Makerere University
College of Computing and Information Sciences

School of Computing and Informatics Technology
CS2114: Artificial Intelligence Test 1
Date: 14^{th}/10/2018, Time 8:00- 9:00Am

Instructions

- The paper has two parts.
- Attempt all questions in Part 1
- Attempt only one (1) question from Part 2

Part 1

1. Here is pseudocode for three agent programs **A, B, C:**

A	**B**	**C**
function $A(percept)$ **return** $f_A()$	**function** $B(percept)$ **return** $f_B(percept)$	**function** $C(percept)$ **persistent:** percepts, initially[] percepts $\longleftarrow$ **push**(percept,percepts) **return** $f_C(percepts)$

In each of these agents, the function f is some arbitrary, possibly randomized, function of its inputs with no internal state of its own; the agent program runs on computer with unbounded memory but finite clock speed. Assume also that the environment and its performance measure are computable.

(a) Suppose the environment is fully observable, deterministic, discrete, single-agent, and static. For which agents, if any, is it the case that, for every such environment, there is some way to choose f such that the agent is perfectly rational? Give an explanation to your answer. [**2 marks**]
Answer: B and C. For a fully observable environment, only the current percept is required for an optimal decision. Because the environment is static, computation is not an issue. Note that Agent A cannot make optimal decisions because it always makes the same decision (or samples a decision from the same probability distribution), having no internal state

(b) Suppose the environment is partially observable, deterministic, discrete, single-agent, and static. For which agents, if any, is it the case that, for every such environment, there is some way to choose f such that the agent is perfectly

rational? Give an explanation to your answer. [**2 marks**]
Answer: C. Agent B, the reflex agent, cannot always function optimally in a partially observable environment.

(c) Suppose the environment is partially observable, stochastic, discrete, single-agent, and dynamic. For which agents, if any, is it the case that, for every such environment, there is some way to choose f such that the agent is perfectly rational? [**2 marks**]
Answer: None of the agents can be optimal for an arbitrary dynamic environment, because we can make the environment complex enough to rended optimal decisions infeasible for any finite-speed machine.

(d) **True /False:** For an environment whose performance measure is always 0. The agents A, B and C are perfectly rational in such environment. [**1 mark**]
Answer: True

2. (a) Informed search strategies use heuristic approach when solving search problems. What is a heuristic and why is it needed. [**3 marks**]
Answer: In a heuristic approach, we discover certain idea and use heuristic functions to search for a goal and predicates to compare nodes.

(b) Consider the search problem in Figure 1 , where S is the start node and G is the goal node. The pair [f;h] at each node indicates the value of the f and h functions for the path ending at that node using A* search. Given this information, what is the cost of the following paths? [**5 marks**]

i. SA
Answer: 1

ii. SB
Answer: 2

iii. AC
Answer: 1

iv. BG
Answer: 1

v. BD
Answer: 1

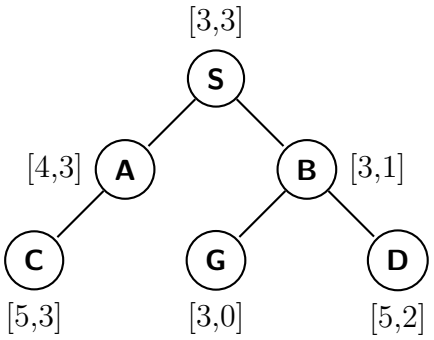


Figure 1: Search

3. (a) You are in charge of arranging n cups of different sizes in n shelves of a cupboard. The shelves are of different sizes and each shelf can accommodate a single cup. If you are to formulate this problem as a CSP. What are the three things you need to specify? Give an example of each. [**6 marks**]
Answer: Variables: shelves/cups, domain: cups/shelves, constraints: size, all different cups/shelves.

   (b) Consider 3 variables with corresponding domains A={1,2,3,4}, B={1,2,3,4} and C ={1,2,3,4}. If these variables are defined in a CSP with the following constraints $A < B$ and $B < C$. Are the arcs fully consistent? If not apply the arc consistency algorithm to the problem and report the resulting domains.[**4 marks**]
Answer: A={1,2}, B={2,3} and C ={3,4}

4. (a) Define the minmax algorithm [**2 marks**]
Answer: The minmax is an algorithm used in adversarial search consisting of two palyers. One player is called a mizimizer who aim at mazimizing a given value while the other the mimimizer aim at minimizing the value.

