COMP 4200/5430 Exam 1

Phong Vo

TOTAL POINTS

56.5 / 60

QUESTION 1

Search 15 pts

1.1 DFS 1 / 1

✓ - 0 pts S->B->E->F->G

1.2 BFS 1 / 1

✓ - 0 pts Correct

1.3 UCS 2 / 2

✓ - 0 pts Correct

1.4 Greedy 2 / 2

✓ - 0 pts Correct

1.5 A* 3 / 3

✓ - 0 pts Correct

1.6 f- minimal state 2 / 2

✓ - 0 pts Good: We must track the remaining air supply by counting the steps where breath can be held, therefore we shall keep a tuple composing of {M, N, A}

1.7 State space 2 / 2

✓ - 0 pts Correct

1.8 Heuristic 1.5 / 2

✓ - 0.5 pts All solutions are correct: See answer sheet

QUESTION 2

GA 15 pts

2.1 Individual Fitness 5 / 5

✓ - 0 pts Good. Solutions are correct and ranking has been done

2.2 two-point Crossover 2 / 2

✓ - 0 pts Correct

2.3 one-point Crossover 2 / 2

✓ - 0 pts Correct

2.4 Offspring evaluations 6 / 6

✓ - 0 pts Offspring fitness and evaluations done

QUESTION 3

MultiAgent Search 15 pts

3.1 Nodes values 6 / 6

✓ - 0 pts Correct

3.2 Pruning 4 / 4

✓ - 0 pts Correct

3.3 Game Tree -x 2 / 2

✓ - 0 pts Correct

3.4 Game Tree - expectmax 0 / 3

✓ - 3 pts Solution not correct and no working for any partial credit.

QUESTION 4

CSP 15 pts

4.1 Constraints 9 / 9

✓ - 0 pts See comments

4.2 Arc-Consistency 6 / 6

✓ - 0 pts Correct

COMP4200 / COMP 5430: Artificial Intelligence
Exam 1
Fall 2019

UMASS - LOWELL

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No.	Topic	Points	Scores
1	Problem Solving with Search	15	
2	Genetic Algorithms	15	
3	Adversarial Search	15	
4	Constraint Satisfaction Problems	15	
Total		60	

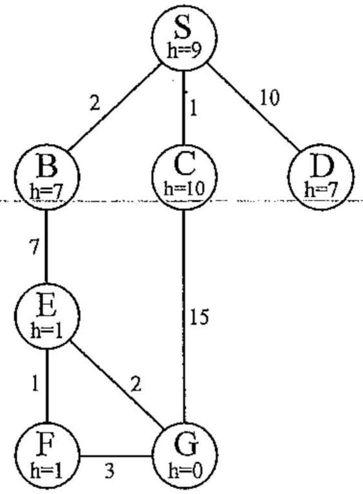
Instructions:

1. This examination contains 9 pages, including this page.
2. All questions are compulsory;
3. Write your answers in this booklet. If you must write on the back page, please indicate **very** clearly on the front of the page that you have written on the back of the page.
4. Typed notes and any other resources, including lecture notes, books, conferring with other students/engineers are not allowed.
5. You may use a calculator. You may not share a calculator with anyone.

Question 1: Problem Solving with Search

[15 pts]

Consider the search graph shown below. S is the start state and G is the goal state. All edges are bidirectional.



For each of the following search strategies, give the path that would be returned, or write *none* if no path will be returned. If there are any ties, assume alphabetical tiebreaking (i.e., nodes for states earlier in the alphabet are expanded first in the case of ties).

