ASTON UNIVERSITY

EXAMINATIONS IN THE FOURTH DIMENSION

CS2320

Introduction to Computational Intelligence

Summer 2 hours

Answer ALL parts of ALL questions

Questions do not all have the same number of marks but the total is 100

THE USE OF CALCULATORS IS NOT ALLOWED

1. What is the physical symbol system hypothesis and why is Lisp suited to implementing it?

(8 marks)

2. a) List processing in Lisp can be usefully represented by the box-and-pointer notation where each list member has two pointers, one to its value, and the other to the rest of the list, as shown by Figure 1.

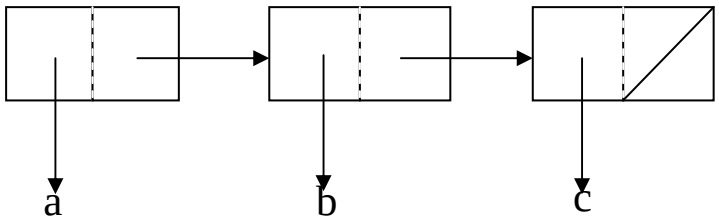


Figure 1: Representation of a Lisp list by the box-and-pointer notation

The following code is a list in Lisp:

```
(england ((winter ((temp chilly)(rainfall high)))
          (summer ((temp warm)(rainfall moderate)))))
```

Represent the list using the box-and-pointer notation. (5 marks)

b) Draw a hierarchical tree structure that is equivalent to the list in a). (4 marks)

1) Give THREE advantages of list processing for artificial intelligence applications.

(3 marks)

2) What is garbage collection in Lisp and how does it work? (4 marks)

1) The following code sets up a variable called `drug` with the value of the association list shown. The list contains the name of the drug and its properties. The properties list the symptoms treated by the drug, the side-effects caused by the drug, and the precautions that should be taken by a person who has been given the drug:

```
(setf drug
   '(new-painkiller
       ((symptoms (headache temperature aching-muscles))
        (side-effects (drowsy numbness dry-mouth))
        (precautions ((drive no)(age ((min 15)(max 65))))))))
```

a) Draw a mind map that represents a template for properties of drugs in general. It should includes the properties given in the Lisp list above as well as TWO more properties that you think are important for a doctor to know about the drug.

(7 marks)

b) Draw a hierarchical tree structure that is equivalent to the Lisp list given above.

(5 marks)

c) Write the function called `get-symptoms` that takes a `drug` variable and returns the list of symptoms as shown in the following example (the '>' sign represents the Lisp prompt in the interpreter):

```
>(get-symptoms drug)
(SYMPTOMS (HEADACHE TEMPERATURE ACHING-MUSCLES))
```

(5 marks)

d) Write a function called `symptom-p` that returns the symptom if the drug treats it or NIL otherwise.
Hint: your function can call the get-symptoms function but does not need to redefine the code for it.

```
>(symptom-p 'headache drug)
  HEADACHE
```

(7 marks)

e) A Lisp function needs to be defined called `match-symptoms` that takes two variables, a list of patient symptoms and a drug (as structured in the drug list shown at the beginning of this question). The function returns the patient symptoms contained in the drug symptoms list and those that are not, as shown in the following example:

```
>(match-symptoms '(headache temperature spots rash) drug)
((MATCHED (HEADACHE TEMPERATURE)) (UNMATCHED (SPOTS RASH)))
```

i) Give the steps in English (NOT Lisp code) for how the function would work.

(7 marks)

ii) Write the Lisp code for the `match-symptoms` function.
Hint: your code can use the two functions specified in parts (c) and (d) without having to redefine the code.

(8 marks)

f) Suppose the drug list given at the start of this question was intended to be part of an Intelligent Knowledge-Based System (IKBS) that helps a doctor choose the most suitable drug for a patient's symptoms.

i) Drugs vary in how well they act on and remove a patient's symptoms. Explain how you would redesign the list of symptoms in a drug so that it can inform the doctor about how effective the drug is for treating each symptom. Your answer should give an example of the new symptom list structure you have designed (i.e. show how it has changed from the symptom list for the example drug given at the beginning of this question).

(5 marks)

ii) Explain how you could use the new symptom list you created in (i) to generate a score for how well a drug matches and treats a patient's set of symptoms.

(6 marks)

iii) Write the Lisp code called `rate-drug` that takes the patient symptoms and a drug and generates a score for that drug's likely effectiveness for the patient.

(10 marks)

2) Suppose we have the following set of rules:

```
P and Q   →  goal
R and S   →  P
W and R   →  Q
T and U   →  Q
V         →  S
START     →  V and R and Q

Working memory = START
```

a) Explain how **forward reasoning** works. Your explanation should include defining the terms **triggered, fired,** and **conflict resolution.**

(8 marks)

b) Apply forward reasoning to the rules above where the only fact known in the working memory is `START`. For each step, show what rules are triggered and how the conflict resolution strategy chooses the one to fire. Also show how the working memory changes.

(7 marks)

c) Convert the rules into a list of rules in Lisp where the list is an association list with the rule conclusion as the property and the rule conditions the value of each property-value pair.

