Prolog Programs

Get started using Prolog facts, rules, and variables

Lesson Overview (Agenda)

In the following lesson, we will explore:

1. Prolog Basics
2. Example: reasoning about family relationships
3. Prolog Rules

Prolog Basics

- Prolog name comes from PROgramming in LOGic
- DO NOT try to compare Prolog programming to the programming you know
- There are no loops, no if-statements, and no variables of the kind you're used to)
- DO NOT try to translate from Python to Prolog or vice versa
- Prolog = Declarative Programming:
    - Declare facts and rules (prolog program) **|:** prompt, or enter in file
    - Run prolog interpreter and load program
    - Issue query (run the program) **?-** prompt
    - Prolog will find a set of variable bindings such that the query is true, or state "no" if it isn't true

TWO contexts, code looks same, but different meaning

1. Writing a Prolog program

Typing Prolog code **into a file**

or Prompt is **|:**

You are making **true statements**

parent(jim,todd).

parent(jim,X)

vs

2. Running a Prolog program

Typing Prolog queries into **a Prolog interpreter**

Prompt is **?-**

You are asking **questions**

?- parent(jim,todd).

?- parent(jim,X).

Meaning is different from context 1

Prolog programs

- A prolog program is a set of statements which are facts and rules, called clauses.
- When writing a prolog program, the programmer has a "world" in mind, and the programmer thinks of and writes down all of the true statements about that world, in prolog syntax.
- Usually we put the set of clauses into a text file with a name that ends with the .pl extension
- Beware the Perl programming language also uses the .pl extension
- Beware that Windows File Explorer (by default) doesn't show the extension of a filename, when you see myfile.pl it might actually have the name myfile.pl.txt

Prolog Interpreter

- A prolog interpreter is necessary to run a prolog program.
- The user runs the prolog interpreter and **consult**s the program file, causing the prolog interpreter to read the prolog program from the file and store the clauses in its memory
- The pseudo-file called **user** corresponds to the programmer typing directly into the interpreter, and those clauses disappear when the interpreter shuts down
- After the program has been consulted into the interpreter, it is ready to run

Running a Prolog program

- In order to run a Prolog program, after the clauses have been loaded into the interpreter from a file, the user asks questions and receives answers
- The questions are issued in Prolog syntax, and they might involve variables.
- The output of a Prolog program is the answer to the question, which might be false or true.
- If the answer is true, the output also includes the **variable bindings** that make the question true
- A true answer can be thought of as "true if the variables have these values"

Working with Prolog: what are the stages?

- Modeling: imagine the world you are representing, and what is true about that world
- **Programming**: Write down all the relevant true facts and rules about that world
- Launch the prolog interpreter and consult the program file
- **Running the Program**: issue queries (questions) to the Prolog interpreter and receive the answers
- To distribute your prolog program to your friends, family and other users, you distribute a binary of the interpreter with your program pre-consulted, set up to automatically issue a kickoff query when it runs

Prolog Basics (Cont'd)

- Usually we put facts and rules in a file (or several files), using a ".pl" extension
- To load our program, we run the prolog interpreter (swipl):
    - Supply our files as arguments on command line

      Or
    - Use the `consult` builtin predicate
        - `consult` adds the contents of the file to current prolog interpreter state

Loading programs: consult

Examples of loading facts and rules from a file:

```
?- consult(myfile).

?- consult('myfile.pl').

?- consult('/path/to/the/file/myfile.pl').
```

Notice:

- the first two examples above are equivalent if the file is named `myfile.pl`, need quotes if name is not a prolog constant (lower case letter followed by letters, underscores, digits)

List notation for consult

We can use prolog's list notation to consult files:

```
?- [myfile].

?- ['myfile.pl'].

?- [file1, file2, 'file3.1'].
```

- If the filename is a single word without the .pl extension, if necessary, prolog will try adding the .pl extension
- If the filename has special characters like period/dot, or begins with a capital letter, it must be in quotes