(a) (1 point) Depth-first graph search S → B → E → F → G

(b) (1 point) Breadth-first graph search

S → C → G

(c) (2 point) Uniform cost graph search

S → B → E → G

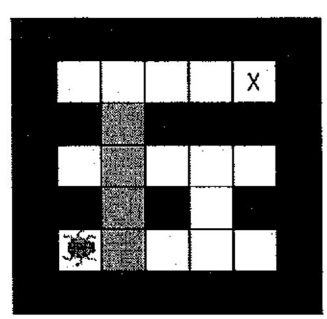
(d) (2 points) Greedy graph search

S → B → E → G

(e) (3 points) A* graph search

S → B → E → G

Parts (f) and (g) The hive of insects needs your help. You control an insect in a rectangular maze-like environment with dimensions $M \times N$, as shown to the right. At each time step, the insect can move into a free adjacent square or stay in its current location. All actions have cost 1.



In this particular case, the insect must pass through a series of partially flooded tunnels. Flooded squares are lightly shaded in the example map shown. The insect can hold its breath for A time steps in a row. Moving into a flooded square requires your insect to expend 1 unit of air, while moving into a free square refills its air supply.

(f) (2 points) Give a minimal state space for this problem (i.e. do not include extra information). You should answer for a general instance of the problem, not the specific map shown.

A tuple of location coordinates $m \in \{1, \dots M\}$ and $N \in \{1, \dots, N\}$ and the remaining air supply $a \in \{1, \dots A\}$

(g) (2 points) Give the size of your state space.

$M \times N \times A$

(h) (2 points) Consider a search problem where all edges have cost 1 and the optimal solution has cost C. Let h be a heuristic which is $\max\{h^* - k, 0\}$, where h^* is the actual cost to the closest goal and k is a nonnegative constant. Circle all of the following that are true (if any).

(a) h is admissible. $h \leq h^*$

(b) h is consistent.

(c) A* tree search (no closed list) with h will be optimal.

(d) A* graph search (with closed list) with h will be optimal.

Question 2: Genetic Algorithms

[15 pts]

Suppose a genetic algorithm uses chromosomes of the form x = abcdefgh with a fixed length of eight genes. Each gene can be any digit between 0 and 9. Let the fitness of individual x be calculated as:

$$f(x) = (a + b) - (c + d) + (e + f) - (g + h) \quad (1)$$

and let the initial population consist of four individuals with the following chromosomes:

$$x_1 = 65413532 \quad (2)$$
$$x_2 = 87126601 \quad (3)$$
$$x_3 = 23921285 \quad (4)$$
$$x_4 = 41852094 \quad (5)$$

(a) (5 points) Evaluate the fitness of each individual, showing all your workings, and arrange them in order with the fittest first and the least fit last.

$f(x1) = (6+5) - (4+1) + (3+5) - (3+2) = 11 - 5 + 8 - 5 = 9$

$f(x2) = (8+7) - (1+2) + (6+6) - (0+1) = 15 - 3 + 12 - 1 = 23$

$f(x3) = (2+3) - (9+2) + (1+2) - (8+5) = 5 - 11 + 3 - 13 = -16$

$f(x4) = (4+1) - (8+5) + (2+0) - (9+4) = 5 - 13 + 2 - 13 = -19$

$f(x_4) < f(x_3) < f(x1) < f(x2)$

4th 3rd 2nd 1st

(b) (Perform the following crossover operations:

ii. (2 points) Cross the second and third fittest individuals using a two–point crossover (*points b and f*, i.e.. alleles c,d,e and f).

	a	b	c	d	e	f	g	h
$f(x1) =$	6	5	4	1	3	5	3	2
$f(x_3) =$	2	3	9	2	1	2	8	5

Crossover

$\Rightarrow$

$c(x_1) = 6 \; 5 \; 9 \; 2 \; 1 \; 2 \; 3 \; 2$

$c(x_3) = 2 \; 3 \; 4 \; 1 \; 3 \; 5 \; 8 \; 5$

iii. (2 points) Cross the first and third fittest individuals (ranked 1st and 3rd) using a one point crossover (points c, i.e. all alleles after c.)

