Introduction to Prolog

Outline

- What is Prolog?
- Prolog basics
- Prolog Demo
- Syntax:
  - Atoms and Variables
  - Complex Terms
  - Facts & Queries
  - Rules
- Examples

What is Prolog?

- Prolog is the most commonly used logic
  - Simple syntax
- PROgramming in LOGic
- High-level interactive language.
- Logic programming language.

What is Prolog? (Cont.)

- Programming languages are of two kinds:
  - **Procedural** (BASIC, Pascal, C++, Java);
  - **Declarative** (LISP, Prolog, ML).
- In procedural programming, we tell the computer **how** to solve a problem.
- In declarative programming, we tell the computer **what** problem we want solved.
- (However, in Prolog, we are often forced to give clues as to the solution method).

The use of Prolog

- Prolog is used in artificial intelligence applications such as:
  - Natural language interfaces,
  - automated reasoning systems and
  - Expert systems: usually consist of a data base of facts and rules and an inference engine, the run time system of Prolog provides much of the services of an inference engine.

What is Prolog used for?

- Good at
  - Grammars and Language processing,
  - Knowledge representation and reasoning,
  - Unification,
  - Pattern matching,
  - Planning and Search.
- Poor at:
  - Repetitive number crunching,
  - Representing complex data structures,
  - Input/Output (interfaces).

Basic Elements of Prolog

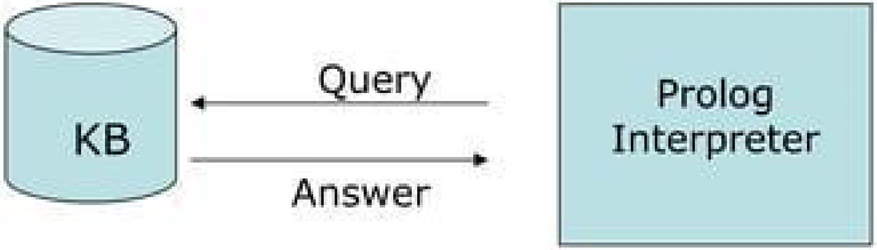
- A program consists of **clauses**. These are of 3 types: **facts, rules,** and **questions** (Queries).
- Some are always true (facts):

```
father( ali, haya).
```

- Some are dependent on others being true (rules):

```
parent( Person1, Person2 ) :-  father( Person1, Person2 ).
```

- To run a program, we ask questions about the database.



Prolog in English

- Example Database:

  - Saleh is a teacher
  - Nora is a teacher
  - Saleh is the father of Jaber.
  - Nora is the mother of Jaber.
  - Hamza is the father of Saleh

  Facts

  - Person 1 is a parent of Person 2 **if** Person 1 is the father of Person 2 **or** Person 1 is the mother of Person 2.

  - Person 1 is a grandparent of Person 2 **if** some Person 3 is a parent of Person 2 **and** Person 1 is a parent of Person 3.

  Rules

- Example questions:
  - Who is Jaber's father?
  - Is Nora the mother of Jaber?
  - Does Hamza have a grandchild?

A knowledge base of facts

- teacher(saleh).
- teacher(nora).
- father(saleh, jaber).
- mother(nora, jaber).
- father(hamza, saleh).

Queries we can ask

```
?- teacher(saleh).                   Yes
?- teacher(nora).                    Yes
?- mother( nora, jaber ).            Yes
?- mother( nora, saleh ).             No
?- grandparent( hamza, X).            Jaber
?- nurse(nora).
ERROR: Undefined procedure: nurse/1
```

More queries we can ask

- ?-teacher(X).
  - X=saleh ;
  - X=nora ;
  - No.
- ?-mother(X,Y).
  - X = nora
  - Y = jaber ;
  - No

Syntax: Atoms and Variables

- **Atoms:**
  - All terms that consist of letters, numbers, and the underscore and start with a non-capital letter are **atoms**: uncle_ali, nora, year2007, ...
  - All terms that are enclosed in single quotes are **atoms**:

    'Aunt Hiba', '(@ *+ ', ...
  - Certain special symbols are also atoms: +, ,, ...

