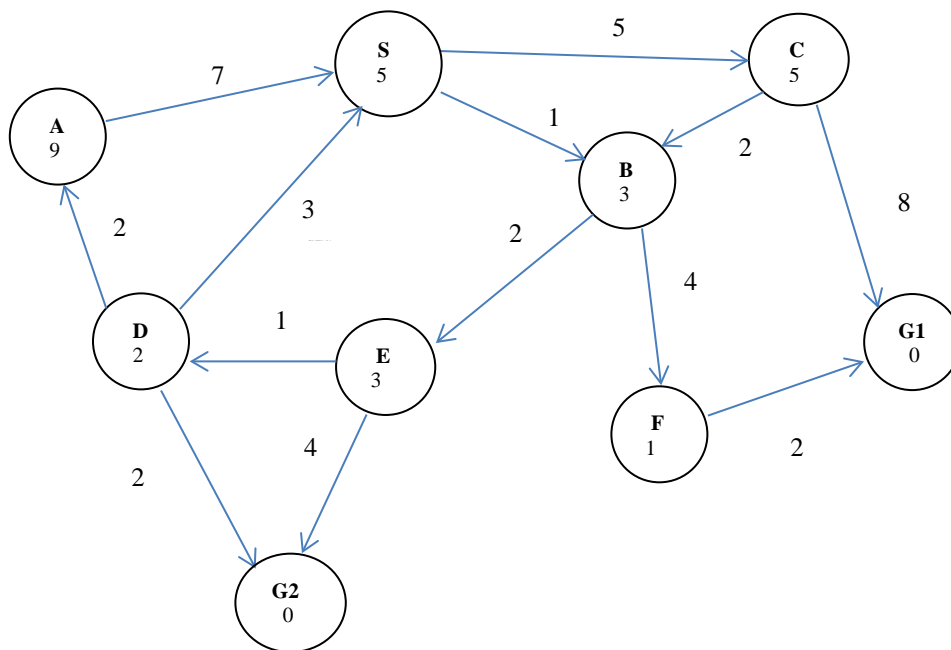
Goal state reached: _____ States popped off OPEN: _____

Iterative Deepening

Goal state reached: _____ States popped off OPEN: _____

A* ($f = g + h$)

Goal state reached: _____ States popped off OPEN: _____



Problem 3 – Expected-Value Calculations (12 points)

- a) Imagine that we are playing a game involving a pair of fair, six-sided dice. It costs \$1 to play the game and one shakes then throws the dice once. The payoff is as follows:

If the values of the two dice are different, you win nothing.

If the values of the two dice are the same, you win in dollars the number on the dice.
(E.g., if you shake a pair of 6's, you win \$6.)

Assume you only have \$1 in your pocket and you play this game once. After playing it once, what is the expected amount of money you will have? Show your work (you should lump together the calculations for the 30 dice rolls where you win nothing).

- b) Which of these functions involve an (explicit) expected-value calculation?

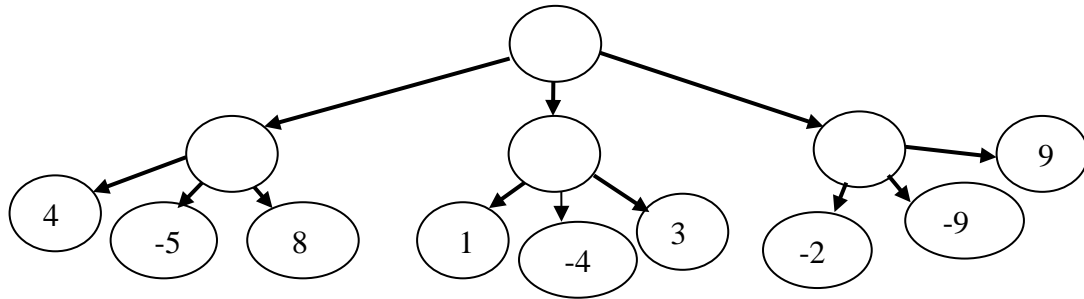
It is fine to circle none or more than one.

