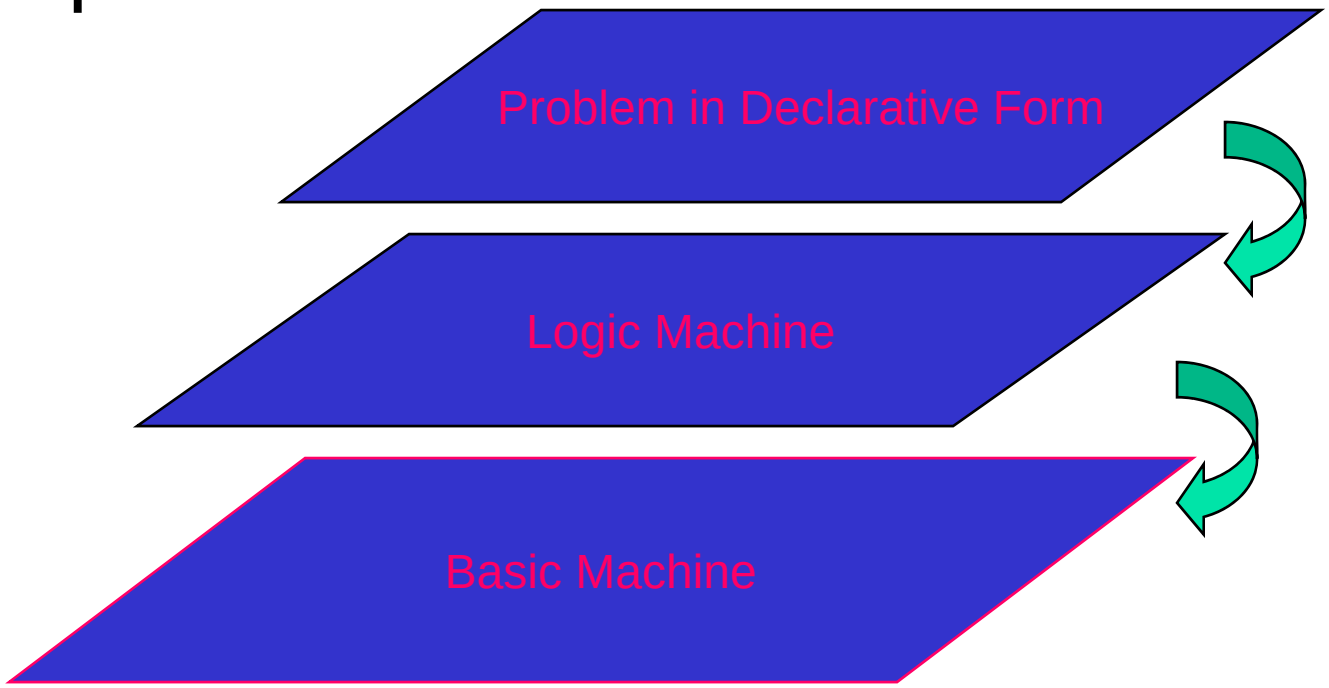
CS344: Introduction to Artificial Intelligence

Pushpak Bhattacharyya
CSE Dept.,
IIT Bombay

Lecture 12–Prolog examples:
Himalayan club, member, rem_duplicate, union, intersection

Introduction

- PROgramming in LOGic
- Emphasis on *what* rather than *how*



A Typical Prolog program

Compute_length ([],0).

Compute_length ([Head|Tail], Length):-

Compute_length (Tail,Tail_length),

Length is Tail_length+1.

High level explanation:

The length of a list is 1 plus the length of the tail of the list.

This is a declarative description of the computation.

Facts

Predicate	**Interpretation**
valuable(gold)	Gold is valuable.
owns(john,gold)	John owns gold.
father(john,mary)	John is the father of Mary
gives (john,book,mary)	John gives the book to Mary

Variables

- Always begin with a capital letter
  - *?- likes (john,X).*
  - *?- likes (john, Something).*
- But *not*
  - *?- likes (john,something)*

Example of usage of variable

Facts:

likes(john,flowers).
likes(john,mary).
likes(paul,mary).

