

Master on Artificial Intelligence

Semantics

WordNet

SentiWordNet

Sentiment
analysis

Introduction to Human Language Technologies

5. Lexical semantics



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Outline

- 1 Semantics
 - Motivation of lexical semantics
 - Resources
- 2 WordNet
 - Definition
 - Similarities
- 3 SentiWordNet
- 4 Sentiment analysis
 - Definition
 - Examples of methods

Semantics

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Semantics deals with the meaning:

- Lexical semantics: deals with the meaning of individual words
- Compositional semantics: deals with the construction of meaning usually in high concordance with syntax

This session focuses on lexical semantics

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Motivation of lexical semantics

Some examples of usefulness:

- Discovery of semantic patterns

Ex: USA **bombed** Hiroshima
They began to **bombard** the defenses
→ A **sense_12533** B

- Determine discourse relations

Ex: [Anna will show up **later.**] [She has **missed the train.**] →
explanation

Ex: [Mathew is good cooking.] [Albert fails making every dish] →
contrast

- Twitter sentiment analysis

Ex: @vooda1: CNN Declines to Air White House Press Conference
Live YES! THANK YOU @CNN FOR NOT LEGITIMI...
positive

Ex: @Slate: Donald Trump's administration: "Government by the
worst men."
negative

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Resources of lexical semantics

- Knowledge-based resources: represented as graphs
 - Ex: WordNet (English lexical ontology)
 - SentiWordNet (sentiment polarity into WordNet)
 - BabelNet (Wikipedia+WordNet)
 - VerbNet (syntactic/semantic verbal behaviour)
 - FrameNet (conceptual behaviour –fine-grained event representation–)
 - ConceptNet (common sense knowledge)
- Corpus-based resources: contextual usage of words
 - Ex: Latent Semantic Analysis (LSA)
 - Word embeddings
 - We will study them in AHLT**

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Resources of lexical semantics

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Resources

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WordNet	https://wordnet.princeton.edu/
SentiWordNet	http://sentiwordnet.isti.cnr.it/
BabelNet	https://babelnet.org/
VerbNet	https://verbs.colorado.edu/verbnet/
FrameNet	https://framenet.icsi.berkeley.edu/fndrupal/
LSA	accessible from
Word embeddings	https://radimrehurek.com/gensim/

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WordNet

- Free large lexical database of English
- Contains only nouns, verbs, adjectives and adverbs
- Words are grouped into synonyms sets (*synsets*)
- each *synset* has an associated gloss and some examples
- *synsets* are interlinked by means of lexical relations

<http://wordnetweb.princeton.edu/perl/webwn>

Word to search for:

Search WordNet

Display Options:

Change

Key: "S:" = Show Synset (semantic) relations, "W:" = Show Word (lexical) relations

Display options for sense: (gloss) "an example sentence"

Noun

- **S: (n) age** (how long something has existed) *"it was replaced because of its age"*
- **S: (n) historic period, age** (an era of history having some distinctive feature) *"we live in a litigious age"*

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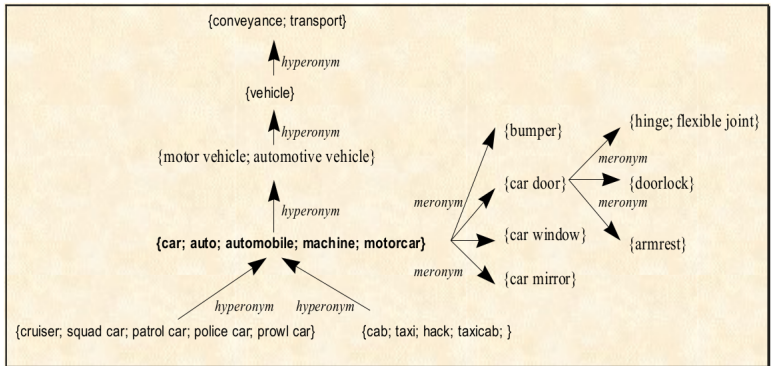
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Lexical relations

Example of Lexical Relation Net



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Lexical relations

- **Synonym**: same meaning. Ex: age - historic_period
- **Antonym**: opposite meaning. Ex: dark - light
- **Homophone**: same sound. Ex: son - sun
- **Homograph**: same written form. Ex: lead (noun - verb)
- **Polysemy**: different related meaning. Ex: newspaper (paper - firm)
- **Homonymy**: different unrelated meaning. Ex: position (place - status)
- **Hypernym**: parent. Ex: cat - feline
- **Hyponym**: child. Ex: feline - cat
- **Holonymy**: group, whole. Ex: class - student
- **Meronymy**: member, part. Ex: student - class
- **Metonymy**: substitution of entity. Ex: We ordered many delicious dishes at the restaurant.

