LING 364: Introduction to Formal Semantics

Lecture 8
February 7th
Administrivia

• again this Thursday
  – (3:30pm – 4:40pm)
    • lecture here in Comm 214
  – (4:45pm – 5:45pm) (EXTRA)
    • lab practice in Social Sciences Lab 224
Administrivia

• Homework 1
  – all graded and returned by email
Last Time

• Modify DCG into one that includes phrase structure

• Basic DCG:
  sentence --> np, vp.
  vp --> v, np.
  v --> [likes].
  np --> [john].
  np --> [mary].

• Query: (we supply two arguments: sentence as a list and an empty list)

  ?- sentence([john,likes,mary],[]).
  Yes (Answer)

• Phrase Structure DCG:
  sentence(sentence(NP,VP)) --> np(NP), vp(VP).
  vp(vp(V,NP)) --> v(V), np(NP).
  v(v(likes)) --> [likes].
  np(np(john)) --> [john].
  np(np(mary)) --> [mary].

• Modified Query: (supply one more argument)
  
  • ?- sentence(PS,[john,likes,mary],[]).
    PS = sentence(np(john),vp(v(likes),np(mary)))
Last Time

• modify basic DCG into one that includes meaning

- **Basic DCG:**
  
  sentence --> np, vp.
  vp --> v, np.
  v --> [likes].
  np --> [john].
  np --> [mary].

- **Query:** (we supply two arguments: sentence as a list and an empty list)

  ?- sentence([john,likes,mary],[]).
  Yes (Answer)

- **Meaning DCG:**
  
  sentence(P) --> np(NP1), vp(P), {saturate1(P,NP1)}.
  vp(P) --> v(P), np(NP2), {saturate2(P,NP2)}.
  v(likes(X,Y)) --> [likes].
  np(john) --> [john].
  np(mary) --> [mary].
  saturate1(P,A) :- arg(1,P,A).
  saturate2(P,A) :- arg(2,P,A).

- **Query:** (supply one more argument)

  ?- sentence(M,[john,likes,mary],[]).
  M = likes(john,mary)

---

**argument saturation**

arg(Nth, Predicate, Argument)

means make Nth argument of Predicate equal to Argument

{ <Goal> } means call Prolog <Goal>
{arg(2,VBm,NPm)} means call arg(2,VBm,NPm)
Today’s Topics

• Review of Homework 1
  – make sure we all understand what’s going on...

• Homework 2
  – usual rules
  – due one week from today
  – email submission (inbox by midnight)
For next time

• Handout
  – Chapter 3: More about Predicates
    • Short Quiz #3 on Thursday
  – (Chapter 4: Modifiers)
    • don’t need to read this for next time
Homework 1 Review
Exercise 1a (4pts)

• Enter Prolog facts corresponding to:
  – Mary is a student
  – Pete is a student
  – Mary is a baseball fan
  – Pete is a baseball fan
  – John is a baseball fan

• Construct the Prolog query corresponding to:
  – who is both a student and a baseball fan?

• Run the query

Sample Answer:

```
student(mary).
student(pete).
baseball_fan(mary).
baseball_fan(pete).
baseball_fan(john).

?- student(X), baseball_fan(X).
X = mary ;
X = pete ;
No
```
Homework 1 Review

• Exercise 1b (2pts)
• Construct the Prolog query corresponding to:
  – who is a baseball fan and not a student?
• Run the query

  • Sample Answer:

```prolog
?- baseball_fan(X), \+ student(X).
X = john ;
No
```
Homework 1 Review

• Exercise 2 (4pts)
  – Two sentences are synonymous if they have the same meaning, i.e. they have the same truth conditions:
  – (5) The square is bigger than the circle
  – (6) The circle is smaller than the square
  – (chapter 1: page 18)
  – we know
  – (R2) If X is bigger than Y, then Y is smaller than X
• Write the Prolog fact and rule corresponding to (5) and (R2)
• Demonstrate you can conclude (6)

• Sample Answer:

```prolog
bigger_than(square,circle).
smaller_than(Y,X) :-
    bigger_than(X,Y).

?- smaller_than(circle,square).
Yes
```
Homework 1 Review

• Exercise 3a (2pts)
  – Two sentences are **contrary** if both can’t be true:
  – (7) The square is bigger than the circle
  – (8) The square is smaller than the circle
  – (chapter 1: page 19)

• Enter the Prolog fact corresponding to (7) and use (R2) from exercise 2
• Construct the Prolog query corresponding to the conjunction of (7) and (8).
• Show the result of the query.

• Sample Answer:

  bigger_than(square,circle).
  smaller_than(Y,X) :-
      bigger_than(X,Y).

