LING 364: Introduction to Formal Semantics

Lecture 28
May 2nd
Administrivia

• Homework 6
  – was due at the beginning of class
• **Today’s Agenda:**
  – A Note on Grading and Course Objectives
  – Homework 6 Review
  – Homework Final
  – Class Evaluations
Back at the Beginning

• [Lecture 1: Slide 13]
• Mix of homeworks and short quizzes
  – expect approx. 6 homework assignments
    • longer and more in-depth in nature
    • worth many more points
  – a short quiz (just about) every week
    • gauge your understanding
• Grading
  – In total, homeworks will generally be worth much more than the short quizzes
    • about a 75-70% / 25-30% ratio
  – There may or may not be a final exam
    • depends on how the class is doing
    • (if so) view it as an opportunity to improve your score
    • if given, it will be a take-home exam worth about 25% of the grade due by midnight the next day
Grading

Points-wise

- Homework Final: 24%
- Other: 77%
- Homework 1: 6%
- Homework 2: 15%
- Homework 3: 12%
- Homework 4: 8%
- Homework 5: 19%
- Homework 6: 10%
- Quizzes: 6%
Course objectives were...

• Two goals:
  – (1) on the theoretical side
  – Understand what is meant by natural language semantics
    • what does it mean to work out the “meaning” of a sentence, phrase or utterance
    • what quasi-technical terms like entailment, possible worlds, truth conditions, quantification, scope ambiguity, synonymy, presupposition, logical deduction, reference, inference rule etc. mean
    • the relation between natural language and formal logic
    • the relation between syntax and semantics with respect to formal grammars
    • awareness of issues and data
    • etc...
Course objectives were...

- Two goals:
  - (2) *on the practical side*
  - gain experience with **formal systems** and build something tangible
    - first-hand experience on how to write logic expressions
    - practice how to formalize notions
    - how to run logical deduction on computers
    - use and write grammars for semantics
    - we'll use SWI-Prolog
    - by the end of this course you will be able to write formal grammars integrating the computation of **meaning** as well as **syntax** for fragments of English
Nature of the Course

• **Formalization of natural language**
  – *involves*...
  
  – being mathematical
  – being used to thinking precisely with respect to manipulating formalisms
  – being comfortable with logic (lambda-calculus)
  – learning to write logic that runs on a computer (otherwise course would be mostly theoretical)

*Each of these can be challenging first time around*
Homework 6 Review
• A simple grammar for tense and time
  • sbar(R) --> adjunct(R1), s(R2), {append(R1,R2,R)}.
  • sbar(R) --> s(R).
  • s(R) --> np, vp(R).
  • np --> [i].
  • np --> [noah].
  • vp(R) --> v(R1,go), [for,a,hike], {append(\{(subset(e,t))\},R1,R)}.
  • vp(R) --> v(R1,have), [a,rash], {append(\{intersect(e,t)\},R1,R)}.
  • v([[t<s]],go) --> [went].
  • v([[t=s]],go) --> [go].
  • v([[s<t]],go) --> [will,go].
  • v([[t<s]],have) --> [had].
  • v([[t=s]],have) --> [have].
  • v([[s<t]],have) --> [will,have].
  • adjunct([[t<s],t=last_month(s)]) --> [last,month].
  • adjunct([[t<s],t=yesterday(s)]) --> [yesterday].
  • adjunct([[s=t],t=today(s)]) --> [today].
  • adjunct([[s<t],t=tomorrow(s)]) --> [tomorrow].
  • infer(R,[[Z<Y]]) :-
    select([[X<Y]],R,R1),
    select(subset(Z,X),R1,\_).
  • % select(X,L,L')
  • % selects X a member of list L,
  • % L' is the list L with X removed
    select(X,[X|L],L).
  • select(X,[Y|L],[Y|Lp]) :- select(X,L,Lp).
Homework 6 Review

• Exercise 1:
  – Tomorrow, I will go for a hike

• Run:
  – ?- sbar(X,[tomorrow,i,will,go,for,a,hike],[]).
  – X = [s<t,t=tomorrow(s),subset(e,t),s<t] ? ;
  – no
  – ?- sbar(X,[tomorrow,i,will,go,for,a,hike],[]), infer(X,Y).
  – X = [s<t,t=tomorrow(s),subset(e,t),s<t],
  – Y = [s<e] ? ;
  – X = [s<t,t=tomorrow(s),subset(e,t),s<t],
  – Y = [s<e] ? ;
  – no

\[
\text{infer}(R,[(X<Z)]) :-
\text{select}((X<Y),R,R1),
\text{select}(\text{subset}(Z,Y),R1,\_).
\]

