Tallinn University of Technology

Department of Computer Science

Past exam paper: Autumn 2013

Principles of Artificial Intelligence

ITI8560

Time allowed TWO Hours

Answer ALL FOUR questions

No calculators, mobile phones or other electronic devices capable of storing or retrieving text may be used.

The print text book (Artificial Intelligence: A Modern Approach, 3rd edition) is allowed.

DO NOT open the examination paper until instructed to do so

Name:	
Student ID:	
Marks (to be filled by teaching staff):	

Question 1

(a) Explain the difference between *uninformed* and *informed* search. List two examples of each type of algorithm. [2 marks]

(b) In the context of graph search, describe what a *heuristic* is and explain what it means for it to be admissible. [2 marks]

(c) Explain what A* search is including the advantages and disadvantages with respect to theoretical properties. [3 marks]

(d) Draw a search tree for the 8-puzzle problem up to depth 4 (start state is at depth 0) using the A* algorithm (omit repeated states) with the evaluation function $f(n) = p(n) + h(n)$, where $p(n)$ is the number of steps from the start state (start state is step 0) and $h(n)$ is the number of misplaced tiles. Note that the actions for sliding tiles should be used in this order: right, left, up and down. Write the values of f and of its components p and h under each state. You may use an abbreviated notation indicating only the tiles that change. [10 marks]

Start state

1	2	3
4	8	5
7	6	

Goal state

1	2	3
4	5	6
7	8	

(e) Briefly explain IDA* search and its advantages and disadvantages. What happens when using IDA* in the search problem in part *(d)* if the IDA* limit is 3? What happens if the limit is 4 (in terms of the number of states)? [3 marks]

Question 2

Consider the problem of deciding whether a propositional logic sentence is true in a given model.

(a) Write a recursive algoritm PL-TRUE?(s, m) that returns *true* if and only if the sentence s is true in the model m (where m assigns a truth value for every symbol in s). The algorithm should run in time linear in the size of the sentence. [7 marks]

(b) Give three examples of sentences that can be determined to be true or false in a *partial* model that does not specify a truth value for some of the symbols. [3 marks]

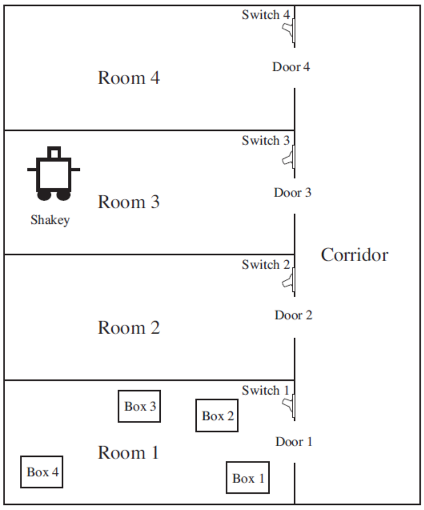
(c) Show that the truth value (if any) of a sentence in a partial model cannot be determined efficiently in general (give examples where such partial assignment does not determine the truth value of the sentence).

[4 marks]

(d) Modify your PL-TRUE? algorithm so that it can sometimes judge truth from partial models, while retaining its recursive structure and linear run time. Test on three examples (that you may have given in part *(c)*) of sentences whose truth in a partial model is not detected by the algorithm. [6 marks]

Question 3

The original STRIPS planner was designed to control Shakey the robot. The following figure shows Shakey's world consisting of four rooms lined up along a corridor, where each room has a door and a light switch.



The actions in Shakey's world include moving from place to place, pushing movable objects (such as boxes), climbing onto and down from rigid objects (such as boxes), and turning light switches on and off. The robot itself could not climb on a box or toggle a switch, but the planner was capable of finding and printing out plans that were beyond the robot's abilities. Shakey's six actions are the following:

- $Go(x, y, r)$, which requires that Shakey be At x and that x and y are locations In the same room r. By convention a door between two rooms is in both of them.
- Push a box b from location x to location y within the same room: $Push(b, x, y, r)$. You will need the predicate Box and constants for the boxes.
- Climb onto a box from position x: $ClimbUp(x, b)$; climb down from a box to position x: $ClimbDown(b, x)$. You will need the predicate On and the constant $Floor$.
- Turn a light switch on or of: $TurnOn(s, b)$; $TurnOff(s, b)$. To turn a light on or off, Shakey must be on top of a box at the light switch's location.

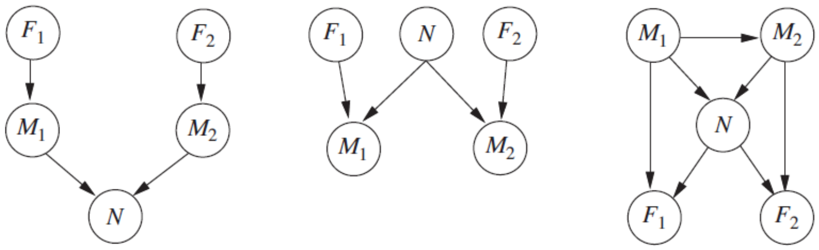
(a) Write PDDL sentences for Shakey's six actions and the initial state from the figure above. [10 marks]

(b) Construct a plan for Shakey to get Box_2 into $Room_2$. [5 marks]

(c) Describe what steps would be required to propositionalise the domain to be solved by SATPlan planning procedure? [5 marks]

Question 4

Two astronomers in different parts of the world make measurements M_1 and M_2 of the number of stars N in some small region of the sky, using their telescopes. Normally, there is a small possibility e of error by up to one star in each direction. Each telescope can also (with much smaller probability f) be badly out of focus (events F_1 and F_2), in which case the scientist will undercount by three or more stars (or if N is less than 3, fail to detect any stars at all). Consider the three networks shown here:



(i) (ii) (iii)

(a) Which of these Bayesian networks are correct (but not necessarily efficient) representations of the preceding information?

[2 marks]

(b) Which is the best network? Explain! [3 marks]

(c) Write out a conditional distribution for $\mathbf{P}(M_1|N)$, for the case where $N \in \{1, 2, 3\}$ and $M_1 \in \{0, 1, 2, 3, 4\}$. Each entry in the conditional distribution should be expressed as a function of the parameters e and/or f. [7 marks]

(d) Suppose $M_1 = 1$ and $M_2 = 3$. What are the *possible* numbers of stars if you assume no prior constraint on the values of N? [4 marks]

(e) What is the *most likely* number of stars, given these observations? Explain how to compute this, or if it is not possible to compute, explain what additional information is needed and how it would affect the result? [4 marks]