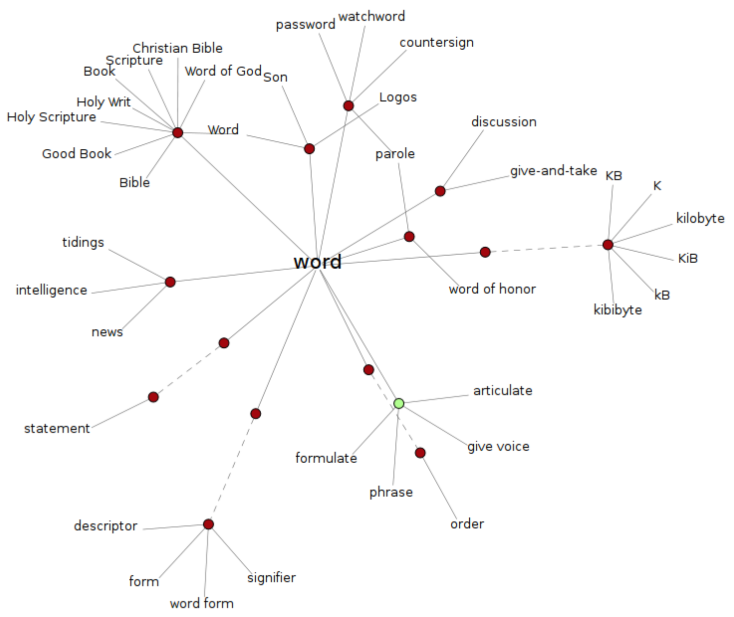
Lexical Semantics

COMP90042 Lecture 9

THE UNIVERSITY OF MELBOURNE



Sentiment analysis revisited

- Bag of words, kNN classifier. Training data:
  - “This is a good movie.” → ☺
  - “This is a great movie.” → ☺
  - “This is a terrible film.” → ☹
- “This is a wonderful film.” → ?

Sentiment analysis revisited

- “This is a wonderful film.” → ☹

- Two problems:
  - The model does not know that “movie” and “film” are synonyms. Since “film” appears only in negative examples the model learns that it is a negative word.
  - “wonderful” is not in the vocabulary (OOV – Out-Of-Vocabulary).

- We need to add word **semantics** to the model.

Sentiment analysis revisited

- “This is a great movie.” → ☺
- “This is a wonderful film.” → ?
- Comparing words directly will not work. How to make sure we compare word **meanings** instead?
- Solution: add this information explicitly through a **lexical database.**

Word semantics

- Lexical semantics (this lecture)
  - How the meanings of words connect to one another.
  - Manually constructed resources: lexicons, thesauri, ontologies, etc.
- Distributional semantics (next)
  - How words relate to each other in the text.
  - Automatically created resources from corpora.

What do words mean?

- Referents in the physical or social world
  - But not usually useful in text analysis
- Their dictionary definition
  - But dictionary definitions are necessarily circular
  - Only useful if meaning is already understood
- Their relationships with other words
  - Also circular, but more practical

