December 2, 2004
Chapter 16
Lexical Semantics
Overview

- What is lexical semantics?; Applications
- Lexeme
- Lexical relations (homonymy, polysemy, synonymy, hyponymy)
- Internal structure of words: thematic roles, selectional restrictions, decomposition
- Generative lexicon: metaphor & metonymy
- Along the way, resources: WordNet, FrameNet
What is lexical semantics? (1/2)

- The study of the meanings of words.
- How do you (as speakers) know what a word means?
- How could you go about systematically describing it?
What is lexical semantics? (2/2)

- Lexical meanings are structured:
  - Predicate-argument structure
  - Relationships between senses
  - Entailments
  - Selectional restrictions
  - Possible potential for decomposition
Applications

- Information extraction
- Information retrieval
- Machine translation
- Natural language understanding
Some terminology: Lexemes

- Lexemes are a kind of signs: pairings of form and meaning.
- Form can be phonological or orthographic.
- Meaning is quantized as ‘senses’.
- A lexeme may have multiple forms (through inflectional morphology).
- … and multiple meanings (polysemy).
- The lexicon is a finite list of lexemes.
Relationships between lexemes

- Homonymy (homophony, homography)
- Polysemy
- Synonymy
- Hyponymy
Homonymy

- A relation that holds between two lexemes that have the same form but unrelated meanings.

- Complicated by the presence of two kinds of form.

<table>
<thead>
<tr>
<th></th>
<th>orth. form</th>
<th>phon. form</th>
<th>meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>homonyms</td>
<td>same</td>
<td>same</td>
<td>unrelated</td>
</tr>
<tr>
<td>homographs</td>
<td>same</td>
<td>different</td>
<td>unrelated</td>
</tr>
<tr>
<td>homophones</td>
<td>different</td>
<td>same</td>
<td>unrelated</td>
</tr>
<tr>
<td>??</td>
<td>same</td>
<td>different</td>
<td>same</td>
</tr>
</tbody>
</table>

- Typically only consider lexemes with the same part of speech.

- Morphology can cause ‘partial’ homonyms, where paradigms only partially overlap, e.g., *found*. 
Homonymy causes problems

- Spelling correction: confusables (your/you’re)
- Speech recognition:
  - Homophones – which form to transcribe?
  - Homonyms – disrupt n-gram statistics
- Text-to-speech: pronunciation selection for homographs
- IR: homonyms, homographs – which documents are really relevant?
Polysemy

- A single lexeme with multiple related senses.
- *bank*: financial institution, biological repository
- How to distinguish polysemy from homonymy?
- How to determine how many senses a word has? (When to split and when to join?)
  - *serve, uncle, bat*
- In what ways can the various senses be related?
- What kinds of problems does polysemy pose?
- Word sense disambiguation: How to tell which sense is intended in a given context.
**Synonymy**

- Two words are synonyms if they share at least one sense.
- Operationalize as a substitutability test.
- Substitutability might fail because:
  - No senses are shared
  - The sense required in a particular example is not shared
  - Particular shades of meaning are not shared: *price*/*fare*
  - Collocational constraints are violated: *big*/*large mistake*
  - Register constraints are violated: Example?
Hyponymy

- A relation that holds between two lexemes where one denotes a subclass of the other
- E.g.,: vehicle (hyponym) :: car (hyponym)
- Establish via an entailment test:
  That is a <hyponym>. ⇒ That is a <hyponym>.
- Related to ontologies, taxonomies, and object hierarchies.
**WordNet: Representing senses and semantic relations**

- A large electronic database of lexical relations
- Browser- and (C) library- based access
- Consists of lexical entries corresponding to unique orthographic forms (within a part of speech), accompanied by sets of senses for each form.
WordNet Statistics

<table>
<thead>
<tr>
<th>Category</th>
<th>Forms</th>
<th>Senses</th>
<th>Word-Sense Pairs</th>
</tr>
</thead>
<tbody>
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<td>141690</td>
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<td>203145</td>
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</tbody>
</table>

http://www.cogsci.princeton.edu/~wn/
WordNets around the World

- Global WordNet Association lists WordNets for:
  Avestan, Baluchi, Basque, Bulgarian, Catalan, Czech, Danish, Dutch, English, Estonian, French, German, Greek, Hebrew, Hindi, Icelandic, Italian, Kannada, Kurdish, Latvian, Marathi, Moldavian, Norwegian, Old Persian, Oriya, Persian, Portuguese, Romanian, Russian, Sanskrit, Serbian, Slovenian, Spanish, Swedish, Tamil, Thai, Turkish

http://www.globalwordnet.org/
**WordNet Synset**

- WordNet representations of meaning and meaning relations are organized around ‘synsets’ (synonym sets).
  
