

11-711: Algorithms for NLP

Homework Assignment #5

Out: December 1, 2015
Due: December 10, 2015

Problem 1

Consider the following context-free grammar fragment that has been augmented with feature structures:

- (1) VP \rightarrow v NP
 <v subcat> = +np
 <VP obj> = NP
 VP = v
- (2) VP \rightarrow v NP PP
 <v subcat> = +np+pp:loc
 <VP obj> = NP
 <VP comp> = PP
 VP = v

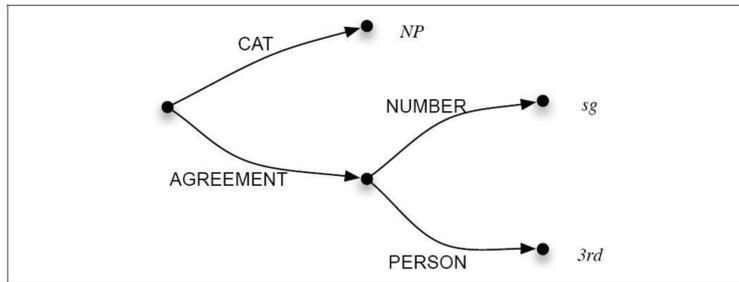
Assume the following feature structures have already been created for the v, NP, and PP parse nodes:

v: [[root left] [subcat +np+pp:loc]]

NP: [[root flowers] [det +] [agr 3s]]

PP: [[root garden] [prep in]]

The parser is now applying the unification constraints in Rule (2) above and is creating the left-hand-side VP constituent. Answer the following questions using the feature structure and DAG notation presented in class: <http://demo.clab.cs.cmu.edu/fa2013-11711/images/e/eb/Unification.pdf>. Specifically, from slide 9:



While you are not required to typeset graph-like figures such as these, all of your text and drawings must be very clear; illegible or otherwise ambiguous solutions will not receive credit.

1. **[15 points]** Convert the feature structures into DAG representations, execute the unification constraints in the rule, and show the resulting feature structures of all parse nodes after performing the unifications as specified in the rule. If the unification fails at any point, clearly indicate the constraint being violated.
2. **[15 points]** Now assume we are applying Rule (1) rather than Rule (2), using the original feature structures of the *v* and *NP* nodes. Again, convert the feature structures into DAG representations, execute the unification constraints in the rule, and show the resulting feature structures of all parse nodes after performing the unifications as specified in the rule. If the unification fails at any point, clearly indicate the constraint being violated.
3. **[10 points]** Explain briefly how the unification constraints in the rules above can be used to disambiguate sentences such as “I left the flowers in the garden”.

Problem 2

2.1 CCG Syntactic Analysis [20 points]

Basic CCG rules:

Forward application: $A/B + B = A$
Backward application: $B + A \backslash B = A$
Composition: $A/B + B/C = A/C$
Composition: $B \backslash A + C \backslash B = C \backslash A$
Conjunction: $A \text{ CONJ } A' = A''$
Type raising: $A = X / (X \backslash A)$
Type raising: $A = X \backslash (X / A)$

Lexical entries:

Alon NP
Bob NP
Chris NP
Daphne NP
Eve NP
chocolates NP
flowers NP
slides N
some NP/N
dislikes (S\NP)/NP
like (S\NP)/NP
likes (S\NP)/NP
gave (S\NP)/NP/NP
and CONJ
but CONJ

Show syntactic analysis of the following sentences using the above rules and lexical entries. Use the notation shown in class: <http://demo.clab.cs.cmu.edu/fa2013-11711/images/8/8b/CCG.pdf>. You do not need to show the type of each rule used (forward, backward, etc.), but you should clearly show each step of your analysis as in the class notes.