- i) *crossover*
- ii) *informationNeeded* (called the *B* function in the textbook)
- iii) *simulated annealing*
- iv) *remainder* (i.e., *informationStillRemaining*)

Problem 4 – Game Playing (14 points)

- a) Apply the *mini-max* algorithm to the partial game tree below, where it is the **maximizer's** turn to play and the game does not involve randomness. The values estimated by the static-board evaluator (SBE) are indicated in the leaf nodes (higher scores are better for the maximizer).

Write the estimated values of the intermediate nodes inside their circles and indicate the proper move of the maximizer by circling one of the root's outgoing arcs.



- b) List one leaf node (if any) in the above game tree whose SBE score need not be computed: _____
 Explain why:

- c) Circle the one answer below that you feel is the *most* correct.
- Minimax and alpha-beta pruning always return the same choice of move; the advantage of alpha-beta pruning is that it usually uses many fewer cpu cycles.
 - The *horizon effect* occurs because we can only search a finite number of moves ahead and might not reach board configurations where the game ends.
 - Using the mini-max algorithm to choose moves means our game-playing algorithm cannot take advantage of poor moves by the opponent.

Problem 5 – Multiple-Choice Questions (20 points)

For each question, circle your answer(s). Unless stated otherwise, choose the one *best* answer.

- a) Even if we use a beam width of 1 and the same tie-breaking procedure, beam search and hill climbing can return different answers. **TRUE FALSE**
- b) If we have an *admissible* heuristic function, then when a node is expanded and placed in CLOSED, we have always reached it via the shortest possible path. **TRUE FALSE**
- c) Which of these is not an *ensemble* method for supervised learning:
 i) bagging ii) boosting iii) broadening
- d) Chi-squared (χ^2) pruning is a method for (ok to circle none or more than one):
 i) game playing ii) overfitting reduction iii) reducing size of OPEN
- e) If all arcs in a search task cost \$7, then uniform-cost search and breadth-first search will definitely produce the same solution: **TRUE FALSE**
- f) Which of the following is/are of central importance for genetic algorithms (ok to circle none or more than one):
 i) admissibility ii) cross over iii) fitness-proportion reproduction
- g) For small datasets, it is acceptable to skip using a TUNING set and instead use the TESTING set to select good parameter settings. **TRUE FALSE**
- h) If best-first search finds some goal node in finite time, then depth-first search will also find a goal node in finite time. **TRUE FALSE**
- i) If depth-first search finds some goal node in finite time, then beam search will also find a goal node in finite time. **TRUE FALSE**
- j) Which of the following is most similar to *simulated annealing*:
 i) cross over ii) decision-tree pruning iii) iterative deepening

Problem 6 – Key AI Concepts (9 points)

Briefly describe each of the following AI concepts and explain each's significance.
(Write your answers *below* the phrases and clearly separate your description and significance.)

Test sets

description:

significance:

Fixed-length feature vectors

description:

significance:

Random restarts

description:

significance:

Problem 7 – Miscellaneous Questions (10 points)

- a) The search algorithm A^* does not terminate until a goal node is removed from the OPEN list. That goal state may have been in the OPEN list for millions of node expansions, which seems inefficient. Why not terminate A^* as soon as a goal node is added to OPEN?

Justify your answer with a simple, concrete example that shows doing so would violate an important property of A^* . Be sure to explain your example, including which important property of A^* is violated. (Don't use more than four nodes in your answer.)

- b) Imagine that the simulated-annealing algorithm is at node A and has randomly chosen node B as the candidate next state. Assume the temperature equals 7, the heuristic score of A is 5, and of B is 3 (higher heuristic scores are better). What is the probability that node B will be accepted as the next state?

Answer: _____