UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2001

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
MSci Honours Degree in Mathematics and Computer Science Part III
MSci Honours Degree in Mathematics and Computer Science Part IV
MEng Honours Degrees in Computing Part IV
MSc in Advanced Computing
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 C494=I4.40

ADVANCES IN ARTIFICIAL INTELLIGENCE

Monday 30 April 2001, 10:00
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators not required

1a Briefly describe the simple, conventional planning agent. Identify its limitations and describe briefly how alternative forms of planning seek to overcome them.

b Apply POP, the partial order planner, to the STRIPS domain with actions:

move(X,Y) pre: *clear(X) & clear(Y) & on(X,Z) & Y≠table &Y≠Z*
post: *on(X,Y) & clear(Z) & not on(X,Z) & not clear(Y)*

move-on-table(X) pre: *clear(X) & on(X,Z) & Z≠table*
post: *on(X,table) & clear(Z) & not on(X,Z)*

with initial state

on(a,table) & on(c,a) & on(d,c) & on(b,table) & clear(b) & clear(c)

and goal

on(a,table) & on(b,a) & on(c,b) & on(d,c)

to compute a plan with the least set of actions.

Return a graphical representation of the computed plan, indicating, for each step in the plan, preconditions and effects of interest. As in the lectures, preconditions of the form A≠B can be dealt with outside the planner, by assuming a≠b, b≠c, a≠c and so on. Briefly explain the computed plan.

c Briefly describe the main features of GRAPHPLAN compared with POP.

The three parts carry, respectively, 30%, 50%, 20% of the marks.

2a Given the following abductive logic program:

T_0:
p (X) if q(X,Y) & not r(Y)
r(X) if not t(X) & h1(X)
r(X) if not h2(X)
q(1,2)
q(3,4)
t(X) if q(X,X)
w(X) if v(X,Y,X) & not s(X)
s(X) if h3(X)
v(5,6,5)
v(4,X,Y)

H_0: *(all ground atoms in the predicates) h1, h2, h3*

IC_0: *if h2(X) & q(X,Y) then false*
if h1(X) & not h3(X) then false

i) Give the corresponding abductive logic program (T,H,IC) used by the [KM90] abductive proof procedure.

ii) Describe the task of the abductive proof procedure, given any observation, and its main components. It is not necessary to describe the proof procedure in detail.

b For the abductive logic program in part a, compute all possible explanations for each of the observations

O1= p(3)

O2= w(5) & p(3)

Describe the working of the abductive proof procedure graphically. For the selection of literals in derivations, assume a left-most selection rule. Return any explanation explicitly.

c Is the KM proof procedure guaranteed to compute minimal explanations only? If yes, justify your answer. If no, give a counterexample.

The three parts carry, respectively, 20%, 50% and 30% of the marks.

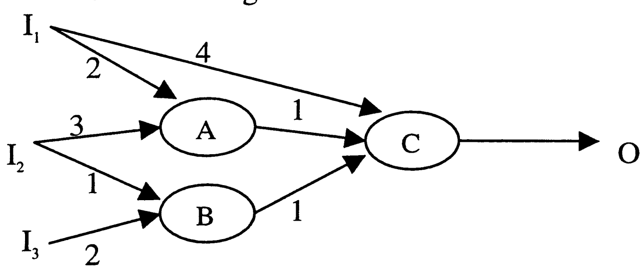
3a Briefly describe the behaviour of decision-theoretic and reinforcement (Q-) learning agents and identify the main differences between them.

b Consider the following diagnostic domain. Individuals may have an enlarged stomach, their skin may be yellow, and they may have recurrent problems vomiting. Typically, pregnant women have an enlarged stomach. Moreover, in some cases pregnant women may vomit frequently. Alcoholics also tend to have an enlarged stomach and to vomit regularly. They are also likely to have a pickled liver, which often causes their skin to look yellow.

i) Construct a Bayesian network for the above, justifying your working, and identifying any missing data required to complete the description.

ii) Map the given Bayesian network onto probabilistic Horn abduction.

c Consider the following neural network:



I_1, I_2 and I_3 are inputs of the network, and O is the output. The nodes labeled A, B, C are perceptron units using the activation function

f(net) = 1 if net > 0,
0 otherwise.

i) What values should be assigned to w_0 for all perceptrons A, B, C so that the output is 1 when the inputs are 1?

ii) Assume w_0=1 for all perceptrons A, B, C. Compute the output, given the inputs I_1=1, I_2=2, I_3=3.

iii) Assume that w_0=-1 for all perceptrons A, B, C. Assume also that the inputs are either 0 or 1. Taking a Boolean interpretation of 0=false and 1=true, give the logical formula computed by the network.

The three parts carry, respectively, 30%, 35% and 35% of the marks.

4a Consider the following set of examples, specifying the action of an academic (goes /doesn't go) to be performed for any specific conference on the basis of its location (EU/US/Asia/Other), the research area of the conference (new/follow-up), whether the academic has his/her own travel grant to attend (yes/no), and whether the academic has a paper to present at the conference (yes/no):

Example	Action	Location	Research area	Grant	Paper
e1	Doesn't go	EU	new	yes	yes
e2	goes	US	new	yes	yes
e3	Doesn't go	US	follow-up	yes	no
e4	Doesn't go	EU	follow-up	no	yes
e5	goes	Other	new	no	no
e6	Doesn't go	Other	follow-up	yes	yes
e7	Doesn't go	Asia	follow-up	no	no
e8	goes	Asia	new	yes	no
e9	Doesn't go	EU	follow-up	no	yes
e10	Doesn't go	EU	new	no	no

i) Learn a decision tree correctly classifying all examples. The tree does not need to be minimal. Concisely justify the construction of the tree.

ii) Show how to classify the new example

Example	Action	Location	Research area	Grant	Paper
e11	?	EU	follow-up	no	yes

with respect to the decision tree in part i).

iii) Assume "goes" is rewritten as yes and "doesn't go" is rewritten as no. Give the logical formula corresponding to the decision tree in part i).

4b Consider the formulation of a simplified event calculus in abductive logic programming terms:

T: $holds(P,T)$ *if* $initiates(E,P)$
$\quad\& \; happens(E,T')$
$\quad\& \; T \geq T'$
$\quad\& \; not \; broken(P,T',T)$

$broken(P,T',T)$ *if* $terminates(E,P)$
$\quad\& \; happens(E,T'')$
$\quad\& \; T > T'' > T'$

H: *happens(t)* for all ground terms *t*

IC: *if happens(E,T) & preconditions(E,P) then holds(P,T)*

i) Extend T to represent the following simplified planning domain. There is a bottle and a plant and two possible actions: emptying the bottle and filling up the bottle. Emptying the bottle requires that the bottle be full. After emptying the bottle, the bottle becomes empty and the plant gets watered. Filling the bottle requires that the bottle be empty and causes the bottle to become full.

ii) Represent the initial situation that the bottle is full and the goal that the plant is watered and that the bottle is full, and suggest a plan for the goal as an abductive explanation for it. There is no need to show the actual derivation of the plan.

iii) Can the plan be computed by the KM abductive proof procedure? Justify your answer.

iv) Can the plan be computed by the KM abductive proof procedure after any syntactic rewriting of the given abductive logic program? Justify your answer.

The two parts carry, respectively, 50% and 50% of the marks.