**UNIVERSITY OF BRISTOL**
**DEPARTMENT OF COMPUTER SCIENCE**

**Examination for the Degrees of**
**BSc, BEng, BA, Meng and MSc**

MAY/JUNE 1998 2 Hours

**COMS 30106**

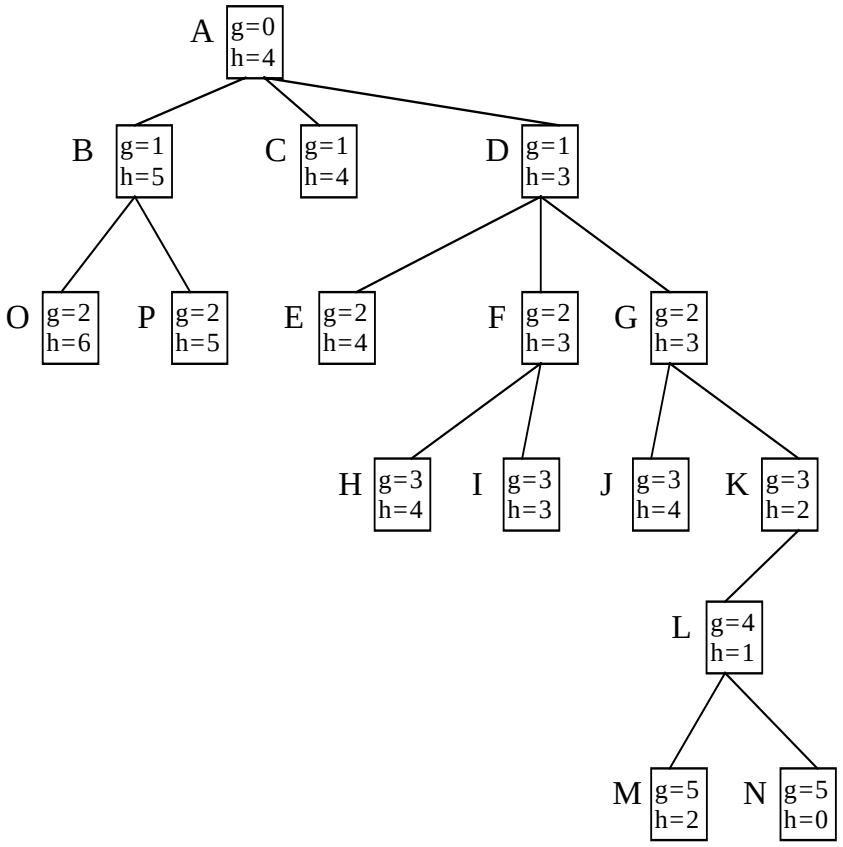
**ARTIFICIAL INTELLIGENCE**
**3/4a & MSc**

This paper contains *FOUR* questions.
The best *THREE* answers will be used for assessment.

Please use *ONE* answer book.

**Q1** a) The A* algorithm expands nodes by minimising $f=g+h$. What do $g$ and $h$ compute respectively? Why is it more efficient to use $f$ rather than $g$ or $h$ alone? Explain the principle of graceful decay of admissibility. Given the following search tree, show the order in which nodes are visited by (i) branch-and-bound search, (ii) best-first search and (iii) A* search.

*[7 marks]*




b) Describe the purpose and functionality of an expert system's explanation subsystem and knowledge base editor. Identify at least 5 guidelines for determining whether an application is suitable for expert system solution.

*[9 marks]*

c) What is an admissible algorithm? What is the condition for algorithm A with $f = g+h$ to be admissible? Given $f_1 = g + h_1$, and $f_2 = g + h_2$ such that $h_1 \leq h_2$ for all states, which of A with $f_1$ and A with $f_2$ is more efficient and why?

*[4 marks]*

**Q2** a) Consider the game of noughts and crosses. Assume that you are playing crosses and it is your turn to play. Assume also that you are using 3-ply search and the following simple evaluation function, E(S) = number of winning lines opened to 'X' - number of winning lines opened to 'O'. (If a board has 3 'O' in line then E = $-\infty$). The current board is shown below.

| | | |
|---|---|---|
| X | | |
| 0 | 0 | |
| X | | 0 |

i) Draw the game tree to 3 ply, showing the values of E at the leaf nodes.

ii) Use Minimax to determine your next move. Show your work.

iii) Show which branches would be pruned if you used $\alpha$ - $\beta$ pruning.

