Computational Logic

Programming Assignment 2

Introduction

In this assignment, we will use First Order Logic to define a scene as a set of formulas and query the set to solve a real world problem. Prolog, a programming language specifically designed for logic problems will be used in this exercise.

First Order Logic Alphabet

- **Variables** - Alphanumeric characters that are used to refer to objects in the domain. In Prolog, capital letters are usually used to represent variables.
  - e.g. X,Y,Z
- **Constants** - Representing objects defined in the domain.
  - In prolog, constant symbols are usually in small-case
  - E.g. mary, green.
- **Term -** A term is an element of the alphabet; a single instance of a Variable or a Constant is defined as a term

- **Predicates** - Map terms to truth values
  - Eg: colour(grass, green) takes the terms grass and green and returns a truth value of True, depending on the definitions of the terms in the database.In Prolog, all objects

First Order Logic Example

First-order logic (FOL) can be used as a language for defining and querying scenes and databases. For example, we can express the family relations shown in Figure 1 through a number of atoms and rules like:

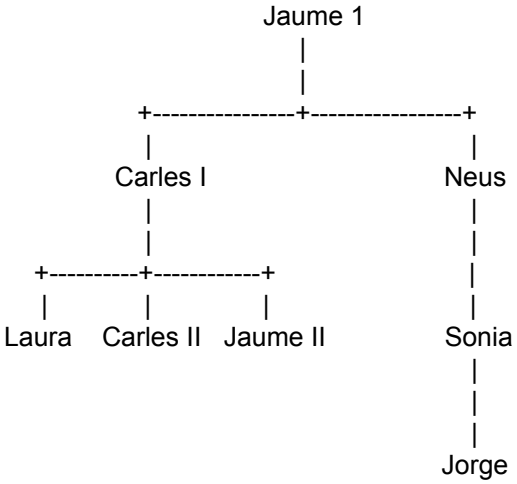

Figure 1: Example Family Tree

Predicates and Constants

We will first define the members of the family using the following terms:

male(jaume1).

male(carles1).

male(carles2).

male(jaume2).

male(jorge).

female(laura).

female(neus).

female(sonia).

jaume1, carles1, carles2, jaume2, jorge, laura, neus and sonia are constant symbols, which denote different objects. In this case, they represent the various people in the family tree.

male() and female() are predicates, in this case, they are being defined so that a query male(jaume1) would evaluate to True whereas a query female(jaume1) would evaluate to False.

parent(carles1,jaume1).

parent(neus,james1).

parent(carles2,carles1).

parent(laura,carles1).

parent(jaume2,carles1).

parent(sonia,neus).

parent(jorge,sonia).

These are predicates of arity=2, defining the relation (in this case, parent) between two constants. The query parent(carles1, jaume1) will evaluate to True. Queries that are not defined in the database would evaluate to False. Eg: parent(carles2, laura) would be evaluated as False.

A query with a free variable will return the values which satisfy the condition defined by the query. Eg. parent(carles1, X), where X is a free variable, will return the value X=jaume1.

Formule

$\forall$ X $\forall$ Y parent(X,Y) $\wedge$ female(Y) $\rightarrow$ mother(X,Y)

Is a formula representing that for all X and all Y in the domain, if Y is a female and Y is a parent of X, then Y is the mother of X.

This can be represented in Prolog as

mother(X,Y) :- parent(X,Y), female(Y).

Note that the implication sign is reversed, commas are used for conjunction, a period is used to end the sentence and all variables are assumed to be universally quantified. The statements presented above are in the file kb1.pl provided to you.

Axioms

The following axioms are assumed to be true while working with logic in Prolog:

1. Unique name assumption: Different constant symbols denote different objects.
2. Domain closure: There are no more objects than those referred to by names in the database
3. Closed world assumption: That which cannot be proved from the database, is assumed to be false.
4. Universal quantification: all variables are assumed to be universally quantified.

