

Foundations of Language Science and Technology: Semantics

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• How can we represent word meaning?

Lexical Semantics

 How is sentence meanings represented, and how do we get from word meaning to the meaning of a complex utterance?

Sentence Semantics, Semantic Construction

 How does the meaning of utterances interact with context?

Text/ Dialogue/Discourse Semantics



Lexical Semantics

What is in the meaning of a word?



What is in the meaning of a word?







- Oxford English Dictionary
- > Webster's

➤ Wahrig /Duden

- A thesaurus is a hierarchically structured lexicon of a language:
 - Roget's Thesaurus (English, since 1805)
 - Dornseiff's "Deutscher Wortschatz nach Sachgruppen" (German, 1910)

WordNet



- WordNet is a big hierachical lexical resoure providing meaning information in terms of relations between concepts in a systematic way.
- A problem: There is no 1:1 relation between words and concepts:
 - The same word can express different concepts (ambiguity)
 - The same concept can be expressed by different words (synonymy)
- The WordNet solution: concepts are represented by "synsets": Sets of synonymous words. "synsets" form the basic units of WordNet
- Synsets are connected by different kinds of semantic FLST: Semantics V(\$200,200, Walfred Pinkal UdS Computerlinguistik



An example: case

- > {case, carton}
- > {case, bag, suitcase}
- > {case, pillowcase, slip}
- > {case, cabinet, console}
- {case, casing (the enclosing frame around a door or window opening)
 }
- > {case (a small portable metal container)}

Semantic Relations in WordNet

- Synonymy
 - ➤ case bag
- Hyponymy/Hypernymy (ISA relation)
 - dolphin mammal
- Meronymy/Holonymy
 - Part Whole : branch tree
 - ➢ Member Group: tree forest
 - ➤ Matter Object: wood tree
- Contrast:
 - Complementarity: boy girl
 - Antonymy: long short



An example



Figure 2. Network representation of three semantic relations among an illustrative variety of lexical concepts



WordNet



English WordNet: about 150.000 lexical items
 Web Interface: <u>http://wordnet.princeton.edu/cgi-bin/webwn2</u>

General Info: <u>http://wordnet.princeton.edu/</u>

- "GermaNet": a German WordNet version with about 90.000 lexical items
- Versions of WordNet for available for about 30 languages
- WordNet consists of different, basically unrelated databases for common nouns, verbs, adjectives (and adverbs)
- The respective hierarchies have a number of "unique beginners" each.





Table 1 List of 25 unique beginners for WordNet nouns

{act, action, activity}
{animal, fauna}
{artifact}
{attribute, property}
{body, corpus}
{cognition, knowledge}
{communication}
{event, happening}
{feeling, emotion}
{food}
{group, collection}
{location, place}
{motive}

{natural object}
{natural phenomenon}
{person, human being}
{plant, flora}
{possession}
{process}
{quantity, amount}
{relation}
{shape}
{state, condition}
{substance}
{time}



- WordNet is big and has very large coverage (concerning both words and word senses)
- WordNet allows, among other things
 > query expansion for Information Retrieval
 > basic inferences via semantic relations
- The mapping from NL expressions to WordNet concepts (in a given language) is trivial (modulo ambiguity), compared Upper Ontologies, which are meant to be language-neutral (but are they?)









Lexical Semantics: The Layer of Predicate-Argument Relations



- (Quasi-)Equivalent sentences with different realization of "the same" semantic argument positions:
 - > Mary likes John
 - John pleases Mary
 - Mary gave Peter the book
 Peter received the book from Mary



- Verbs with varying number of explicit argument positions, and varying realization of "the same argument".
 - > The window broke
 - > A rock broke the window
 - John broke the window with a rock
 - The plane flew to Frankfurt
 John flew the plane to Frankfurt
 John flew Bill with the plane to Frankfurt



• Thematic roles describe the conceptual participants in a situation in a generic way, independent from their grammatical realization.