Words and senses

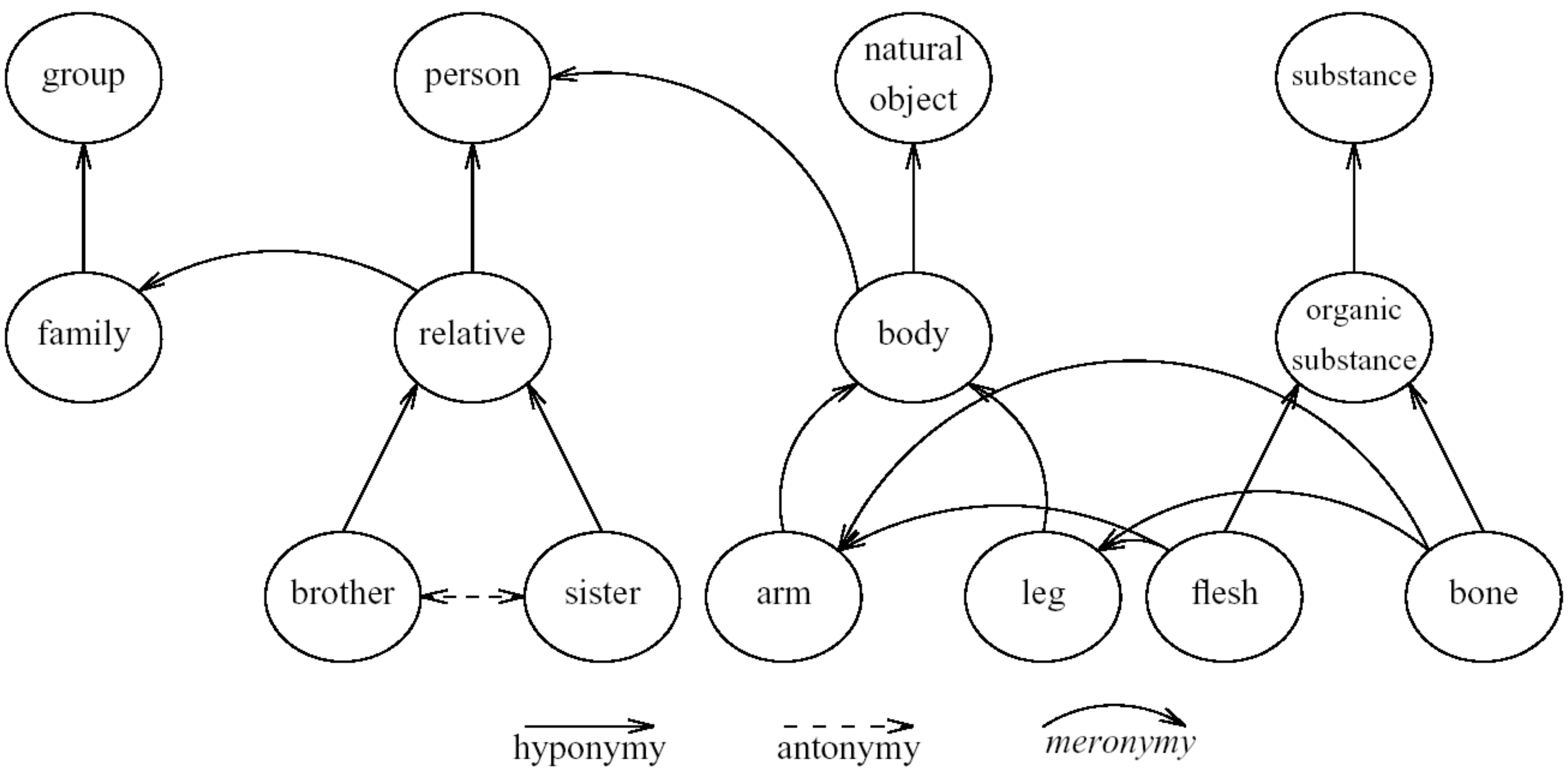
Bank (noun):

1. A financial institution; a building where a financial institution offers services; a repository; a container for holding money
2. Land sloping down to a body of water

- *Bank* has many senses (more than just these)
- 1 and 2 are ***homonyms***
  - Considered different lexical items by lexicographers
- 1 shows ***polysemy***
  - Related senses of the same lexical item

Basic Lexical Relations

- Synonyms (same) and antonyms (opposite/complementary)
- Hypernyms (generic), hyponyms (specific)
- Holoynms (whole) and meronyms (part)



WordNet

- A database of lexical relations
- English WordNet includes ~120,000 nouns, ~12,000 verbs, ~21,000 adjectives, ~4,000 adverbs
- WordNets available in most major languages (www.globalwordnet.org, https://babelnet.org/)
- English version freely available (accessible via NLTK)

Synsets

- The nodes of WordNet are not words, but meanings
- There are represented by sets of synonyms, or *synsets*

>>> nltk.corpus.wordnet.synsets(‘bank’)

