

# CS 540: Introduction to Artificial Intelligence

Midterm Exam: 5:30-7:30 pm, October 22, 2015  
Beatles Room at Epic

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 *eight* problems on *ten* pages.

Name \_\_\_\_\_

Student ID \_\_\_\_\_

<u>Problem</u>	<u>Score</u>	<u>Max Score</u>
1	_____	20
2	_____	15
3	_____	8
4	_____	12
5	_____	18
6	_____	9
7	_____	9
8	_____	9
TOTAL	_____	100

## Problem 1 – Decision Trees (20 points)

Assume that you are given the set of labeled *training examples* below, where each feature is binary valued and a ‘name’ field is included for convenience. You choose to learn a decision tree and select ‘+’ as the default output if there are ties.

Name	F1	F2	F3	Output
<i>Ex1</i>	<i>T</i>	<i>F</i>	<i>T</i>	+
<i>Ex2</i>	<i>T</i>	<i>F</i>	<i>T</i>	+
<i>Ex3</i>	<i>F</i>	<i>T</i>	<i>T</i>	+
<i>Ex4</i>	<i>T</i>	<i>T</i>	<i>F</i>	+
<i>Ex5</i>	<i>T</i>	<i>T</i>	<i>T</i>	-
<i>Ex6</i>	<i>F</i>	<i>F</i>	<i>T</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* over *F3*, i.e., in alphabetic order.)

Initials: \_\_\_\_\_

- c) In *bagging*, one creates copies of the training set by uniformly drawing with replacement. Show a possible copy below; be sure to explain your work. Just show the examples' NAMES for simplicity.

Assume you have a six-sided die that you use in this process and that the first dozen tosses of this die produce these numbers in this left-to-right order: 5, 6, 1, 4, 3, 6, 1, 5, 2, 2, 5, 3.

- d) Your friend Ida Smart suggests

We should add the following feature to our dataset:  
*the number of the first three features that have value T*

Describe below what the 'real' ID3 would do with this numeric feature, including showing information-gain calculations. Even though this new feature has a small number of different values, you need to treat it like a numeric-valued feature. (You only need to discuss what ID3 would do on the *first* call to it; you need not show recursive steps, if any.)

Does your answer to *Part (b)* change? \_\_\_\_\_

Why or why not?

**Copied for your convenience:**

Name	F1	F2	F3	Output
Ex1	T	F	T	+
Ex2	T	F	T	+
Ex3	F	T	T	+
Ex4	T	T	F	+
Ex5	T	T	T	-
Ex6	F	F	T	-

## 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 (so lower is better) 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.

### Hill-climbing

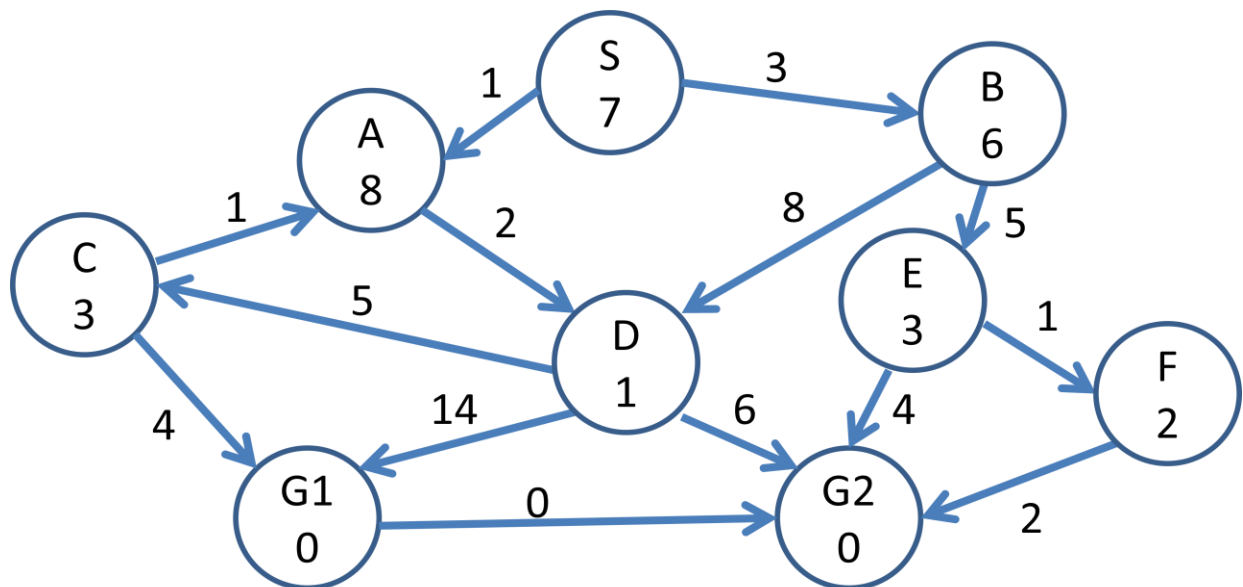
Goal state reached: \_\_\_\_\_ States popped off OPEN: \_\_\_\_\_

### Iterative Deepening

Goal state reached: \_\_\_\_\_ States popped off OPEN: \_\_\_\_\_

### A\* ( $f = g + h$ )

Goal state reached: \_\_\_\_\_ States popped off OPEN: \_\_\_\_\_



### Problem 3 – Probabilistic Reasoning (8 points)

Using the probability table below, answer the following questions. Write your numeric answer on the line provided and show your work in the space below each question.

