Assignment 3

Introduction to AI - CS 487, Fall 2022

Assignment 3

Deliverables: Submit a pdf file containing a report with the answers. **Your deliverable should include your student ID in the filename**

Note that this assignment is to be done **individually**. Cheating in any way, including giving your work to someone else, will result in failing this assignment (a mark of zero will be given).

Theoretical Exercises

Exercise 1 (20 points)

Represent the following sentences in first-order logic, using a consistent vocabulary (which you must define):

1. Some students took French in spring 2001.
2. Every student who takes French passes it.
3. Only one student took Greek in spring 2001.
4. The best score in Greek is always higher than the best score in French.
5. Every person who buys a policy is smart.
6. No person buys an expensive policy.
7. There is an agent who sells policies only to people who are not insured.
8. There is a barber who shaves all men in town who do not shave themselves.
9. A person born in the UK, each of whose parents is a UK citizen or a UK resident, is a UK citizen by birth.
10. A person born outside the UK, one of whose parents is a UK citizen by birth, is a UK citizen by descent.
11. Politicians can fool some of the people all of the time, and they can fool all of the people some of the time, but they can't fool all of the people all of the time.
12. All Greeks speak the same language. (Use $Speaks(x, l)$ to mean that person x speaks language l.)

Exercise 2 (20 points)

Write a general set of facts and axioms to represent the assertion "Wellington heard about Napoleon's death" and to correctly answer the question "Did Napoleon hear about Wellington's death?"

Exercise 3 (30 points)

This question considers Horn KBs, such as the following:

$$P(F(x))P(x)$$
$$Q(x)P(F(x))$$
$$P(A)$$
$$Q(B)$$

Let FC be a breadth-first forward-chaining algorithm that repeatedly adds all consequences of currently satisfied rules; let BC be a depth-first left-to-right backward-chaining algorithm that tries clauses in the order given in the KB. Which of the following are true?

1. FC will infer the literal $Q(A)$.
2. FC will infer the literal $P(B)$.
3. If FC has failed to infer a given literal, then it is not entailed by the KB.
4. BC will return *true* given the query $P(B)$.
5. If BC does not return *true* given a query literal, then it is not entailed by the KB.

Exercise 4 (30 points)

Suppose a knowledge base contains just the following first-order Horn clauses:
Ancestor(Mother(x),x)
Ancestor(x,y) $\wedge Ancestor(y,z) Ancestor(x,z)$ Consider a forward chaining algorithm that, on the jth iteration, terminates if the KB contains a sentence that unifies with the query, else adds to the KB every atomic sentence that can be inferred from the sentences already in the KB after iteration $j-1$.

1. For each of the following queries, say whether the algorithm will (1) give an answer (if so, write down that answer); or (2) terminate with no answer; or (3) never terminate.
   (a) $Ancestor(Mother(y), John)$
   (b) $Ancestor(Mother(Mother(y)), John)$
   (c) $Ancestor(Mother(Mother(Mother(y))), Mother(y))$
   (d) $Ancestor(Mother(John), Mother(Mother(John)))$

2. Can a resolution algorithm prove the sentence $\neg Ancestor(John, John)$ from the original knowledge base? Explain how, or why not.

3. Suppose we add the assertion that $\neg(Mother(x)x)$ and augment the resolution algorithm with inference rules for equality. Now what is the answer to (b)?