If $X < Y$ and $Z \subseteq Y$ we can infer: $X < Z$
Exercise 2:

Diagram “Yesterday, Noah had a rash”

\[
[t < s, t = yesterday(s), \text{intersect}(e, t), t < s]
\]

\[
\text{sbar}(R) \rightarrow \text{adjunct}(R1), s(R2), \{\text{append}(R1, R2, R)\}.
\]

\[
[t < s, t = yesterday(s)]
\]

\[
\text{adjunct} \rightarrow \text{adjunct}((t < s), \text{ yesterday}(s)) \rightarrow \text{[yesterday]}
\]

\[
[t < s, \text{intersect}(e, t), t < s]
\]

\[
\text{s}(R) \rightarrow \text{np}, \text{vp}(R).
\]

\[
\text{np}
\]

\[
\text{np}(noah) \rightarrow [t < s]
\]

\[
\text{vp}
\]

\[
\text{vp}(v) \rightarrow v(R1, \text{have}), [a, \text{reash}], \{\text{append}([\text{intersect}(e, t)], R1, R)\}.
\]

\[
\text{vp}(v) \rightarrow v([t < s], \text{have}) \rightarrow \text{[had]}
\]
Homework 6 Review

- **Exercise 3**: Inconsistency
- Explain formally what is wrong with the following sentences:
  - (i) # Yesterday, I will go for a hike
  - (ii) # Tomorrow, Noah had a rash

```prolog
?- sbar(X,[yesterday,i,will,go,for,a,hike],[[]]), inconsistent(X).
X = [t<s,t=yesterday(s),subset(e,t),s<t] ;
X = [t<s,t=yesterday(s),subset(e,t),s<t] ;
no
?- sbar(X,[tomorrow,noah,had,a,rash],[[]]), inconsistent(X).
X = [s<t,t=tomorrow(s),intersect(e,t),t<s] ;
X = [s<t,t=tomorrow(s),intersect(e,t),t<s] ;
no
inconsistent(R) :-
    select((X<Y),R,R1),
    select((Y<X),R1,_).
```
Homework Final
Homework Final

• Instructions
  – 7 Questions
  – Due tomorrow by midnight in my mailbox
    • deductions if you’re late
    • zero points if you are a day late
  – Answer as many questions as you can in the time available
  – Attempt every question
  – It’s a second chance to show you understand the course material, homework reviews, etc.
    • Good luck!
Homework Final

• Instructions
  – *Do not panic.*
  – Consult referenced homework slides
  – Consult homework reviews
    • *All questions on this homework final can be answered with the knowledge in those lecture slides*
  – You may discuss the homework final
    • you must cite classmates or other sources
Question 1

• [Homework 1: Lecture 3]

• **Introduction to Prolog and Truth Conditions**
  – Let database fact p represent the proposition “All dogs bark”
    • [4pts] Construct the Prolog statement for “it is not the case that both all dogs bark and not all dogs bark”
    • [4pts] Show that the translated (into Prolog) statement is a tautology.
  – (Submit your Prolog run.)
Question 2

- [8pts] Give a phrase structure grammar for the following sentences.
- Why is John sad?
  - \[CP \text{[Adv \, why]} \text{[Cbar \, [C \, is]} \text{[IP \, [NP \, John]} \text{[VP \, [V \, trace]} \text{[AP \, [NP \, trace]} \text{[Abar \, [A \, sad]]]}\]
- Why is John not sad?
  - \[CP \text{[Adv \, why]} \text{[Cbar \, [C \, is]} \text{[IP \, [NP \, John]} \text{[NegP \, [Neg \, not]} \text{[VP \, [V \, trace]} \text{[AP \, [NP \, trace]} \text{[Abar \, [A \, sad]]]}\]
- Why isn't John sad?
  - \[CP \text{[Adv \, why]} \text{[Cbar \, [C \, isn't]} \text{[IP \, [NP \, John]} \text{[NegP \, [Neg \, trace]} \text{[VP \, [V \, trace]} \text{[AP \, [NP \, trace]} \text{[Abar \, [A \, sad]]]}\]