$$f(x_2) = 8 \quad 7 \quad 1 \mid 2 \quad 6 \quad 6 \quad 0 \quad 1$$
$$f(x_3) = 2 \quad 3 \quad 9 \mid 2 \quad 1 \quad 2 \quad 8 \quad 5$$

$$\Rightarrow \begin{cases} c(2) = 8 \quad 7 \quad 1 \mid 2 \quad 1 \quad 2 \quad 8 \quad 5 \\ c(3) = 2 \quad 3 \quad 9 \mid 2 \quad 6 \quad 6 \quad 0 \quad 1 \end{cases}$$

(c) (6 points) Suppose the new population consists of the four offspring individuals received by the crossover operations in the above question. Evaluate the fitness of the new population, showing all your workings. Has the overall fitness improved?

$$f(x_1) = (6+5) - (9+2) + (1+2) - (3+2) = -2$$
$$f(x_2) = (2+3) - (4+1) + (3+5) - (8+5) = -5$$
$$f(x_3) = (8+7) - (1+2) + (1+2) - (8+5) = 2$$
$$f(x_4) = (2+3) - (9+2) + (6+6) - (0+1) = 5$$

Overall fitness = 9 + 2 3 − 16 − 19 = −3

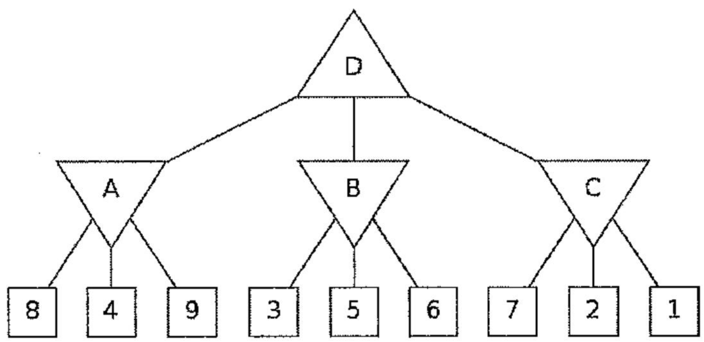
So, the overall fitness turns from −3 to 0

Question 3: Adversarial Search

[15 pts]

1. Consider the game tree shown below. Triangles that point up, such as at the top node (root), represent choices for the maximizing player; triangles that point down represent choices for the minimizing player. Assuming both players act optimally, use alpha-beta pruning to find the value of the root node. The search goes from left to right; when choosing which child to visit first, choose the left-most unvisited child. In the first set of boxes below, enter the values of the labeled nodes. Then, select the leaf nodes that don't get visited due to pruning.

   Hint: Note that the value of a node where pruning occurs is not necessarily the maximum or minimum (depending on which node) of its children. When you prune on conditions $V > \beta$ or $V < \alpha$, assume that the value of the node is V.



   (a) Enter the values of the labeled nodes

   (1 point) A: 4

   (2 point) B: 3

   (2 point) C: 2

   (1 point) D: 4

   (b) (4 points) List the leaf values that don't get visited due to pruning. For each value, give an explanation why it was not visited (i.e. why pruning occurred by giving the values of α and β.

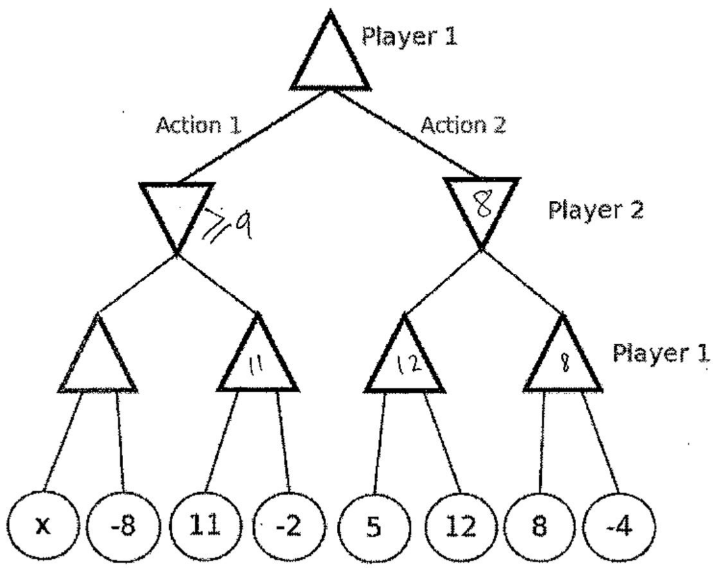
- because when the first branch A has visited, α updates = 4.
- When branch $\boxed{B}$ is visited, $\boxed{3}$ is satisfied $3 < 4 (= \alpha)$

