CS2550

THE UNIVERSITY OF WARWICK

Second Year Examinations: Summer 2014

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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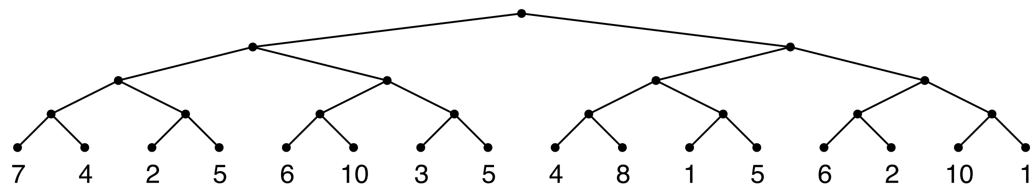
1. (a) Describe possible procedures for deriving heuristics for a problem to be solved using search, and how you might combine multiple heuristics into a single useful heuristic. [5]

   (b) Explain the operation of the minimax algorithm for adversarial search, and state the assumptions under which it is optimal and complete. [3]

   (c) In the context of the following game tree, use the minimax algorithm to determine which move the first player should choose, and what utility they should expect. Assume that the first player aims to maximise their utility. You should show the resulting search tree. [4]



   (d) Describe the alpha-beta pruning algorithm for minimax and show how it operates on the game tree in part (c), assuming that the first player is the maximising player. State which move the first player should choose. [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]

   (f) Describe how to adapt the search when using the minimax algorithm, to avoid going down to the leaf nodes of the tree. [4]

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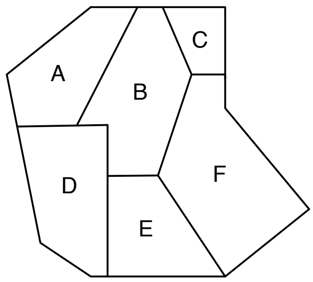
2. (a) Explain how the following heuristics operate in a backtracking search.
   - minimum remaining values,
   - degree heuristic, and
   - least constraining value. [6]

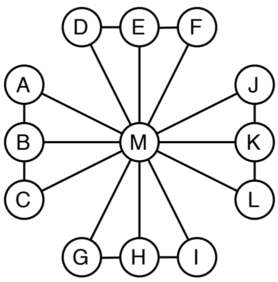
   (b) Suppose that you are given a CSP represented by the map shown below, containing variables $\{A, B, C, D, E, F\}$ corresponding to regions in the map, such that regions should be coloured from the set $\{red, green, blue\}$ with the constraint that adjacent regions must not be the same colour.



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

   ii. Use the backtracking algorithm with forward checking to solve this CSP, using appropriate heuristics. Show all the steps carried out and justify the choices made with regard to attribute selection and value assignment at each stage. [6]

   (c) With reference to the following constraint graph, explain how cutset conditioning can be used to make the search more efficient, and state numerically the upper bound on the number of nodes expanded with and without cutset conditioning. Assume each variable is to be assigned a value from the set $\{low, medium, high\}$. [6]



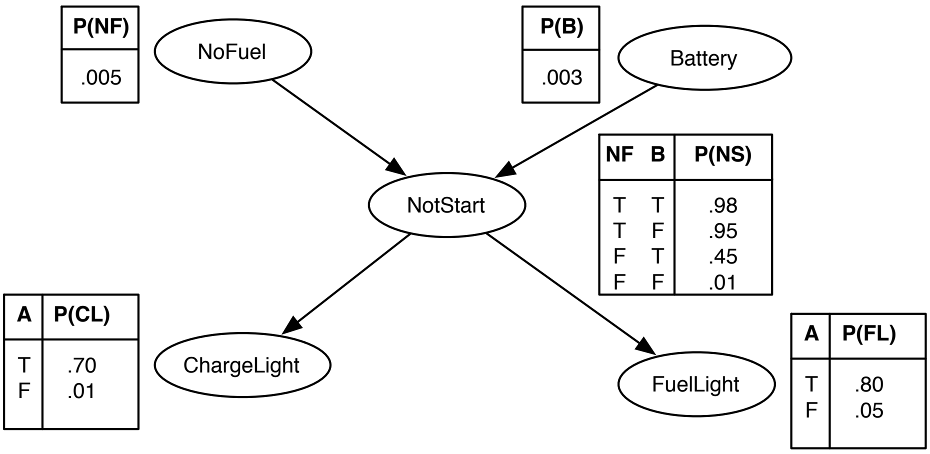
   (d) Describe how properties of an environment, such as its observability, impact on the design for an intelligent agent. [4]