Question:

?- likes(john,X)

Answer:

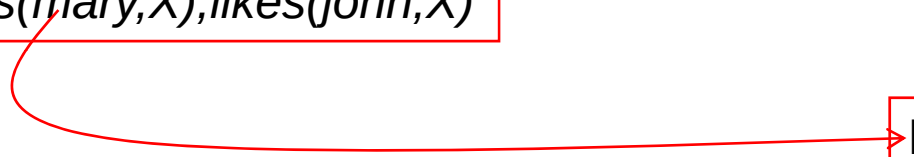
X=flowers and wait
;
mary
;
no

Conjunctions

- Use ‘,’ and pronounce it as *and*.
- Example
  - Facts:
    - likes(mary,food).
    - likes(mary,tea).
    - likes(john,tea).
    - likes(john,mary)
- ?-
    - likes(mary,X),likes(john,X).
    - Meaning *is anything liked by Mary also liked by John?*

Backtracking *(an inherent property of prolog programming)*

likes(mary,X),likes(john,X)

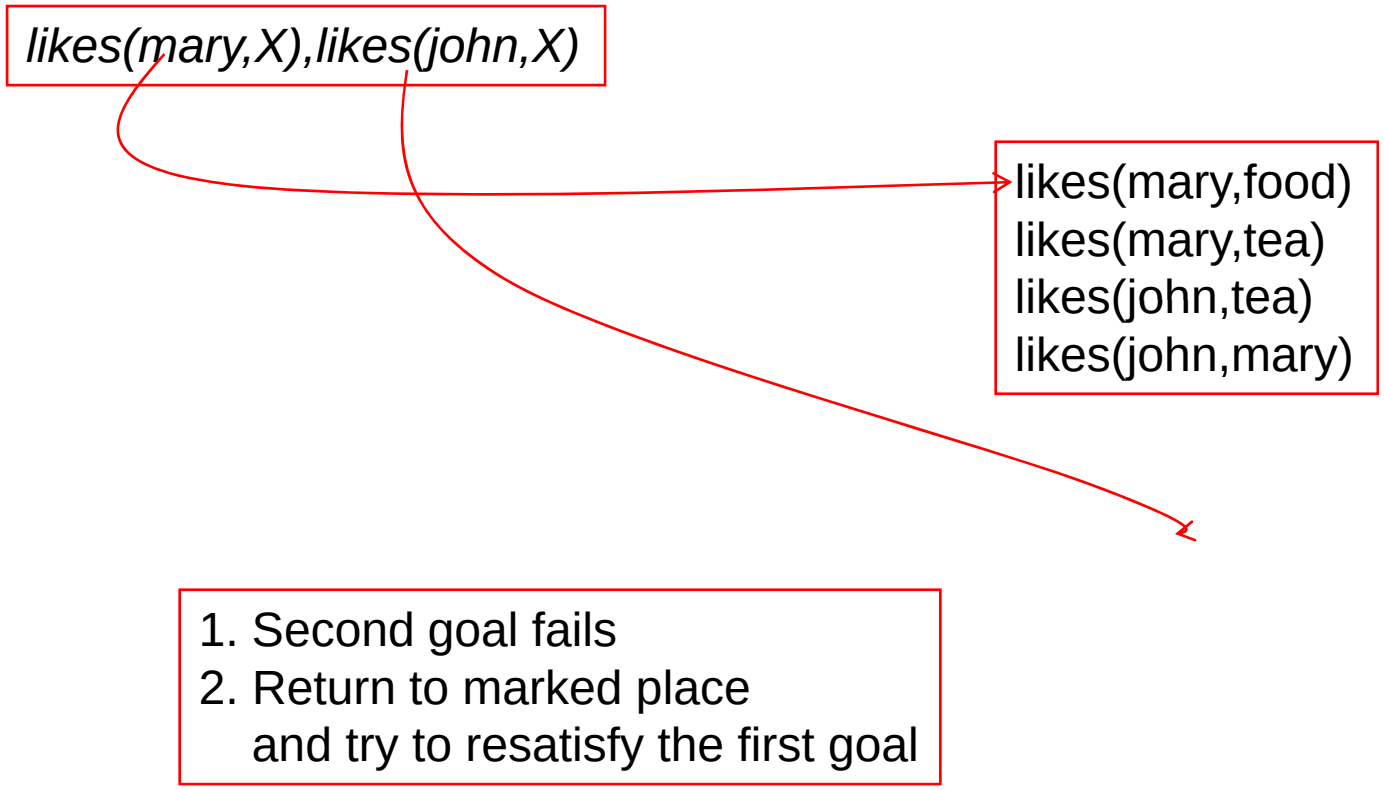


likes(mary,food)
likes(mary,tea)
likes(john,tea)
likes(john,mary)