  So $\boxed{\boxed{5} \text{ and } \boxed{6} \text{ are skipped.}}$

- when branch $\boxed{C}$ is visited, $\alpha = 4$, $\beta = \infty$; $2 < 4$

$7 > 4 \Rightarrow$ so $\boxed{2}$ is picked, $\Rightarrow$ $\boxed{\boxed{1} \text{ is skipped.}}$

2. Consider the following game tree, where one of the leaves has an unknown payoff, x. Player 1 moves first, and attempts to maximize the value of the game



(a) (2 points) Assume Player 2 is a minimizing agent (and Player 1 knows this). For what values of x is Player 1 guaranteed to choose Action 1 for their first move?

$x > 8$

(b) (3 points) Assume Player 2 chooses actions at random with each action having equal probability (and Player 1 knows this). For what values of x is Player 1 guaranteed to choose Action 1?

$x \geq 11$

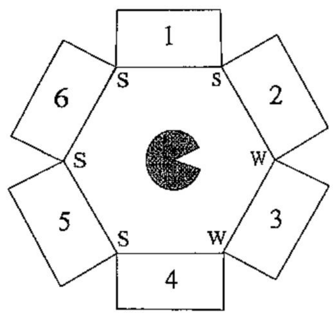
Question 4: CSPs: Trapped Pacman

[15 pts]

Pacman is trapped! He is surrounded by mysterious corridors, each of which leads to either a pit (P), a ghost (G), or an exit (E). In order to escape, he needs to figure out which corridors, if any, lead to an exit and freedom, rather than the certain doom of a pit or a ghost.

The one sign of what lies behind the corridors is the wind: a pit produces a strong breeze (S) and an exit produces a weak breeze (W), while a ghost doesn't produce any breeze at all. Unfortuantely, Pacman cannot measure the the strength of the breeze at a specific corridor. Instead, he can stand *between* two adjacent corridors and feel the max of the two breezes. For example, if he stands between a pit and an exit he will sense a strong (S) breeze, while if he stands between an exit and a ghost, he will sense a weak (W) breeze. The measurements for all intersections are shown in the figure below.

Also, while the total number of exits might be zero, one, or more, Pacman knows that two neighboring squares will *not* both be exits.



Pacman models this problem using variables X_i for each corridor i and domains P, G, and E.

(a) (9 points) State the binary **AND** unary constraints for this CSP (either implicitly or explicitly).
hint: There are atleast six binary and three unary constraints hence the points allocation

Binary:

$X_1 = P$ OR $X_2 = P$, $X_2 = E$ OR $X_3 = E$

$X_3 = E$ OR $X_4 = E$, $X_4 = P$ OR $X_5 = P$

$X_5 = P$ OR $X_6 = P$, $X_6 = P$ OR $X_1 = P$

$\forall i,j$ adjacent $Adj(i,j)$ $\begin{cases} \neg X_i = E \\ \neg X_j = E \end{cases}$

Unary:

$X_2 \neq P$

$X_3 \neq P$

$X_4 \neq P$

(b) (6 points) Cross out the values from the domains of the variables that will be deleted in enforcing arc consistency.

X_1	P	~~G~~	~~E~~
X_2	~~P~~	G	E
X_3	~~P~~	G	E
X_4	~~P~~	G	E
X_5	P	~~G~~	~~E~~
X_6	P	G	E