THE UNIVERSITY OF NEW SOUTH WALES

Examination

Session 1/2000

COMP3411

Artificial Intelligence

- Time allowed: **2 hours**
- Total number of questions: **8**
- Answer **all** questions
- The questions are **not** of equal value
- Answer *each* question in a **separate** book
- This paper can be retained by the candidate

ANSWERS MUST BE WRITTEN IN INK. EXCEPT WHERE THEY ARE EXPRESSLY REQUIRED, PENCILS MAY BE USED ONLY FOR DRAWING, SKETCHING OR GRAPHICAL WORK

Question 1 [8 Marks]

Agents:

Explain the difference between a reflex-based agent (without internal state) and a utility-based agent.

Do not use more than four sentences for each of the agents.

Question 2 [16 Marks]

Search:

A) **[6 marks]**

Consider the maze in figure 1.

Explain what operators you would choose for your search. For uninformed search, which strategy is more suited: depth first search or breadth first search?

Justify your answer.

Hint: Your answer may depend on what you choose as search operators.

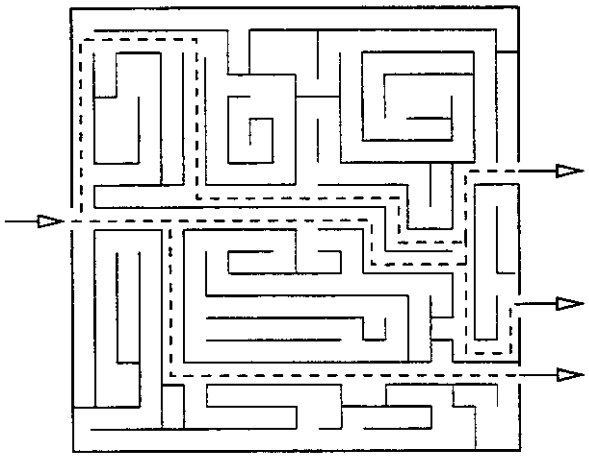

Figure 1: Maze: entry on the left side. Three possible exits on the right side. The possible paths through the maze are indicated by the dashed lines.

B) **[5 marks]**

Informed Search: Explain the criterion for a heuristic to be an admissible heuristic for A^*.

C) **[5 marks]**

Give an admissible heuristic for the maze problem above (which also gives non-zero values).

Question 3 [10 Marks]

Game Playing:

Draw a (binary) Minimax search tree of depth 4 (consider the root node to be at depth 0). Show what values are assigned to each node. Choose an evaluation of the leaf nodes so that different values are used and that it is clearly demonstrated how the Minimax evaluation works for the rest of the tree.

Question 4 [13 Marks]

Logic:

A) **[4 marks]**

Consider the following sentence in first-order logic:

$$\forall x \exists y \; Rich(father(x)) \wedge Rich(mother(y)) \Rightarrow Well\_off(x) \wedge Well\_off(y) \wedge Older(x, y).$$

Decide for each symbol (apart from '(', ')', '$\wedge$', '$\vee$', '$\neg$') in the sentence, whether it is a constant, a variable, a function symbol or a predicate symbol.

B) **[9 marks]**

Translate the following sentences into first-order logic. Say explicitly which of the symbols you use are constants, predicates, functions, etc.

i) All students who take an AI subject are smart.

ii) There is a student whose sister takes an AI subject.

iii) There is at least one subject in which the score of Sandra is higher than the score of Peter.

Question 5 [12 Marks]

Reasoning:

Consider the following family relationship: Peter has married a widowed woman with a daughter, called Sandra. Subsequently, Peter's father William marries Sandra. This is formalised below along with general knowledge about family relationships.

Prove that Peter is his own grandfather using resolution!

Transform the given sentences into clausal form and draw the refutation tree.

- $\forall x, y \; Stepfather(x, y) \Rightarrow Parent(x, y)$.
- $\forall x, y \; Parent(x, y) \wedge Male(x) \Rightarrow Father(x, y)$.
- $\forall x, y, z \; Father(x, y) \wedge Parent(y, z) \Rightarrow Grandfather(x, z)$.
- $\forall x, y, z \; Married(x, y) \wedge Father(x, z) \Rightarrow Parent(y, z)$.
- $Stepfather(Peter, Sandra)$. $Married(William, Sandra)$. $Father(William, Peter)$. $Male(Peter)$.

Question 6 [19 Marks]

Planning:

Consider the following planning problem: Sandra is at home and she wants to study for an exam. In order to study for the exam, she has to get books from the library. Furthermore, she needs to get a Pizza before she studies, as she is also hungry. Before she can pick up a Pizza, she has to order the Pizza over the phone. The only phone available is at her home.

Given are the following actions *GoTo(Library)*, *GoTo(PizzaShop)*, *GoTo(Home)*, *PickUpBooks*, *PickUpPizza*, and *OrderPizzaOverPhone*.

A) **[7 marks]**
Formulate the precondition and the effect for each of the actions, including the *Start* and *Finish* 'action'.

B) **[8 marks]**
Show how a partial order planner constructs a plan for achieving Sandra's goal of bringing the books and Pizza home.

C) **[4 marks]**
Explain how you can ensure that Sandra picks up the Pizza on her way home (as opposed to her way to the library), so that the Pizza is still warm when she reaches home.

Question 7 [16 Marks]

Reasoning under uncertainty - Bayesian belief networks:

Consider the following situation:

- You have installed a burglar alarm in your house. The burglar alarm will go off with a probability of 0.9, if there is a burglar in the house. Furthermore, it will also go off with a probability of 0.1, if the windows are open, as cockroaches and other animals may enter your house and trigger the alarm. If both, a burglar is in your house and you left your windows open, the alarm will go off with probability 0.91. In all other cases, the alarm goes off with a probability of 0.01.
- A burglar will come into your house with probability 0.01, if the windows are closed and with probability 0.1, if the windows are open.
- You leave your windows open with a probability of 0.2.

A) **[6 marks]**
Draw a Bayesian belief network including probability tables which represents the above given probabilistic dependencies among the three variables W (*windows open*), B (*burglar in house*), and A (*alarm goes off*).

B) **[6 marks]**
Given that you closed your windows, what is the probability of the alarm going off?

C) **[6 marks]**

Given that the alarm in your house went off, what is the probability that a burglary took place, if you left your windows closed?

Show your calculations for all the necessary conditional probabilities in the questions above.

Question 8 [16 Marks]

Machine Learning - Naive Bayesian Classifier:

Animals are described by two boolean-valued attributes *hairy* and *smelly* and classified as either '+' or '–'.

Given are the following training examples:

No	hairy	smelly	class
1	n	n	–
2	n	y	–
3	y	y	–
4	n	n	–
5	n	y	+
6	y	n	+

A) **[10 marks]**

Estimate the probabilities needed for a Naive Bayesian classifier.

B) **[6 marks]**

Which class would the Naive Bayesian classifier assign to the following two animals?

No	hairy	smelly	class
7	n	n	?
8	y	n	?