Special file name "user"

- We can type facts and rules directly into prolog with the file name `user` (EOF character to finish)
- Those facts and rules will be lost when we exit the prolog interpreter

```
?- [user].

|: abc.

|: like(zzz).

|: ^D% user://1 compiled 0.00 sec, 2 clauses

true.

?-
```

Simple first program

Contents of the file called `first.pl`:

```
% a simple program stating that xyz is true

% xyz means nothing in particular

xyz.
```

Run the first program

Assume % is the command line prompt

```
% swipl

Welcome to SWI-Prolog (threaded, 64 bits, version 8.0.3)

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).

?- [first].

true.

?- xyz.

true.
```

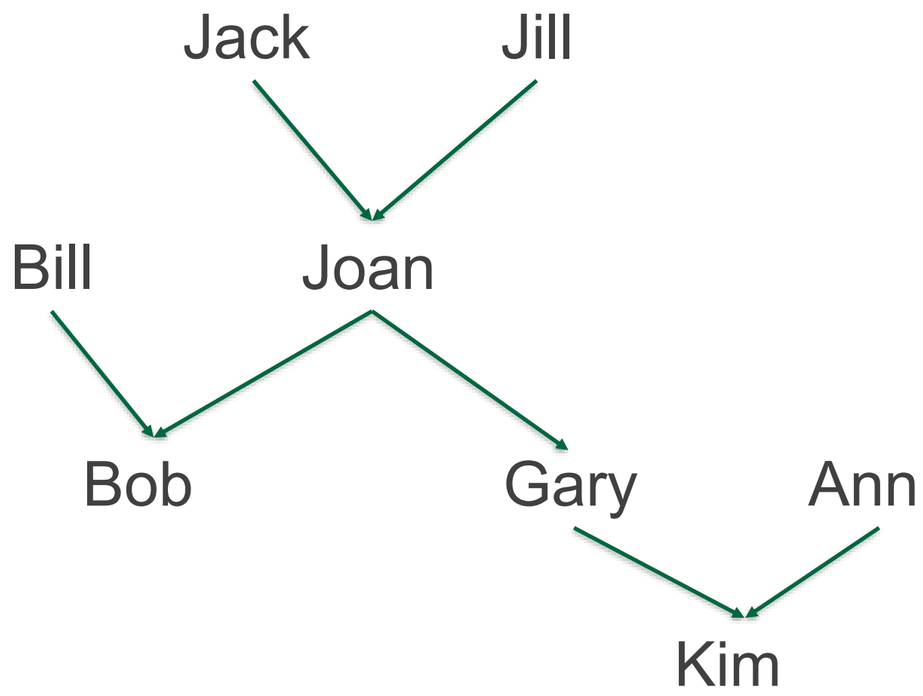
Time to check your learning!

Let’s see how many key concepts from prolog basics you recall by answering the following questions!

1. What built-in predicate do we use to load programs from files into the prolog interpreter?
2. When the user is consulted, to type facts/rules directly into a prolog interpreter, what happens to those facts/rules when the prolog interpreter is terminated?

Example: Family Relationships

Consider the following family tree:



Family Relationships (cont'd)

The arrow points from a parent to a child.

We can represent this as a prolog program (notice there are no capital letters yet)

```
% parent(X,Y) means that X is a parent of Y

parent(jack, joan).

parent(jill, joan).

parent(bill, bob).

parent(joan, bob).

parent(joan, gary).

parent(gary, kim).

parent(ann, kim).
```

Declarative Comments

We need to state what a predicate means when we define it.

