COMP-424: Sample problems for the midterm

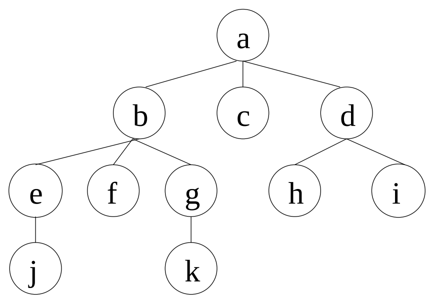
Note: These problems are intended to provide additional practice for the midterm.

1. You are the designer of a new route finding system for a car. The driver types the desired destination, and can select a preference, e.g. fastest driving time or shortest distance. The route finder suggests a route. The driver may take the suggested route all the way, or part of the way. In the second case, the driver may ask the system for guidance again, or may go on without asking. The auto makers would like the route finder to be efficient, and to adapt to the preferences of different drivers.

   What search and/or planning methods would be appropriate for this problem? Motivate your answer. What would the states, operators, costs and goals be? Would you use any heuristics?

2. List the order in which nodes are visited in the tree below for each of the following three strategies (choosing leftmost branches first in all cases):

   - Depth-first search.
   - Depth-first iterative-deepening search (increase depth by 1 in each iteration).
   - Breadth-first search.



3. Prove that if h is an admissible heuristic, then $h(n^*) = 0$ for all goal nodes n^*.

4. Consider the problem of missionaries and cannibals: 3 missionaries and 3 cannibals are on one side of a river, along with a row boat that is capable of transporting either 1 or 2 occupants. The objective is to find a way in which to move both the missionaries and the cannibals to the opposite side of the river, without ever allowing the number of cannibals on a river bank to exceed the number of missionaries (including the occupants of the boat), because then the cannibals would eat the missionaries. We would like to do this as quickly as possible.

   Formulate this as a search problem. Specify the representation of the states, operators, goal, start state and cost function. Can you find an admissible heuristic?

5. Towers of Hanoi. This is a classical problem, in which you have 3 pegs, A B and C, and a number N of discs with different diameters. A larger disc cannot be placed on top of a smaller disc. The discs are initially placed on peg A, and the goal is to move them all on peg C, in a minimal number of moves.

   Formulate this as a search problem. Specify the representation of the states, operators, goal, start state and cost function. Find an admissible heuristic, and show that it is admissible.

6. Russell and Norvig, Problem 6.5. Provide a propositional description of the given text, and write the proofs for the book questions.

7. How many Boolean operators (connectors) can there be? Why are some of them not very useful?

8. Are the following statements true or false?

   (a) All search algorithms are complete.

   (b) A^* search is complete.

   (c) A^* terminates immediately when a goal state is found.

9. [15 points] **Satisfiability:**
   For each of the following statements, state whether it is valid, satisfiable or unsatisfiable. If it is satisfiable, give a satisfying assignment of values to the variables.

   (a) $P \vee Q$

   (b) $P \implies P$

   (c) $(P \implies Q) \wedge (Q \implies R) \wedge (R \implies \neg P)$

   (d) $(P \wedge Q) \vee (P \wedge \neg Q)$

   (e) $(P \vee Q) \wedge (P \vee \neg Q)$

10. Translate the following sentences into first-order logic:

    (a) All students who take AI like to play games.

    (b) No students who take AI like to play games.

    (c) On Saturday, all students either go to a party or work, but not both,

    (d) All students go to a party on Saturday, except those taking AI.

    (e) Exactly two students go to a party.

11. **STRIPS notation:**

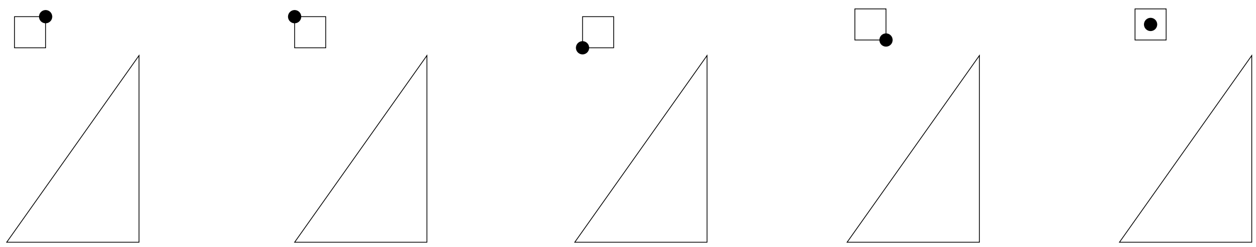
    Suppose we want to drive a car from Montreal (M) to Toronto (T). The key must be in the ignition in order to be able to drive the car. Initially we have the key in our pocket and we want the key to be there again at the end of the plan. In order to construct a plan, we have 4 operators: Drive(M) (drive to Montreal), Drive(T), Insert(Key) (put the key in the ignition), Remove(Key). We also have a few propositions to describe possible world characteristics: InPocket(Key), InIgnition(Key), At(Car, M), At(Car,T).

    Describe the four operators above in STRIPS notation. You will need to specify preconditions and postconditions (in terms of add and delete effects) for each operator.

12. Russell and Norvig, pg. 412, problem 11.4.

13. Motion planning

Consider a small square robot which can move in X-Y and a larger triangular obstacle. Draw the configuration-space transform, assuming that the reference point of the robot is in (a) the upper-right corner of the robot; (b) the upper-left corner; (c) the lower-left corner; (d) the lower-right corner; and (e) the center of the robot.



(a) (b) (c) (d) (e)