Lexical Semantics

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Overview

1. What did we learn last?

2. Lexical Semantics
   - Word Meaning
   - Encoding Meaning
   - Lexical Resources

3. What will we learn next?
What do we do in Computational Semantics

- Construction of a **Semantic Representation**
  - Logical Form
- **Semantic Resolution**: context knowledge for disambiguation and search reference objects
  - Lexical semantics, Syntax, Context
- **Semantic Inference**: what is relevant knowledge, world knowledge
  - Choice of Logical Form language, possibility of combining it with world knowledge, and tools for inference

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1 Ingrid Fischer, Sylvia Weber Russell: Semantic issues in NLP
Task of Lexical Semantics

- Capture word meaning
- Capture lexical generalizations
  - transitive vs. intransitive, animate subject vs. nonanimate
- Provide means for resolving lexical ambiguities
  - No no to unrelated lexical entries in the grammar
  - Yes yes to incorporating taxonomic knowledge into lexicon, i.e. adding structured and relational view to the collection of words
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What is Word’s Meaning?

- Dictionary Definition?
  - When we want to know what a word means we look it up in a dictionary
  - Authoritative, comprehensive → more accurate than any individual’s knowledge of the meaning of a word?
  - How to interpret the dictionary definition?
  - Look up its words? This is circular.
  - Cases of transparent circularity, e.g.:
    - Pride: the quality or state of being proud
    - Proud: feeling or showing pride
What is Word’s Meaning?

- Meaning = Referent?
  - Language is used to talk about the world
  - Words stand for objects, relations and events in the world
  - Consider the meaning of a word to be the entity it refers to
  - Meaning of a phrase to be an expression of first-order predicate calculus
  - Non-referential terms have meaning
    - the king of France
  - Abstract notions have meaning
    - beauty
  - Co-referring terms can have different meaning
    - morning star, evening star (both terms denote Venus)
What is Word’s Meaning?

- **Meaning = Mental Image?**
  - Concept: mental grouping of similar objects, events, people, e.g. chair:
  - Mental image contains common features for the items in that concept
    - chair: components: legs, seat, back; function: can be sat on
    - adjectives can augment or defeat default features: e.g. 3-legged chair, baby chair
  - People may have different mental images: e.g. lecture (students vs lecturer’s perspective)
  - Some words don’t have associated images: e.g. truth, incompatible
What is Word’s Meaning?

- **Meaning = Situated in Context?**
  - meaning is set of contexts where it is appropriate to use an expression
  - meaning is what the user meant
  - Same propositional content can have different meaning
    - e.g. *Simpsons are on, Are Simpsons on?*
  - Speaker knows something and wants to increase hearer’s knowledge
  - Speaker is ignorant and wants to be informed
  - linguistic form of the utterance communicates speaker’s goal
So, what is Word’s Meaning?

- Meaning is not simply:
  - Dictionary definition
  - Mental image
  - Context construct

- So what is it?
- How far can we get?
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Selectional Restrictions

- Predicates impose constraints on their arguments
  - *read* (human subject, textual object)
  - *switch* (human subject, technical object)

- Use the predicate to disambiguate its arguments

- Example "dish":
  - plate for eating off
  - course of a meal
  - communications device
Selectional Restrictions

- Sometimes, the noun selects the appropriate sense of the verb:
  - which airlines serve Denver?
  - which airlines serve breakfast?
  - (placenames which are also food names?)
- Bidirectional restrictions:
  - I’m looking for a place that serves vegetarian dishes.
  - serve (2) * dish (3) = 6 combinations
  - only one of these does not violate the selectional restrictions
Selectional Restrictions

- Phrase structure grammars can implement selectional restrictions
  - create an ontology (e.g. human, animate, ...)
  - constrain the phrase structure rules
    - e.g. $VP \rightarrow V_{kill} NP_{animate}$
      - constrain the semantic interpretation
    - e.g. eat([being], [food])
- However, this creates brittle grammars
  - insufficient information
  - novel uses
What did we learn last?
Lexical Semantics
What will we learn next?