[Follow the bracketing given exactly. Treat trace as if it was a real word. Treat isn't as a single word in Prolog: ‘isn’t’.]
Question 2

- [Homework 2: Lecture 8]
- **Phrase Structure and Meaning Grammars**
  - [3pts] Show your grammar works.
  - Why is John sad?
    - ?- cp(PS,[why,is,john,trace,trace,sad],[]).
  - Why is John not sad?
    - ?- cp(PS,[why,is,john,not,trace,trace,sad],[]).
  - Why isn’t John sad?
    - ?- cp(PS,[why,’isn’t’,john,trace,trace,trace,sad],[]).
  - (Submit your runs.)
Question 2

• [Homework 2: Lecture 8]
• Phrase Structure and Meaning Grammars
  – [6pts] Modify your rules involving trace to allow empty categories as follows:
    • Old rule: \( x(x(\text{trace})) \rightarrow [\text{trace}] \).
    • New rule: \( x(x(\text{trace})) \rightarrow [] \).
  – Show your new rules work.
  – How many parses for each of the following queries?
    – Why is John sad?
      • \(-\) \( \text{cp(PS, [why, is, john, sad], [])} \).
    – Why is John not sad?
      • \(-\) \( \text{cp(PS, [why, is, john, not, sad], [])} \).
    – Why isn’t John sad?
      • \(-\) \( \text{cp(PS, [why, ‘isn’t’, john, sad], [])} \).
  – (Submit your runs.)
Question 3

• [Homework 3: Lecture 13]
• **Phrase Structure and Meaning Grammars Contd.**
• [8pts] Give a meaning grammar for sentence/meaning pairs:
  – dog(shelby). Shelby is a dog
  – (white(shelby), dog(shelby)). Shelby is a white dog
  – [Assume *white* is an *intersective adjective*.]
• [6pts] Evaluate your generated meanings against the Prolog versions of the following possible worlds:
  – (A) Shelby is a dog and Shelby is white
  – (B) Shelby is a dog and Shelby is brown
• (Submit your runs and possible worlds.)
Question 4

- [Homework 4: Lecture 18] **Plural and Mass Terms.**
- Assume the **lattice-style definition** for the plural *dogs*:
  - :- dynamic dog/1.
  - dogs(Plural) :- findall(X,dog(X),L), plural(L,Plural).
  - plural(L,X+Y) :- selectone(X,L,L1), selectone(Y,L1,\_).
  - plural(L,X+PL) :- selectone(X,L,L1), plural(L1,PL).
  - selectone(X,[X|L],L).
  - selectone(X,[Y|L],L2) :- selectone(X,L,L2).
- [4pts] Give a Prolog query for “two dogs”
- [4pts] Give a Prolog query for “two or more dogs”
- [4pts] Give a Prolog query for “not more than two dogs”
**Question 5**

- [Homework 5: Lecture 22]
- **Truth Tables and Quantification.**
- Assume the Prolog definitions given in HW 5 for logical implication (⇒) and negation (¬)
- [8pts] Are \( P \Rightarrow Q \) and \( \neg Q \Rightarrow \neg P \) equivalent?
- Prove your answer using Prolog truth tables
- (Submit your Prolog query and run.)
Question 6

- [Homework 5: Lecture 22]
- **Truth Tables and Quantification.**
- Define $|S|$ to be the size of set $S$
  - examples:
    - $|\{a,b\}| = 2$
    - $|\{a,b,c\}| / 2 > |\{a\}|$
- [10pts] Give the set-theoretic, i.e. **Generalized Quantifier-based**, semantics for the sentences:
  - Most men smoke
  - Most smokers are men
- (You may use set notation or Prolog notation.)
- (There is no need to run a Prolog query.)
Question 7

• [Homework 6: Lecture 27]
• **Tense and Aspect.**
• [8pts] Give the relations between S, E, T for the sentences:
  – John had left yesterday
  – John has left
• [3pts] According to the theory, what is semantically odd about?
  – # John has left yesterday
Summary

• **Total: 82 pts**
  – Q1: 8pts
  – Q2: 19pts
  – Q3: 14pts
  – Q4: 12pts
  – Q5: 8pts
  – Q6: 10pts
  – Q7: 11pts