THE UNIVERSITY OF WARWICK

Second Year Examinations: Summer 2018

Artificial Intelligence

Time allowed: 2 hours.

Answer **FOUR** questions.

Read carefully the instructions on the answer book and ensure that the particulars required are entered on the front cover of EACH answer book you use.

Approved calculators may be used.

1. (a) Suppose you are deciding whether to drive to buy a takeaway meal. A friend borrowed your car earlier in the day, and you do not know whether they re-fuelled before returning it. There is a 20% chance that they got fuel. If they re-fuelled then the probability of successfully getting food before the takeaway closes is 0.7, otherwise the probability of success is 0.3. You assign a successful outcome a utility of $+100$ and an unsuccessful outcome a utility of -100.

    i. Show a decision tree for the problem. [4]

    ii. Solve the decision tree to determine whether you should drive to get a meal. [6]

    iii. Represent the problem using an influence diagram. [4]

    iv. Suppose that your friend sent a text message saying that they got fuel, and that there is a 99% chance that they did indeed get fuel if they sent such a text. Extend the influence diagram to incorporate this additional information. [3]

    (b) i. Explain the process of selecting and fulfilling open preconditions in a partial-order planner. [2]

    ii. Describe how a clobbering conflict might occur during planning, and how to resolve it. [3]

    iii. Describe how a partial-order planner can be modified to perform conditional planning, and why this is useful. [3]

2. (a) Consider a search problem containing states $\{A, B, C, D, E, F, G, H\}$ in which the legal successors and action costs are given in the table below, where $X \rightarrow n$ denotes that X can be reached with cost n, and $S(\cdot)$ is the successor function. The start state is A and the goal state is H.

$S(\cdot)$	Successors and costs
$S(A)$	$B \rightarrow 9, C \rightarrow 3, D \rightarrow 6$
$S(B)$	$A \rightarrow 9, H \rightarrow 4$
$S(C)$	$A \rightarrow 3, E \rightarrow 5, G \rightarrow 7$
$S(D)$	$A \rightarrow 6, E \rightarrow 3$
$S(E)$	$D \rightarrow 3, C \rightarrow 5, F \rightarrow 5$
$S(F)$	$E \rightarrow 5, G \rightarrow 4$
$S(G)$	$C \rightarrow 7, F \rightarrow 4, H \rightarrow 6$
$S(H)$	$B \rightarrow 4, G \rightarrow 6$

Show the state space graph for this problem. [3]

(b) Suppose that you are given a heuristic, h_1, defined by the following table.

Node	A	B	C	D	E	F	G	H
h_1	13	4	3	12	15	9	3	0

For each of the following tree search methods, show the resulting search tree, giving the sequence in which nodes are removed from the queue, and stating how many nodes are expanded. You should also state the route found and its associated cost. Assume that nodes are inserted into the queue in alphabetical order. When expanding a node, do not generate any of its ancestors.

i. Uniform cost search. [5]

ii. Greedy best-first search. [3]

iii. A* search. [5]

(c) Now suppose that you are given a higher-valued heuristic, h_2, defined as $h_2 = h_1 \times 3$.

i. Use A* to determine a route from A to H using h_2 as the heuristic, showing the search tree and giving the sequence of nodes expanded. State the route found and its associated cost. [3]

ii. Does h_2 lead to the optimal path being discovered, and would this always be the case? Explain your reasoning. [2]

(d) Formally prove that A* is an optimal search strategy for locally finite state space graphs. [4]

3. (a) Explain, using examples, how *forward* and *backward chaining* control reasoning in rule-based systems. [3]

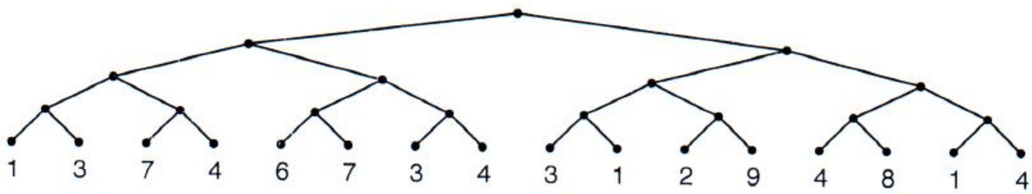
   (b) i. What is meant by conflict resolution in the context of rule-based systems? [2]

   ii. Describe how and why recency, refractoriness and specificity are useful techniques for conflict resolution. [3]