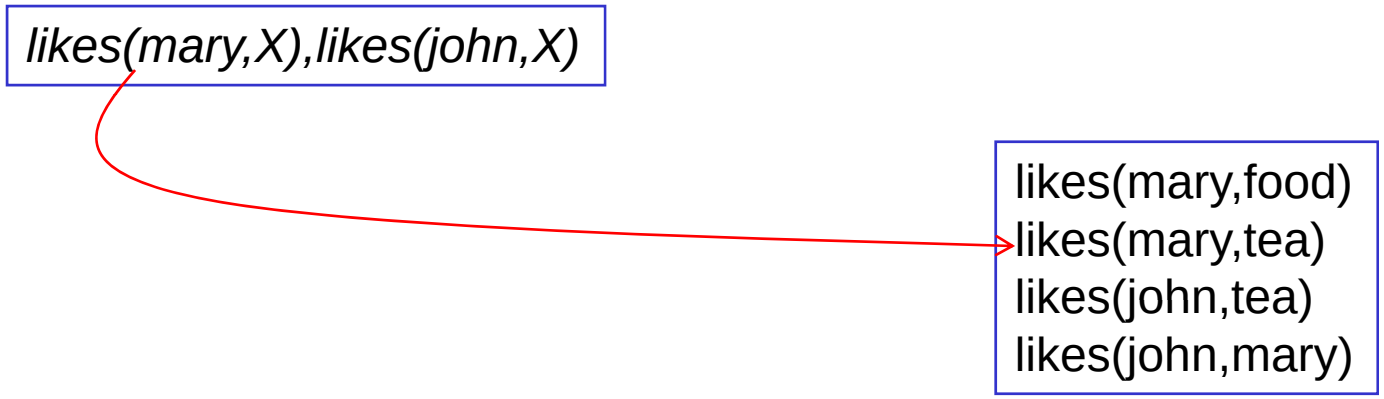
1. First goal succeeds. *X=food*
2. Satisfy *likes(john,food)*

Backtracking *(continued)*

Returning to a marked place and trying to resatisfy is called *Backtracking*

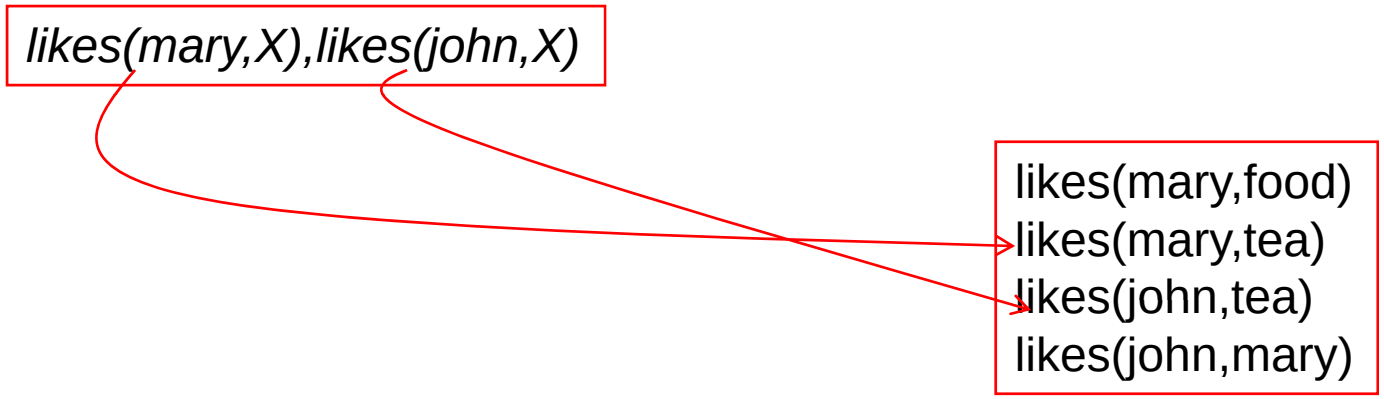


Backtracking *(continued)*



1. First goal succeeds again, *X=tea*
2. Attempt to satisfy the *likes(john,tea)*

Backtracking *(continued)*



1. Second goal also suceeds
2. Prolog notifies success and waits for a reply

Rules

- Statements about *objects* and their *relationships*
- Expess
  - *If-then conditions*
    - *I use an umbrella if there is a rain*
    - *use(i, umbrella) :- occur(rain).*
  - *Generalizations*
    - *All men are mortal*
    - *mortal(X) :- man(X).*
  - *Definitions*
    - *An animal is a bird if it has feathers*
    - *bird(X) :- animal(X), has_feather(X).*

Syntax

- **<head> :- <body>**
- Read **':-' as 'if'.**
- E.G.
  - *likes(john,X) :- likes(X,cricket).*
  - *"John likes X if X likes cricket".*
  - *i.e., "John likes anyone who likes cricket".*
- Rules always end with '.'.

An example Prolog Program

Shows path with mode of conveyeance from city C_1 to city C_2

- :-use_module(library(lists)).

- byCar(auckland,hamilton).
- byCar(hamilton,raglan).
- byCar(valmont,saarbruecken).
- byCar(valmont,metz).

