UNIVERSITY OF EDINBURGH

FACULTY OF SCIENCE

ARTIFICIAL INTELLIGENCE 2

Monday, 9th June, 1986 — 14.00 - 17.00

Examiners: Chairman J A M Howe

External B du Boulay

INSTRUCTIONS TO CANDIDATES

1. Candidates on the third or later years for the degree of B.A. (Arts), B.Com., B.Sc. (Social Science), B.Sc. (Science) and LL.B. should put (3) after their names on the script book.

2. Answer any FOUR questions, writing each answer in a separate script book. All questions carry equal weight.

3. Each question is marked out of 25. The marks at the side of the questions show how these are apportioned.

1. Consider the following puzzle:

There are 8 sticks lined up as in figure 1. By moving exactly 4 sticks, you are to achieve the configuration depicted in figure 2. Each move consists of picking up a stick and jumping over exactly two other sticks and then setting it down onto a fourth stick. For example, in figure 3, stick d could be moved onto stick a or g passing over sticks c & b or e & f, respectively. It could not be moved anywhere else. In fig 4 stick d cannot be moved at all.

Fig 1:

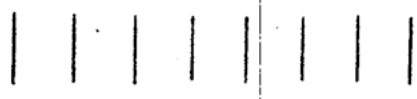
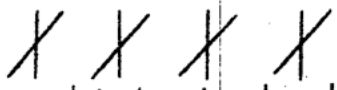


Fig 2:



[represents two sticks crossed]

Fig 3:

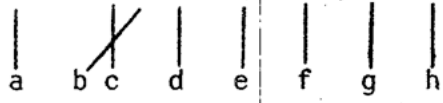


Fig 4:

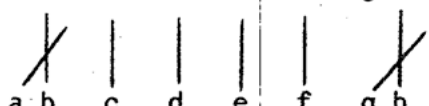
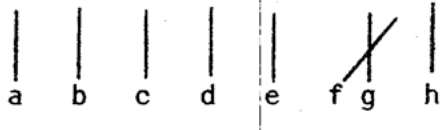


Fig 5:



Use state space search to solve this problem:

a) Decide on a notation for representing states.

[2]

b) Using this notation, show i. the initial state
ii. a goal state (is there more than one?)

[2]

c) Give the details of all the operators. For each:

i. describe its preconditions
ii. give an example (i.e. apply the operator to a state and give the new state).

[5]

d) Describe how the search space can be generated. Illustrate your answer by drawing part of the search space. Include all moves at level one. Expand one of these moves to level two. Label each arc with the operator being used. You should not duplicate states which are essentially identical due to symmetry. For example, figures 3 and 5 represent essentially the same state.

[6]

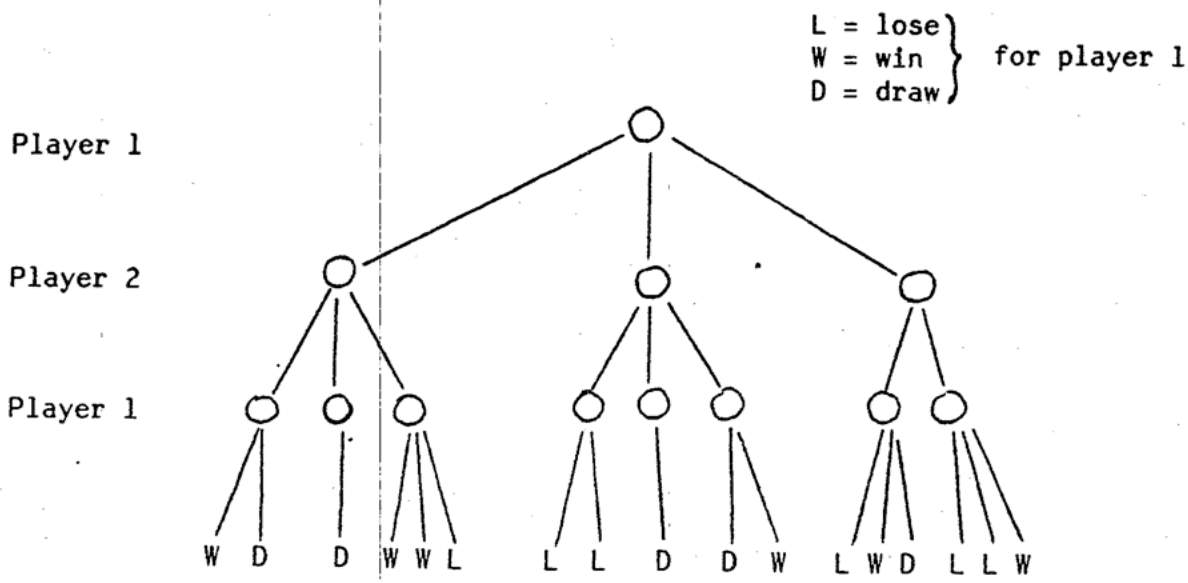
e) Give one heuristic evaluation function which might be helpful in solving this problem. Illustrate your function by evaluating two example states. Explain why the heuristic is likely to be helpful and discuss its shortcomings.

[6]

f) Unless your heuristic is extremely effective, or you are quite lucky, solving this problem by hand, is painful. It turns out to be quite easy if you search backwards from the goal state. Why? Hint: Solve the problem, observe what happens.