*[8 marks]*

b) What is knowledge engineering? List 2 characteristics of human expertise that make knowledge engineering difficult. Suggest an alternative to knowledge engineering.

*[4 marks]*

c) State the physical symbol system hypothesis and its main consequence. Describe the Turing test and give one argument against it.

*[4 marks]*

d) Briefly describe semantic networks, frames and scripts. In particular, state content and use of each of these knowledge representation techniques.

*[4 marks]*

**Q3** a) Consider the following set of training examples, described in Table I by two attributes, and in Table II by three attributes.

| I. | Al | A2 | Class |
|---|---|---|---|
| 1 | T | T | + |
| 2 | T | T | + |
| 3 | T | F | – |
| 4 | T | F | – |
| 5 | F | F | – |
| 6 | F | T | – |

| II. | Al | A2 | A3 | Class |
|---|---|---|---|---|
| | T | T | T | + |
| | T | T | F | + |
| | T | F | T | – |
| | T | F | F | – |
| | F | F | F | – |
| | F | T | T | – |

i) Compute the entropy of the training set {1,2,3,4,5,6} ? What is the entropy of subset {5,6}? Is the entropy of examples in Tables I and II the same ?

ii) For examples in Table I, draw two decision trees: with A1 and A2 in the root, respectively. Compare the informativity of A1 and A2.

iii) For examples in Table I, write a logical formula or an IF-THEN rule describing class +.

iv) For examples in Table II, compare the informativity of A3 with that of A1 and A2.

v) For examples in Table II, draw one of the trees with A3 in the root.

*[12 marks]*

b) Explain the meaning of consistency and completeness. What is noise? What is overfitting? What is pruning?

*[4 marks]*

c) Given are the following three clauses *C1, C2* and *C3.*

```
list([P|Q]):-list(Q).
list([U,V|W]):-list([V|W]).
list([X,Y|Z]):-list(Z).
```

i) Give all the pairs *Ci, Cj* such that *Ci* is more general than *Cj* under theta-subsumption.

ii) What is a refinement graph ? Draw a part of a refinement graph, with root `list(L).`

*[4 marks]*

**Q4** a) Consider the following set of training examples, described in Table I by two attributes, and in Table II by three attributes.

I.

| | Al | A2 | Class |
|---|---|---|---|
| 1 | T | T | + |
| 2 | T | T | + |
| 3 | T | F | – |
| 4 | T | F | – |
| 5 | F | F | – |
| 6 | F | T | – |

II.

| Al | A2 | A3 | Class |
|---|---|---|---|
| T | T | T | + |
| T | T | F | + |
| T | F | T | – |
| T | F | F | – |
| F | F | F | – |
| F | T | T | – |

i) Describe two main uses of heuristics in rule learning.

ii) Compute the predicted classification accuracy of the rule

```
Class = + IF A2 = T
```

using the relative frequency as well as the Laplace estimate. If they are different, explain why, if not, explain why not.

iii) Explain what is the "current training set" in rule learning. Write the current training set of a partially developed rule `Class = + IF A2 = T.`

iv) Explain the meaning of consistency and completeness of a hypothesis. Is `Class = + IF A2 = T` consistent? Is it complete?

*[8 marks]*

b) i) Give a pseudo-code of a covering algorithm for rule learning.

ii) Give a pseudo-code of a decision tree building algorithm.

iii) Explain what is the "current training set".

*[7 marks]*

c) i) Define generality using theta-subsumption.

ii) Let *C1* theta-subsume *C2*. Which clause is more general?

iii) Are the following two clauses comparable *w.r.t.* theta-subsumption? Is any of the two clauses theta-subsumed by the other?

```
d(X,Y):- p(Y,X), p(W,V)
d(X,Y):- p(Y,X)
```

iv) How do you test whether `d(a,b)` is covered by the clause `d(X,Y):- p(Y,X)`?

*[5 marks]*