[Synset('bank.n.01'), Synset('depository_financial_institution.n.01'), Synset('bank.n.03'), Synset('bank.n.04'), Synset('bank.n.05'), Synset('bank.n.06'), Synset('bank.n.07'), Synset('savings_bank.n.02'), Synset('bank.n.09'), Synset('bank.n.10'), Synset('bank.v.01'), Synset('bank.v.02'), Synset('bank.v.03'), Synset('bank.v.04'), Synset('bank.v.05'), Synset('deposit.v.02'), Synset('bank.v.07'), Synset('trust.v.01')]

>>> nltk.corpus.wordnet.synsets(‘bank’)[0].definition()

u'sloping land (especially the slope beside a body of water)‘

>>> nltk.corpus.wordnet.synsets(‘bank’)[1].lemma_names()

[u'depository_financial_institution', u'bank', u'banking_concern', u'banking_company']

Lexical Relations in wordnet

- Connections between nodes are lexical relations
- Including all the major ones mentioned earlier

```
>>> print nltk.corpus.wordnet.lemmas('sister')[0].antonyms()
```

[Lemma('brother.n.01.brother')]

```
>>> nltk.corpus.wordnet.synsets('relative')[0].hypernyms()
```

[Synset('person.n.01')]

```
>>> nltk.corpus.wordnet.synsets('body')[0].part_meronyms()
```

[Synset('arm.n.01'), Synset('articulatory_system.n.01'), Synset('body_substance.n.01'), Synset('cavity.n.04'), Synset('circulatory_system.n.01'), Synset('crotch.n.02'), Synset('digestive_system.n.01'), Synset('endocrine_system.n.01'), Synset('head.n.01'), Synset('leg.n.01'), Synset('lymphatic_system.n.01'), Synset('musculoskeletal_system.n.01'), Synset('neck.n.01'), Synset('nervous_system.n.01'), Synset('pressure_point.n.01'), Synset('respiratory_system.n.01'), Synset('sensory_system.n.02'), Synset('torso.n.01'), Synset('vascular_system.n.01')]

Word similarity with paths

- Want to go beyond specific lexical relations
  - E.g. *money* and *nickel* are related, despite no direct lexical relationship