   (b) For the game-tree shown in Figure: 2(a), state for which values of **x** the dashed branch will be pruned off by the $\alpha - \beta$ pruning technique. If the pruning will not happen for any value of **x** write "none". If pruning will happen for all values of x write "all".[**1$\frac{1}{2}$ marks**]
Answer: $x \geq 2$

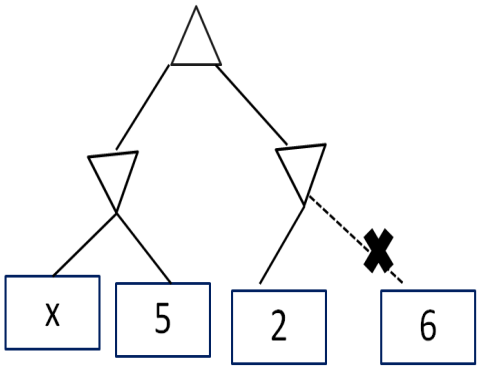
   (c) For the game-tree shown in Figure: 2(b), state for which values of **x** the dashed branch will be pruned off by the $\alpha - \beta$ pruning technique. If the pruning will not happen for any value of x write "none". If pruning will happen for all values of **x** write "all".[**1$\frac{1}{2}$ marks**]
Answer: None

Part 2

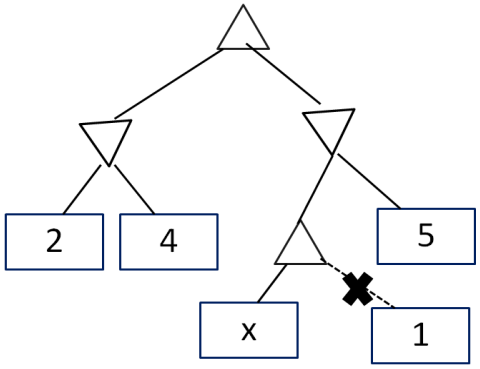
Attempt only one question

5. A bus company has five buses: A, B, C, D, and E and two bus-stops: town service bus-stop and upcountry bus-stop. The company would like to schedule a time slot and bus-stop for each bus to either arrive to a bus-stop or depart from a bus-stop. The company has four time slots: 1, 2, 3, 4 for each bus-stop, during which it can schedule an arrival or departure of a bus. The company must find an assignment that meets the following constraints:

   - Bus A has got engine problems and must arrive in time slot 1.
   - Bus C can only arrive at the bus-stop during or after time slot 3.
   - Bus B is running out of fuel but it can arrive at most time slot 2.



(a)



(b)

Figure 2: Game trees

- Bus C must arrive before bus D departs, because some passengers must transfer from C to D.
- No two buses can reserve the same time slot for the same bus-stop.

(a) Complete the formulation of this problem as a CSP in terms of variables, domains, and constraints (both unary and binary). Constraints should be expressed implicitly using mathematical or logical notation rather than with words. **[3 marks]**
Answer:
Variables: A, B, C, D, E for each bus
Domains: a tuple (bus-stop type, time slot) for bus-stop type $\in$ {upcountry, domestic} and time slot $\in$ {1, 2, 3, 4}.
Constraints: $B[1] \leq 2$, $A[1] = 1$, $C[1] < D[1]$, $C[1] \geq 3$, $A \neq B \neq C \neq D \neq E$

(b) For the following subparts, the following two constraints were added:

- Bus A, B, and D cater for upcountry travelers and can only use the upcountry bus-stop.
- Bus C and E cater for town service travelers and can only use the town service bus-stop.

i. With the addition of these two constraints above , the company can completely reformulate the CSP. You are given the variables and domains of the new formulation. Complete the constraint graph for this problem given the original constraints and the two added ones. [**4 marks**]
Answer: Variables: A, B, C, D, E for each bus and Domain ∈ {1,2,3,4}

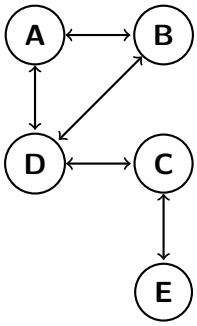


Figure 3: Constraint graph

ii. What are the domains of the variables after enforcing arc-consistency? Begin by enforcing unary constraints. (Cross out values that are no longer in the domain.) [**2 marks**]

A	1	2	3	4
B	1	2	3	4
C	1	2	3	4
D	1	2	3	4
E	1	2	3	4

Answer: $A \in \{1\}$, $B \in \{2\}$, $C \in \{3\}$, $D \in \{4\}$, $E \in \{1, 2, 4\}$

iii. List one solution for the CSP. [**1 mark**]
Answer: (A, 1), (B, 2), (C, 3), (D,4), (E, 1)

6. Consider the state space graph shown in Figure 4 (S is the initial state and G is the goal state, numbers on the links are path/link costs and the numbers next to the states are heuristic estimates). Each edge can be traversed in both directions.

