# CSE 415 Midterm exam

Yuchen Wang

TOTAL POINTS

**71 / 100**

QUESTION 1

## DFS, BFS, and IDDFS 18 pts

### 1.1 (a) (i) BFS 2 / 4

✓ **- 1 pts Missing Ordering SABCG**

✓ **- 1 pts Missing Ordering SBACG**

**- 1 pts** Missing Ordering SABG

**- 1 pts** Missing Ordering SBAG

**- 0 pts** Listed all required state visitations orderings

### 1.2 (a) (ii) DFS 2 / 4

✓ **- 1 pts Missing ordering SABCG**

✓ **- 1 pts Missing ordering SBCG**

**- 1 pts** Missing ordering SABG

**- 1 pts** Missing ordering SBG

**- 0 pts** Listed all required state visitations orderings

### 1.3 (b) True or False 8 / 10

✓ **- 2 pts (i) False**

**- 2 pts** (ii) False

**- 2 pts** (iii) False

**- 2 pts** (iv) True

**- 2 pts** (v) False

**- 0 pts** Correct

QUESTION 2

## State Spaces and The Combinatorial Explosion 18 pts

### 2.1 State for Farmer Fox; initial state 3 / 4

**- 2 pts** Part (i) not specific for Farmer-Fox-Chicken-Grain.

**- 0 pts** Correct

**- 1 pts** Part (ii) does not give a state representation in the sense of the course.

**- 2 pts** Initial state not given or not correct.

**- 2 pts** Part (i): You are addressing the question of goal state, not WHAT A STATE SHOULD REPRESENT.

✓ **- 1 pts Right idea but vague compared with full-scoring answers.**

**- 0 pts** Click here to replace this description.

**- 2 pts** Part (i) You are answering a different question.

**- 1 pts** Part (i) not quite correctly stated.

**- 1 pts** Part (ii) Need to give a sample state rep. rather than an English description.

### 2.2 TOH successors 0 / 3

**- 0 pts** Correct

**- 2 pts** Successors must be states, not operators.

**- 1 pts** There are some illegal items listed here as successors.

✓ **- 3 pts incorrect**

**- 2 pts** Partially correct.

**- 1 pts** Mostly correct.

### 2.3 TOH State-space size 0 / 1

**- 0 pts** Correct

✓ **- 1 pts incorrect**

### 2.4 (c) (i) TTS number of states after 1 move 1 / 1

✓ **- 0 pts Correct**

**- 1 pts** Incorrect

### 2.5 (c) (ii) after 2 moves 1 / 1

✓ **- 0 pts Correct**

**- 1 pts** Incorrect

**- 1 pts** Need to divide by 2 since W can place the 2 pieces in 2 different orders but end up in the same state.

### 2.6 (c) (iii) after 3 moves 0 / 1

- **0 pts** Correct
- **1 pts** Incorrect

✓ **- 1 pts Need to divide by 2 since W can make the 2 moves in either order but arrive at the same state.**

### 2.7 (c) (iv) after 4 moves 0 / 1

- **0 pts** Correct

✓ **- 1 pts Incorrect**

### 2.8 (d) (i) node visitations for iteration with cutoff 0 1 / 1

✓ **- 0 pts Correct**

- **1 pts** Incorrect

### 2.9 (d) (ii) cutoff 1 1 / 1

✓ **- 0 pts Correct**

- **1 pts** Incorrect

### 2.10 (d) (iii) cutoff 2 1 / 1

✓ **- 0 pts Correct**

- **1 pts** Incorrect

### 2.11 (d) (iv) cutoff depth 3 1 / 1

✓ **- 0 pts Correct**

- **1 pts** Incorrect

### 2.12 (d) (v) total node visitations 1 / 1

✓ **- 0 pts Correct**

- **1 pts** Incorrect

### 2.13 (d) (vi) Why is repeated work OK? 1 / 1

✓ **- 0 pts Correct**

- **1 pts** Incorrect

QUESTION 3

## Minimax and Alpha-Beta 16 pts

### 3.1 Minimax 10 / 10

✓ **- 0 pts Correct**

- **2 pts** a incorrect (should be 5)
- **2 pts** b incorrect (should be 7)
- **2 pts** c incorrect (should be 5)
- **2 pts** d incorrect (should be 8)
- **2 pts** e incorrect (should be 3)

### 3.2 Alpha-beta 2 / 2

✓ **- 0 pts Correct**

- **2 pts** Did not mark an edge (should have marked the edge to the 3 leaf node)
- **2 pts** Marked one or more edges other than the 3 leaf node