(6 marks)

3) Freemind is an open-source program for creating **mind maps** that was used during the laboratory classes for this module. Explain how Freemind can help with developing Intelligent Knowledge-Based Systems (IKBSs). Your answer should include the following issues:

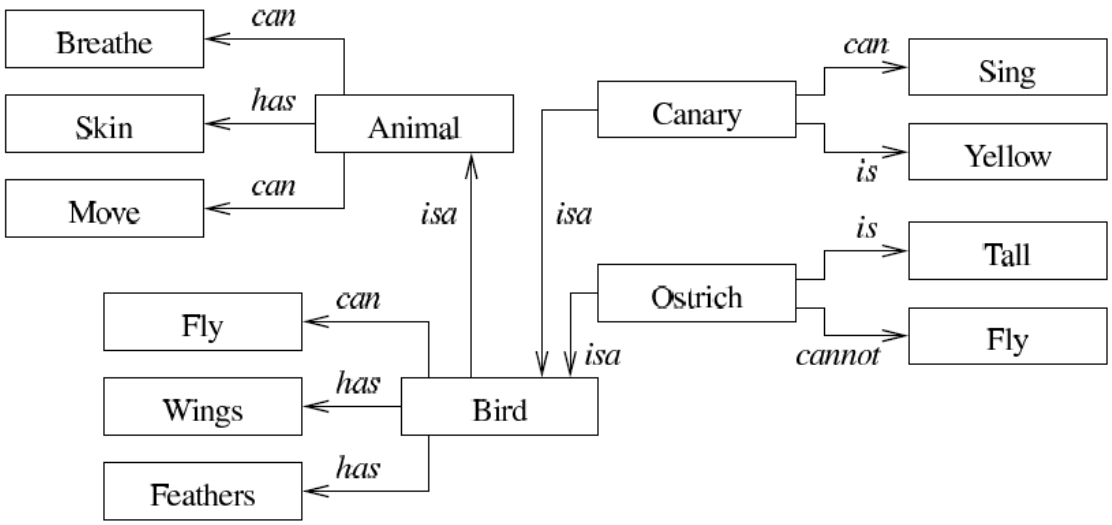
a) how mind maps and the particular features of Freemind help knowledge engineers elicit (ie obtain or capture) expert knowledge from human experts;

(10 marks)

b) how the XML representation of mind maps in Freemind helps translate the mind maps into code for an IKBS

(5 marks)

c) how Lisp lists can represent mind map structures. (7 marks)



1) The figure above shows a semantic network

a) List all the properties of an ostrich that can be determined from the network. (7 marks)

b) Draw a semantic network for the concept of a chair and the concept of a cushion to demonstrate the process of **intersection search** used in semantic networks to find relationships between two concepts.

(10 marks)

c) Explain the process of **inheritance** in a semantic network and provide some psychological evidence for it.

(8 marks)

2) This question is about search algorithms.

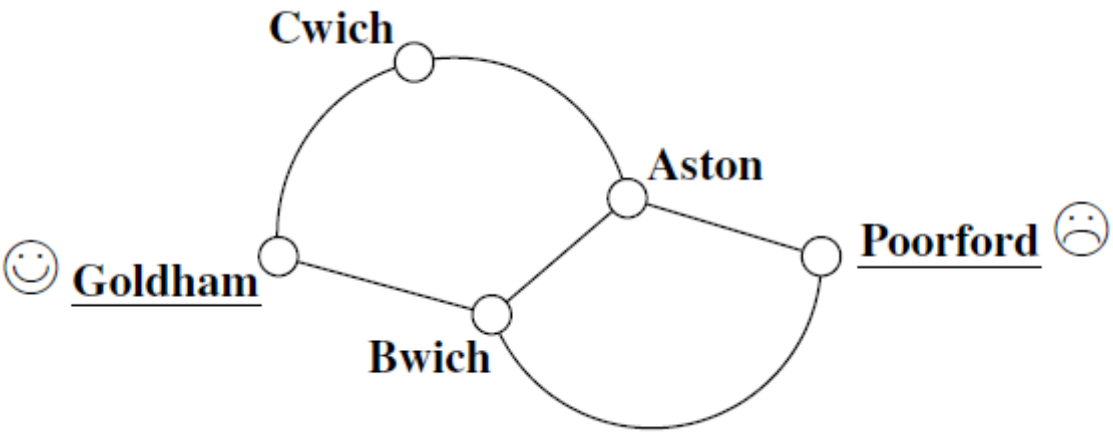
a) Identify the main operational difference between the breadth-first and depth-first search algorithms.

(5 marks)

b) Describe the steps of the iterative deepening depth-first search algorithm. Give your answer either in the form of a complete flowchart or as a list of steps.

(10 marks)

c) The following map shows several towns and all existing roads between them.



Consider applying breadth-first search and depth-first search to the problem of finding a route from Poorford to Goldham in the above scenario. When there are several alternatives that can be taken from a particular town, they should be ordered alphabetically by the name of the destination. For example, at Poorford we would consider the option of continuing via Aston before considering the other option of continuing via Bwich.

i) Which path will be found by breadth-first search? (5 marks)
ii) Which path will be found by depth-first search? (5 marks)
iii) Which path will be found by the iterative deepening depth-first search? (5 marks)

Give your answers by writing out the entire sequence of towns along the path and explain how you obtained it in each case.

END OF EXAMINATION PAPER