Doctoral Exam in Artificial Intelligence
January 1996

Problem 1:
Consider the following sentences:

i. All the people in room 101 are either professors or students.

ii. If a student is in room 101, then some advisor of his is also in room 101.

iii. The advisor of any student is a professor.

iv. Someone is in room 101.

v. Some professor is in room 101.

Let $\mathcal{L}$ be a first-order language containing the following predicates.

p(X) — X is a professor.
s(X) — X is a student.
a(X,Y) — X advises Y.
r(X) — X is in room 101.

A. (10 points) State each of the sentences (i) – (v) in $\mathcal{L}$.

B. (10 points) Show that (v) can be proven from (i) – (iv) using resolution.

C. (5 points) Is this a Horn theory? Explain.

Problem 2: (10 points)
You are given the problem of determining whether a set of formulas in the propositional calculus, such as

$p \vee q \vee \neg r.$
$(\neg p \wedge q) \Leftrightarrow r.$
$p \Rightarrow \neg(q \Rightarrow r).$
...

is consistent. Describe how you could use state-space search to solve this problem. What are the states? What are the operators? What kind of search technique should you use?

Problem 3: (10 points)
Back propagation in neural networks may be considered as an instance of hill climbing. Explain how. What is the space being searched? What is the objective function being minimized? How is the direction of motion computed?

Problem 4: (15 points)
Consider a program doing inductive learning of a concept c(X). The program's current definition of c(X) is the formula

$$c(X) \Leftrightarrow [\exists_Y\ p(X,Y) \wedge q(f(X),Y)]$$

where the predicates p and q and the function f are assumed to be known. For each of the following, state whether it is a generalization of the above definition, a specialization, or neither.

A. $c(X) \Leftrightarrow \exists_Y\ p(X,Y)$.

B. $c(X) \Leftrightarrow [p(X,f(X)) \wedge q(f(X),f(X))]$.

C. $c(X) \Leftrightarrow [\exists_Y\ p(a,Y) \wedge q(f(a),Y)]$. (a is a constant.)

D. $c(X) \Leftrightarrow [\forall_Y\ p(X,Y) \wedge q(f(X),Y)]$.

E. $c(X) \Leftrightarrow [\forall_Y\ p(X,Y) \Rightarrow q(f(X),Y)]$.

Problem 5: (15 points)
Syntactic parsing is a module in both natural language processors and in compilers. State briefly (1 or 2 sentences each) three reasons that the NLP problem is harder than the compilers problem.

Problem 6: (10 points)
Consider the following four sentences, each using the preposition "with".

i. I ate dessert with Mrs. Ginzberg. (= in company with Mrs. G)

ii. I ate dessert with enthusiasm. (= in an enthusiastic manner)

iii. I ate dessert with a spoon. (= using a spoon)

iv. I ate dessert with a cup of coffee (= in combination with coffee).

A. How could an AI program choose the correct meaning of "with"?

B. Why is it important that an AI program should distinguish between these meanings of "with"?

Problem 7: (15 points)
Consider a microworld consisting of bodies of data, file names, and directories. The directory system is flat, not hierarchical. The following two fluents are defined:

in-dir(name,dir) — There exists a file dir/name.

contains(dir, name, data) — The file dir/name contains the specified data. (A file may contain more than one body of data.)

The following actions are defined:

copy(dir1, name1, dir2, name2) — Create a file name2 in directory dir2 and initialize its contents from dir1/name1. The file dir2/name2 must not exist prior to the copy.

append(dir1, name1, dir2, name2) — Add the data in dir1/name1 to the file dir2/name2. The file dir2/name2 must already exist.

delete(dir, name) — Delete the file dir/name.

a. Using the situation calculus, state an axiom characterizing the effect of "copy".

b. Using the situation calculus, state a frame axiom applying to "delete".

c. Is it possible to represent this microworld in a STRIPS representation? If so, give the representation; if not, explain the difficulty.