CS2550

THE UNIVERSITY OF WARWICK

Second Year Examinations: Summer 2019

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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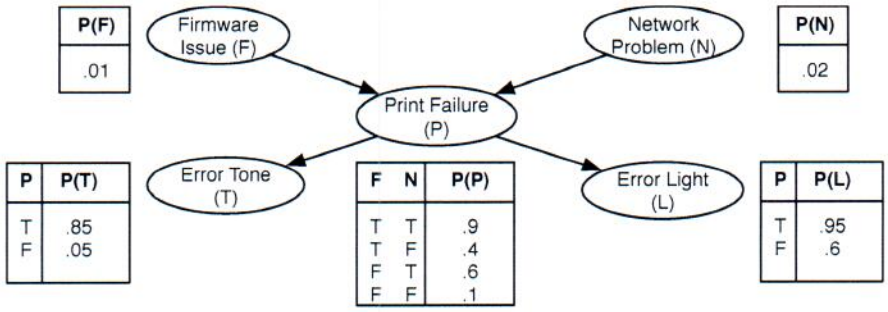
1. (a) Given a knowledge base KB and query sentence α, such that $\alpha = A \vee C$ and $KB = A \wedge (A \vee B) \wedge (B \vee \neg C) \wedge (\neg B \vee C)$, use inference by enumeration to determine whether $KB \models \alpha$. [4]

   (b) Suppose that there are two tests, that use independent methods, for determining whether a site might be of archaeological interest. Test A has a true positive rate of 79% and a false positive rate of 12%. Test B has a true positive rate of 73% and a false positive rate of 9%. Suppose there are a number of possible sites and you must select one for investigation. Each site has a 1 in 100 chance of being of archaeological interest. If you must select just one of the tests, which would you choose and why? Justify your answer mathematically, giving the relevant probabilities. [6]

   (c) Given the following Bayesian network use inference by enumeration to compute the probability of N given that T and L are observed. [12]

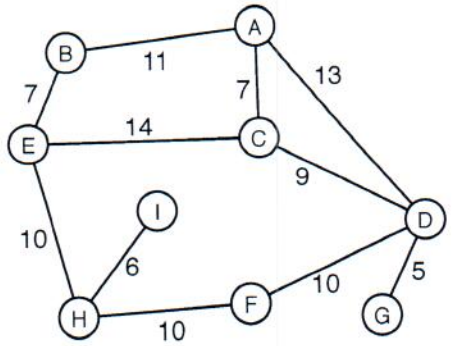


   (d) Suppose that you are given an ordered set of nodes $\langle X_1, X_2, \ldots, X_n \rangle$. Describe how you would use Pearl's construction algorithm to create a Bayesian Network. [3]

Continued...

2. (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	34	23	30	39	15	16	44	6	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. In the case of ties between nodes, assume that nodes are inserted into the queue in alphabetical order. When expanding a node, do not generate its parent.

i. Uniform cost search. [5]

ii. Greedy best-first search. [4]

iii. A* search. [5]

(b) Now suppose that you are given another heuristic, h_2, defined by the following table.

Node	A	B	C	D	E	F	G	H	I
h_2	34	28	24	38	17	16	85	7	0

Is this heuristic guaranteed to result in the optimal path being discovered by the A* algorithm? Explain your reasoning. [2]

(c) Explain how iterative deepening can be used to reduce the memory overhead of A*. [5]

(d) Explain how tree search can be modified to perform a graph search. Why might this be useful? [4]

Continued...

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]

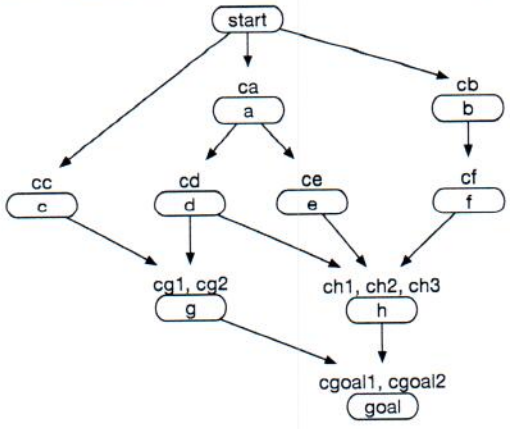
   (c) Suppose that a rule-base contains the following rules, with initial known facts $\{A, B\}$. Suppose that the aim is to infer H. Show how both forward chaining and backward chaining approaches operate, stating which rules are fired and the state of the knowledge base at each point of the reasoning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

$$\begin{array}{|l|}\hline A \rightarrow F \\ A \wedge D \rightarrow E \\ B \rightarrow D \\ B \wedge F \rightarrow G \\ E \wedge B \rightarrow C \\ F \rightarrow H \\ G \rightarrow H \\ H \rightarrow E \\ \hline \end{array}$$

   (d) 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. Explain what is meant by action monitoring and plan monitoring. Considering the following plan, assuming a, b, c, d and e have been executed and g is selected for execution, what is the result of action monitoring and plan monitoring?



[5]

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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 have a CSP containing variables $\{A, B, C, D, E, F\}$ which must be assigned values from the set $\{1, 2, 3\}$, such that the following constraints hold.

   $\{A \neq B, A \neq C, A \neq D\}$
   $\{B \neq A, B \neq C, B \neq D, B \neq E, B \neq F\}$
   $\{C \neq A, C \neq B, C \neq F\}$
   $\{D \neq A, D \neq B, D \neq E\}$
   $\{E \neq B, E \neq D, E \neq F\}$
   $\{F \neq B, F \neq C, F \neq E\}$

   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 CSP from part (b) to make the search more efficient, and state the upper bound on the number of nodes expanded with and without cutset conditioning. [6]

   (d) Suppose that the behaviour of a smart heating system is controlled by n parameters. Describe how you would use a genetic algorithm to find values for these parameters, including in your answer an explanation of how crossover and mutation operate in this context. [4]

Continued...

5. (a) Suppose you are deciding whether to go for a run or not. Your running jacket is old, sometimes leaks, and is not breathable, meaning you sometimes get sweaty. If you go for a run, the probability of getting wet if it rains is 0.8, and is 0.1 otherwise. The probability of rain is 0.2. You associate running without getting wet a utility of $+50$, you give the outcome of getting wet while running a utility of -20 and not going out a utility of 0.

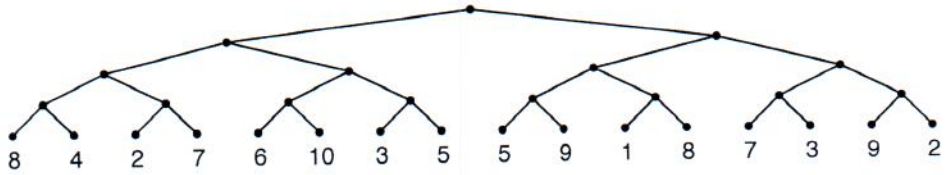
   i. Show a decision tree for the problem. [4]

   ii. Solve the decision tree to determine whether you should go for a run. [6]

   (b) Explain what is meant by syntax, semantics and pragmatics in the context of knowledge based systems. [3]

   (c) Using inference by enumeration, show whether the following is valid:
   $p \rightarrow q, \neg q \rightarrow r, r; \therefore p$ [3]

   (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) In games where the legal moves by a player are determined by chance, explain how the minimax algorithm can be extended to determine the optimal move for a player. [2]

End