UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2004

BEng Honours Degree in Computing Part III
MEng Honours Degree in Information Systems Engineering Part IV
BSc Honours Degree in Mathematics and Computer Science Part III
MSc in Advanced Computing
PhD
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute
This paper is also taken for the relevant examinations for the Associateship of the Royal College of Science

PAPER C394=I4.40

ADVANCES IN ARTIFICIAL INTELLIGENCE

Wednesday 5 May 2004, 14:30
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators required

Section A *(Use a separate answer book for this Section)*

1a Give the formal definition of a *minimal* explanation. Illustrate the definition by means of a simple concrete example of a minimal and a non-minimal explanation within an abductive logic program of your choice.

b Consider the following abductive logic program <T,H,IC>:

T: p(x) **if** q(x) **and** r(x)
q(x) **if** a(x) **and** s(x)
q(x) **if** b(x)
r(x) **if** b(x) **and** s(x)
r(x) **if** a(x)
s(x) **if** c(x)

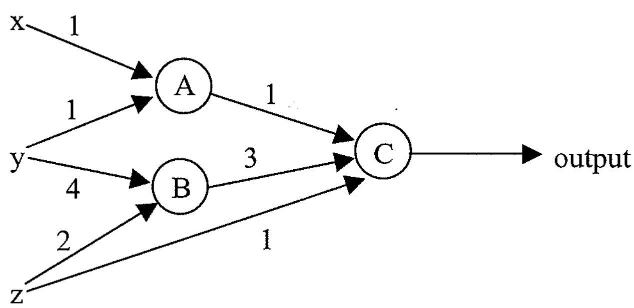
H: All ground atoms in the predicates a, b, and c.

IC: **if** a(x) **and** c(x) **then false**.

i) Give *two* minimal explanations for r(1).

ii) Can these be extended to be minimal explanations of p(1)? In each case where this is possible, give the explanation for p(1) and explain why it is minimal. Otherwise, explain briefly why it cannot be extended so.

c Consider the following neural network composed of perceptron units using the activation function: h(U) = 1 if U > 0;
0 otherwise.



i) Suppose the bias weight w_0 for all three perceptrons is 1. Calculate the output of each of the perceptrons for the inputs x=2, y=-1, z=1.

ii) Suppose the bias weight w_0 for all three perceptrons is –1, and that all inputs are either 0 or 1. Taking the Boolean interpretation of 0 = false and 1 = true, what logical formula is computed by the network?

iii) Can backpropagation be used to train this network? Why or why not?

The three parts carry, respectively, 20%, 40%, and 40% of the marks.

2a Briefly describe the basic idea behind SATplan.

b Consider the following planning domain:

I have been working hard revising all day, and I want to have some tea. I have cold water, teabags, and a teapot (initially closed). In order to put something into the teapot, it must be open. I can make tea by steeping teabags in a closed teapot that contains hot water. There are five possible actions,

To *open* something
To *heat* something
To *put* something into the teapot
To *close* something
To *steep* something

Using the predicates *open*, *closed*, *have, cold*, *hot*, and *in-pot*:

i) Express the initial state and the goal in the situation calculus representation, using the *holds* predicate.

ii) Express the operators in the STRIPS representation.

iii) Express one possible minimal plan in the event calculus representation.

c Apply the POP algorithm to the STRIPS representation of the domain and draw a diagram showing the final computed plan. Clearly indicate causal links with solid arrows and threat resolutions with dashed arrows.

The three parts carry, respectively, 15%, 45%, and 40% of the marks.

Section B *(Use a separate answer book for this Section)*

3a Information gain is reduction in entropy after splitting on some attribute A.

i) What is the formula for calculating Entropy?

ii) What is the formula for calculating Information Gain?

b The lecturers of Advances in Artificial Intelligence (AAI) course are interested in using a machine learning classification system that can predict the performance of a student on the final exam. To construct its decision the classifier has access to the below data summarizing past results:

- Proportion of lectures attended (All, Some, None)
- Amount of revision (Lots, Medium, Little)
- Degree course (MAC, Comp/JMC)
- Exam Performance (Passed, Failed)

The table below is a small illustrative dataset of twelve former AAI students with respect to the target classification "*Exam performance*".