Queries In Prolog

To run queries on Prolog, you must first load the Prolog command line interface. To do this, go to the directory containing the files and type the command *swipl* on your terminal.

This should give you the following screen:

Welcome to SWI-Prolog (threaded, 64 bits, version 7.4.2)
SWI-Prolog comes with ABSOLUTELY NO WARRANTY. This is free software.
Please run ?- license. for legal details.

For online help and background, visit http://www.swi-prolog.org
For built-in help, use ?- help(Topic). or ?- apropos(Word).

?-
To load the database, enter the following command:

?- consult('kb1.pl').

Now, to run a query, for example, to list all the mothers in the database and their children, enter the following command:
?- mother(X,Y).

This will result in the following output:

X = sonia,
*Y = neus **;***
X = jorge,
Y = sonia.

To find the sister of Carles II, run

?- sister(X,carles2).

Resulting in the output:

X = laura

An example of a referring expression in this context would be to refer to Sonia without explicitly naming the associated symbol. In this case, we note that Sonia is a female and her parent is also a female. Thus, the referring expression in this case can be:

?- female(X),parent(X,Y),female(Y).

Resulting in the output:
X = sonia,
Y = neus.

Real World Problem Example:

We are given the following problem statement that we will first represent using logical formulas and then query the knowledge base to find the answer:

Brenda, who lives in Smalltown, USA, has been diagnosed with breast cancer. If a patient has a breast cancer diagnosis, they should have a surgery. Dr. Amy is the only surgeon in Smalltown, while Dr. Bruce is a surgeon in Knoxville. Since a cancer patient cannot travel, the surgery must be performed in the same town. Find out who can perform the surgery on Brenda.

To start, we will first represent the fact that Brenda has cancer:

cancer(brenda).

Next, we introduce the two surgeons:

surgeon(bruce).
surgeon(amy).

Then we can write predicates defining the towns of the three characters:

town(brenda,smalltown).
town(bruce,knoxville).
town(amy,smalltown).

Represent the fact that one who has cancer needs surgery:

needs_surgery(X) :- cancer(X).

And finally the formula that represents that the surgery must be performed by a surgeon who lives in the same town as the patient:

performed_surgery(X,Y) :- needs_surgery(X),surgeon(Y),town(X,Z),town(Y,Z).

These predicates have been defined in the file kb3.pl. You can load the file in Prolog using the command:
?- consult('kb2.pl').

Then, to query the knowledge base to see who performed the surgery on Brenda, you can use the following command:

?- performed_surgery(brenda,Y).

Resulting in the answer:

Y = amy.

Installing Prolog

Follow the instructions on the following page to install SWI-Prolog on your system:

https://wwu-pi.github.io/tutorials/lectures/lsp/010_install_swi_prolog.html

Please let me know if you have any difficulty installing the program.

Assignment

You are given the following statement in English, which must be translated into logical statements

A murder was committed last night, the police have five suspects, Albert, Bruno, Carmen, Daniel and Elisa. There are four objects which the police believe might have been the murder weapon: a knife, a lead pipe, a gun and a candlestick. The knife had the fingerprints of Albert and Elisa, the lead pipe those of Daniel and Bruno, the gun those of Carmen and Bruno while the candlestick has the fingerprints of Albert and Daniel. Security footage from the house shows a person entering the house with a hat and it may be assumed that the murderer was wearing a hat. Of the suspects, only Albert, Carment and Elisa have hats. On further investigation, the police determined that the gun and the knife were antiques that were too valuable to be used as murder weapons.

After writing the logical statements, you must write a suitable query to find out the murderer and the murder weapon.

Submission and Evaluation

You must submit the pl file containing the knowledge base for the problem as well as a pdf file explaining the statements you have chosen and the query that returns the murderer and the murder weapon. You will be graded on the originality and efficiency of the statements in the file.

Submission deadline : 17/06/2017 at 23:59.

Submit using an email to pritish.chandna@upf.edu. Each submission must have the subject Computational Logic Lab 2 Group <Group Number>