- **Variables:**
  - All terms that consist of letters, numbers, and the underscore and start with a capital letter or an underscore are **variables**: X, Jaber, Lama, ...
  - _is an anonymous variable: two occurrences of _are different variables.
  - E.g. if we are interested in people who have children, but not in the name of the children, then we can simply ask: ?- parent(X,_).

Syntax: Complex Terms

- **Complex terms**
  - **Complex terms** are of the form:

    functor (*argument*, ..., *argument*).
  - Functors have to be atoms.
  - Arguments can be any kind of Prolog term, e.g., complex terms.
    - likes(lama,apples), likes(amy,X).

Syntax: Facts & Queries

- **Facts** are complex terms which begin with lower case alphabetic letter and ends with a full stop.
  - teacher(nora).
  - female(aunt hiba).
  - likes(alia,choclate).
- **Queries** are also complex terms followed by a full stop.
  - ?- teacher(nora).

Query

Prompt provided by the Prolog interpreter.

Syntax: Rules

- A Prolog rule consists of a head and a body.

```
a(X) :- b(X), c(X)
```

head body

- **Rules** are of the form *Head* :- *Body*.
- Like facts and queries, they have to be followed by a full stop.
- *Head* is a complex term.
- *Body* is complex term or a sequence of complex terms separated by commas.

```
happy(uncle_ yussef) :- happy(nora).
grandparent( Person1, Person2 ) :- parent( Person3,   Person2 ) ,
parent( Person1, Person3 ).
```

A knowledge base of facts & Rules

- happy(uncle_ yussef) :- happy(nora).

if ... then ...: If happy(nora) is true, then happy(uncle_ yussef) is true.

- parent(Person1, Person2) :- father(Person1, Person2).
- parent(Person1, Person2) :- mother(Person1, Person2).

  Person 1 is a parent of Person 2 if Person 1 is the father of Person 2 or Person 1 is the mother of Person 2.

- grandparent(Person1, Person2) :- parent(Person3, Person2) , parent(Person1, Person3).

  Person 1 is a grandparent of Person 2 if some Person 3 is a parent of Person 2 and Person 1 is a parent of Person 3.

Querying slide 15

- ?- happy(nora).   Yes
- ?-happy(uncle_yussef). yes
- ?- happy(X).
  - X = uncle_yussef ;
  - X = nora ;
  - No
- Does Hamza have a grandchild?
- ?- grandparent(hamza,_).
  - Yes

Facts & Rules containing variables

- teacher(saleh).
- teacher(nora).
- father(saleh, jaber).
- mother(nora, jaber).

- This knowledge base defines 3 predicates:
  - teacher/1.
  - father/2, and
  - mother/2.
- teacher(X) :- father(Y,X), teacher(Y),mother(Z,X), teacher(Z).
- For all X, Y, Z, if father(Y,X)is true and teacher (Y) is true and mother(Z,X) is true and teacher (Z) is true, then teacher (X) is true.
- I.e., for all X, if X's father and mother are teachers,

  then X is a teacher.

Summary

- A Prolog program consists of a database of facts and rules, and queries (questions).
  - Fact: ... .
  - Rule: ... :- ... .
  - Query: ?- ... .
  - Variables: must begin with an upper case letter or underscore.
    - Nora, _nora.
  - Constants (atoms): begin with lowercase letter, or enclosed in single quotes.
    - uncle_ali, nora, year2007, .
    - **numbers** 3, 6, 2957, 8.34, ...
  - **complex terms** An atom (the functor) is followed by a comma separated sequence of Prolog terms enclosed in parenthesis (the arguments).
    - likes(lama,apples), likes(amy,X).