Prolog Introduction

What is a Prolog Program?

- A program consists of a database containing **one or more facts**
  - **A fact is a relationship between a collection of objects**
  - **dog (fido).**
    - **Fido is a dog**
      - **it is true that Fido is a dog**
  - **mother (mary , joe).**
    - **Mary is the mother of Joe**
      - **it is true that Mary is the mother of Joe**
  - **compete (ali , leila , tennis).**
    - **Ali and Leila compete in tennis**
      - **it is true that Ali and Leila compete in tennis**

What is a Prolog Program? – 2

- Relationships can have any number of objects
- Names are usually chosen to be meaningful
  - **Within Prolog, names are just arbitrary strings. It is people who give meaning to names.**

What is a Prolog Program? – 3

- And a program consists of a database of **zero or more rules**
  - **A rule is an if...then relationship of facts**
  - **use (umbrella) :- weather (raining).**
    - **use an umbrella if weather is raining**
  - **use (umbrella) :- weather (raining) , own (umbrella).**
    - **use an umbrella if weather is raining and you own an umbrella**
  - **use (umbrella) :- weather (raining) , (own (umbrella) ; borrow (umbrella)).**
    - **use an umbrella if weather is raining and you either own an umbrella or can borrow an umbrella**

More on rules

- Rules have the general structure

  head :- body

  - **Only one fact can be in the head – the consequent**
  - **The body is a boolean combination of predicates**
  - **Use , (and) and ; (or) and () (parenthesis) to logically organize the "condition" – the antecedent**

- Rules are written backwards to
  - **emphasize the backward chaining for database search**
  - **be more regular in structure, since the head is only one predicate**

Constants

- **Constants** are names that begin with lower case letters
  - **ali, leila, tennis, dog, fido, mother, mary, joe, umbrella, raining, weather, own, borrow**
  - **names of relationships are constants**

Variables

- In place of **constants** in facts and rules one can have **variables**
  - **variables are names that begin with upper case letters**
    - **X, Y, Who, Whom, List, Person**

      loves (Everyone , barney).
    - **Everyone loves barney**
      – for all values of Everyone it is the case that loves(Everyone, barney) is true.

      noisy (Singer) :- valkyrie (Singer) ;
      tenor (Singer).
    - **A Singer is noisy if they are a Valkyrie or a tenor**

Variables – 2

```
dwarf ( Person )  :-  brother ( Person,  Other ) ,
                      dwarf ( Other ).
```

> A person is a dwarf, if they the brother of other and the other is a dwarf

» Variables can also begin with _ (underscore)

```
_                  (anonymous variable)
_1    _abc         (not anonymous variable )
```

Running a Prolog Program

- Programs are stored in one or more files that are **consulted**
- On Prism to run SWI Prolog enter

  % swipl

- The following prompt appears

  ?-

- Consult the appropriate file(s) – **add to the database**

  ?- consult ('ring.pl').

  > **SWI-prolog does not have a reconsult predicate, only consult is used**

  > **The following is an abbreviation**

  ?- [ring , tower , 'utilities.pl'].

Running a Prolog Program – 2

- Make zero or more queries (next slides)
- Exit prolog

  ?- CTRL-d /* and for consult (user) */

  consult (user) enables you to enter facts & rules into the database without storing them in a file. It is not an effective way to work with Prolog, as it is error prone

Queries

- A **query** in Prolog is boolean combination of predicates – like the antecedent of a rule

  > **A query is like a rule, except we leave out the consequent true**

  true :- dwarf (alberich).

  > **becomes simply**

  dwarf (alberich).

