Last class
- Introduction to lexical semantics
  - Compositional semantics
  - Homonymy
  - Polysemy

Today
- Metaphor
- Synonymy, hyponymy
- Lexical semantic resources
- Word sense disambiguation

Polysemous lexemes
- For any given single lexeme we would like to be able to answer the following questions:
  - What distinct senses does it have? [last class]
  - How are these senses related?
  - How can they be reliably distinguished?
- Answers dictate how well semantic analyzers, search engines, NL generators, and MT systems perform their tasks.

How are these senses related?
- Hasn't received much attention from lexicographers
- Important as systems begin to handle a wider variety of input texts...and encounter novel uses of words
  - Metaphor
  - Metonymy

Metaphor
- Situations where we refer to, and reason about, concepts using words and phrases whose meanings are appropriate to other completely different kinds of concepts.
  - Love is a rose. Time is money.
- Conventional metaphors
  - That doesn't scare Digital, which has grown to be the world's second-largest computer maker by poaching customers of IBM's mid-range machines.
  - COMPANY AS PERSON metaphor
  - Fuqua Industries Inc. said Triton Group Ltd., a company it helped resuscitate, has begun acquiring Fuqua shares.
  - And Ford was hemorrhaging; its losses would hit $1.54 billion in 1980.
Metonymy

- Situations where we denote a concept by naming some other concept *closely related to it*.
  - He likes Shakespeare.
    » AUTHOR FOR AUTHOR’S WORKS
  - The White House had no comment.
    » PLACE FOR INSTITUTION
  - Give the coke to the ham sandwich.
    » ???

Computational approaches

- Convention-based approaches
  - Rely on formal representations of conventional metaphors and metonyms
  - Assumes that a small set of these will suffice
  - Semantic analysis applies them to figurative language
- Reasoning-based approaches
  - View metaphor and metonymy interpretation as general analogical reasoning tasks rather than as problems specific to language processing
  - Assume that metaphors depend on inherent structural similarities between the meaning representations derived compositionally from the input and the correct representations that capture the intended meaning of the input.
  - No large-scale solutions to either problem to date.

Topics for today

- Metaphor
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Synonymy

- Lexemes with the same meaning
- Invoke the notion of *substitutability*
  - Two lexemes will be considered synonyms if they can be substituted for one another in a sentence without changing the meaning or acceptability of the sentence
    » How big is that plane?
    » Would I be flying on a large or small plane?
    » Miss Nelson, for instance, became a kind of big sister to Mrs. Van Tassel's son, Benjamin.
    » We frustrate 'em and frustrate 'em, and pretty soon they make a big mistake.
    » Also issues of *register*:
      - Social factors that surround the use of possible synonyms, e.g. politeness, group status.
Hyponymy

- Pairings where one lexeme denotes a subclass of another

  vehicle (hypernym)

  car (hyponym)

WordNet

- Handcrafted database of lexical relations
- Three separate databases: nouns; verbs; adjectives and adverbs
- Each database is a set of lexical entries (according to unique orthographic forms)
  - Set of senses associated with each entry

<table>
<thead>
<tr>
<th>Category</th>
<th>Unique Forms</th>
<th>Number of Senses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noun</td>
<td>94474</td>
<td>116317</td>
</tr>
<tr>
<td>Verb</td>
<td>10319</td>
<td>22066</td>
</tr>
<tr>
<td>Adjective</td>
<td>20170</td>
<td>29881</td>
</tr>
<tr>
<td>Adverb</td>
<td>4546</td>
<td>5677</td>
</tr>
</tbody>
</table>

Sample entry

The noun “bass” has 8 senses in WordNet.

1. bass - (the lowest part of the musical range)
2. bass, bass part - (the lowest part in polyphonic music)
3. bass, basso - (an adult male singer with the lowest voice)
4. sea bass, bass - (flesh of lean-fleshed saltwater fish of the family Serranidae)
5. freshwater bass, bass - (any of various North American lean-fleshed freshwater fishes especially of the genus Micropterus)
6. bass, bass voice, basso - (the lowest adult male singing voice)
7. bass - (the member with the lowest range of a family of musical instruments)
8. bass - (nontechnical name for any of numerous edible marine and freshwater spiny-finned fishes)

Distribution of senses

- Zipf distribution of senses
### WordNet relations

<table>
<thead>
<tr>
<th>Relation</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypernym</td>
<td>From concepts to superordinates</td>
<td>breakfast ←→ meat</td>
</tr>
<tr>
<td>Hypernym</td>
<td>From concepts to subtypes</td>
<td>meal ←→ lunch</td>
</tr>
<tr>
<td>Has-Member</td>
<td>From groups to their members</td>
<td>faculty ←→ professor</td>
</tr>
<tr>
<td>Has-Part</td>
<td>From members to their groups</td>
<td>copilot ←→ crew</td>
</tr>
<tr>
<td>Part-Of</td>
<td>From wholes to parts</td>
<td>table ←→ leg</td>
</tr>
<tr>
<td>Antonym</td>
<td>Opposites</td>
<td>course ←→ meal</td>
</tr>
<tr>
<td>Antonym</td>
<td>Opposites</td>
<td>leader ←→ follower</td>
</tr>
</tbody>
</table>

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### Adjectives/adverbs

<table>
<thead>
<tr>
<th>Relation</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antonym</td>
<td>Opposite</td>
<td>heavy ⇐⇒ light</td>
</tr>
<tr>
<td>Adverb</td>
<td>Opposite</td>
<td>quickly ⇐⇒ slowly</td>
</tr>
</tbody>
</table>

### Word sense disambiguation

- Given a fixed set of senses is associated with a lexical item, determine which of them applies to a particular instance of the lexical item
- Two fundamental approaches
  - WSD occurs during semantic analysis as a side-effect of the elimination of ill-formed semantic representations
  - Stand-alone approach
    » WSD is performed independent of, and prior to, compositional semantic analysis
    » Makes minimal assumptions about what information will be available from other NLP processes
    » Applicable in large-scale practical applications

### Machine learning approaches

- Inductive machine learning methods
  - Supervised
  - Bootstrapping
  - Unsupervised
- Emphasis is on acquiring the knowledge needed for the task from data, rather than from human analysts.
**Inductive ML framework**

- **Examples of task**: (features + class)
- **description of context**: correct word sense
- **ML Algorithm**: classifier (program)
- **Novel example**: (features) → **Classifier** (program) → class

**Feature vector input**

- **target**: the word to be disambiguated
- **context**: portion of the surrounding text
  - Tagged with part-of-speech information
  - Select a “window” size
  - Stemming or morphological processing
  - Possibly some partial parsing
- **Convert the context into a set of features**
  - Attribute-value pairs
    - Numeric or nominal values

**Collocational features**

- Encode information about the lexical inhabitants of *specific* positions located to the left or right of the target word.
  - E.g. the word, its root form, its part-of-speech
  - An electric guitar and *bass* player stand off to one side, not really part of the scene, just as a sort of nod to gringo expectations perhaps.
  - [guitar, NN1, and, CJC, player, NN1, stand, VVB]

**Co-occurrence features**

- Encodes information about neighboring words, ignoring exact positions.
  - **Features**: the words themselves (or their roots)
  - **Values**: number of times the word occurs in a region surrounding the target word
  - Select a small number of frequently used content words for use as features
    - 12 most frequent content words from a collection of *bass* sentences drawn from the WSJ: fishing, big, sound, player, fly, rod, pound, double, runs, playing, guitar, band
    - Co-occurrence vector (window of size 10) for the previous example: [0,0,0,1,0,0,0,0,0,1,0]