### 3.3 Alpha-beta rearrange three 2 / 2

✓ **- 0 pts Correct**

- **2 pts** Did not put the 8 first (the order of the others doesn't matter)
- **2 pts** No answer

### 3.4 Alpha-beta rearrange children of root 2 / 2

✓ **- 0 pts Correct**

- **2 pts** Did not put the c subtree first (the order of the rest doesn't matter if b.ii was correct)
- **2 pts** No answer

QUESTION 4

## Expectimax Search 18 pts

### 4.1 Agent A 7 / 7

✓ **- 0 pts Correct**

- **4 pts** Incorrect expectation node
- **3 pts** Incorrect max node

### 4.2 Agent B 3 / 7

- **0 pts** Correct

✓ **- 4 pts Expectations Incorrect**

- **2 pts** Expectations Partially correct
- **2 pts** Bottom max nodes Incorrect
- **1 pts** Top max node incorrect

### 4.3 Agent C 0 / 4

- **0 pts** Correct

✓ **- 4 pts Incorrect**

QUESTION 5

## MDP Properties and Discounted Future Rewards 14 pts

### 5.1 Maximum total reward from B 3 / 3

✓ **- 0 pts** Correct

**- 2 pts** No work shown, final result is wrong

**- 1 pts** work shown but final result is wrong

**- 3 pts** No answer

### 5.2 Maximum weighted total rewards 7 / 7

✓ **- 0 pts** Correct

**- 7 pts** no work is shown, answer is wrong

**- 6 pts** attempted to solve, answer is wrong

**- 3 pts** solution partially correct, final answer is wrong

**- 5 pts** partially correct attempt to solve- work shown for only of the states - final answer is wrong

**- 1 pts** one item wrong final answer

**- 2 pts** two items wrong final answer

**- 7 pts** no answer provided

**+ 1 pts** one of the items is correct

**- 4 pts** final answers wrong, solution partly on the right track

### 5.3 Expected total discounted reward 0 / 4

**- 0 pts** Correct

**- 4 pts** wrong answer

**- 2 pts** Attempted to solve, wrong final answer

✓ **- 4 pts** No answer provided

**- 1 pts** partially correct, final answer is not correct

QUESTION 6

## Admissible Heuristics and Dominance 16 pts

### 6.1 (a) (i) Maze -- Euclidean distance heuristic 4 / 4

✓ **- 0 pts** Correct

**- 4 pts** no answer :(

**- 1 pts** but why?

### 6.2 (a) (ii) Maze -- Manhattan distance heuristic 4 / 4

✓ **- 0 pts** Correct

**- 1 pts** but why?

**- 2 pts** it is admissible, but not for that reason

**- 4 pts** it is admissible

### 6.3 (a) (iii) which will be more efficient 4 / 4

✓ **- 0 pts** Correct

**- 4 pts** manhattan is preferable because it is also admissible and dominates the euclidean heuristic

**- 4 pts** no answer :(

**- 1 pts** but why?

**- 0.5 pts** it's superior bc it dominates euclidean

**- 1 pts** manhattan is preferable but not for the reason given

### 6.4 (b) Are dominating heuristics always better? 0 / 4

**- 0 pts** Correct

**- 4 pts** no answer :(

**- 0.5 pts** h_j could be far more computationally expensive than h_i

**- 4 pts** argument doesn't make sense/apply

**- 4 Point adjustment**

we always want to avoid expanding nodes/unnecessary computation

Name (Last name, first name (as in your registration)): Yu chen Wang

# CSE 415–Winter 2019 — Midterm Exam

by the Staff of CSE 415, Winter 2019

**INSTRUCTIONS:** Read these instructions carefully. Write your full name at the top of this cover page, last name first. Make sure you have all 7 pages.

Write your UW student number and your UWNetID where shown below.

Put your answers within the spaces provided in the questions. Write legibly and if you use a pencil, make sure that you write darkly enough that a normal scanner will pick up your writing. If you need more space, use the margins. Do all problems. This is a CLOSED-BOOK, CLOSED-NOTES examination. Do not use any books, notes, calculators, or other electronic devices. There are six problems worth a total of 100 points. Each problem has multiple parts, and the allocations of points among the parts are as shown on each individual problem. Note that some problems may be significantly easier or more time-consuming than others. However, the overall time to complete the exam is estimated to be 40 minutes for a student familiar with the material.