[4]

2. a) Use the mini-max search procedure on the following hypothetical game tree to determine whether player 1 has a guaranteed winning strategy. If so, what is it?



[8]

b) Sometimes, examining all the nodes in a game tree is unnecessary. Apply the technique of alpha/beta pruning to the tree and indicate which nodes need not have been examined. Assume nodes are examined left to right. Carefully explain the justification for the pruning done.

[10]

c) In most games (e.g. chess) it is not feasible to look far enough ahead to see final game positions which indicate win, loss, or draw. Describe how games trees can still be used to determine what a player's next move should be. What problems may be encountered? Use noughts and crosses as an example.

[7]

3. Consider the following rule set:

1 m → assert(i)
2 b → assert(a)
3 i → assert(d)
4 j → assert(e)
5 c & d → assert(a)
6 k → assert(e)
7 e & f → assert(b)
8 l → assert(i)
9 g & h → assert(c)

Goal: prove a
Definition: assert(x) add "x" to the data base
Data Base: {j,f,m}

a) Draw the AND/OR goal tree that would be generated by problem reduction with "assert(a)" as the root node. [6]

b) Draw all sub-trees which correspond to solutions in this goal tree. [3]

c) In part b) problem reduction was used, i.e. start with the goal, and work backwards by reducing to sub-goals to find a solution to the problem. Now use state space search and work forward from the data. The operators are the production rules, a "state" is the set of assertions in the data base. Draw the complete search space implicit in these rules and data. Label each arc with the appropriate operator (i.e. rule). Hint: The Root node is the initial state: {j,f,m}. [8]

d) Compare the amount of search required to find the solution for the two approaches in parts a) and c). If there is any difference, is it due to one approach being inherently better, or to something about the particular rule set? If it is the rule set, identify the characteristic(s) responsible for the difference. [5]

e) What is the relationship between the two control strategies, forward and backward chaining, and the two approaches to problem solving, state space search and problem reduction? [3]

4. a) For one of the following expert systems:

* CENTAUR
* INTERNIST

describe the overall strategy used to obtain a diagnosis during a typical session. This entails the following:

i. Briefly mention the knowledge representation formalism(s) used.

[4]

ii. After initial data is entered, how are possible diagnosis inferred?

[4]

iii. How is the asking of further questions controlled? Is the question sequencing sensible? Are irrelevant questions avoided?

[4]

b) The following production rules are part of the rule base for an expert system. We require that questions 2 & 3 never get asked before question 1. If we use forward chaining as the control strategy, how can the rule base be modified to ensure the correct question ordering?

a v b $\rightarrow$ assert(i) & ask(question1)

d & a $\rightarrow$ ask(question2)

b $\rightarrow$ assert(d) & ask(question3)

[6]

c) In parts a & b we have seen two approaches for controlling the order in which questions are asked in an expert system. Discuss the advantages and/or disadvantages of these approaches.

[7]

5. Some sentences contain subordinate clauses, which can themselves be viewed as sentences since they contain a subject and a verb. For example, in

The man who ate haggis painted the house

the phrase "who ate haggis" is a subordinate clause, where "who" is regarded as a pronoun.

Given the following lexical categories:

Art:	a, the, this
N:	man, haggis, house, cow, grass, side, road, dog, cat, rat, postmen
V:	eat, eats, ate, paint, paints, painted, stand, stands, stood, hate, hates, hated, kill, kills, killed
Pronoun:	he, it, she, who, that, which
Prep:	by, on, below, of

a) Draw syntactic tree diagrams for the following sentences, using the phrasal categories S (for Sentence), NP (for Noun Phrase) and PP (for Prepositional Phrase) and the lexical categories given.

i. He eats haggis.
ii. The man who ate haggis painted the house.
iii. The cow eats the grass that stands by the side of the road.
iv. The dog that killed the cat that ate the rat hates postmen.

[8]

b) Construct an RTN which will parse sentences i. - iv. to produce the structures you assigned in part a).

[9]

c) The RTN you gave in b) should parse the following ungrammatical sentences as well as those in a):

The man she eat haggis paint the house.
The cow eat the grass who stand by the side of the road.

Unless the RTN machanism is extended or the lexical categories subdivided, it is impossible to give an RTN which will parse the sentences in a) but not these ungrammatical ones. Explain why. Describe an extension to the RTN mechanism to achieve the desired effect.

[8]

7. In writing a program to recognize configuration of rectangular blocks, you start with the problem of representing edges of bodies making up a scene. Would you adopt a line-finding technique similar to that used by Roberts' program or an edge proposing technique similar to that used by Shirai's program?

a) Outline each technique.

[20]

b) In justifying your choice, comment briefly on the strengths and weaknesses of the two techniques.

[5]

8. a) Waltz developed the line labelling technique for segmenting scenes containing plane faced polyhedra.

i. Explain the rationale underlying the generation of labels in Waltz's scheme.

[7]

ii. Outline the methods used to apply line labelling to a typical scene.

[7]

b) Turner generalised the approach to include regular curved objects.

i. Discuss the problems that arise when handling surfaces that are non-planar.

[5]

ii. Explain the rationale underlying Turner's labelling scheme.

[6]