The comment character is %

```
% yellow(X) means that X is of yellow colour

yellow(sun).

Or

% yellow(X) is true when X is of yellow colour

yellow(sun).
```

Variables (begin with capital, X on this slide)

Context 1 (making statements):

```
% yellow(X) means that X is of yellow colour

yellow(sun).    % means the sun is yellow

Or

% yellow(X) is true when X is of yellow colour

yellow(X).      % means that everything is yellow
```

Context 2 (asking questions)

```
?- yellow(sun)  % is the sun yellow?

?- yellow(X).   % is there something X that is yellow?
```

Family Relationships (cont'd)

We can type our family relationships program into a file called family.pl and load it into prolog :

% swipl

?- [family].

true.

?- parent(bill,bob).

true.

?- parent(jim,bob).

false.

Predicates and constants

We have defined a `parent` predicate of arity 2 (2 arguments).

We use the notation `parent/2` to indicate a `parent` predicate of arity 2

The general form is $\texttt{predicate(term}_1\texttt{,term}_2\texttt{,…,term}_k\texttt{)}$

The number of terms is the arity of the predicate, and if the arity is 0, the parenthesis can be left out (remember `xyz` from `first.pl` a few slides back?)

Closed world assumption

Prolog operates according to the closed-world assumption:

The only things that are true are the things we state, and the logical entailments of what we state.

In our program about family relationships, there are only 7 persons: no other persons exist in the closed world

How many of those persons have parents? (only 4 have parents in the closed world)

Prolog Queries and Variable Bindings

A variable begins with a capital letter, or a single underscore is the anonymous variable.

Here's a query with a variable, typing return after P=jack:

```
?- parent(P,joan).

P=jack .

?-
```

Here we type semi-colon ; after P=jack, meaning find another solution:

```
?- parent(P,joan).

P=jack;

P=jill

?-
```

Anonymous Variable

Anonymous variable _ represents something but we don't care what it is.

```
?- parent(X,_).     % query context, who has a child

X = jack

?- parent(X,Y).    % who has a child, and which child?

X = jack

Y = joan
```

Time to check your learning!

Let’s see how many key concepts from the family program you recall by answering the following questions!

What is meant by the arity of a predicate?

What constitutes a prolog variable?

What is the closed world assumption?

Prolog Rules

We have a parent relation defined in our family.pl program

Now let's think about an ancestor relation defined in English:

If person X is a parent of person Y, then person X is an ancestor of person Y

Also

If person X is a parent of person Y, and person Y is an ancestor of person Z, then person X is an ancestor of person Z

More compactly:

If parent(X,Y) then ancestor(X,Y)

If parent(X,Y) and ancestor(Y,Z) then ancestor(X,Z)

Prolog Rules (cont'd)

A rule such as

if P then Q

is written the opposite way around in Prolog as

```
Q :- P
```

We read that as "Q if P" and it means that when we are trying to show that Q is true, we can succeed by showing that P is true

ancestor rules

We can write our rules about ancestors in Prolog form:

```
ancestor(X,Y):-parent(X,Y).

ancestor(X,Z):-parent(X,Y), ancestor(Y,Z).
```

Note that comma "," means "and" in Prolog

The scope of variables is the single clause

We haven't used it yet, but ";" means "or" in Prolog

There would be problems if we said

```
ancestor(X,Z):-ancestor(X,Y),ancestor(Y,Z).
```

Even though it's true, a Prolog programmer would not say that (why?).

ancestor query

Let's add the ancestor clauses to our family.pl program, then

```
?- [family].

true.

?- ancestor(X,Y).
```

We can keep typing ";" to see all of Prologs answers to this query.

Let's also try the same query with the problematic version of that ancestor rule.

Time to check your learning!

Let’s see how many key concepts from Prolog rules you recall by answering the following questions!

How would we write "if a then b" as a Prolog rule

How would we write "if X is a student, then X is a person" as a Prolog rule?

Conclusion

In this lesson, you learned how to

- Write and run simple Prolog programs
- Use Prolog facts in programs
- Use Prolog variables in programs and queries
- Use Prolog rules in programs

In the next lesson, you will learn

- More details about how Prolog answers queries