Logic Programming

Prolog as a Language

Temur Kutsia

Research Institute for Symbolic Computation
Johannes Kepler University Linz, Austria
`kutsia@risc.jku.at`

Prolog as a Language

- Syntax
- Operators
- Equality
- Arithmetic
- Satisfying goals

Syntax

Terms:

- constant
- variable
- structure

Constants

- Naming (specific objects, specific relationships)
  - `likes mary john book wine owns jewels can_steal`
  - `a`
  - `void`
  - `=`
  - `'george-smith'`
  - `-->`
  - `george_smith`
  - `ieh2304`
- Integers (size is implementation dependent)

Non-Constants

The following symbols are not constants:

- `2340ieh` – begins with a number.
- `george-smith` – contains a dash.
- `Void` – begins with a capital.
- `_alpha` – begins with an underscore.

Variables

Begin with a capital or with an underscore:

- `Answer`
- `Input`
- `_3_blind_mice`

Anonymous variable: a single underscore

- `likes(john,_).`
- Need not be assigned to the same variable `likes(_,_).`

Structures

Collection of objects (*components*), grouped together in one object.

Help organize.

Make code more readable.

Structures

Example: an index card for a library

- Author’s Name
- Title
- Date
- Publisher
- Name could be split also first, last, etc.

Examples

- `owns(john, book).`
- One Level:
  ```
  owns(john, wuthering_heights).
  owns(mary, moby_dick).
  ```
- Deeper:
  ```
  owns(john, book(wuthering_heights,bronte)).
  owns(john, book(wuthering_heights,
       author(emily,bronte))).
  ```

Questions

- Does John own a book by the Bronte sisters?
  ```
  owns(john, book(X,author(Y,bronte))).
  ```
- For the yes/no question
  ```
  owns(john, book(_,author(_,bronte))).
  ```
  (note that two _'s could match different objects)

Equality

An infix operator =

- `X = Y`
  a match is attempted between expression `X` and expression `Y`.
- PROLOG does what it can to match `X` and `Y`.

Example: Instantiating

`X` is uninstantiated.

`Y` is an object.

`X = Y`: `X` and `Y` will be matched.

Thus `X` will be instantiated by the object `Y`.

```
?- X = rides(man,bicycle).

X = rides(man,bicycle).
```

Example: Symbols

```
?- policeman = policeman.
true.

?- paper = pencil.
false.

?- 1066 = 1066.
true.

?- 1206 = 1583.
false.
```

Arguments Instantiated

Equating structures – matching arguments.

```
?- rides(man,bicycle) = rides(man,X).
X = bicycle.
```

Arguments Instantiated

```
?- a(b,C,d(e,F,g(h,i,J))) =
   a(B,c,d(E,f,g(H,i,j))).

B = b
C = c
E = e
F = f
H = h
J = j
```

Equality

```
?- X = X.
true.

?- Y = X.
Y = X.
```

Equality

```
?- X = Y, X = 1200.
X = 1200, Y = 1200.
```

Arithmetic Comparisons

```
=
\=
<
>
=<
>=
```

Arithmetic

```
?- 123 > 14.
true.

?- 14 > 123.
false.

?- 123 > X.
ERROR: Arguments are not sufficiently
instantiated
```

Example

`Prince` was a prince during year `Year` if
    `Prince` reigned between years `Begin` and `End`, and
    `Year` is between `Begin` and `End`.

```
prince(Prince, Year) :-
reigns(Prince, Begin, End),
Year >= Begin,
Year =< End.

reigns(rhodri, 844, 878).
reigns(anarawd, 878, 916).
reigns(hywel_dda, 916, 950).
reigns(lago_ad_idwal, 950, 979).
reigns(hywel_ab_ieuaf, 979, 985).
reigns(cadwallon, 985, 986).
reigns(maredudd, 986, 999).
```

Runs

Was Cadwallon a prince in 986?

```
?- prince(cadwallon, 986).
true.
```

Was Rhodri a prince in 1995?

```
prince(rhodri, 1995).
false.
```

Who Was a Prince When

Who was the prince in 900?

```
?- prince(Prince, 900).
Prince = anarawd ;
false.
```

Who was the prince in 979?

```
?- prince(Prince,979).
Prince = lago_ad_idwal ;
Prince = hywel_ab_ieuaf ;
false.
```

Invalid Question

When was Cadwallon a prince?

```
?- prince(cadwallon, Year).
ERROR: Arguments are not sufficiently
instantiated
```

Calculating

Calculating the population density of a country:
Population over the area. (NB. the built-in predicate `is`.)

```
density(Country, Density) :-
pop(Country, Pop),
area(Country, Area),
Density is Pop/Area.

pop(usa, 305).
pop(india, 1132).
pop(china, 1321).
pop(brazil, 187).

area(usa, 3).
area(india, 1).
area(china, 4).
area(brazil, 3).
```

Questions

What is the population density of USA?

```
?- density(usa, X).
X = 101.667 ;
false.
```

Questions

What country has which density?

```
?- density(X, Y).
X = usa
Y = 101.667 ;

X = india
Y = 1132 ;

X = china
Y = 330.25 ;

X = brazil
Y = 62.3333 ;
false.
```

Arithmetic Operations

```
X + Y
X - Y
X * Y
X / Y
X mod Y
```

How Prolog Answers Questions

Program:

```
female(mary).

parent(C, M, F) :-
mother(C, M),
father(C, F).

mother(john, ann).
mother(mary, ann).

father(mary, fred).
father(john, fred).
```

Question:

```
?-female(mary), parent(mary,M,F), parent(john,M,F).
```

How does it work?

Matching

An uninstantiated variable will match any object.

That object will be what the variable stands for.

An integer or atom will only match itself.

A structure will match another structure if

- they have the same functor and the same number of arguments and
- all the corresponding arguments match.

How Is this Matched?

```
?- sum(X+Y) = sum(2+3).

X = 2,
Y = 3
```