	LECTURES	REVISION	DEGREE	EXAM PERFORMANCE
1	All	Little	Comp/JMC	Passed
2	All	Medium	Comp/JMC	Passed
3	Some	Lots	MAC	Passed
4	Some	Lots	MAC	Passed
5	Some	Medium	Comp/JMC	Passed
6	Some	Lots	Comp/JMC	Passed
7	None	Lots	Comp/JMC	Failed
8	None	Medium	Comp/JMC	Failed
9	Some	Little	MAC	Failed
10	Some	Little	MAC	Failed
11	Some	Little	Comp/JMC	Failed
12	Some	Little	Comp/JMC	Failed

i) What is the entropy of this collection of training examples with respect to the target function classification?

ii) Using concepts from Information theory choose the *best* attribute to represent the root of the tree (show all your calculations).

c i) Using concepts from information theory construct the complete decision tree correctly classifying all examples. (show all your calculations)

ii) Which formula does the tree represent, with respect to the target classification process?

iii) Classify the example shown below with respect to your constructed tree.

	LECTURES	REVISION	DEGREE	EXAM PERFORMANCE
13	Some	Medium	Comp/JMC	?

The three parts carry, respectively, 20%, 40 and, 40% of the marks.

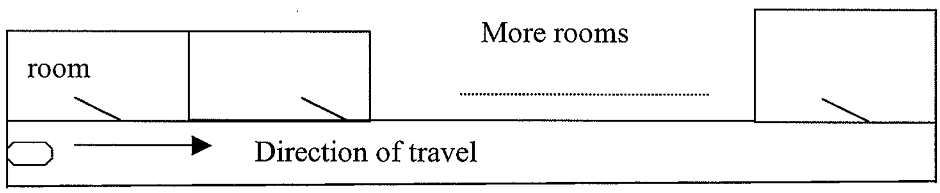
4a In Reinforcement Learning an agent learns by trial and error interactions with its environment. The agent exists in an environment with a set of possible states S, a set of possible actions A, and a reward (or punishment) r_t that the agent receives at time t each time it takes an action in a state. The objective of Reinforcement Learning is to find an optimal policy.

i) Describe what is meant by an optimal policy.

ii) Q-Learning is a way of computing optimal policy. Give the Q-Learning algorithm for computing an optimal policy in a deterministic world.

b i) If S is the set of all environment states, P is the set of percepts of the state of the environment available to an agent, and A is the set of the actions it can perform on the environment, give a functional characterisations of an hysteretic agent with an internal set of memory states, M.

ii) A security robot has to move down a corridor on the left of which there are a series of rooms as depicted in the following picture. The doors may be open or closed. The robot does not know how many rooms there are. Its task is to move down the corridor looking for unoccupied rooms with lights left on. It always starts at the end of the corridor.



When it detects a door it opens it, if need be, and checks if the room is unoccupied with lights on. If this is the case it enters the room, turns the lights off, exits the room and closes the door. If the room is occupied, or the lights are off, it just closes the door. It then continues down the corridor, repeating the above for each door it comes across down the corridor. It does nothing when it comes to the end of the corridor – when it perceives a wall in front of it.

Assume that the robot has the following set of percepts:

wall_front	there is a wall immediately in front of it
door	there robot is next to a door
open	the door next to the robot is open

person_in_room	the room with the open door next to the robot is occupied
lights_on	the room with the open door next to the robot has lights on

together with the negation of each of these percepts, denoted by not(P). For example,

not(lights-on)	the room with the open door next to the robot does not have lights on

Also assume it has the following action repertoire:

move_down_corridor	move a short distance down the corridor - always less than the distance between two doors
open_door	open a door when next to the door
enter_room	move through an opened door into a room when next to opened door
exit_room	move through an opened door just out of a room
close	close an opened door when next to the door
turn_lights_off	turn lights off when inside a room

and that its actions always succeed.

Specify a suitable memory set and define the response function for this robot viewed as an hysteretic agent. A response can include a sequence of actions, including the empty sequence {}.

The two parts carry, respectively, 30% and 70% of the marks.