**POLICY ON QUESTIONS AND CLARIFICATIONS:** Do not ask questions during the exam. Instead, if you find one of the exam problems to be ambiguous or unclear, state your objection here on the cover page, clearly identifying the problem number and part number, as well as describing your issue (and continue in the margin on the page of the problem, if necessary). If your objection is accepted by the grader, then points may be adjusted in your score.

| | |
|---|---|
| UW Student Number: | 182672P |
| UWNetID | markP6 |

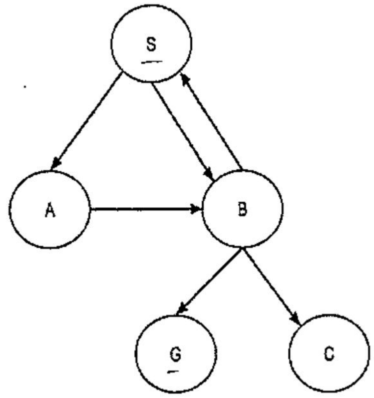



Figure 1: Graph for Question 1. Nodes S is the start node and node G is the goal node.

# 1 (18 points) DFS, BFS, and IDDFS (by Divye)

(a) Give all possible orderings of state visitations (in figure 2), when looking for the goal node G from S.

Note: The ordering of state visitations can change depending on which successor you visit first.

(i) (4 points) BFS: SABG SBAG SABC SBAC

(ii) (4 points) DFS: SABG ~~SBG~~ SABC SBG SBC

(b) (10 points) Answer True or False

(i) BFS will always return the optimal path where all edges have varied cost: True

(ii) BFS will always find the goal state faster (in terms of state visitations) than DFS: False

(iii) DFS will always return the optimal path where all edges have the same cost: False

(iv) IDDFS will always return the optimal path where all edges have the same cost: True

(v) DFS will always visit more nodes than BFS if the goal state is at a shallow depth in an otherwise deep tree: False

## 2 (18 points) State Spaces and The Combinatorial Explosion (by Steve)

(a) (i) (2 points) Describe what a state for the Farmer-Fox-Chicken-Grain has to represent, and (ii) (2 points) give a possible representation for its initial state.

(i) [Ffcg] F → farmer c → chicken we can ~~represent~~ left bank state
f → fox g → grain and infer right bank state. (ii) [Ffcg]

(b) Generating successors. (i) (3 points) For this 4-disk Towers-of-Hanoi puzzle state, [[1],[2],[3,4]] list the successors in the same order that they would be generated by trying all the operators in order:

- $\phi_0$: Move a disk from peg 1 to peg 2
- $\phi_1$: Move a disk from peg 1 to peg 3
- $\phi_2$: Move a disk from peg 2 to peg 1
- $\phi_3$: Move a disk from peg 2 to peg 3
- $\phi_4$: Move a disk from peg 3 to peg 1
- $\phi_5$: Move a disk from peg 3 to peg 2

(ii) (1 point) How large is the state space for this puzzle?

(c) (4 points) Combinatorial explosion.

For a game of Toro-Tile Straight on an $n$-by-$n$ board with no forbidden squares and $k > 3$, give expressions for the numbers of distinct states:

(i) after exactly 1 move. $n^2$
(ii) after exactly 2 moves. $n^2(n^2-1)$
(iii) after exactly 3 moves. $n^2(n^2-1)(n^2-2)$
(iv) after exactly 4 moves. $n^2(n^2-1)(n^2-2)(n^2-3)$

(Consider the states to be distinct if an element-by-element comparison of the contents of the boards would find at least one mismatch.)

(d) (6 points) Suppose we are using IDDFS to search a binary tree. At first, the algorithm examines only the root. Then, it examines the root and its immediate children (i.e., the tree to a depth of 1). Then it searches the tree to a depth of 2, etc.

How many node visitations does it make in each iteration:

(i) Iteration with cutoff depth 0: 1
(ii) Iteration with cutoff depth 1: 3 (1+2)
(iii) Iteration with cutoff depth 2: 7 (1+2+4)
(iv) Iteration with cutoff depth 3: 15 (1+2+4+8)
(v) Assuming it stops at the end of this last iteration, what is the total of node visitations it had made (counting all repeats)? 26
(vi) Why is the repeated work generally considered to be acceptable in a case like searching a tree with branching factor 2 or greater using IDDFS?

Because. time for repeated work is acceptable compare to the whole run time.