a)  $\text{Prob}(A=\text{true} \wedge B=\text{true})$  ? \_\_\_\_\_

b)  $\text{Prob}(A=\text{false})$  ? \_\_\_\_\_

c)  $\text{Prob}(A=\text{true} \vee C = \text{true})$  ? \_\_\_\_\_

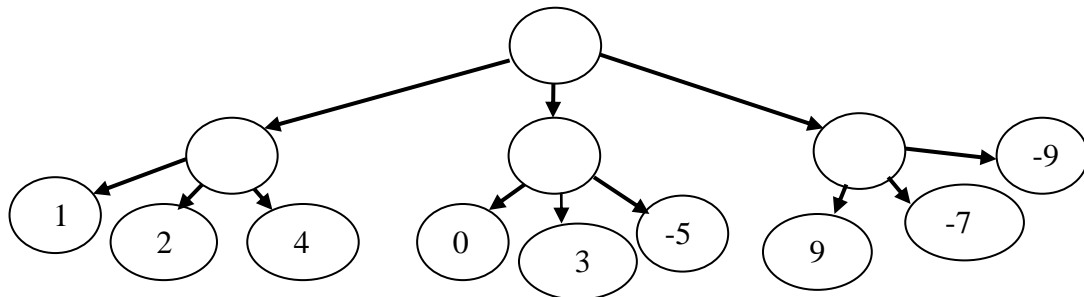
d)  $\text{Prob}(B = \text{false} \wedge C=\text{true} \mid A=\text{false})$  ? \_\_\_\_\_

A	B	C	Prob
false	false	false	0.01
false	false	true	0.20
false	true	false	0.15
false	true	true	0.04
true	false	false	0.25
true	false	true	0.10
true	true	false	0.18
true	true	true	0.07

### Problem 4 – Game Playing (12 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. Process this game tree working left-to-right.



- b) List the first leaf node (if any) in the above game tree whose SBE score need not be computed: *the node whose score =* \_\_\_\_\_

Explain why:

- c) Assume we wanted to create software that that solves *one*- player games that do not involve randomness. Which of the following algorithms would be the best to include in your solution? Circle one and briefly explain your answer.

- i. Alpha-beta Pruning
- ii. Fitness Slicing
- iii. Iterative Deepening

## Problem 5 – Multiple-Choice Questions (18 points)

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

- a) Simulated Annealing never makes ‘downhill’ (i.e., bad) moves unless at a local maximum. **TRUE FALSE**
- b) If we have an *admissible* heuristic function, then when a goal node is expanded and placed in CLOSED, we have always reached it via the shortest possible path. **TRUE FALSE**
- c) If BFS finds a solution, is A\* guaranteed to find a solution as well? **YES NO**
- d) *Beam search* suffers from the *overfitting* problem. **TRUE FALSE**
- e) Which of the following are true about using *tune sets* (ok to circle none or more than one):
- i) they are likely to produce models with worse accuracy on the *train set*
  - ii) they are likely to produce models with better accuracy on the *test set*
  - iii) they are not needed in the *k-NN* algorithm
- f) The ID3 pruning algorithm searches *feature space*. **TRUE FALSE**
- g) Circle (zero or more) correct completions to the following:  
*Minimax and alpha-beta pruning will always choose the same move*
- i) *if the number of nodes considered is the same for the two algorithms.*
  - ii) *if the maximum lookahead depth is the same for the two algorithms.*
  - iii) *if neither ever needs to call the SBE.*
- h)  $Prob(A / B)$  is always larger than  $\min(Prob(A), Prob(B))$ . **TRUE FALSE**
- i) *Joint probabilities* result from making independence assumptions. **TRUE FALSE**

## Problem 6 – Key AI Concepts (9 points)

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

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### *Fitness-proportional Reproduction*

description:

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significance:

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### *Parameter Tuning*

description:

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significance:

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### *The Coming Singularity*

description:

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significance:

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### Problem 7 – Miscellaneous Questions (9 points)

- a) Consider the following game. You spend your last \$10 to play. How much money do you expect to have after playing the game? Show your work.

First, you flip a fair coin.

If heads, you flip the fair coin again.

If the second flip of the coin comes up heads you win \$5 otherwise you win nothing.

If tails, 1% of the time you win \$100 else you win \$10.

- b) For each of the search algorithms below, briefly provide one strength and one weakness compared to *breadth-first search*. No need to explain your answers.

i.  $A^*$

Strength: \_\_\_\_\_

Weakness: \_\_\_\_\_

ii. *Beam search*

Strength: \_\_\_\_\_

Weakness: \_\_\_\_\_

**Problem 8 – More Miscellaneous Questions (9 points)**

- a) Is it accurate to view Uniform Cost Search as a special case of the A\* algorithm? \_\_\_\_\_  
Justify your answer below.
- b) Assume Entity A = 100010 and Entity B = 010101 are crossed over to form two children in a genetic algorithm. Show two possible children and explain your answer by illustrating the process of generating them via cross over.
- c) Draw a search space where heuristic search (i.e.,  $f=h$ ) finds a different answer than A\* (i.e.,  $f=g+h$ , where  $h$  is admissible). Use no more than four nodes and explain your answer.