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

(b) Suppose a doctor sees a patient with a high temperature. The doctor knows that disease A causes a rash in 80% of cases. The doctor also knows the prior probability of disease A is 1/50,000, and the prior probability of a patient having a high temperature is 1/100. What is the probability that the patient has disease A? [3]

(c) Suppose that there are two tests, that use independent methods, for determining whether shale gas is present at a site. Test A is 97% effective at identifying shale gas when it is present, but has a 15% false positive rate. Test B is 90% effective at identifying shale gas and has a 5% false positive rate. You have a set of possible sites, each of which has a 1 in 100 chance of having shale gas. Suppose that you only have time to use one of the tests. Which test returning positive is more indicative of the presence of shale gas? Justify your answer mathematically, giving the relevant probabilities. [6]

(d) Using the Bayesian network given below compute the probability of $NoFuel$ given that $ChargeLight$ and $FuelLight$ are true. You should use inference by enumeration and show your working. [12]



P(NF)
.005

P(B)
.003

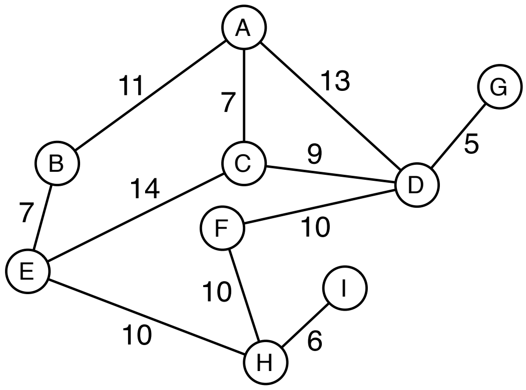
NF	B	P(NS)
T	T	.98
T	F	.95
F	T	.45
F	F	.01

A	P(CL)
T	.70
F	.01

A	P(FL)
T	.80
F	.05

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	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. [5]

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_1	34	28	24	38	17	16	85	7	0

i. Use A* to determine a route from **A** to **I** 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. For the above problem, 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) Using the Venn diagram decision procedure, determine if the following are valid or invalid syllogisms:

All hawks are birds
Some birds are brown [2]
∴ Some hawks are not brown

All hawks are birds
Some birds are brown [2]
∴ Some hawks are brown

All cars are vehicles
No house is a car [2]
∴ No house is a vehicle

(b) In the context of rule-based systems, describe the processes of forward and backward chaining. Use examples to illustrate how these processes work. [3]

(c) Anna's cricket team, Coventry, is going to play her friend Bill's team, Durham. Bill offers Anna a friendly bet: whoever's team loses will buy the dinner next time they meet up. They never spend more than £30 on dinner. Had there been no bet, they would share the cost of dinner equally. When deciding whether to accept this bet, Anna will have to assess her team's chances of winning (which will vary according to the weather on the day). She estimates the probability of her team winning when the Weather is wet to be 0.75 and the probability of her team winning if the weather is dry to be 0.2. The prior probability of it raining is 0.2.

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

ii. Solve the decision tree. [5]

iii. Represent the problem using an influence diagram. [3]

iv. Extend the influence diagram to show how you would incorporate the availability of a weather forecast. What additional information will be required to solve the new influence diagram? [4]

6. (a) Define the terms causal link and clobbering in the context of partial order plans. [4]

   (b) Show how a partial-order regression planner works by deriving a plan for the Blocks World problem described below. The available operators are as follows.

   $Action(PutOnTable(b),$
   $Precond : On(b, x) \wedge Clear(b),$
   $Effect : On(b, Table) \wedge Clear(x) \wedge \neg On(b, x))$

   $Action(PutOn(b, x),$
   $Precond : On(b, z) \wedge Clear(b) \wedge Clear(x),$
   $Effect : \neg On(b, z) \wedge \neg Clear(x) \wedge Clear(z) \wedge On(b, x))$

   The initial state for the problem is
   $On(C, A) \wedge On(A, Table) \wedge On(B, Table) \wedge Clear(B) \wedge Clear(C)$
   and the goal state that your plan must achieve is
   $On(A, B) \wedge On(B, C) \wedge On(C, Table) \wedge Clear(A)$. [5]

   (c) Describe what is meant by conditional planning, and why it is useful. [4]

   (d) Suppose you have been asked to design a system for the control of a heating system.

      i. Describe how you would use a genetic algorithm to identify the best set of parameters for the system, including in your answer an explanation of crossover and mutation. [6]

      ii. Describe how you could use hill-climbing instead of a genetic algorithm, and explain how you would try to prevent your algorithm getting stuck in a local optima. [4]

      iii. Would there be any advantage to using A* to find the best set of parameters? Explain your reasoning. [2]