# 3 (16 points) Minimax and Alpha-Beta (by Rob)

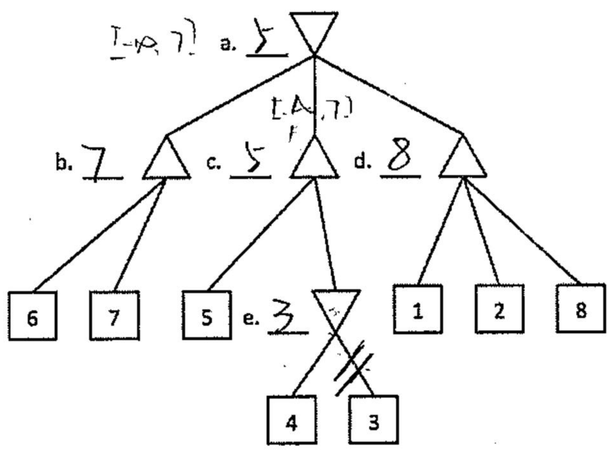



Figure 2: Minimax tree for Question 3.

(a) (10 points) Minimax Search On the tree above, fill in the values of the interior nodes after executing the minimax search algorithm without alpha-beta pruning. (Note that the tree root is a minimizing node.)

(b) Alpha-Beta Pruning

  (i) (2 points) Now assume the minimax algorithm uses alpha-beta pruning. Draw slashes over any edges that would be pruned from the tree above. Assume nodes are evaluated from the left to right.

  (ii) (2 points) Rearrange the three leaf nodes on the right subtree (the children of d) to maximize the number of pruned nodes that would occur from alpha-beta. Write the nodes in their new order from left to right below.

  8 2 1

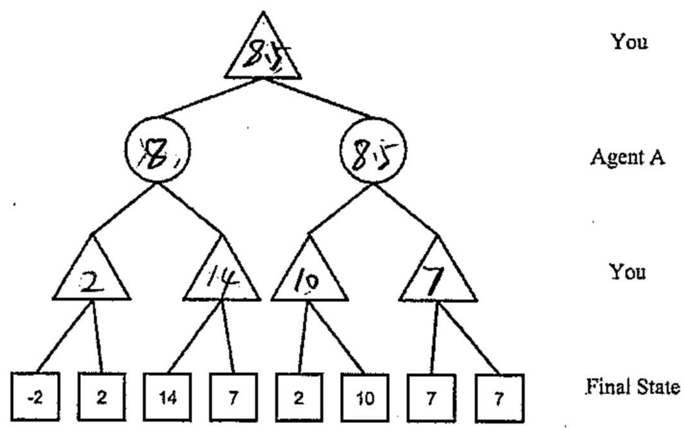
  (iii) (2 points) Now rearrange the order of the subtrees of the root (nodes b,c,d) to maximize the number of pruned nodes that would occur from alpha-beta. Use the order of d's child nodes that you specified in the previous question. Assume the order of any other nodes besides b, c, d, and d's children stay the same. Write the new order of b, c, and d from left to right below.

  c b d

## 4 (18 points) Expectimax Search (by Jifan)

In this zero-sum game, you will play against three agents, Agent A, Agent B and Agent C. Each agent will play one game against you. Your objective is to maximize the score in each game.

(a) (7 points) First, you will be playing against Agent A, which is a naïve agent designed to randomly choose a move with equal probabilities. Please fill out the appropriate scores in the tree nodes below (expectation nodes are denoted by circles).

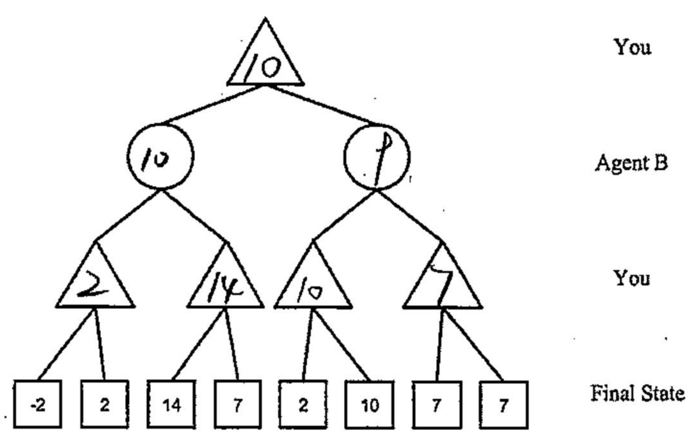



$5\frac{1}{4} + 6\frac{1}{2}$

$\frac{21}{4} + \frac{13}{2}$

$\frac{34}{6}$

(b) (7 points) Second, you will be playing against Agent B. Agent B is a rather smart agent that chooses the best move to its advantage with probability $\frac{2}{3}$. That being said, it also chooses the other move with probability $\frac{1}{3}$. Please fill out the appropriate scores in the tree nodes below (expectation nodes are denoted by circles).