- byTrain(metz,frankfurt).
- byTrain(saarbruecken,frankfurt).
- byTrain(metz,paris).
- byTrain(saarbruecken,paris).

- byPlane(frankfurt,bangkok).
- byPlane(frankfurt,singapore).
- byPlane(paris,losAngeles).
- byPlane(bangkok,auckland).
- byPlane(losAngeles,auckland).

- go(C1,C2) :- travel(C1,C2,L), show_path(L).

- travel(C1,C2,L) :- direct_path(C1,C2,L).

- travel(C1,C2,L) :- direct_path(C1,C3,L1),travel(C3,C2,L2),append(L1,L2,L).

- direct_path(C1,C2,[C1,C2,' by car']):- byCar(C1,C2).
- direct_path(C1,C2,[C1,C2,' by train']):- byTrain(C1,C2).
- direct_path(C1,C2,[C1,C2,' by plane']):- byPlane(C1,C2).

- show_path([C1,C2,M|T]) :- write(C1),write(' to '),write(C2),write(M),nl,show_path(T).

Prolog's computation

- **Depth First Search**
  - **Pursues a goal till the end**
- **Conditional AND; *falsity* of any goal prevents satisfaction of further clauses.**
- **Conditional OR; *satisfaction* of any goal prevents further clauses being evaluated.**

What happens on failure

- **REDO the immediately preceding goal.**

Fundamental Principle of prolog programming

- **Always place the more general rule AFTER a specific rule.**

CUT

- **Cut tells the system that**

  IF YOU HAVE COME THIS FAR

  DO NOT BACKTRACK

  EVEN IF YOU FAIL SUBSEQUENTLY.

  ‘CUT’ WRITTEN AS ‘!’ ALWAYS SUCCEEDS.

Fail

- This predicate always fails.
- *Cut* and *Fail* combination is used to produce negation.
- Since the LHS of the neck cannot contain any operator, *A* → *~B* is implemented as

B :- A, !, Fail.

B.

Predicate Calculus

- Introduction through an example *(Zohar Manna, 1974):*
  - Problem: A, B and C belong to the Himalayan club. Every member in the club is either a mountain climber or a skier or both. A likes whatever B dislikes and dislikes whatever B likes. A likes rain and snow. No mountain climber likes rain. Every skier likes snow. *Is there a member who is a mountain climber and not a skier?*
- Given knowledge has:
  - Facts
  - Rules

A syntactically wrong prolog program!

1. member(a).
2. member(b).
3. member(c).
4. mc(X);sk(X) :- member(X) /* X is a mountain climber or skier or both if X is a member; operators NOT allowed in the head of a horn clause; hence wrong*/
5. like(X, snow) :- sk(X). /*all skiers like snow*/
6. \+like(X, rain) :- mc(X). /*no mountain climber likes rain; \+ is the not operator; negation by failure; wrong clause*/
7. \+like(a, X) :- like(b,X). /* a dislikes whatever b likes*/
8. like(a, X) :- \+like(b,X). /* a dislikes whatever b likes*/
9. like(a,rain).
10. like(a,snow).

?- member(X),mc(X),\+sk(X).

Correct (?) Prolog Program

```
member(a).
member(b).
member(c).
member(X):-\+mc(X),fail.
member(X).
member(X):-\+sk(X),!,fail.
member(X).
like(a,rain).
like(a,snow).
like(a,X) :- \+ like(b,X).
like(b,X) :- like(a,X),!,fail.
like(b,X).
mc(X):-like(X,rain),!,fail.
mc(X).
sk(X):- \+like(X,snow),!,fail.
sk(X).
g(X):-member(X),mc(X),\+sk(X),!.
```

Member (membership in a list)

```
member(X,[X|_]).
member(X,[_|L]):- member(X,L).
```

Prolog's way of making and breaking a list

Problem: to remove duplicates from a list

```
rem_dup([],[]).
rem_dup([H|T],L) :- member(H,T), !, rem_dup(T,L).
rem_dup([H|T],[H|L1]) :- rem_dup(T,L1).
```

Note: The cut ! in the second clause needed, since after succeeding at member(H,T), the 3rd clause should not be tried even if rem_dup(T,L) fails, which prolog will otherwise do.

Union (lists contain unique elements)

```
union([],Z,Z).
union([X|Y],Z,W):-
   member(X,Z),!,union(Y,Z,W).
union([X|Y],Z,[X|W]):- union(Y,Z,W).
```

Intersection (lists contain unique elements)

```
intersection([],Z,[]).
intersection([X|Y],Z,[X|W]):-
   member(X,Z),!,intersection(Y,Z,W).
intersection([X|Y],Z,W):-
   intersection(Y,Z,W).
```