   (c) Suppose that a rule-base contains the following rules, with initial known facts $\{A, C\}$. Suppose that the aim is to infer Z. Show how both forward chaining and backward chaining approaches operate, stating which rules are fired and the state of the knowledge base at each point of the reasoning process. [7]

$$\boxed{\begin{array}{l} A \rightarrow E \\ B \wedge F \rightarrow Z \\ C \wedge A \rightarrow F \\ D \rightarrow Y \\ E \rightarrow B \\ F \rightarrow Z \end{array}}$$

   (d) Describe the minimax with alpha-beta pruning algorithm and show how it operates on the following tree, where the first player is the maximising player. State which move the first player should choose, and what utility they should expect. You should show the resulting search tree. [7]

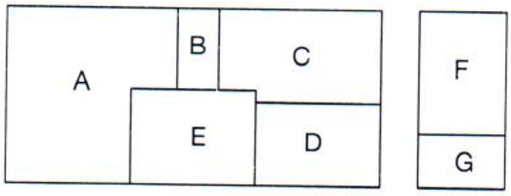


   (e) Describe how a cut point can be chosen for a depth-first search of the game tree, as carried out by the minimax algorithm. [3]

4. (a) Explain the following heuristics, and how and why they are used in a backtracking search:

   - minimum remaining values,
   - degree heuristic, and
   - least constraining value. [6]

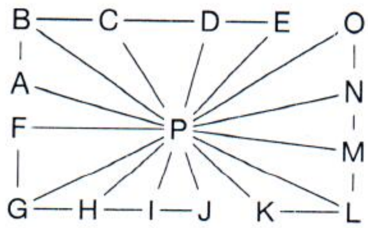
   (b) Suppose that you are given the following map, corresponding to the CSP containing variables $\{A, B, C, D, E, F, G\}$ such that the variables represent regions in the map, and regions should be assigned values from the set $\{low, medium, high\}$ with the constraint that adjacent regions must not have the same value.



   i. Draw the constraint graph for this problem. [3]

   ii. Find a solution to this problem using the backtracking algorithm with forward checking and application of appropriate heuristics to select variables and values. Show all the steps carried out by the algorithm. [6]

   (c) Explain how cutset conditioning could be used in the following constraint graph to make the search more efficient, and state the upper bound on the number of nodes expanded with and without cutset conditioning. Assume that each variable has the same domain, which is of size 3. [6]



   (d) Suppose that you are given the following heuristics for a tree-search problem, where $b*$ represents the effective branching factor.

	h_1	h_2	h_3	h_4	h_5
$b*$	1.93	1.77	2.30	1.42	1.79

   i. Which heuristic would you choose and why? [2]

   ii. Suppose that you are given additional heuristic h_6 with corresponding $b* = 1.42$. What would you use as a heuristic, and why? [2]

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5. (a) Probabilistic inference can be used to support different kinds of reasoning. Explain four common uses. [4]

(b) Suppose a doctor sees a patient with a high temperature. The doctor knows that infection A causes a high temperature in 90% of cases. The doctor also knows the prior probability of infection A occurring is $1/1000$, and the prior probability of a patient having a high temperature is $1/3000$. What is the probability that the patient has infection A? [3]

(c) Suppose that there are two tests, X and Y, for a disease. Test X is 98% effective at identifying the disease when it is present, but has a 8% false positive rate. Test Y is 85% effective at identifying the disease and has a 3% false positive rate. The tests use independent methods of identifying the disease. It is known that 1 in 100 people have the disease. Suppose a person can be tested using only one of the tests. Which test returning positive is more indicative of a person having the disease? Justify your answer mathematically and give $P(disease|X)$ and $P(disease|Y)$. [6]

(d) Using either truth tables or rules of inference for propositional logic, show whether the following argument is valid or not: $a \rightarrow b, \neg b \rightarrow c, c; \therefore a$ [3]

(e) Using the Venn diagram decision procedure, determine if the following are valid or invalid syllogisms:

All Cacti are Plants
Some Plants are Green
$\therefore$ Some Cacti are not Green [2]

All Cats are Mammals
No Dog is a Cat
$\therefore$ No Dog is a Mammal [2]

(f) Describe the operation of a simulated annealing search. [5]
