LIN 350: Computational Semantics, Fall 2018, Erk

Homework 4: Lambda terms and semantics construction

Due: Tuesday November 20, 2016

A perfect solution to this homework will be worth *100* points.

Please submit this homework online on Canvas. If you would like to write out some of the problems by hand and scan the result, feel free to do so, but please make sure the scan is legible.

1. **Semantics construction (40 pts)**

   For this problem, you will do semantics construction.

   Here are the relevant lexical entries:

word	POS-tag	lambda term	type
John	PN	$\lambda P.P(J)$	$\langle\langle e,t\rangle,t\rangle$
rabbit	N	$\lambda x.rabbit(x)$	$\langle e,t\rangle$
duck	N	$\lambda x.duck(x)$	$\langle e,t\rangle$
sleep	V_I	$\lambda x.sleep(x)$	$\langle e,t\rangle$
bite	V_T	$\lambda R\lambda u.\Big(R(\lambda v.bite(u,v))\Big)$	$\langle\langle\langle e,t\rangle,t\rangle,\langle e,t\rangle\rangle$
a	Det	$\lambda P\lambda Q.\exists x.P(x)\wedge Q(x)$	$\langle\langle e,t\rangle,\langle\langle e,t\rangle,t\rangle\rangle$
every	Det	$\lambda P\lambda Q.\forall x.P(x)\rightarrow Q(x)$	$\langle\langle e,t\rangle,\langle\langle e,t\rangle,t\rangle\rangle$

   For each of the following sentences, sketch the phrase structure analysis, and associate each node in the syntactic structure with its semantic representation. Please show both the lambda expression and the semantic type at each node. (Hint: Use the types to make sure everything fits together as intended.) Perform beta reduction as often as possible in each step. (Please ignore issues of tense.)

   Please do this by hand, rather than using the NLTK parsing and semantics construction methods.

   Show your work: At each node, show each individual beta reduction step on the way to the final logical form.

   (a) John sleeps.

   (b) Every rabbit sleeps.

   (c) A duck bit every rabbit.

2. **Semantics construction in NLTK (30pts.)**

   The file `grammar.py` contains a grammar that can be used as an NLTK `FeatureGrammar` (feature-based context free grammar). See the demo on the schedule page (November 15) on how to use it.

   This grammar can produce logical form representations for sentences like "Vincent dances" or "Mia knows a boxer" or "Vincent is a criminal". If you want to see some, run `basicsem.py`.

   Please extend the grammar in the following ways.

   (a) Extend the grammar such that it can handle adjectives (attributive use), as in "Mia knows a happy boxer". Extend the lexicon such that it can handle the adjective "happy". Test your extended grammar as described in the demo on the schedule page (November 15).

   In your solution, please list your grammar extension, along with the semantic representation that it derives for the sentence "Mia knows a happy boxer."

   Extra credit (5 pts.): Extend the grammar such that it can also handle predicative uses of adjectives, as in "Vincent is happy".

   Hint: You may want to consider separate lexical entries for attributive and predicative uses of "happy". You will also need the *copula* "be"; while we haven't done its semantics yet, its syntax is given in the last grammar of the demo on the schedule page (November 15).

   In your solution, please list your grammar extension, along with the semantic representation that it derives for the sentence "Vincent is happy."

   (b) Extend the grammar such that it uses event variables for intransitive verbs. For the sentence "Vincent dances", it should derive

   ```
   exists e.(dance(e) & agent(e,vincent))
   ```

   Hint: The type for intransitive verbs stays the same. So in constructing a new lambda term, with event variable, for an intransitive verb, you may want to work off of the old one.

   In your solution, please list your grammar extension, along with the semantic representation that it derives for the sentence "Mia collapses"

   Extra credit (5 pts.): Also extend the grammar such that it uses event variables for transitive verbs. For the sentence "every criminal kills a boxer", you should get

   ```
   all x.(criminal(x) -> exists e z1.(boxer(z1) & kill(e) &
          agent(e,x) & patient(e,z1)))
   ```

Hint: The type for transitive verbs also stays the same.

In your solution, please list your grammar extension, along with the representation that it derives for the sentence "every boxer knows Vincent".

3. **Underspecification (30 pts.)**

Each of the following phrases has a scope ambiguity between the underlined subphrases. For each of the phrases, describe in words what the two different readings are, and indicate what your preferred reading of the phrase is.

(a) Human Microbiome Project: a map of every bacterium in the body

(b) A business continuity plan is now an essential part of every organization's workplace strategy

(c) Both rooms had access to a private balcony.

(d) We also distributed a survey among all the members of the network.

(e) So, all merchandise is not evidence in that case.

(Note: all these phrases were found online using some simple Google patterns.)