- Given WordNet, find similarity based on path length in hypernym/hyponym tree

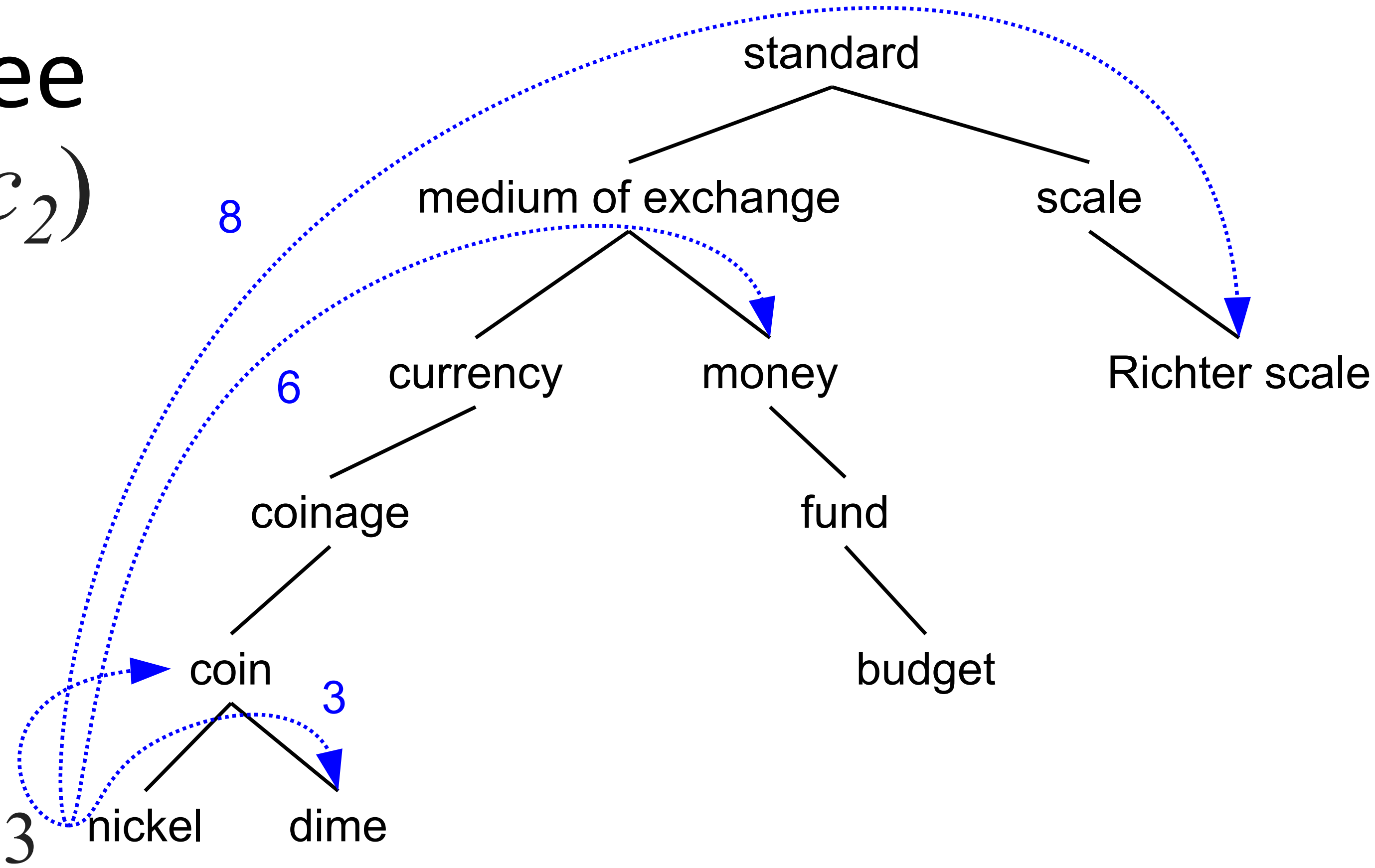
$$\text{simpath}(c_1,c_2) = 1/\text{pathlen}(c_1,c_2)$$

simpath(*nickel,coin*) = $1/2 = .5$

simpath(*nickel,currency*) = $1/4 = .25$

simpath(*nickel,money*) = $1/6 = .17$

simpath(*nickel,Richter scale*) = $1/8 = .13$



Beyond path length

- Problem: edges vary widely in actual semantic distance
  - Much bigger jumps near top of hierarchy
- Solution 1: include depth information (Wu & Palmer)
  - Use path to find lowest common subsumer (LCS)
  - Compare using depths

$$\text{simwup}(c_1, c_2) = \frac{2 * \text{depth}(\text{LCS}(c_1, c_2))}{\text{depth}(c_1) + \text{depth}(c_2)}$$

simwup(*nickel*,*money*) = 2*2/(3+ 6) = .44

simwup(*nickel*,*Richter scale*) = 2*1/(3 + 6) = .22

Information content

- But count of edges is still poor semantic distance metric
- Solution 2: include statistics from corpus (Resnik; Lin)
  - P(c): prob. that word in corpus is instance of concept *c*

