Foundations of Natural Language Processing
Lecture 18a
Introduction to Semantics

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Last Time:  Syntactic parsing

Now:  How can syntax inform meaning?

- Desiderata for formal semantic representations of sentences
- Method for constructing semantic representations from a syntax tree.

We will start with:

- What is meaning?

- What should a representation of meaning capture?
Meaning

• One grand goal of artificial intelligence is to *understand* what people mean when they talk.

• But how do we know if we succeeded?
Literal Meaning

Semantics is concerned with how expressions relate to ‘the world’. This includes both their

- truth conditions and denotation (literal meaning)

- connotation (other associations)

For now, we’re interested only in literal meaning.
Eliza

Joseph Weizenbaum wrote the computer program Eliza in 1969 to demonstrate how easily people can be fooled into thinking that machines have some deep understanding.

young woman: Men are all alike.
eliza: In what way?
young woman: They’re always bugging us about something specific or other.
eliza: Can you think of a specific example?
young woman: Well, my boyfriend made me come here.
eliza: Your boyfriend made you come here?
young woman: He says I’m depressed much of the time.
eliza: I am sorry to hear you are depressed.
young woman: It’s true. I’m unhappy.
eliza: Do you think coming here will help you not to be unhappy?

Online demo: http://www.manifestation.com/neurotoys/eliza.php3
What is meaning? What is understanding?

- These are deep philosophical questions

- NLP usually takes a more pragmatic view: can the computer behave as though it understands (in order to do what we want)?
  - Dialogue systems (e.g., Eliza)
  - Machine translation
  - Question answering

- What issues will we face in building such systems?
A Concrete Goal

• We would like to build
  – a machine that answers questions in natural language.
  – may have access to knowledge bases
  – may have access to vast quantities of English text

• Basically, think Alexa!

• This is typically called Question Answering
Semantics

• To build our QA system we will need to deal with issues in **semantics**, i.e., meaning.

• Sentential semantics: how word meanings combine (study now)
  
  – Who did what to whom; when, how, why. . .
    
    John loves Mary  \( \neq \)  Mary loves John
    
    \( \Rightarrow \)  Someone loves Mary

• Lexical semantics: the meanings of individual words (study after that)
  
  E.g., John is male, Mary is female,
  loves is more closely related to like than to sees, antonym of hate. . .
What we’ve learned so far about sentential syntax

• It captures linguistic generalisations about grammaticality (*substitutability*)

• It generates an unbounded set of grammatical sentences via a finite lexicon and finite rules (*recursion*)

• We can induce probabilistic grammars from a treebank, and so tackle (pervasive) syntactic ambiguity.
What about Meaning?

- Sentential syntax reveals information about sentence meaning

  \[\text{John loves Mary} \quad \Rightarrow \quad \text{love}(j, m)\]

  \[\text{Mary is loved by John} \quad \Rightarrow \quad \text{love}(m, j)\]

- Decisions about how to resolve syntactic ambiguity are tied up with decisions about (intended) meaning.

- Syntactic ambiguity (almost) always yields a semantic ambiguity.

- Resolving syntactic ambiguities does *not*, however, resolve all semantic ambiguities
  - word sense, semantic scope, anaphoric expressions
    *all to be studied later in this course*

  so reasoning about *context* is also very important
  *(also studied later in this course)*
Summary

- Meaning representations are important for many NLP tasks because they captures:
  - Who did what to whom in a way that abstracts away from (irrelevant) syntactic details
  - Valid inference, and information about reference

- Linguistic syntax informs meaning (and *vice versa*)
What we’ll study now. . .

- Principle of Compositionality

- Exploit compositionality to augment a grammar with a semantic component, which \textit{deterministically derives} the logical form of a sentence from its syntax tree.