Lexical Semantics

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Roadmap

- Lexical semantics
  - Motivation & definitions

  - Word senses

  - Tasks:
    - Word sense disambiguation
    - Word sense similarity

  - Distributional similarity

What is a plant?

There are more kinds of **plants** and animals in the rainforests than anywhere else on Earth. Over half of the millions of known species of **plants** and animals live in the rainforest. Many are found nowhere else. There are even **plant**s and animals in the rainforest that we have not yet discovered.

The Paulus company was founded in 1938. Since those days the product range has been the subject of constant expansions and is brought up continuously to correspond with the state of the art. We're engineering, manufacturing, and commissioning world-wide ready-to-run **plants** packed with our comprehensive know-how.

Lexical Semantics

- So far, word meanings discrete
  - Constants, predicates, functions

- Focus on word meanings:
  - Relations of meaning among words
    - Similarities & differences of meaning in sim context
  - Internal meaning structure of words
    - Basic internal units combine for meaning

Terminology

- **Lexeme**:
  - Form: Orthographic/phonological + meaning
  - Represented by lemma
    - **Lemma**: citation form; infinitive in inflection
      - Sing: sing, sings, sang, sung,...

- **Lexicon**: finite list of lexemes

Sources of Confusion

- Homonymy:
  - Words have same form but different meanings
    - Generally same POS, but unrelated meaning
    - E.g. bank (side of river) vs bank (financial institution)
      - bank[1] vs bank[2]
    - Homophones: same phonology, diff't orthographic form
      - E.g. two, to, too
    - Homographs: Same orthography, diff't phonology

- Why do we care?
  - Problem for applications: TTS, ASR transcription, IR

Sources of Confusion II

- Polysemy
  - Multiple RELATED senses
    - E.g. bank: money, organ, blood,…

  - Big issue in lexicography
    - # of senses, relations among senses, differentiation
    - E.g. serve breakfast, serve Philadelphia, serve time

Relations between Senses

- Synonymy:
  - (near) identical meaning
  - Substitutability
    - Maintains propositional meaning

  - Issues:
    - Polysemy – same as some sense
    - Shades of meaning – other associations:
      - Price/fare; big/large; water H_2O
    - Collocational constraints: e.g. babbling brook
    - Register:
      - social factors: e.g. politeness, formality

Relations between Senses

- Antonyms:
  - Opposition
    - Typically ends of a scale
      - Fast/slow; big/little
    - Can be hard to distinguish automatically from syns

- Hyponomy:
  - Isa relations:
    - More General (hypernym) vs more specific (hyponym)
      - E.g. dog/golden retriever; fruit/mango;
  - Organize as ontology/taxonomy

Word Sense Disambiguation

– Application of lexical semantics

– Goal: Given a word *in context,* identify the appropriate sense
  – E.g. <u>plants</u> and animals in the rainforest

– Crucial for real syntactic & semantic analysis
  – Correct sense can determine
    – Available syntactic structure
    – Available thematic roles, correct meaning,..

Robust Disambiguation

- More to semantics than P-A structure
  - Select sense where predicates underconstrain

- Learning approaches
  - Supervised, Bootstrapped, Unsupervised

- Knowledge-based approaches
    - Dictionaries, Taxonomies

- Contexts for sense selection

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Biological Example

The Paulus company was founded in 1938. Since those days the product range has been the subject of constant expansions and is brought up continuously to correspond with the state of the art. We're engineering, manufacturing and commissioning world-wide ready-to-run **plants** packed with our comprehensive know-how. Our Product Range includes pneumatic conveying systems for carbon, carbide, sand, lime and many others. We use reagent injection in molten metal for the…

Industrial Example

Label the First Use of "Plant"

Disambiguation Features

- Key: What are the features?
  - Part of speech
    - Of word and neighbors
  - Morphologically simplified form
  - Words in neighborhood
    - Question: How big a neighborhood?
      - Is there a single optimal size? Why?
  - (Possibly shallow) Syntactic analysis
    - E.g. predicate-argument relations, modification, phrases
  - Collocation vs co-occurrence features
    - Collocation: words in specific relation: p-a, 1 word +/-
    - Co-occurrence: bag of words..

- Train classifiers to predict senses w/these features

WSD Evaluation

- Ideally, end-to-end evaluation with WSD component
  - Demonstrate real impact of technique in system
  - Difficult, expensive, still application specific

- Typically, intrinsic, sense-based
  - Accuracy, precision, recall
  - SENSEVAL/SEMEVAL: all words, lexical sample

- Baseline:
  - Most frequent sense

- Topline:
  - Human inter-rater agreement: 75-80% fine; 90% coarse

Word Similarity

- Synonymy:
  - True propositional substitutability is rare, slippery

- Word similarity (semantic distance):
  - Looser notion, more flexible
  - Appropriate to applications:
    - IR, summarization, MT, essay scoring
      - Don't need binary +/- synonym decision
      - Want terms/documents that have high similarity
        - Differ from relatedness

- Approaches:

  - Distributional
  - Thesaurus-based

Distributional Similarity

- Unsupervised approach:
  - Clustering, WSD, automatic thesaurus enrichment

- Insight:
  - "You shall know a word by the company it keeps!"
    - (Firth, 1957)
  - A bottle of *tezguino* is on the table.
  - Everybody likes *tezguino*.
  - *Tezguino* makes you drunk.
  - We make *tezguino* from corn.

- Tezguino: corn-based, alcoholic beverage

Distributional Similarity

- Represent 'company' of word such that similar words will have similar representations
  - 'Company' = context

- Word represented by context feature vector
  - Many alternatives for vector

- Initial representation:
  - 'Bag of words' binary feature vector
  - Feature vector length N, where N is size of vocabulary
    - $f_i = 1$ if $word_i$ within window of w, 0 o.w.

Binary Feature Vector

	arts	boil	data	function	large	sugar	summarized	water
apricot	0	I	0	0	1	1	0	1
pineapple	0	1	0	0	1	1	0	1
digjtal	0	0	1	1	1	0	1	0
i11forn1ation	0	0	1	1	1	0	1	0

Distributional Similarity Questions

- What is the right neighborhood?
    - What is the context?

- How should we weight the features?

- How can we compute similarity between vectors?