Semantic Theory: Lexical Semantics II

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Structure of this course

- Basic Semantic Relations
- WordNet
- Predicate-Argument Structure
- PropBank and FrameNet
- Event Semantics

Basic Semantic Relations

- Synonymy:
  - Identity of meaning (context-specific, for a given sense)
- Hyponymy (inverse relation: Hypernymy):
  - the sub-/superconcept relation:
  - *car - truck, dog - animal, kill - murder*
- Meronymy (inverse relation: Holonymy):
  - General part-of relation, with three (well-motivated) sub-relations:
  - Physical Part – Whole relation: *branch – tree*
  - Member – Group relation: *tree – forest*
  - Matter – Object relation: *wood – tree*

Relations expressing contrast

- Antonymy or Contrast:
  - *good – bad, expensive – cheap, tall – short*
- Complementarity:
  - *man – woman, married – single, alive – dead*
- Converseness/ inverse relation:
  - *buy – sell, parent – child, taller than – shorter than*

WordNet

- WordNet represents a layer of the semantic lexicon of English as a network of semantic relations, with the hyponymy relation as its backbone.
- The nodes of the semantic network are „synsets“: Sets of synonymous words, which represent concepts/ word senses.
- Synsets directly provide synonymy information, and information about the word-concept mapping: A (orthographic) word has all those senses/ synsets as readings, of which it is a member.
- In cases where no or too few synonyms are available for sense distinction, WordNet glosses and examples help to disambiguate.

Senses of *car*

- S: (n) **car**, auto, automobile, machine, motorcar
- S: (n) **car**, railcar, railway car, railroad car
- S: (n) **car**, gondola
- S: (n) **car**, elevator car
- S: (n) cable car, **car**

Synsets + glosses + examples

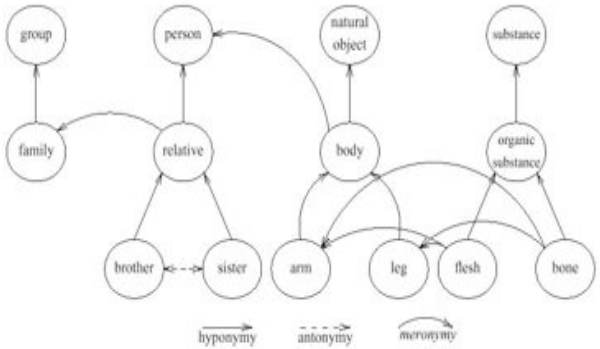
- **car**
  - { car, auto, automobile, machine, motorcar }
  - a motor vehicle with four wheels; usually propelled by an internal combustion engine
  - *"he needs a car to get to work"*

Hyponyms of *motor vehicle*

- S: (n) **motor vehicle**, automotive vehicle (a self-propelled wheeled vehicle that does not run on rails)
- ***direct hyponym*** / *full hyponym*
  - S: (n) amphibian, amphibious vehicle (a flat-bottomed motor vehicle that can travel on land or water)
  - S: (n) bloodmobile (a motor vehicle equipped to collect blood donations)
  - S: (n) car, auto, automobile, machine, motorcar (a motor vehicle with four wheels; usually propelled by an internal combustion engine) *"he needs a car to get to work"*
  - S: (n) doodlebug (a small motor vehicle)
  - S: (n) four-wheel drive, 4WD (a motor vehicle with a four-wheel drive transmission system)
  - S: (n) go-kart (a small low motor vehicle with four wheels and an open framework; used for racing)
  - S: (n) golfcart, golf cart (a small motor vehicle in which golfers can ride between shots)
  - S: (n) hearse (a vehicle for carrying a coffin to a church or a cemetery; formerly drawn by horses but now usually a motor vehicle)
  - S: (n) motorcycle, bike (a motor vehicle with two wheels and a strong frame)
  - S: (n) snowplow, snowplough (a vehicle used to push snow from roads)
  - S: (n) truck, motortruck (an automotive vehicle suitable for hauling)

A small fragment of the WN graph

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



WordNet

- English WordNet is by far the largest lexical-semantic resource:
  - 150.000 lexical items
  - 120.000 synsets
  - 200.000 word-sense pairs
- WordNet is extensively used in many Language technology applications.
- Versions of WordNet currently available for about 45 languages (with large differences in coverage, design, and availability)
- "GermaNet": a German WordNet version with about 100.000 lexical items.