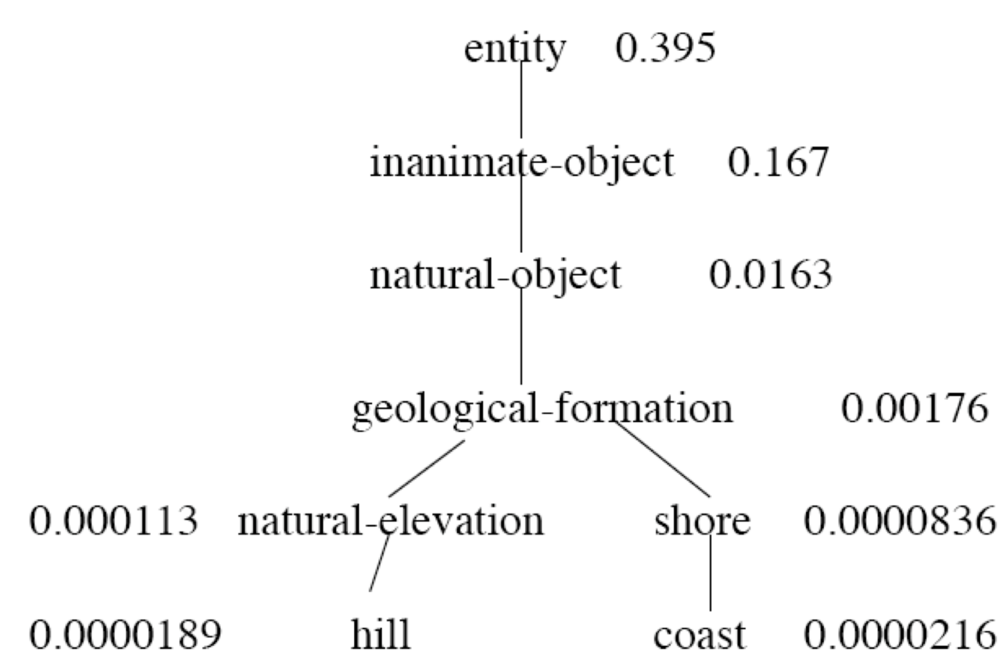
$$P(c) = \frac{\sum_{w \in words(c)} count(w)}{N}$$

  - information content (IC)

$$IC(c) = -\log P(c)$$

  - Lin distance

$$\text{simlin}(c_1, c_2) = \frac{2 * \text{IC}(\text{LCS}(c_1, c_2))}{\text{IC}(c_1) + \text{IC}(c_2)}$$



Sentiment analysis revisited

- “This is a great movie.” → ☺
- “This is a wonderful film.” → ?
- Comparing words using WordNet paths work well if our classifier is based on word similarities (such as kNN)
- But what if we want sense as a general feature representation, so we can employ other classifiers?
- Solution: map words in text to senses in WordNet explicitly.

Word sense disambiguation

- Hacky (but popular) “solutions”:
  - Assume the most popular sense
  - For word similarity, take minimum across senses
- A better solution: Word Sense Disambiguation
- Good WSD potentially useful for many tasks in NLP
  - In practice, often ignored because good WSD too hard
  - Active research area

Supervised WSD

- Apply standard machine classifiers
- Feature vectors typically words and syntax around target
  - But context is ambiguous too!
  - How big should context window be? (typically very small)
- Requires sense-tagged corpora
  - E.g. SENSEVAL, SEMCOR (available in NLTK)
  - Very time consuming to create!

Less supervised approaches

- Lesk: Choose sense whose dictionary gloss from WordNet most overlaps with the context
- Yarowsky: Bootstrap method
  - Create a small seed training set
    - *plant* (factory vs. vegetation): *manufacturing plant*, *plant life*
  - Iteratively expand training set with untagged examples
    - Train a statistical classifier on current training set
    - Add confidently predicted examples to training set
  - Uses *one sense per collocation, one sense per document*
- Graph methods in WordNet

Other databases - Framenet

- A lexical data base of *frames*, typically prototypical situations
  - E.g. “apply_heat” frame
- Includes lists of *lexical units* that evoke the frame
  - E.g. *cook*, *fry*, *bake*, *boil*, etc.
- Lists of *semantic roles* or *frame elements*
  - *E.g.* “the cook”, “the food”, “the container”, “the instrument”
- Semantic relationships among frames
  - “apply_heat” is Causitive of “absorb_heat”, is Used by “cooking_creation”

Moving on to the corpus

- Manually-tagged lexical resources an important starting point for text analysis
- But much modern work attempts to derive semantic information directly from corpora, without human intervention
- Let’s add some distributional information

Reading

- JM3 C.1-C.3