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Similarities in WordNet

- Shortest Path Length: $Sim(s_1, s_2) = \frac{1}{1+SPL(s_1, s_2)}$
where $SPL(s_1, s_2)$ = Shortest Path Length from s_1 to s_2
- Leacock & Chodorow: $Sim(s_1, s_2) = -\log \frac{SPL(s_1, s_2)}{2 \cdot MaxDepth}$
where $depth(s)$ = depth of s in the ontology
 $MaxDepth = \max_{s \in WN} depth(s)$
- Wu & Palmer: $Sim(s_1, s_2) = \frac{2 \cdot depth(LCS(s_1, s_2))}{depth(s_1) + depth(s_2)}$
where $LCS(s_1, s_2)$ = Lowest Common Subsumer of s_1 and s_2
- Lin: $Sim(s_1, s_2) = \frac{2 \cdot IC(LCS(s_1, s_2))}{IC(s_1) + IC(s_2)}$
where $IC(s) = -\log_2 P(s)$ = information content of s (from frequencies in a corpus)

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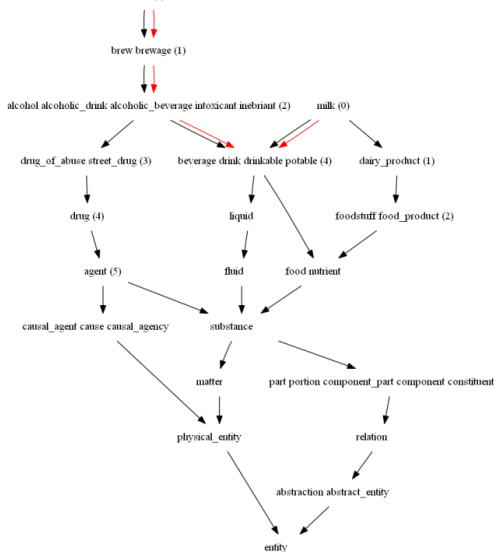
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Example / exercise

Sandipan Dey (UMBC) beer (0)



$$spl(beer, milk) = 4$$

$$Sim_{spl}(beer, milk) = 0.2$$

$$Sim_{wp}(beer, milk) = 0.71$$

$$Sim_{spl}(drug, milk)?$$

$$Sim_{wp}(drug, milk)?$$

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Extension of wordnet that adds for each synset 3 measures:

- `positive_score`
- `negative_score`
- `objective_score = 1 - positive_score - negative_score`

Wordnet		SentiWordnet		
Antonym Synsets	Gloss	obj	pos	neg
bad.a.01	having undesirable or negative qualities	0.375	0.0	0.625
good.a.01	having desirable or positive qualities. . .	0.25	0.75	0.0
bad.n.01	that which is below standard or expectations as of ethics or decency	0.125	0.0	0.875
good.n.03	that which is pleasing, valuable, useful	0.375	0.625	0.0

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Definition

Different subtasks:

- **Opinion detection**: given a piece of text (document or sentence), is it an objective text or a subjective one?
- **Polarity classification**: given a subjective piece of text, is it a positive opinion or a negative one?
- **Opinion extraction**: given a subjective piece of text, recognise the focuses of the opinion (templates <entity, aspect, polarity>).

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Unsupervised sentiment analysis

Possible solution:

$$h(D) = \sum_{s \in \hat{D}} score(s)$$

\hat{D} is usually the set of synsets related to adjectives, or to nouns and adjectives, or to noun, verb, adjective and adverb.

- Opinion detection:

$$score(s) = pos_s + neg_s$$

- Polarity classification:

$$score(s) = pos_s - neg_s$$

Pros:

- no need for training corpora

Cons:

- low results
- need for pos and wsd taggers

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Supervised sentiment analysis

Possible solution:

Bag of words with Naïve Bayes

$$h(D) = h(w_1, \dots, w_n) = \underset{y}{\operatorname{argmax}} P(y) \prod_{i=1}^n P(w_i|y)$$

where y is the category (e.g., positive/negative, subjective/objective), and w_1, \dots, w_n is the bag of words related to D

Pros:

- higher results
- no need for pos and wsd taggers

Cons:

- need for training corpora

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Hybrid approach for sentiment analysis

Possible solution:

- Combine two supervised methods with SentiWordnet method
- I.e., consensuate the output of the three methods, using *voting*, for instance:
 - if at least 2 of the methods answer y then output y
 - else output the answer of the method with better accuracy in the training corpus

The combination improves the results of the isolated methods

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Annex

- Base on the Bayes' theorem:

$$P(y|x_1, \dots, x_n) = \frac{P(y)P(x_1, \dots, x_n|y)}{P(x_1, \dots, x_n)}$$

- Naïve assumption of independence between features:

$$P(y|x_1, \dots, x_n) \approx P(y) \prod_{i=1}^n P(x_i|y)$$

- *Maximum likelihood estimation* of $P(y)$ and $P(x_i|y)$ as training model
- Test prediction as:

$$h(x_1, \dots, x_n) = \underset{y}{\operatorname{argmax}} P(y) \prod_{i=1}^n P(x_i|y)$$

- Need a smoothing technique to avoid zero counts:
in NLTK never seen features are discarded