  \{ chump, fish, fool, gull, mark, patsy, fall guy, sucker, schlemiel, shlemiel, soft touch, mug \}

- A word sense in WordNet is a synset.

- Semantic relations (hyponymy, membership, part-of, antonymy) are relations between synsets.
Internal Structure of Words

- Thematic roles
- Selectional restrictions
- Primitive decomposition
- Semantic fields
Thematic roles

- Deep roles:
  - Kim broke a bat.
  - $\exists e, x, y \ Isa(e, \text{Breaking}) \land \text{Breaker}(e, \text{Kim}), \land \text{BrokenThing}(e, y) \land Isa(y, \text{bat})$

- Shallower ‘theta’ roles:
  - $\exists e, x, y \ Isa(e, \text{Breaking}) \land \text{Agent}(e, \text{Kim}), \land \text{Theme}(e, y) \land Isa(y, \text{bat})$

- Theta roles intend to capture the similarities between participants across events.

- Possibly useful in syntax-semantics interface for statements of ‘linking theory’.
Problems with Theta Roles

- Linking theory is notoriously prone to exceptions
- Originally confined only to NP and PP arguments of verbs
- Some verbs describe the same event from different perspectives.
  → Can’t predict theta roles from the event itself
    - Amie bought the sandwich from Benson for $3
    - Benson sold Amie the sandwich for $3
    - Amie paid Benson $3 for the sandwich
- A modern, corpus-based approach: FrameNet
Selectional Restrictions

- Senses of lexemes enforce selectional restrictions on their arguments:
  - Which airlines serve Denver?
    - *ServedThing* is a geographical location
  - Which airlines serve breakfast?
    - *ServedThing* is a meal
  - → Can be leveraged for word-sense disambiguation.

- Note that selectional restriction violations usually lead to incongruity and/or coerced readings, rather than strict ungrammaticality.
Specificity of selectional restrictions

- Varied:
  - In rehearsal, I often ask the musicians to imagine a tennis game.
  - They tell of jumping over beds they can’t imagine clearing while awake.
  - I cannot even imagine what this lady does all day.
  - Atlantis lifted Galileo from the launch pad.
  - Mr. Kruger lifted the fish from the water.
  - To diagonalize a matrix is to find its eigenvalues.
- Not drawn from a limited set of primitives.
**Representing Selectional Restrictions**

- Semantic contribution of a verb like *eat*:
  
  \[ \exists e, x, y \text{Isa}(e, \text{Eating}) \land \text{Agent}(e, x), \land \text{Theme}(e, y) \land \text{Isa}(y, \text{EdibleThing}) \]

- Representation of the phrase *ate a hamburger*:
  
  \[ \exists e, x, y \text{Isa}(e, \text{Eating}) \land \text{Agent}(e, x), \land \text{Theme}(e, y) \land \text{Isa}(y, \text{EdibleThing}) \land \text{Isa}(y, \text{hamburger}) \]

- Instead of defining concepts corresponding to the classes required for selectional restrictions, use WordNet synsets: \{ food, nutrient \}

- \{ hamburger, beefburger \} is a hyponym of \{ food, nutrient \}
Creativity and the Lexicon

● We can use more word meanings than can be explicitly listed in the lexicon.

● The extensions are systematic, not haphazard.

● Productive processes for creating new senses include:
   ● Metaphor
   ● Metonymy
Metaphor

- Using metaphor, we refer to and reason about concepts using terminology appropriate to completely different kinds of concepts.

- Corporation as Person
  - That doesn’t scare Digital, which has grown to be the world’s second-largest...
  - Triton Group Ltd., as company it helped resuscitate, has begun acquiring Fuqua shares.
  - But if it changed its mind, however, it would do so for investment reasons, the filing said.
**Metonymy**

- The use of one concept to refer to another concept closely related to it.
  - **Product for Process:**
    GM killed the Fiero because it had dedicated a full-scale factory to building the plastic bodied car...  
  - **Author for Works**
    He likes Shakespeare.
  - **Place for Institution**
    The White House had no comment.
Approaches to Metaphor and Metonymy

- Convention-based approaches hard-code metaphors such as **CORPORATION** as **PERSON** and metonymies like **PRODUCT FOR PROCESS**.

- Reasoning-based approaches treat this as a problem for general, not necessarily linguistic, reasoning, such as analogical reasoning.
Summary

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- Next time: Dialogue & conversation agents