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

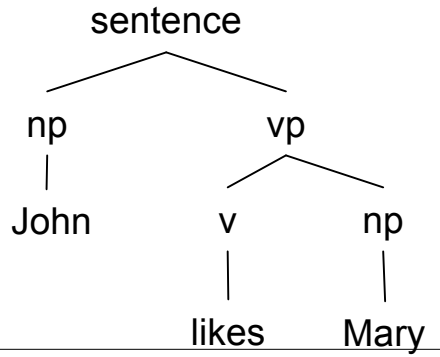
- **Basic DCG:**

```
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)
```

```
sentence(np(john),vp(v(likes),np(mary)))
```



- **Phrase Structure DCG:**

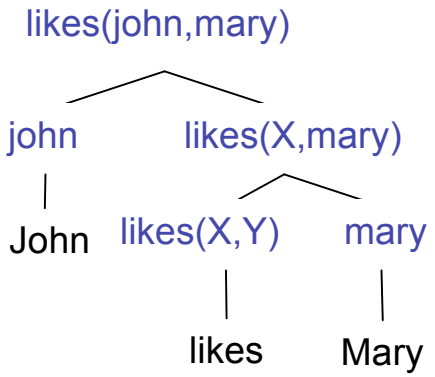
```
sentence(sentence(NP,VP)) --> np(NP), vp(VP).
vp(vp(V,NP)) --> v(V), np(NP).
v(v(likes)) --> [likes].
np(np(john)) --> [john].
np(np(mary)) --> [mary].
```

- **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:**

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vp --> v, np.
v --> [likes].
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np --> [mary].
```

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

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)`

- **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)0`

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

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:

```
?- 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:

```
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
```

Homework 1 Review

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

?- retract(p).
Possible World #2

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

Homework 2

Exercise 1

- (5pts) Give a **basic** DCG grammar that covers the following sentences
  - $[_{Sbar}[_{S}\ [_{NP}$ John] $[_{VP}\ [_{V}$ is$][_{NP}\ [_{DET}$ a$][_{N}$ student]]]]]
  - $[_{Sbar}[_{S}\ [_{NP}$ Pete] $[_{VP}\ [_{V}$ is$][_{NP}\ [_{DET}$ a$][_{N}$ student]]]]]
  - $[_{Sbar}[_{S}\ [_{NP}$ Mary] $[_{VP}\ [_{V}$ is$][_{NP}\ [_{DET}$ a$][_{N}$ baseball fan]]]]]
  - $[_{Sbar}[_{S}\ [_{NP}$ Pete] $[_{VP}\ [_{V}$ is$][_{NP}\ [_{DET}$ a$][_{N}$ baseball fan]]]]]
  - $[_{Sbar}[_{S}\ [_{NP}$ John] $[_{VP}\ [_{V}$ is$][_{NP}\ [_{DET}$ a$][_{N}$ 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
  - $[_{Sbar}\ [_{NP}$ Who$]\ [_{S}\ [_{VP}\ [_{V}$ is$]\ [_{NP}[_{NP}\ [_{DET}$ a$][_{N}$ student$]]]]][_{CONJ}$ and$][_{NP}\ [_{DET}$ a$][_{N}$ baseball fan$]]]]]]$
  - $[_{Sbar}\ [_{NP}$ Who$]\ [_{S}\ [_{VP}\ [_{V}$ is$]\ [_{NP}[_{NP}\ [_{DET}$ a$][_{N}$ student$]]]]][_{CONJ}$ and$][_{NP}\ [_{NEG}$ not$][_{NP}[_{DET}$ a$][_{N}$ 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 ...