THE UNIVERSITY OF WARWICK

Second Year Examinations: Summer 2016

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.

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1. (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 refractoriness and specificity are useful techniques for conflict resolution. [3]

   (c) Suppose you are deciding what train to catch, and could use your mobile phone to download the current timetable. You are unsure whether you charged your phone, but there is a 40% probability that it is charged. If the phone is charged there is a 70% probability of successfully downloading the timetable. You assign a successful outcome a utility of $+50$ and an unsuccessful outcome a utility of -50. If the phone is not charged the probability of success is 0.1%.

   i. Create a decision tree for this problem. [4]

   ii. Solve the decision tree to determine whether you should try to download the timetable. [6]

   (d) Define the terms causal link and clobbering in the context of partial order plans, and state how to avoid a clobbering conflict. [3]

   (e) Describe the operation of conditional planning in the context of POP. [4]

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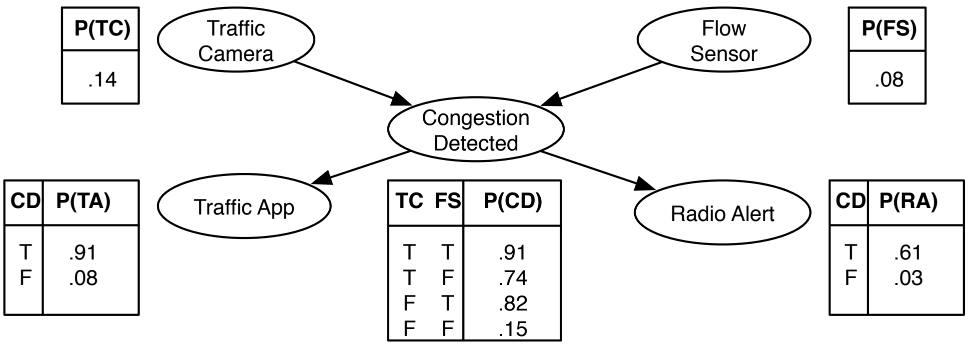
2. (a) Explain the four types of reasoning that can be done using probabilistic inference. [4]

   (b) Suppose that there are two independent sensors, *traffic camera (TC)* and *flow sensor (FS)*, for detecting congestion on road R. TC is 92% effective at identifying congestion when it is present, but has a 28% false positive rate. FS has a true positive rate of 71% and a 19% false positive rate. Suppose that the probability of congestion on R is 0.7. Which sensor returning positive is a better indicator of congestion, assuming only a single sensor is used? Justify your answer mathematically and give $P(congestion|TC)$ and $P(congestion|FS)$. [6]

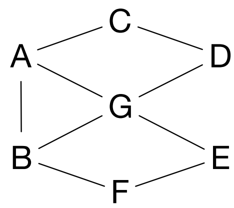
   (c) Using inference by enumeration and the Bayesian network below, compute the probability of *Congestion Detected* given *Traffic App* and *Radio Alert* are true. [12]



   (d) Suppose that you are tasked with constructing a Bayesian Network for a traffic management system, and are given an ordered set of nodes $\langle X_1, X_2, \ldots, X_n \rangle$. Describe how you would use Pearl's Bayesian Network construction algorithm to create the network. [3]

3. (a) Explain the following heuristics, and how they are used in a backtracking search.
   - minimum remaining values,
   - degree heuristic, and
   - least constraining value. [6]

   (b) Consider a CSP containing variables $\{A, B, C, D, E, F, G\}$ that must be assigned values from the set $\{red, green, blue\}$. Suppose we have the constraint that certain regions must not be the same colour, as defined by the constraint graph given below. Use the backtracking algorithm and the heuristics from part (a) to find a solution to this problem. Show all the steps carried out by the algorithm.



[6]

   (c) Explain how cutset conditioning could be used in the CSP from part (b) to make the search more efficient. State the upper bound on the number of nodes expanded with and without cutset conditioning. [6]

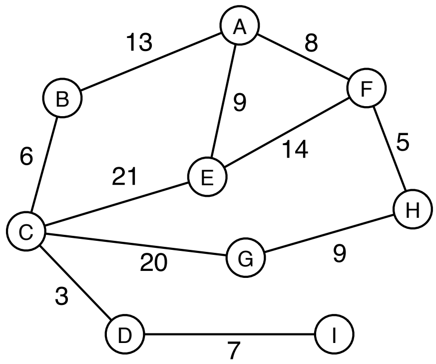
   (d) Suppose that you have been tasked with determining the control parameters for an automated flood defence system. These parameters are stored in a vector of length n.

      i. Describe how you would use a genetic algorithm to solve this problem, including in your answer an explanation of how crossover and mutation operate in this context. [5]

      ii. Would there be any advantage to using A* instead of a genetic algorithm? Explain your reasoning. [2]

4. (a) Consider the state space shown below, in which the arcs represent the legal successors of a node. Arcs are bi-directional and are labelled with the cost of performing the corresponding action. The start state is **A** and the goal is **I**. Suppose that you are given a heuristic, h_1, defined by the following table.

Node	A	B	C	D	E	F	G	H	I
h_1	20	15	10	7	21	20	27	26	0



For each of the following search methods, show the resulting search tree, list the sequence in which nodes are removed from the queue, and state 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 [6]

ii. Greedy best-first search [4]

iii. A* search [5]

(b) Consider the problem of starting in state **I** with **A** being the goal state, in the same state space as above. Suppose that you are given a heuristic, h_2, defined by the following table.

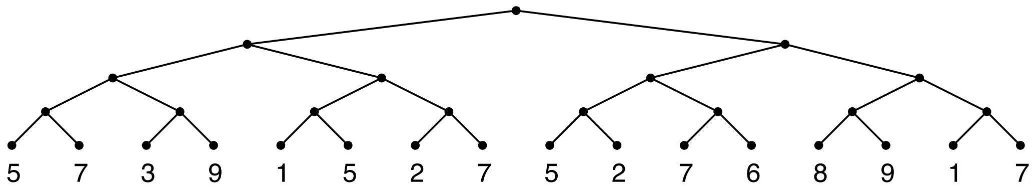
Node	A	B	C	D	E	F	G	H	I
h_2	0	25	19	20	5	8	15	13	20

i. Use A* to determine a route from **I** to **A** using h_2 as the heuristic, showing your search tree and giving the sequence of nodes expanded. State the route found and its associated cost. [4]

ii. Given that you might expect the same route between A-I and I-A, which is the better heuristic, h_1 or h_2, and why? [2]

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

5. (a) 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]



(b) i. Describe how a cut point can be chosen for a depth-first search of the game tree, as carried out by the minimax algorithm. [4]

ii. Explain the horizon problem that is potentially faced when using such a cut point. How can this be avoided? [4]

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

All hills are mountains
Some mountains have snow [2]
$\therefore$ Some hills have snow

All hills are mountains
Some mountains have snow [2]
$\therefore$ Some hills do not have snow

(d) Briefly outline alternative procedures for how you might determine heuristics for a search problem, and how you might combine multiple heuristics into a single useful heuristic. [6]