  ?- bigger_than(square,circle),
     smaller_than(square, circle).
  No
Homework 1 Review

• Exercise 3b (3pts)
  – Two sentences are contrary if both can’t be true:
  – (7) The square is bigger than the circle
  – (8) The square is smaller than the circle
  – (chapter 1: page 19)
• Enter the Prolog fact corresponding to (8) and (R3)
  – (R3) If X is smaller than Y, then Y is bigger than X
• Construct the Prolog query corresponding to the conjunction of (7) and (8).
• Show the result of the query.

• Sample Answer:
  
  smaller_than(square,circle).
  bigger_than(Y,X) :-
      smaller_than(X,Y).

  ?- bigger_than(square,circle),
     smaller_than(square,circle).
  No
Exercise 4 (4pts) Extra Credit

- From Quiz 1:
  - 3. Given the statement “All crows are black”, give an example of a sentence expressing a tautology involving this statement?
- Possible answer:
  - All crows are black or not all crows are black
- Let Prolog predicate p/0 denote the proposition “All crows are black”
  - ?- assert(p). “All crows are black is true in this world”
- Construct the Prolog version of the tautology
- Show that it is true no matter what the scenario
- Construct a contradictory statement involving p
- Show that it is false not matter what the scenario

Sample Answer:

Possible World #1
?- assert(p).

?- p; \+ p.
Yes
?- p, \+ p.
No

Possible World #2
?- retract(p).

?- assert(p).

?- p; \+ p.
Yes
?- p, \+ p.
No
Homework 2
Exercise 1

• (5pts) Give a **basic** DCG grammar that covers the following sentences

  - \([S\bar{S} [NP \text{John}] [VP [V \text{is}][NP [DET \text{a}] [N \text{student}]]]]\)
  - \([S\bar{S} [NP \text{Pete}] [VP [V \text{is}][NP [DET \text{a}] [N \text{student}]]]]\)
  - \([S\bar{S} [NP \text{Mary}] [VP [V \text{is}][NP [DET \text{a}] [N \text{baseball fan}]]]]\)
  - \([S\bar{S} [NP \text{Pete}] [VP [V \text{is}][NP [DET \text{a}] [N \text{baseball fan}]]]]\)
  - \([S\bar{S} [NP \text{John}] [VP [V \text{is}][NP [DET \text{a}] [N \text{baseball fan}]]]]\)

• Show your grammar accepts the sentences

  - e.g. the query

    • ?- sbar([john, is, a, student], []). should return **Yes**
Exercise 2

• (4pts) Augment your grammar to include the following questions
  – [Sbar [NP Who] [S [VP [V is] [NP [DET a][N student]]]]]
  – [Sbar [NP Who] [S [VP [V is] [NP [DET a][N baseball fan]]]]]
  – [Sbar [NP Who] [S [VP [V is] [NP [NEG not] [NP [DET a][N student]]]]]]
  – [Sbar [NP Who] [S [VP [V is] [NP [NEG not] [NP [DET a][N baseball fan]]]]]]
• Show your grammar accepts the questions

• NOTE:
  – for simplicity, we’re not generating empty categories here
Exercise 3

• (4pts) Augment your grammar to include the following conjoined questions

  – \([Sbar[NP \text{ Who}] [S [VP [\text{ is}] [NP[\text{ DET a}[N \text{ student}]]]]][\text{ CONJ and}][NP[\text{ DET a}[N \text{ baseball fan}]]]]]
  
  – \([Sbar[NP \text{ Who}] [S [VP [\text{ is}] [NP[\text{ DET a}[N \text{ student}]]]]][\text{ CONJ and}][NP[\text{ NEG not}][NP[DET a][N \text{ baseball fan}]]]]]

• Show your grammar accepts the questions

• **HINT:**
  – you need to write a rule for NP conjunction
  – the order of this rule with respect to the other NP rules will matter for Prolog computation
    • i.e. if your grammar loops, you may want to adjust the order of the rules for NP
Exercise 4

• (12pts) Modify your grammar obtained so far, i.e. by Exercise 3, to include phrase structure
• Show your grammar produces phrase structure for the previously mentioned sentences and questions
Exercise 5

• (12pts) Modify your grammar obtained so far, i.e. by Exercise 3, to generate meaning
  – e.g.
    • student(mary).
    • student(X), \+ baseball_fan(X).

• Show your grammar produces appropriate meanings for the previously mentioned sentences and questions
Summary

• Points
  – Exercise 1: 5pts
  – Exercise 2: 4pts
  – Exercise 3: 4pts
  – Exercise 4: 12pts
  – Exercise 5: 12pts
  – Total: 37 pts
Reminder

• Confused?
  – Help with homework
  – Lab session on Thursday ...