CARDIFF UNIVERSITY
EXAMINATION PAPER

Academic Year:	2009/2010
Examination Period:	Spring
Examination Paper Number:	CM0312
Examination Paper Title:	Artificial Intelligence II
Duration:	2 hours

Do not turn this page over until instructed to do so by the Senior Invigilator.

Structure of Examination Paper:

There are 4 pages.

There are 4 questions in total.

There are no appendices.

The maximum mark for the examination paper is 75 and the mark obtainable for a question or part of a question is shown in brackets alongside the question.

Students to be provided with:

The following items of stationery are to be provided:

ONE answer book.

Instructions to Students:

Answer THREE questions.

The use of a translation dictionary between English or Welsh and another language, provided that it bears an appropriate school stamp, is permitted in this examination.

1. **Games**

   (a) How does α-β pruning extend the minimax algorithm? Explain why despite these modifications both algorithms return the same result.

   [9]

   (b) Describe how to modify the minimax algorithm for non-deterministic games where each player selects a "lottery" instead of an exact game state. Explain why α-β pruning fails for such games in general.

   [8]

   (c) Consider a non-deterministic game where players can win or lose money. For each move the players select among four lotteries. Each lottery randomly selects one of six resulting game states with equal likelihood. Furthermore, the maximum amount a player can win or lose is $£20$. Explain how α-β pruning can be implemented for this game such that it returns the same result as your algorithm from Question 1 (b).

   [8]

2. **Constraints**

   Assume there are n examinations $E_1, E_2, \ldots, E_n$ and m time slots $t_1, t_2, \ldots, t_m$ at which these examinations could take place. The problem is to assign time slots to examinations, such that all examinations are finished as soon as possible, i.e., different examinations may be scheduled at the same time. However, whenever any student is taking two different examinations, they must be scheduled at different times, otherwise the student would have to be in two places at the same time.

   (a) Represent this as a constraint satisfaction problem and describe the structure of the constraint graph.

   [6]

   (b) Describe the backtracking with forward-checking algorithm for solving such constraint satisfaction problems. State two heuristics that could be used to try to improve the performance of this algorithm.

   [13]

   (c) Will backtracking with forward-checking find an optimal solution for the examinations scheduling problem such that all examinations are finished as soon as possible? If this is the case, explain why. If not, briefly describe an efficient approach that will achieve this.

   [6]

3. **Bayesian Networks**

Consider the problem of detecting whether an e-mail contains a virus. We use four Boolean random variables to model this problem:

V : indicates whether the e-mail contains a virus (true) or not (false);
A : indicates whether the e-mail has an attachment (true) or not (false);
L : indicates whether the e-mail is long (true) or not (false);
K : indicates whether the sender is known to the receiver (true) or not (false).

(a) If we use a naive Bayesian approach, we make the assumption $\mathbf{P}(A, L, K|V) = \mathbf{P}(A|V)\mathbf{P}(L|V)\mathbf{P}(K|V)$. What does this assumption mean in terms of independence and/or conditional independence of any of the variables A, L, K,and V? Draw a Bayesian Network (without the conditional probability tables) that corresponds to this assumption. Justify its structure.

[6]

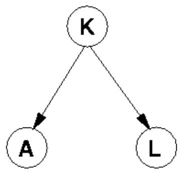
(b) (i) Given an e-mail with $A =$ true, $L =$ false, $K =$ false, compute the probability that it contains a virus using the probabilities listed in the table below under the assumption from Question 3(a).

(ii) Can we fill in the probability table below with eight arbitrary real numbers? If so, say why, if not, list the conditions that the entries in the table must fulfil.

V	$P(A =$ true$\|V)$	$P(L =$ true$\|V)$	$P(K =$ true$\|V)$	$P(V)$
false	0.2	0.8	0.8	0.8
true	0.9	0.2	0.1	0.2

[11]

(c) Now assume someone constructed the following Bayesian Network for the variables A, L and K only:



Examining the lengths of 1000 e-mails whose senders were known to the receiver gave the following results. 200 of these e-mails were long. However, among the e-mails which had attachments, only 100 were long.

Does this data support the assumptions made for the above Bayesian network? If not, suggest a suitable network structure. What implications, if any, has this result on the structure of the Bayesian network in Question 3(a)? Justify your answer.

[8]

4. **First-Order Logic**

(a) Describe the steps necessary to prove that two first-order logic sentences $\mathbf{X}$ and $\mathbf{Y}$ are logically equivalent using resolution.

[6]

(b) Translate the following sentences into first-order logic, using reasonably named predicates, functions, and constants. If you think a sentence is ambiguous, clarify which meaning you are representing.

$\mathbf{A}$: "There is at most one cat who does not eat fish."

$\mathbf{B}$: "All cats, except those living in Cardiff, eat fish."

Why is it hard to express these sentences in propositional logic?

[8]

(c) Consider the two sentences

$\mathbf{C}$: $\forall x\ [\exists y\ P(x,y)] \Rightarrow Q(x)$

$\mathbf{D}$: $\forall x, y\ P(x,y) \Rightarrow Q(x)$

Prove that $\mathbf{C}$ entails $\mathbf{D}$ using resolution.

[11]