CS182 Midterm
Fall Term 1994

There are **six** exam problems below. You are to do **all six** problems. There are a total of 90 points. You have 90 minutes for the exam. Use the points assigned to each problem to help gauge the amount of time you should spend on the problem.

Good luck!

Question 1 (10 points)

Turn the following WFFs into clauses:

1. `(∀x (IceCream(x) ⇒ Food(x)))`
2. `(∀x (Fudge(x) ⇒ Food(x)))`
3. `(∀xy ((Food(x) ∧ Food(y) ∧ Cold(x) ∧ Merge(x,y)) ⇒ Cold(y)))`
4. `(∃x(∃y(IceCream(x) ∧ Cold(x) ∧ Fudge(y) ∧ Merge(x,y))))`

Now prove:

5. `(∃z(Fudge(z) ∧ Cold(z)))`

Question 2 (15 points)

The design of an intelligent agent system depends on the environment in which the agent will operate as well as on the agent's capabilities (the types and range of its perceptual abilities, the actions it can take) and the tasks it is designed to perform. Choose *one* of the following pairs of system types (i.e., choose *either* Category A *or* Category B) and do the following:

(a) Contrast the environment properties of the two domains in the category; in particular, discuss whether or to what extent each is accessible, deterministic, static vs. dynamic, and episodic vs. nonepisodic.

(b) On the basis of your commentary in part (a), decide which would be more challenging to build, and argue briefly why this is the case. Use concepts developed in the course in your argument. Do *not* give just a vague, general answer.

(c) For each system, name the simplest agent architecture that suffices for implementation, and briefly justify your choice. Again, give justification in terms of concepts developed in the course.

Category A: Medical Systems

1. X-ray analysis. Given: X-ray. Task: provide classification.

2. Pulmonary disease specialist. Given: symptoms. Task: identify disease(s) and treatment(s).

Category B: Household Systems

1. Swimming pool cleaner. Given: perception of current swimming pool water, surface features of sides and bottom. Task: vacuum up dirt, algae, etc.

2. Food shopper. Given: weekly menus. Task: fill the pantry.

Question 3 (15 points)

You are representing botanical information about a newly discovered plant product, quatkum, that grows on the planet Twin-Mars (a Mars-size planet on which some things grow). On Twin-Mars all fruits have seeds. No vegetables have seeds. You have not yet figured out whether quatkums are a fruit or a vegetable; they can't be both.

(a) Represent in FOPC each of the facts given below. If it is not possible to represent a fact, explain why. Describe briefly the semantics of the nonlogical symbols you use.

(b) For each fact say whether or not it could be represented in a network/frame inheritance hierarchy. If the answer is "no," briefly explain why not. Note, you do *not* need to give the representation if the answer is "yes."

1. All quatkums are either fruits or vegetables but not both.

2. No quatkum has a soft skin.

3. Most quatkums ripen in January.

4. There is a quatkum in your tent.

N.B. For fact Number 1 your WFF *must* ensure that all quatkums are of the same category; i.e., it can't be that one quatkum is a fruit and a different one is a vegetable.

Question 4 (20 points)

Pictured below is a simple one-player game played on a board with fifteen holes arranged in a triangle. When the game starts (in the configuration shown), there are 14 pegs on the board and a single unused hole in the middle. The object of the game is to remove all but one of the pegs from the board.

The only legal move is a jump by a peg to an empty hole. A jump may *only* take place diagonally, and *only* when the intermediate hole is filled by another peg. If a peg performs a jump, the intermediate peg is *removed* from the board. In this respect, the rules for moving are similar to checkers. For example, the dotted arrow indicates one of the two legal moves available at the opening.

Note that it is possible to arrive in a board state where more than one peg is still on the board, but no more jumps can be made, because the pegs are isolated. Such a state is *not* considered a solution of the game. Note also that we are interested in knowing more than just whether a solution exists given the initial board configuration.

