CSC 594 Topics in AI – Applied Natural Language Processing

Fall 2009/2010

5. Semantics

Natural Language Semantics

- Semantics of a sentence is the meaning of the sentence.
- And the meaning comes from:
 - meanings of the words/phrases in the sentence; plus
 (semantic) relations between the words/phrases
- Underlying assumption Compositionality
 - The meaning of a sentence is a composition of the meanings of its parts.
 - This assumption is not always true, especially for words/phrases which have idiomatic/non-literal meaning.
 - e.g. "It's raining <u>cats and dogs</u>"

Semantic AnalysisDerive the meaning of a sentence.

• Often applied to the result of syntactic analysis.

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" <u>John</u>	ate	the cake.	"		
NP	V	NP			
((act	ion	INGEST)	· svi	ntactic v	٥rl

- ((action INGEST) ; syntactic verb (actor JOHN-01) ; syntactic subj (object FOOD)) ; syntactic obj
- To do semantic analysis, we need a (semantic)
- dictionary (e.g. WordNet, http://www.cogsci.princeton.edu/~wn/).

Various Semantic Analyses

- There are many aspects and levels in the meaning of a sentence:
 - Word meanings/senses, concepts
 - Semantic relations
 - Quantifiers (e.g. "Every boy loves a dog") - Truth value in a model
 - Inference
 - e.g. entailment "He was snoring" entails "He was sleeping"
- · Various representations of meaning
 - First-order Predicate Logic (FOPL)
 - Slot-filler structures or frames
 - Semantic networks
 - Web Ontology Language (OWL) ← new
 - etc.

Word Senses

• Many words have more than one sense (ambiguous words) - an applicable sense varies depending on the context.

A word may also have several parts-of-speech. •

- The noun "bass" has 8 senses in WordNet.

- The noum "bass" has 8 senses in WortNet. 1. bass¹ (the lowest part of the musical range) 2. bass², bass part¹ (the lowest part in polyphonic music) 3. bass³, bass part¹ (the lowest part in polyphonic music) 4. sea bass¹, bass⁴ (the lean flesh of a saltwater fish of the family Serranidae) 5. freshwater bass¹, bass⁵ (any of various North American freshwater fish with lean flesh (especially of the genus Micropterus)) 6. bass⁶, bass voice¹, basso² (the lowest adult male singing voice) 7. bass⁷ (the member with the lowest range of a family of musical instruments) 8. bass⁸ incontechnical name for any of numerous edible marine and freshwater spiny-finned fishes) The adjective "bass" has 1 sense in WortNet. 1. bass¹, deep⁶ (having or denoting a low vocal or instrumental range) *"a deep voice"; "a bass voice is lower than a baritone voice"; "a bass clarinet"*

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Ontology

- · Word senses (not words) can be grouped into a set of broad classes - semantic concepts.
- The set of semantic concepts is called **ontology**.
- ٠ Typical major classes:
 - substance, quantity, quality, relation, place, time, position, state, action, affection, event, situation
- For each class, there are many sub-classes, which are often organized in a hierarchy. e.g. WordNet



Relations between Senses

- Synonyms two senses of two different words that are identical – e.g. couch/sofa, vomit/throw up
- Antonyms -- two senses of two different words that are opposite

 e.g. long/short, cold/hot, rise/fall
- Hyponyms one word sense is more specific (a subclass) than
 another word sense
- Hypernyms -- one word sense is more general (a superordinate) than another word sense
 Superordinate vehicle fruit furniture manimal

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- Hyponym car mango chair dog
- Hyponym/hypernym relation creates a taxonomy of word senses/concepts
- Meronyms/Holonyms part-whole relations – e.g. table -> leg (meronym), leg -> table (holonym)

Source: Jurafsky & Martin "Speech and Language Processing"





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Thematic Roles (1)

- Consider the following examples:
 - John broke the window with the hammer.
 - The hammer broke the window.
 - <u>The window</u> broke.
- Although in each sentence the surface position of the three words are different, they play the same semantic roles (deep roles; thematic roles)
 - John AGENT
 - the window THEME (or OBJECT)
 - the hammer -- INSTRUMENT

Thematic Roles (2)

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• There are several commonly used thematic roles:

Thematic Role	Definition		
AGENT	The volitional causer of an event		
EXPERIENCER	The experiencer of an event		
FORCE	The non-volitional causer of the event		
THEME	The participant most directly affected by an event		
RESULT	The end product of an event		
CONTENT	The proposition or content of a propositional event		
NSTRUMENT	An instrument used in an event		
BENEFICIARY	The beneficiary of an event		
SOURCE	The origin of the object of a transfer event		
COM	The destination of an able tof a transfer mont		

Thematic Role	Example		
AGENT	The waiter spilled the soup.		
EXPERIENCER	John has a headache.		
FORCE	The wind blows debris from the mall into our yards.		
THEME	Only after Benjamin Franklin broke the ice		
RESULT	The French government has built a regulation-size baseball diamond		
CONTENT	Mona asked "You met Mary Ann at a supermarket?"		
INSTRUMENT	He turned to poaching catfish, stunning them with a shockin device		
BENEFICIARY	Whenever Ann Callahan makes hotel reservations for her boss.		
SOURCE	I flew in from Boston.		
GOAL	I drove to Portland.		
But it's difficult to	o come up with a standard set of roles or to define them.		

Linking Syntax and Semantics

- Same thematic role could be realized in various syntactic positions.
 - John broke the window with the hammer.
 - <u>The hammer</u> broke <u>the window</u>.
 - The window broke.
- · To link syntax and semantics to derive a semantic representation of a sentence, one common approach is by Lexical Semantics - encode the semantic constraints which a word imposes upon other words in specific relations (arguments).
 - [BREAK [AGENT animate] [THEME inanimate] [INSTR utensil]]
 [BREAK [AGENT utensil] [THEME inanimate]]

 - [BREAK [AGENT inanimate]]

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Selectional Restrictions

- Specifications of the legal combinations of senses that can co-occur are called Selectional Restrictions constraints which a predicate imposes on the semantic types of its arguments.
 - e.g. [READ [AGENT person] [THEME text]]
- · Semantic constraints (on nouns) specify the most general types - all sub-types/hyponyms in the ontology are legal.



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Syntax-Semantics Integrated Approaches

- Two major approaches:
 - 1. Semantic grammar
 - In texts of a limited domain, certain constructs appear only with a specific semantic context.
 - Write a grammar that is cast in terms of the major semantic categories of the domain.
 e.g. air travel domain

 FLIGHT-NP -> DET FLIGHT-CNP

 FLIGHT-CNP -> FLIGHT-N
 _
 - 2. Encode both syntax and semantic constraints in the grammar
 - Example: LINK system (by Prof. Steve Lytinen)
 - Grammar formalism based on Unification Grammar

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