When typesetting your solutions, make sure to use a fixed-width font so that your dashed lines are properly aligned with the text of the sentence. Use sufficient spacing to ensure that your solutions are entirely unambiguous. In Latex, you can use the verbatim environment (see the source of this document). In Microsoft Word, use a font such as Courier. For example:

```
Bob      likes      Daphne
NP       (S\NP)/NP    NP
-----
                S\NP
-----
                S
```

Sentences to analyze:

1. Alon gave Chris some slides
2. Alon and Chris like Bob
3. Bob likes Daphne but Daphne dislikes Bob
4. Chris gave Daphne flowers and Eve chocolates
5. Eve gave Alon and Bob chocolates and Chris flowers

2.2 CCG Semantic Analysis [20 points]

CCG semantic rules:

Forward application:	$A/B:S + B:T = A:S.T$
Backward application:	$B:T + A\backslash B:S = A:S.T$
Coordination:	$X:A \text{ CONJ } X':A' = X'': \lambda S (A.S \& A'.S)$
Coordination for lambda-free constituents:	$X:A \text{ CONJ } X':A' = X'':A \& A'$
Composition:	$X/Y:A \ Y/Z:B = X/Z: \lambda Q (A.(B.Q))$
Type raising:	$NP:a = T/(T\backslash NP): \lambda R (R.a)$

Semantically annotated lexical entries:

Alon NP:a
Bob NP:b
Chris NP:c
Daphne NP:d
exam N:e
slides N:s
some NP/N: $\lambda X \text{ some}(X)$
the NP/N: $\lambda X \text{ the}(X)$
walks $S\backslash NP$: $\lambda X \text{ walks}(X)$
grades $(S\backslash NP)/NP$: $\lambda Y \lambda X \text{ grades}(X,Y)$
like $(S\backslash NP)/NP$: $\lambda Y \lambda X \text{ like}(X,Y)$
likes $(S\backslash NP)/NP$: $\lambda Y \lambda X \text{ likes}(X,Y)$
dislikes $(S\backslash NP)/NP$: $\lambda Y \lambda X \text{ dislikes}(X,Y)$
gave $(S\backslash NP)/NP/NP$: $\lambda Z \lambda Y \lambda X \text{ gave}(X,Y,Z)$
and CONJ
but CONJ

Show syntactic and semantic analysis of the following sentences using the above rules and lexical entries. Clearly show each step of your analysis. Your solution should resemble the following example:

Bob	likes	Daphne
NP:b	$(S \backslash NP) / NP : \lambda Y . \lambda X . \text{likes}(X, Y)$	NP:d

$S \backslash NP : \lambda X . \text{likes}(X, d)$		

S:likes(b,d)		

Sentences to analyze:

1. Bob grades the exam
2. Alon gave Chris some slides
3. Alon likes Bob and Chris
4. Bob likes Daphne but Daphne dislikes Bob and likes Alon

2.3 Categorical Unification Grammar [20 points]

Vocabulary:

friend
friends
he
I
like
likes
movie
movies
my
the
walk
walked
walks
you

Adding appropriate syntactic features to the basic S, N, and NP categories, show how the following could be parsed using a categorical framework. For each sentence, show your lexical entries and the syntactic analysis. See CCG slides 30–35 for examples of what we’re looking for. No semantic analysis is required for these examples, only syntactic. Your features should clearly ensure that only grammatically correct sentences parse for the given vocabulary. Note that the vocabulary is **not** sorted by category. Assigning categories is part of your task. See the class slides for notation and examples. Remember that you can have more than one rule for a single word.

Sentences to analyze:

1. I walk
2. you walk
3. he walks
4. he walked
5. my friend likes the movie
6. my friends like the movies

You don't need to analyze the following sentences, but your grammar should successfully parse the grammatical sentences, and should reject the ungrammatical sentences (indicated with an asterisk):

- my friends like movies
- *my friends like movie
- I like you
- *I like he
- *he likes I
- movies like you
- *movie like you

You may ignore the transitive sense of “walk”, so a grammar that rejects “I walk you” will get full credit, even though the sentence is grammatical in real English.