(a) For each of the following graph search strategies (use graph search with a closed/visited list), mark which, if any, of the listed paths it could return. Note that for some search strategies the specific path returned might depend on tie-breaking behavior. In any such cases, make sure to mark all paths that could be returned under some. tie-breaking scheme.[**7 mark**]

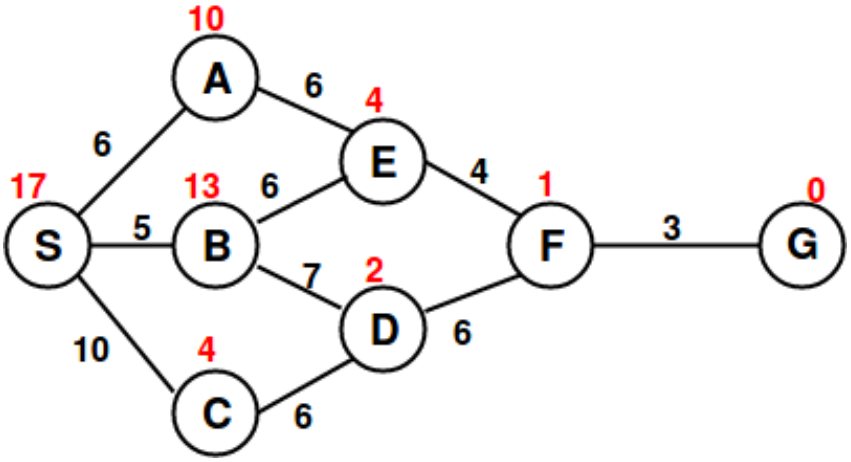


Figure 4: Search space graph

Search Algorithm	S,A,E,F,G	S,B,E,F,G	S,B,D,F,G	S,C,D,F,G
Depth first search	X	X	X	X
Breadth first search	X	X	X	X
Uniform cost search		X		
A* Search	X			
Greedy search				X

(b) Is the heuristic used consistent?. Explain your answer in one sentence **[3 mark]**

Answer: No because $h(S) - h(A) > cost(S, A)$**,** $h(S) - h(C) > cost(S, C)$**,** $h(B) - h(D) > cost(B, D)$ **and** $h(B) - h(E) > cost(B, E)$

7. Consider the game tree shown in Figure 5

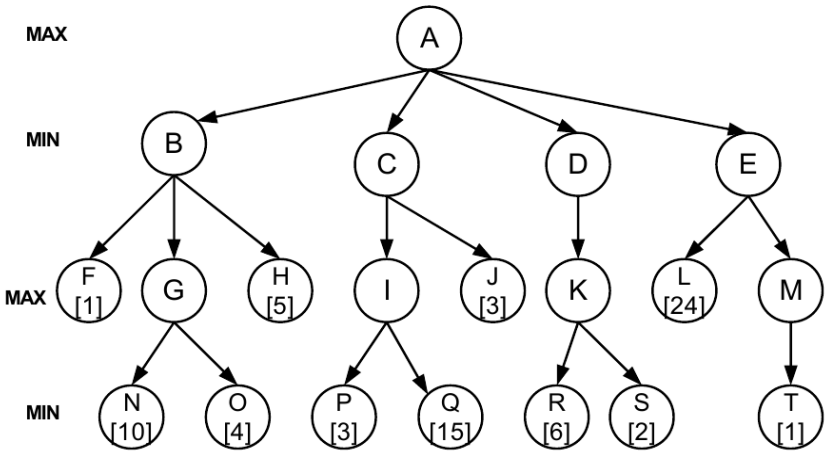


Figure 5: Game tree

(a) Using minimax algorithm , indicate the values of the following nodes.

i. A =
Answer: 6

ii. B =
Answer: 1

iii. C =
Answer: 3

iv. D =
Answer: 6

v. E =
Answer: 1

vi. G =
Answer: 10

vii. I =
Answer: 15

viii. K =
Answer: 6

ix. M =
Answer: 1

(b) Using minimax algorithm , what is the best next move from A? (**Indicate a letter**)
Answer: D

(c) By evaluating the tree from **Left to right**, Indicate the nodes that are pruned off by the $\alpha - \beta$ pruning algorithm and explain why they are pruned off.
Answer: O

End