John gave Mary the book

Mary received the book from John



[John]_{Subj} gave [Mary]_{DObj} [the book]_{AObj}

[Mary]_{Subj} received [the book]_{DObj} [from John]_{PObj}





John gave Mary the book

Mary received the book from John



give:	Subj	\leftrightarrow	Agent
	AObj	\leftrightarrow	Theme
	DObj	\leftrightarrow	Recipient

receive:Subj \leftrightarrow RecipientAObj \leftrightarrow ThemePObj_from \leftrightarrow Agent



[John]_{Subj} gave [Mary]_{DObj} [the book]_{AObj}

[Mary]_{Subj} received [the book]_{DObj} [from John]_{PObj}



[John]_{ag} gave [Mary]_{rec} [the book]_{pat}

[Mary]_{rec} received [the book]_{pat} from [John]_{ag}



 give(ag: John, pat: the book , rec: Mary)
 receive(ag: John, pat: the book , rec: Mary)

TRANSACTION(ag: John, pat: the book , rec: Mary)

A More Complex Example



- Airbus sells five A380 planes to China Southern for 220 million Euro
- China Southern buys five A380 planes from Airbus for 220 million Euro
- Airbus arranged with China Southern for the sale of five A380 planes at a price of 220 million Euro
- Five A380 planes will go for 220 million Euro to China Southern



- A lexicon with thematic role information for verbs and other relational expressions, organised in frames (like "Commercial Transaction", "Self Motion"), containing
 - Role Information
 - Grammatical realisation patterns (Role Linking)
 - Annotations of example sentences (from BNC) for all use variants of words
- Current release: 700 frames, about 8000 lexical units (mostly verbs)
- Planned: A total of 15000 verb descriptions
- <u>http://framenet.icsi.berkeley.edu/</u>
- SALSA: The Saarbrücken Lexical Semantics Annotation and Analysis Project – A corpus-based, large, application-oriented lexicalsemantic resource based on FrameNet



Sentence Semantics Semantic Construction



Dolphins are mammals, not fish. $\forall d (dolphin(d) \rightarrow mammal(d) \land \neg fish(d))$

Dolphins live in pods. $\forall d (dolphin(d) \rightarrow \exists x (pod(p) \land live-in (d,p))$

Dolphins give birth to one baby at a time. $\forall d (dolphin(d) \rightarrow \forall x \forall y \forall t (give-birth-to (d,x,t) \land give-birth-to (d,y,t)$ $\rightarrow x=y)$



Logic as a framework for NL semantics



- (First-order) Logic supports precise, consistent and controlled meaning representation via truth-conditional interpretation.
- (First-order) Logic provides deduction systems to model inference processes, controlled through a formal entailment concept.

Textbook: L.T.F. Gamut, Logic, Language, and Meaning. Volume1:Introduction to Logic. University of Chicago Press 1991

Logic as a framework for NL semantics

 But: How do we get from word meaning to sentence meaning? How can the semantic composition process be modelled?





















A Solution: Type Theory





Logic as a framework for NL semantics



 How do we get from word meaning to sentence meaning? How can the semantic composition process be modelled?

Textbook: L.T.F. Gamut, Logic, Language, and Meaning. Volume2: Intensional Logic and Logical Grammar. University of Chicago Press 1991





Discourse Semantics





- Definite noun phrases
 - Some students do not own the Gamut textbook. They are reading the book in the library



• Definite noun phrases

Some students do not own the Gamut textbook. They are reading the book in the library

• Definite noun phrases: Bridging

I would like to read the logic introduction recommended for the semantics course. But I do not remember the title.



Every student is familiar with the basic properties of FOL.

- John always is late.
- Its hot and sunny everywhere.
- Dolphin from different pods interact from time to time. Bill owns an expensive car.



They (usually) start at 9.

- Semantic potential (by semantic construction)
- Context-specific meaning (by resolution)
- Intended utterance information (by inference)