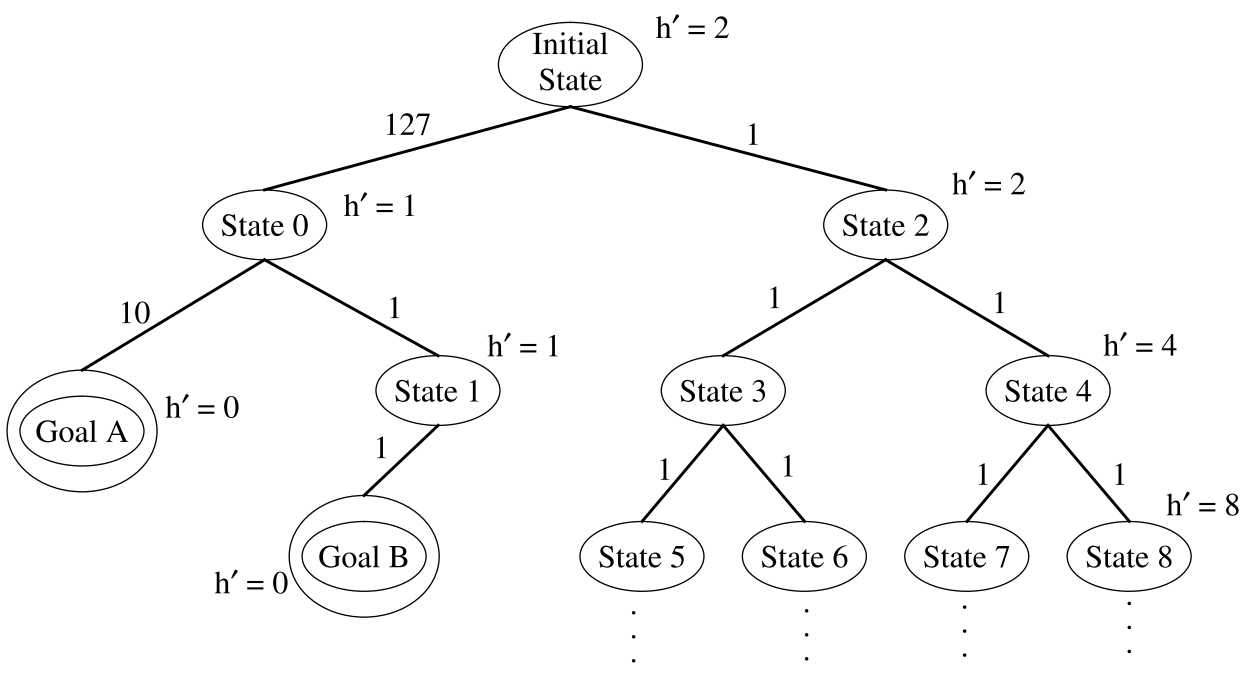
(a) Provide a representation of this problem sufficient for doing uninformed search with a search system of the types covered in this course and used in the search programming assignment. You do not need to use LISP code or LISP pseudocode, as long as your notation is clear and unambiguous. You are permitted to use both a node and a board position as parameters to your operators if you desire; keep in mind that your domain encoding should scale well to larger-sized boards.

(b) Is path cost important in this problem? If so, why? If not, why not?

(c) Describe two different admissible heuristics which informed search algorithms could make use of in this domain. The second figure below might help you in thinking about the characteristics of the search space: consider the moves possible for the peg at the top of the triangle. Argue the admissibility of the heuristics, and be sure that the heuristics actually *guide* the search in some fashion (i.e., search does not proceed exactly as it would with an uninformed algorithm).

Question 5 (15 points)

Consider the following binary tree example, where the goal states are as indicated (we have only two: `goal_A` and `goal_B`) and the subtree under State 2 extends infinitely.



The path costs are listed on the edges. We have an admissible heuristic function `h′(n)` as follows:

```
h′(goal states) = 0
h′(init) = 2
h′(state_0) = 1
h′(state_1) = 1
h′(state_2) = 2
h′(state_3,4) = 4
h′(state_5,6,7,8) = 8
h′(state_...16) = 16
```
etc.

We also have the A* node evaluation function: `f(n) = g(n) + h(n).`

(e) If `g(n) = 0` and `h(n) = h′(n)`, is the solution optimal? What is the time complexity?

(f) If `g(n) = path cost` and `h(n) = 0`, is the solution optimal? What is the time complexity?

(g) If `g(n) = path cost` and `h(n) = h′(n)`, is the solution optimal? What is the time complexity?

Question 6 (15 points)

Consider the following argument:

(a) If I have a dollar, I can buy a coke.

(b) If I have a dollar, I can buy a bag of pretzels.

(c) I have a dollar.

(d) Therefore, I can buy a coke and a bag of pretzels.

Do the following:

1. Give a naive encoding of (a) through (c) in FOPC and show how (d) is derived; make the inference rules you use clear. You may use any of the inference rules discussed in class.
2. Give a brief statement of what, intuitively, causes the problem.
3. Give a re-encoding of the problem in situation calculus and describe how that overcomes the problem.