CSC 416

Question Set 4

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A set of questions based on chapter 3 of Coppin's Artificial Intelligence Illuminated.  This chapter deals with knowledge representation, and how it pertains to the field and study of AI.

GRADE = ( X + N + LF + A + R ) = (158 + 12 + 5 + 4 + (-86) ) = 93

1. Suppose that a search tree has root A, which has children B, C, and D, that B has children E and F, that C has children G, H, I, and J, and that D has child K. Furthermore, suppose that nodes F and I are goal nodes. (5) **5**
    a. What is the **branching factor** of the root of the tree?
        - 3
    b. What is the **branching factor** of the tree?
        - 2.5
    c. How many **complete paths** are there in the tree?
        - 2
    d. How many **partial paths** are there in the tree?
        - 5
    e. How many **paths** are there in the tree?
        - 29
2. Which of the following statements are true about NP-complete problems? (10) **10**
    a. If X is NP-complete, then a solution to X can be found quickly (i.e., in polynomial time).
        - FALSE
    b. If X is NP-complete, then any given solution to X can be verified quickly (i.e. in polynomial time).
        - FALSE
    c. A decision problem is a question in some formal system with a yes-or-no answer, depending on the values of some input parameters.
        - TRUE
    d. The satisfiability problem (SAT) is the problem of determining whether or not a Boolean expression written using only AND, OR, NOT, variables, and parentheses can be made to evaluate to true by an appropriate assignment of TRUE or FALSE values to the variables of the expression.
        - TRUE
    e. The traveling salesman problem (TSP) is the problem of determining the shortest path through a set of cities which begins and ends at a particular city.
        - TRUE
    f. SAT is NP-complete.
        - TRUE
    g. TSP is NP-complete.
        - TRUE
    h. TSP can be transformed into SAT.
        - TRUE
    i. The concept of NP-complete was introduced in 1971 by Stephen Cook in a paper entitled The complexity of theorem-proving procedures on pages 151-158 of the Proceedings of the 3rd annual ACM symposium on Theory of Computing, though the term NP-complete did not appear anywhere in his paper.
        - TRUE
    j. According to Don Knuth, the name “NP-complete” was popularized by Alfred Aho, John Hopcroft and Jeffery Ullman in their celebrated textbook “The Design and Analysis of Computer Algorithms”. He reports that they introduced the change in the galley proofs he had conducted of the Theoretical Computer

Science community. Other suggestions made in the poll included “Herculian”, “formidable”, Steiglitz’s “hard-boiled” in honor of Cook, and Shen Lin’s acronym “PET”, which stood for “probably exponential time”, but depending on which way the **P versus NP problem** went, could stand for “provably exponential time” or “previously exponential time”.

- TRUE

3. The traveling salesman problem instance presented in Figure 3.8 can be modeled in LISP by means of 5 property lists constructs, one of which is: `(setf (symbol-plist ‘a) ‘(b 900 c 600 d 700 e 600))`. Write down all five property list constructs in LISP—this one and the remaining four. (5) **5**

```
(setf (symbol-plist ‘a) ‘(b 900 c 600 d 700 e 600))
(setf (symbol-plist ‘b) ‘(a 900 c 800 d 1100 e 1700))
(setf (symbol-plist ‘c) ‘(a 600 b 800 d 700 e 1500))
(setf (symbol-plist ‘d) ‘(a 700 b 1100 c 700 e 600))
(setf (symbol-plist ‘e) ‘(a 600 b 1700 c 1500 d 600))
```

4. Write a recursive LISP function called `distance` to compute the distance of a tour represented as a list, in the context of the property list representation. This function is to take one argument, a list like `(A E D C B A)` or `(C B E D A C)`, and returns the total distance traveled in the tour, a number like `3600` or `4400`. (10) **10**

```
(defun distance (L)
  (cond
    ((= (length L) 1) 0)
    (t
      (+ (get (car L) (second L)) (distance (cdr L)))
    )
  )
)
```

5. How many possible tours are there for a traveling salesman problem with 12 cities? Provide the number as a sequence of digits. (5) **5**
   - There are 12! = 12 * 11 * 10 * 9 * 8 * 7 * 6 * 5 * 4 * 3 * 2 * 1 = 479,001,600 possible tours for 12 cities
6. What is a **heuristic**? (2) **2**
   - A heuristic is a rule or assumption designed to make an algorithm more efficient.

7. Design a decision tree that enables you to identify an item from a category in which you are interested (e.g., cars, animals, pop singers, films, etc.). (10) **9**

```
        Is it from
    the tea plant?
           /   \
         Y/     \N
         /       \
     Is it      Is it
     green?     red?
     / \        /     \
   Y/   |N    Y|       \N
   /    |      |        \
Green  Is it   Rooibos   Is it
Tea.   white?  Tea.      minty smelling?
      / |                / \
    Y/  |N             Y/   \N
    /   |              /     \
White  Black        Mint    Other
Tea.   Tea.         Tea.    Herbal Tea.
```

8. Design a suitable representation and draw the complete search tree for the following problem:
A farmer is on one side of the river and wishes to cross the river with a wolf, a chicken, and a bag of grain. He can only take one item at a time in his boat with him. He can't leave the chicken alone with the grain, or it will eat the grain, and he can't leave the wolf alone with the chicken, or it will eat the chicken. How does he get all three safely across to the other side? (15) **15**

```
Let each node's label define what is currently on the
"goal" side of the river.  W=wolf, G=grain, and C=chicken.
(‡)=nothing, as the initial state. *( )* denotes a goal state.

                      (‡)
         ____________/ | \____________
        /              |              \
      (W)             (G)             (C)
      / \             / \             / \
     /   \           /   \           /   \
   (WG) (WC)       (GW) (GC)       (CW) (CG)
     |               |
     |               |
  *(WGC)*         *(GWC)*
```

9. In computer science, what does the term "combinatorial explosion" refer to? (2) **2**
    - Combinatorial explosion is the idea that the possible solutions to a problem grow explosively as the domain of the problem increases.
10. Which problem was used in the text to illustrate the power of "problem reduction"? (2) **2**
    - The Towers of Hanoi problem was used in the text to illustrate problem reduction.
11. What is a **goal tree**? (4) **4**
    - A goal tree is a semantic tree with two types of goals (and-goals and or-goals) and two types of nodes (and-nodes and or-nodes). An and-goal is satisfied if all of its

subgoals are satisfied, whereas an or-goal is satisfied if any one of its subgoals are satisfied.

12. Give an example of an application of a goal tree, other than solving the Towers of Hanoi problem. (12) **10**
    - A goal tree could be used in attempting to design a game-playing agent, for tic-tac-toe or chess, for example.  A goal tree would not be very effective in solving a game such as Arimaa, however, due to its inherent complexity and nature of design.