$14 \times \frac{2}{3} + 2 \times \frac{1}{3}$

$\frac{28+2}{3} =$

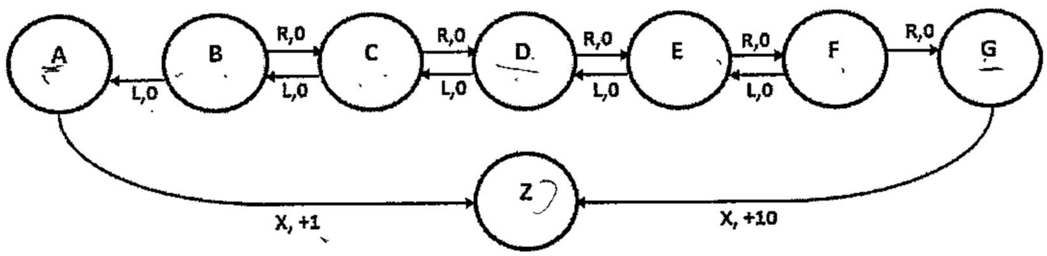
$\frac{2 \times 10 + 7}{3}$

(c) (4 points) Third, you will be playing against Agent C. Agent C is really smart and chooses the best move to its advantage with probability 1. What kind of algorithm taught in class is specifically designed for playing against the type of agent like Agent C? Answer with at most two words (you will get zero for this problem if it has more than two words):

best-first.

# 5 (14 points) MDP Properties and Discounted Future Rewards (by Hamid and Steve)

In this problem, we consider the MDP shown in the figure below.




Throughout this problem:

- The start state is $B$.
- States A and G are exit states from which only the X action is allowed.
- State Z is the terminal state. Transitioning from A to Z or G to Z results in a positive reward, and after that the episode ends.
- The allowed actions at states B, C, D, E, and F are L and R (for "Left" and "Right").
- Assume that discount factor $\gamma = 1$, except where otherwise stated.
- Assume all actions are deterministic (no noise) except where otherwise stated.

(a) (3 points) What is the maximum total reward that can be obtained starting at state $B$ (taking any number of turns)?

10

(b) (7 points) If the discount rate $\gamma = 0.1$, what will be the maximum possible (weighted) total rewards from each of the states $s \in \{A, B, C, D, E, F, G\}$?

~~A = 1~~ ~~B~~

A 1    D $\frac{1}{100}$    G 10

B $\frac{1}{10}$    E $\frac{1}{10}$

C $\frac{1}{100}$    F 1

(c) (4 points) Assume $\gamma = 0.5$ and that the actions L and R are now noisy with 10% noise. For example, in state B, with action L, the probability of going to A is 0.9 and the probability of going to C is 0.1. Assuming the agent starts in state F and can take only two turns, what is the expected total discounted reward value, given that its first action is to (try to) move Right? Hint: compute the expectation of the values coming from move 2.

# 6 (16 points) Admissible Heuristics, Dominance (by Sam and Steve)

(a) (12 points) Suppose a maze is represented by a graph with one node per room and and edge between nodes n1 and n2 provided that n1 and n2 are adjacent and there is no wall between them. Assume the rooms are square cells in a rectangular grid. Let's assume that the cost of each edge is 1. Consider the following heuristic evaluation functions for solving this maze using the A* method: Euclidean distance between n and the goal, Manhattan distance between n and the goal. We assume that the distance is taken from the center point of the room, and that the goal is also a specific room. For example, the Euclidean distance from (4,7) to (14, 2) is $\sqrt{125}$, and the Manhattan distance is 15.

(i) (4 points) Is the Euclidean distance an admissible heuristic for this problem? Why or why not?

Yes, because Euclidean between two point is less than lower bound of actual distance.

(ii) (4 points) Is the Manhattan distance an admissible heuristic for this problem? Why or why not?

Yes, because Manhattan distance is shortest path in actual situation.

(iii) (4 points) Which is likely to prove more efficient in terms of the number of nodes opened by A* and why?

Manhattan distance. because Manhattan dominates Euclidean.

(b) (4 points) We say that a heuristic $h'$ *dominates* $h$ (written $h \preceq h'$) when $h(v) \leq h'(v)$ for all $v \in V$. Consider an infinite sequence of admissible, dominating heuristics:

$$h_1 \preceq h_2 \preceq h_3 \preceq h_4 \preceq \ldots$$

Is there any situation in which we'd prefer running $A^*$ with $h_i$ instead of $h_j$ for $i < j$? Provide an argument or counterexample.

Yes, when expanded nodes is not important factor and each node almost equal.

~~tTke~~