Basic Uses of WordNet Information in Language technology

- Query expansion with WordNet synonyms/hyponyms
- Measuring semantic distance by (normalised) path length
- WordNet as an ontology, a database of axioms feeding logical inference

  $\forall x(family(x) \rightarrow group(x))$

  $\forall x(person(x) \rightarrow \exists y(substance\_m(y,x) \wedge body(y))$

  $\forall x(body(x) \rightarrow \exists y(part\_m(y,x) \wedge leg(y))$

  $\forall x(body(x) \rightarrow \exists y(part\_m(y,x) \wedge arm(y))$

  (Next week: Description Logic)

Limitations of WordNet

- Much of WordNet information is only informally represented (in glosses and examples).
- WordNet consists of different unrelated data-bases for common nouns, verbs, adjectives (and adverbs). - No information about cross-categorial sense distinctions.
- Wide variation of granularity in different parts of WordNet.
- In general, WordNet tends to be too fine-granular (branching factor and depth of hierarchy).
- WordNet focusses on paratactic semantic relations. No information how to build predicate-argument structure.
- No information about selectional constraints/ preferences.
- WordNet (of course) does not solve the (notoriously hard) problem of word-sense disambiguation.

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Extended WordNet

- The key idea: exploit the rich information contained in the definitional glosses.
- Intent is to automatically (1) syntactically parse the glosses, (2) transform glosses into logical forms and (3) semantically tag the nouns, verbs, adjectives and adverbs of the glosses.
- Example:
  - Excellent
  - Gloss: „of highest quality“
  - Logical form: excellent(x1) → of(x1,x2)& highest(x2)& quality(x2)
- http://xwn.hlt.utdallas.edu/

Inverse Relations

- The inverse relation (covered by WordNet‘s heterogeneous „antonymy“ relation) implicitly states a regularity about of the respective concepts involved to their arguments:

taller_than(x,y) ↔ shorter_than(y,x)
parent_of(x,y) ↔ child_of(y,x)
like(x,y) ↔ please(y,x)

More complex inversion-like correspondences

Mary gave Peter the book
Peter received the book from Mary

John sold the car to Bill for 3,000€
Bill bought the car from John for 3,000€

Verb alternations

John sells the book.
The book sells for 19.95€.

Mary reads the book
The book reads easy.

Verb alternations

The window broke
A rock broke the window
John broke the window with a rock

$break_3(x,y,z) \models break_2(z,y) \models break_1(y)$

The plane flew to Frankfurt
John flew the plane to Frankfurt
John flew Bill with the plane to Frankfurt

$fly_3(x,y,z) \models fly_2(z,y) \models fly_1(y)$

Predicate-argument structure correspondences

- Verbs with varying number of explicit argument positions, and varying realization of "the same argument".
- (Quasi-)Equivalent sentences with different realization of "the same" semantic argument positions.

Thematic Roles (Fillmore 1968)

- Thematic roles describe the conceptual participants in a situation in a generic way, independent from their grammatical realization.
- Thematic roles form a small, closed, and universally applicable inventory conceptual argument types.
- A typical role inventory might consit of the roles: Agent, Theme (Patient, Object),Recipient, Instrument, Source, Goal, Beneficiary, Experiencer

Role Annotation Examples

– *[The window]$_{pat}$ broke*
– *[A rock]$_{inst}$ broke [the window]$_{pat}$*
– *[John]$_{ag}$ broke [the window]$_{pat}$ [with a rock]$_{inst}$*

– *[Peter]$_{ag}$ gave [Mary]$_{rec}$ [the book]$_{pat}$*
– *[Mary]$_{rec}$ received [the book]$_{pat}$ [from Peter]$_{ag}$*

Role-linking Information

- Linking information, provided in the lexicon, maps syntactic functions to semantic roles
- An example:

give:	SB →	Agent
	OA →	Theme
	OD →	Recipient
receive:	SB →	Recipient
	OA →	Theme
	OP-from →	Agent

- Some linguistic theories try to model role linking by general principles (linking theory). No precise and complete linking theory is available.

Thematic Roles

- Allow to represent the semantic correspondence between (uses of) relational concepts in a systematic way – thereby supporting basic lexical-semantic inference.
- Support a systematic representation of the mapping between syntactic complements and semantic argument positions (role-linking).
- Support the systematic description of selectional preferences and constraints (e.g.: Agent is animate, Source and Goal are locations)
- Support the encoding and application of additional inference rules.

The Role Dilemma

- A closed inventory of 8 or 12 or even 20 roles is not sufficient to describe the wealth of predicate-argument relations.

  Options:
- Use role names in a more or less arbitrary way, or:
- Assume a much greater role inventory, e.g.: Use different roles for every verb (modulo Alternation)

PropBank

- PropBank: Annotation of Penn TreeBank with predicate-argument structure. Verbs come with individual roles.
- Generalisation over alternation patterns of single verbs (the *break* case).
- No generalisation across lexeme boundaries (the *give/receive* case).
- Efficient annotation process, high inter-annotator agreement

PropBank Example: *expect*

Roles:

Arg0: expecter
Arg1: thing expected

Example: Transitive, active:

Portfolio managers **expect** *further declines in interest rates.*

Arg0:	*Portfolio managers*
REL:	*expect*
Arg1:	*further declines in interest rates*

PropBank example: *give*

Roles:

