Practice Exam Problems: Semantics

Natural Language Processing (JHU 601.465/665)

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Note: In some of the problems, `1` and `2` are used as variables, meaning the `sem` attributes of the first and second children of a node.

This convention is used on Homework 5, where it is explained and illustrated in the file `http://www.cs.jhu.edu/~jason/465/hw-sem/arith.gra`. You could use these problems as a warmup for HW5, or vice-versa.

1. In this question you should specify semantic features in the style of Homework 5.

   (a) [4 points] Recall that $\mathsf{hat} = \lambda x\ \mathsf{hat}(x)$. Suppose $f(\mathsf{hat}) = \lambda x\ \mathsf{big}(x), \mathsf{hat}(x)$. What is f as a lambda term?

   (*Hint:* Your answer should begin with λg so that the formal argument g can be bound to the actual argument hat.)

   (b) [4 points] Fill in the missing semantic features of the rules below so that *a big red hat* has the (somewhat bogus) semantics $(\exists x)\ \mathsf{big}(x), \mathsf{red}(x), \mathsf{hat}(x)$.

   NP[sem=_____] → a N[sem=2]

   N[sem=λx _____] → Adj[sem=1] N[sem=2]

   N[sem=hat] → hat

   Adj[sem=big] → big

   Adj[sem=red] → red

   (c) [4 points] Same as question (b), but different features are provided, so your answer will be different. ((b) provided trivial Adj, Det rules so the N, NP rules had to be complicated; here it is the other way around.) *Hint:* Question (a) is relevant.

   NP[sem=1(2)] → Det[sem=1] N[sem=2]

   N[sem=1(2)] → Adj[sem=1] N[sem=2]

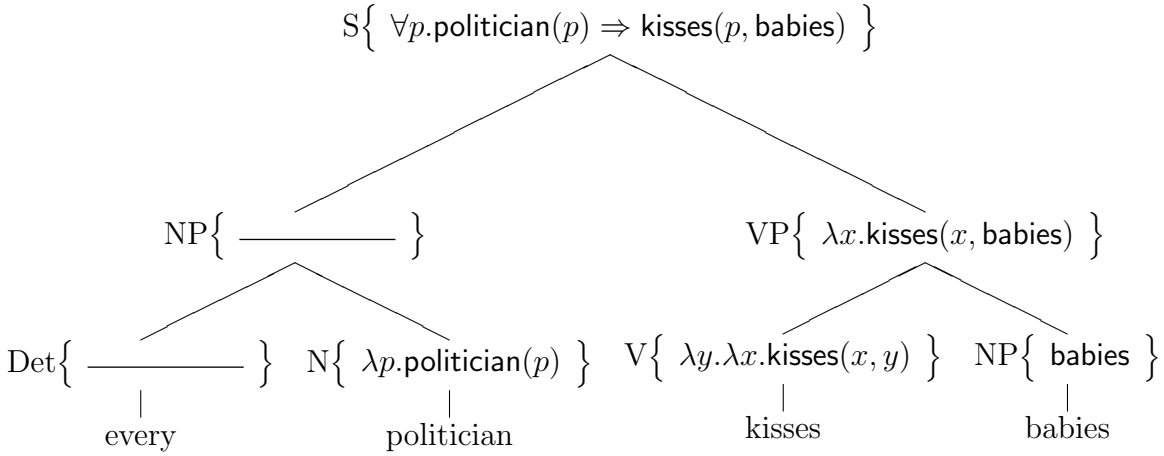
   N[sem=hat] → hat

   Adj[sem=_____] → big

   Adj[sem=_____] → red

   Det[sem=_____] → a

2. [30 total points] Here is a syntactic and semantic analysis of the sentence `every politician kisses babies`:



(a) [3 points] Recall that in compositional semantics, every context-free rule is annotated with semantic features, showing how to build up the semantics on the parent from the semantics on the children.

At each binary node of the tree above, draw a $\Rightarrow$ if the annotated binary context-free rule has the form

$$X\{\alpha(\beta)\} \rightarrow Y\{\alpha\}\ Z\{\beta\} \text{ (i.e., left child is a function applying to right child)}$$

or a $\Leftarrow$ if it has the form

$$X\{\beta(\alpha)\} \rightarrow Y\{\alpha\}\ Z\{\beta\} \text{ (i.e., right child is a function applying to left child)}$$

Throughout this problem, assume that all binary rules are annotated in one of those two ways. (We did some extended examples in class under that assumption.)

(b) [6 points] In the tree above, fill in the semantics for *every politician*; then fill in the semantics for *every*.

(c) [6 points] The tree above claims that the meaning of the sentence is

$$\forall p.\mathsf{politician}(p) \Rightarrow \mathsf{kisses}(p, \mathsf{babies})$$

As with any brief attempt to capture the meaning of a sentence in logic, this representation is not perfect. Which of the following are problems with the representation? *(circle <u>all</u> that apply)*

i. The number of quantifiers shown in the semantics is wrong. (*Note*: Quantifiers are things like ($\forall$, $\exists$, most, few, Gen, ...)

ii. The $\forall$ quantifier is arguably in the wrong place; it should appear inside the first argument of kisses.

iii. babies has the wrong type to be the second argument of kisses.

iv. All instances of $\mathsf{kisses}(x, y)$ should be replaced with $\mathsf{kisser}(x), \mathsf{kissee}(y)$.

v. $\lambda y.\lambda x.\mathsf{kisses}(x, y)$ should be $\lambda x.\lambda y.\mathsf{kisses}(x, y)$.

vi. The sentence is semantically ambiguous, even given this syntactic parse tree (so there should be a second meaning listed as well).

vii. none of the above

(d) [4 points] Forget about the previous question, and just assume from now on that the tree above is the correct syntactic and semantic representation of `every politician kisses babies`. You should give your answers in the same style.

What is the correct semantics for `every politician that we met kisses babies`?

(e) [5 points] Below, draw the syntax tree for `every politician that we met kisses babies`.

Hint: You will want at least one slashed category (gap) somewhere. Also, `politician that we met` should be a constituent.

(f) [6 points] Under this analysis, what is the semantics of the word `that`?

Hint: To show your work (which can help with partial credit), fill in the semantics at *each* node in your syntax tree. You may want to work from the top down. Also annotate each node with $\Rightarrow$ or $\Leftarrow$ as above.