PRACTICE PROBLEMS FOR THE MIDTERM EXAM
CS534 ARTIFICIAL INTELLIGENCE. S98
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I. Search

1. Exercise 4.4 from the textbook.
2. Exercise 4.10 from the textbook.
3. We have computed optimal paths under the assumption that COSTS are non-negative. Suppose that we remove that assumption. Discuss how allowing some of the costs to be negative would affect the search methods below, and give an example.
   - Depth 1st
   - Breadth 1st
   - Depth–limited Search
   - Iterative Deepening Search
   - Uniform Cost Search
   - Branch-and-bound
   - Greedy Search
   - A*
   - IDA*
   - Hill-climbing
   - Simulated Annealing
   - Beam Search

II. More Search

1. Use your expertise from Project 1 to solve Exercise 5.1 from the textbook.
2. Discuss how you would use simulated annealing to solve the planning problem on Project 2. Define precisely which energy function and which schedule function you would use.
3. How does the simulated annealing procedure described in the paper "Optimization by Simulated Annealing" by Kirkpatrick, Gelatt, and Vecchi differ from the procedure described by Russell and Norvik on Figure 4.15 (see p. 113). Explain advantages and disadvantages of both approaches.

III. Logic and logic programming

1. Translate the following logical sentences into English
   - $\forall x[human(x) \Rightarrow mortal(x)]$
   - $\forall x \exists y (x > y)$
   - $\exists z \forall w (z > w)$

What is the truth value of the last two sentences on the set of natural numbers? on the set of integer numbers?

2. Translate the following English sentences into logic
   - All purple mushrooms are poisonous

   - No purple mushrooms is poisonous

   - All mushrooms are either purple or poisonous

   - All mushrooms are either purple or poisonous but no both

   - All purple mushrooms except one is poisonous

   - There are exactly two purple mushrooms

3. Consider the following five logical statements.
   - $\forall x[equal(x, x)]$
   - $\forall x, y[equal(x, y) \Rightarrow equal(y, x)]$
   - $\forall x, y, z[equal(x, y) \wedge equal(y, z) \Rightarrow equal(x, z)]$
   - $equal(b, a)$
   - $equal(b, c)$

   (a) Prove by refutation using resolution that $equal(c, a)$ is a logical consequence of the five sentences above. (Remember to show the unifications used during the process.)

   (b) Construct a logic program with these five statements and show that proving $equal(c, a)$ using backward chaining from the logic program is equivalent to proving $equal(c, a)$ from the five statements by refutation using resolution.

4. What is in your opinion the main achievement of Robinson's "A machine-oriented logic based on the resolution principle" paper?

IV. Planning

1. Exercise 11.9
2. Show with an example the difference between situation search and plan search.
3. Represent the towers-of-Hanoi puzzle (see my undergrad. final exam) in situation calculus and the STRIPS language and solve it using POP.

V. Rule-based and Expert Systems

1. Consider the following set of rules (taken from Luger and Stubblefield's "Artificial Intelligence Structures and Strategies for Complex Problem Solving" textbook.
   - if the engine is getting gas, and the engine will urn over, then the problem is spark plugs.
   - if the engine does not turn over, and the lights do not come on then the problem is battery or cables.
   - if the engine does not turn over, and the lights do come on then the problem is the starter motor.
   - if there is gas in the fuel tank, and there is gas in the carburetor then the engine is getting gas.

(a) Write the rules in a formal language of your choice.

(b) Devise a realistic car failure situation which can be diagnosed using these rules and show how the rule-based system would construct a diagnosis.

(c) Discuss how you would implement an explanation module to be added to the rule-based system so it can explain in English how the system reached its diagnosis.

2. Buchanan and Smith discuss in their "Fundamentals of Expert Systems" paper the need to reason with uncertainty. Explain where uncertainty may appear in the knowledge and how uncertainty is represented and handled in expert systems. Illustrate your answer with an example.

VI. Frames and Inheritance

In his paper "A Framework for Representing Knowledge", Minksy states

> Here is the essence of the frame theory: When one encounters a new situation (or makes a substantial change in one's view of a problem) one selects from memory a structure called a "frame". This is a remembered framework to be adapted to fit reality by changing details as necessary.

1. Explain how "frames", "details", and "changing details are necessary" are represented/implemented.
2. Illustrate with an example a frame system consisting of at least four different frames.
3. Describe in your example the notion of inheritance.