Meaning in Language Technology

- Domain-specific
  - Domain: Financial institutions, word = bank
  - Domain: Restaurant: word = dish
- Application-specific
  - Summarisation, term extraction: salient words, words appearing in a definition context (By the term X we mean...)
  - Language modelling: in just those contexts where it matters to the application we have training data which our model uses to disambiguate
- AI perspective:
  - Weak: just performing a useful task, understanding isn’t required
  - Strong: need a complete account of meaning, e.g. For unrestricted domain machine translation (so-called AI-complete problems)
Meaning in Language Technology

• Approach: model the relationships between words

1 Know when two different words have related meanings: **Synonyms** – are words with identical or similar meanings.
   - Network of related words (paradigmatic perspective)
   - Semantically (Wordnet)

2 Know when one word has different meanings: **Polysemy** – the capacity for a sign (e.g., a word, phrase, etc.) to have multiple meanings. **Homophony** – a word that is pronounced the same as another word but differs in meaning.
   - Significant aspects of context (syntagmatic perspective)
   - Collocation analysis

3 Word-sense disambiguation
Lexical Relationships

- Hyponym/Hypernym = generic/specific
  - e.g. *fork* is a kind of cutlery — fork is a hyponym of *cutlery*
  - *cutlery* is a hypernym of *fork*
- Induces forest structure on a set of words
- Also gives a measure of semantic relation
Lexical Relationships

• Holonym/Meronym (whole/part): 3 subtypes:
  1 Part: bone is part of arm
  2 Member: arm is member of body
  3 Substance: bone is substance of horn

• Synonym/Antonym:
  – same vs complementary referential meanings

• Hypernym/Troponym:
  – walk is a hypernym of stroll
    ★ To walk is one way to stroll
  – stroll is a troponym of walk
    ★ To stroll is a particular way to walk
Lexical Relationships

- Entails:
  - Walking entails stepping
  - Snoring entails sleeping

- Many more lexical relationships exist...

Note that for entailment common sense reasoning and background knowledge is of a major importance.

Suppliers of semantic information useful for common sense reasoning and background knowledge are valency, case frame databases FrameNet, Sumo.

(Verb) valency refers to the number of arguments controlled by a verbal predicate.
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Resources, Tools for Exploring Lexical Semantics

- **Tesaurus:**
  - Synonyms and Antonyms
- **Wordnet:**
  - [http://wordnet.princeton.edu/](http://wordnet.princeton.edu/)
  - Synonyms and Antonyms
  - Hypernyms and Hyponyms, Hypernyms and Troponyms
  - Meronyms and Holonyms
  - Entails
- **FrameNet:**
  - [http://framenet.icsi.berkeley.edu/](http://framenet.icsi.berkeley.edu/)
  - Word’s syntactic semantic valences via frame semantics
- **PropBank, NomBank, VerbNet, ...**
WordNet

- English wordnet
  - Four categories: noun, verb, adjective, adverb
  - Nouns: 120,000; Verbs: 22,000; Adjectives: 30,000; Adverbs: 6,000
- Wordnet in other languages [www.globalwordnet.org]
  - Wordnets exist for: Basque, Spanish, Czech, Dutch, Estonian, French, German, Italian, Portuguese, Spanish, Swedish
• Words are ambiguous
  – e.g. fork in earlier slide
  – the different senses participate in different lexical relations
• Nodes in Wordnet represent *synonym sets*, or synsets.
  – e.g. chump, fish, fool, gull, mark, patsy, fall guy, sucker, schlemiel, shlemiel, soft touch, mug
• Applications:
  – Overcome limitations in other data (e.g. PP attachment)
  – Implement selectional restrictions (use WordNet categories on grammar productions)
FrameNet

- **Semantic frame** a conceptual structure that describes a particular type of situation, object, or event and the participants and propositions involved in it.

- **Lexical unit** is a pairing of a word with a meaning, where each sense of a polysemous word belongs to a different semantic frame.

  - [Matilde$_{Cook}$] **fried** [the catfish$_{Food}$] [in a heavy iron skillet$_{HeatingInstrument}$]
FrameNet

- English FrameNet
  - valency, semantic frame lexical database
  - 8,900 lexical units
  - 6,100 of which are fully annotated, in more than 625 semantic frames
- Application: Text Annotation using FrameNet for text understanding
What did we learn today?

- What is word’s meaning
- Ways of encoding the meaning
- Meaning in language technology
- Lexical Resources: WordNet, FrameNet...
- Applications
What will we learn during the rest of semester?

- First Order Logic (FOL) as a Logical Form (LF) Language
- Discourse Representation Theory (DRT) as a Logical Form Language
- Constructing DRT structures (DRS) from utterances
- Use of Inference Engines
- Modeling Domain + NLP + Inference Engines