- Use comma (and), semicolon (or) and parenthesis to form a query expression

- Most common is to have a single predicate

Queries – 2

- **Answer** is a **binding of the variables** that make the query **expression true** – if no variables then the **answer** is **yes**. If no such binding exists, the **answer** is no
- The database is searched to match the query.
- The search
  - **Uses backward chaining**
  - **is depth first**
  - **is sequential through the database from first to last**
- Try the exercise on ring.pl

Structures

- **Structures** are a means of grouping a collection of other objects
  - **Structures are also called compound terms, or complex terms**
  - **The name of a structure is called a functor**
  - **The items within a structure are called components**
- The general pattern is

  functor (component_1 , component_2 ,
  ...
  component_n)

Structures – 2

- Components can also be structures – recursive definition

```
If component_1 = functor1 ( comp1, comp2 )
  > giving
functor ( functor1 ( comp1, comp2 ),
                component_2 ,
                ...
                component_n )
  > from
functor ( component_1 , component_2 ,
                ...
                component_n )
```

Example structures

- Books have authors and titles, so we could have

  book (dickens , great_expectations)

- People have books. In particular, Leila could have Great Expectations

  has (leila , book (dickens , great_expectations))

- Facts in Prolog are structures where the predicate is the functor of a structure and the arguments of the predicate are the components of the structure

Characters

- Prolog is based on the ASCII character set
- Characters are treated as small integers 0 .. 127
- Characters may be
  - **printed**
  - **read from a file or keyboard**
  - **compared**
  - **take part in arithmetic operations**
- Characters are distinguished as
  - **printing – visible on the paper**
  - **nonprinting – look like whitespace**

Operators

◊ All operators in Prolog are functors, even , ; and :-

> A rule such as

```
dwarf ( Person )  :-  brother ( Person , Other ) ,
                      dwarf ( Other ) .
```

> is a shorthand for

```
:- (    dwarf ( Person )
  , , (  brother ( Person , Other )
       , dwarf ( Other )
       )
  ).
```

Operators – 2

- Arithmetic and relational operators are also functors, thus

  a + b * c internally is + (a , * (b , c))

- This is inconvenient so Prolog permits operators to be written in standard infix notation
  - **You will learn later how you can define your own infix operators**

Arithmetic

- The arithmetic operators **do not do** arithmetic. No assignments are made
  - > **It is simply pattern matching – infix operators are simply a convenience for expressing a structure**

5 = 4 + 1. ==> no
4 + 1 = 4 + 1. ==> yes
1 + 4 = 4 + 1. ==> no

  - > **Use the operator is to do arithmetic**

5 is 4 + 1. ==> yes **1 + 4 is 4 + 1. ==> no**

- Arithmetic is only done on the right!
- Right hand side is evaluated using arithmetic, then a pattern match is made with the left hand side.

Arithmetic – 2

◊ Can use variables in arithmetic expressions for pattern matching

A = 4 + 1. ==> A has the pattern "4+1"
– spaces removed

A is 4 + 1. ==> A has as value the pattern 5

> **In some Prologs the latter expression simply responds yes, so try the following.**

A is 4 + 1 , A = 5. ==> A = 5 is the binding for true

> **More complex example**

B is 3 + 2 , C is B * 5 , A is C + B
==> B = 5, C = 25, A =30

Lists

- Lists are a ubiquitous structure in many programming languages. The syntax changes (to protect the innocent?)
  - » **Actually () are used to delimit structure components and to provide precedence for operators, so using them for lists as well would be confusing.**
- The structure is

  [item-1 , item-2 , ... , item-n]

  [a , b , c]

  [a , [b , c] , [[[d]]] , e , [ ]]
- The empty list is **[ ]**

Lists - 2

- The square bracket notation is a shorthand in place of using the functor **.** , dot

  [a , b , c] is really . (a , . (b , . (c , [ ])))

- Lists have a **head** (first) and a **tail** (rest), thus

  [Head | Tail]

- But you do not have operators to extract the head and tail, all you have is pattern matching
  - **We will look at example Prolog utilities on lists to demonstrate**

- Empty list has no head or tail

  [ ] ≠ [_ | _]

Equal pattern matching

» **Standard match**

> **A = B**

> **A \= B**

» **Arithmetic values**

> **A is expression**

> **expr1 =:= expr2** **equal values**
expr1 =\= expr2 **not equal values**

Strict pattern match

» == structures identical

» \== structures not identical

> f(a, b) == f(a, b) –> yes

> f(a, b) == f(a, X) –> no

SWIPL Help

- You can get help with the following predicates.

help. **Brings up a help window from which you can search for information**

help(functor).
Brings up a help window for the predicate with the name "functor"

help(is).
Brings up a help window for the predicate named "is".