Arg0: giver
Arg1: thing given
Arg2: entity given to

Example: double object

The executives **gave** *the chefs a standing ovation.*

Arg0:	*The executives*
REL:	*gave*
Arg2:	*the chefs*
Arg1:	*a standing ovation*

PropBank: Limitations

- Role assignment is to some part motivated by syntactic structure.
- No cross-lexical generalisations
- No cross-lingual generalisation
- This is illustrated by the following “Trends in argment numbering“, taken from annotators guidelines
  - Arg0 = agent
  - Arg1 = direct object / theme / patient
  - Arg2 = indirect object / benefactive / instrument / attribute / end state
  - Arg3 = start point / benefactive / instrument / attribute
  - Arg4 = end point

(3 Slides taken over from Baker/Hajic/Palmer/Pinkal, ACL 2004)

Cross-Lexical Regularities

- 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

Frame Semantics (Fillmore 1976 and later)

- Structured schemata representing complex prototypical situations, events, and actions are the basic inventory for the conceptual modelling of the world. These are called frames.
  - Examples: Commercial transaction, Self motion, Communication-request
- Frames are „evoked“ by NL expressions,typically content words (also called frame-evoking elements (FEEs) or target words).
  - FEEs for commercial transaction: *buy, sell, pay, spend, cost, charge, price, change, debt, credit, merchant, broker, shop, tip, fee, honorarium, tuition*

Frame Semantics Cont’d

- Thematic roles are neither universal nor lemma-specific: Role specifications have local validity for the target words of a frame (therefore also called frame elements/ FEs).
  - FEs for Communication_request: SPEAKER, ADDRESSEE, MESSAGE, Medium, ...
  - FEs for Commercial transaction: BUYER, SELLER, GOODS, PRICE, ...

Frame-semantic Representation

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

Common frame-semantic representation:

Frame: COMMERCIAL_TRANSACTION
SELLER: Airbus
BUYER: China Southern
GOODS: five A380 superjumbo planes
PRICE: 220 million Euro

The Berkeley FrameNet Database

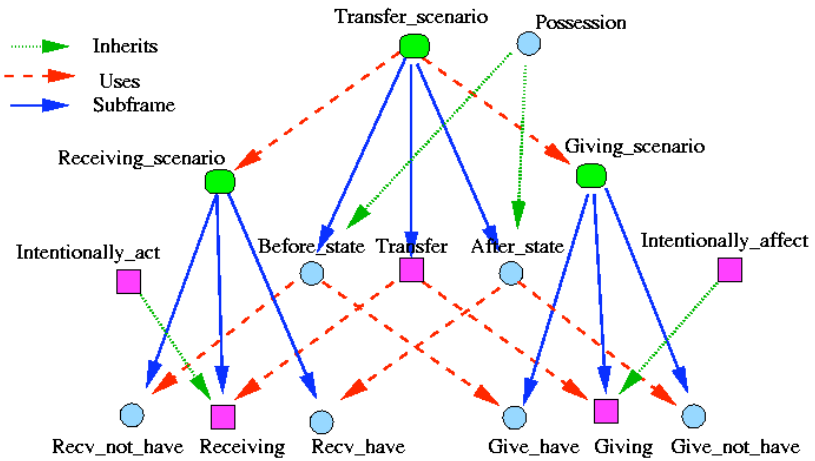
The FrameNet database consists of:

- A data-base of frames with
  - Descriptions of frames with inventory of Roles/Frame elements and associated lemmas
  - Frame-to-Frame Relations
- A lexicon with
  - Frame information
  - Grammatical realisation patterns (role linking information)
  - Annotations of example sentences (from BNC) for all use variants of words

The Berkeley FrameNet Database

- Current release: 700 frames, about 10,000 lexical units (mostly verbs)
- Planned: A total of 15000 verb descriptions
- http://framenet.icsi.berkeley.edu/

Frame-to-Frame-Relations



FrameNet: Advantages

- FrameNet models the core lexicon of English (relational) expressions, mostly verbs, but also deverbal nouns and relational adjectives.
- Semantic representation at a generally appropriate level of granularity and abstraction plus implicit role linking information through grammatical realization patterns support the basic part of semantic construction: Computation of predicate-argument structure.
- Role information plus Frame-to-Frame relations support inference.
- Frame structure is generally valid acros languages: Frame Semantics as a platform for cross-lingual lexical-semantic resources (FrameNet for German (SALSA, Saarbrücken), Spanish, Japanese under work, FrameNet for French and Scandinavian languages planned).

FrameNet: Limitations

- Few and rather unsystematic information about Frame-to-Frame Relations (hierachical relations, causation etc.)
- Too fine-grained for CL application: E.g., different frames for Giving and Receiving, because of differences in „perspectivasation“.
- Too course-grained for CL application: *good/bad* are both in MORALITY_EVALUATION frame, believe/know are both in AWARENESS frame.
- Lack of coverage of the FN database (English as well as other languages)
- Frame-to-Frame Relations are only partially and not systematically represented, some of them have no concise definition („Uses“) and are not very useful
- Frame-based semantic parsers only provide semantic information on the aboutness level.