Mining Unstructured Data
4. Lexical semantics

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Facultat d'Informàtica de Barcelona

Outline

Semantics

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

Outline

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

Outline

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)

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 (word2vect, glove, fasttext, ...)
    Contextual word embeddings as compositional semantics (BERT, RoBERTA, GPT3, ...)

Resources of lexical semantics

WordNet	`https://wordnet.princeton.edu/`
SentiWordNet	`https://github.com/aesuli/SentiWordNet`
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/`

Outline

Outline

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

https://en-word.net/lemma/demo

Open English Wordnet

LEMMA Search

OPTIONS ▼

Nouns

(n) demo, demonstration *a visual presentation showing how something works "the lecture was accompanied by dramatic demonstrations" "the lecturer shot off a pistol as a demonstration of the startle response"*

MORE ▶

Verbs

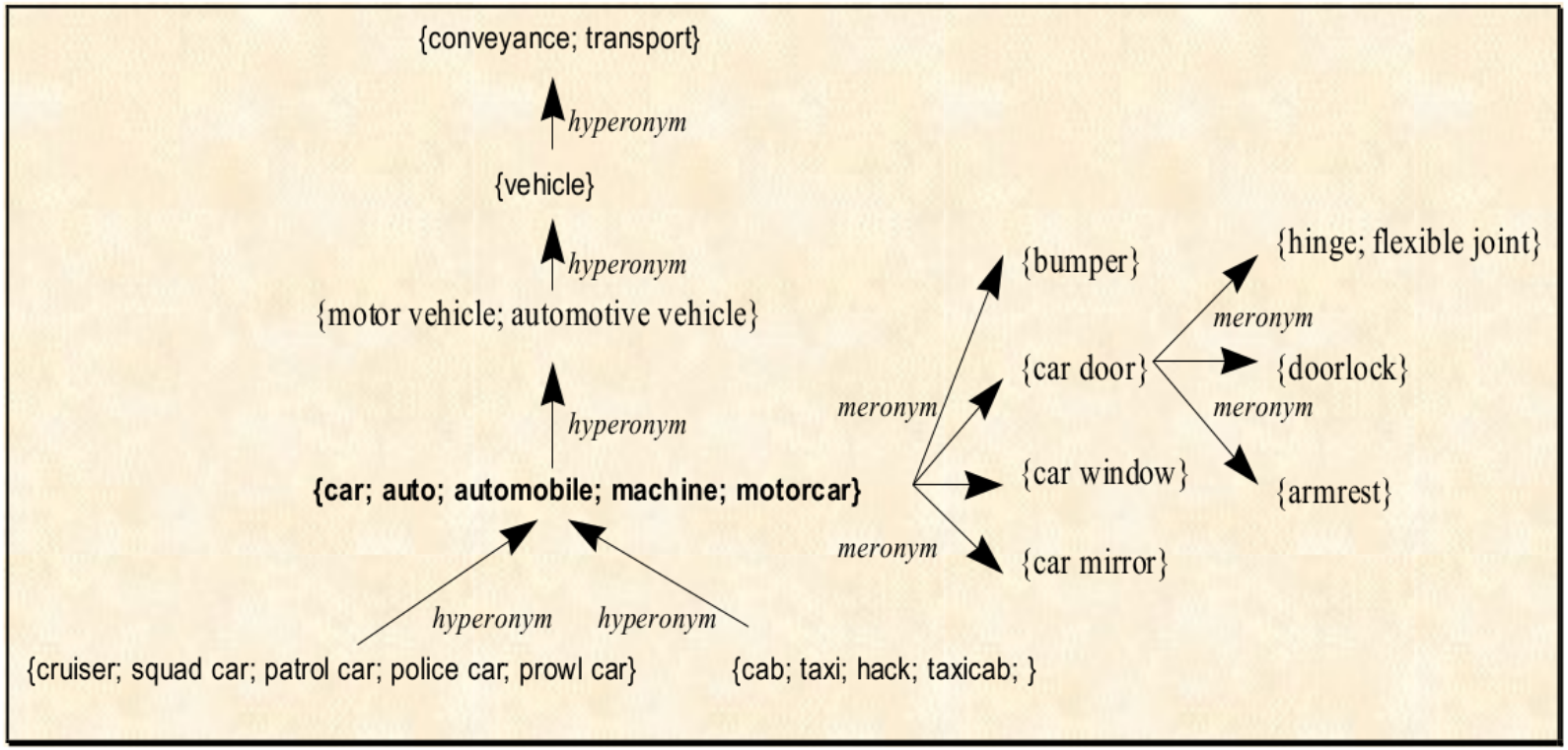
(v) demo, demonstrate, exhibit, present, show *give an exhibition of to an interested audience "She shows her dogs frequently" "We will demo the new software in Washington"*

MORE ▶

Download As: JSON RDF XML

Lexical relations

Example of Lexical Relation Net



Lexical relations

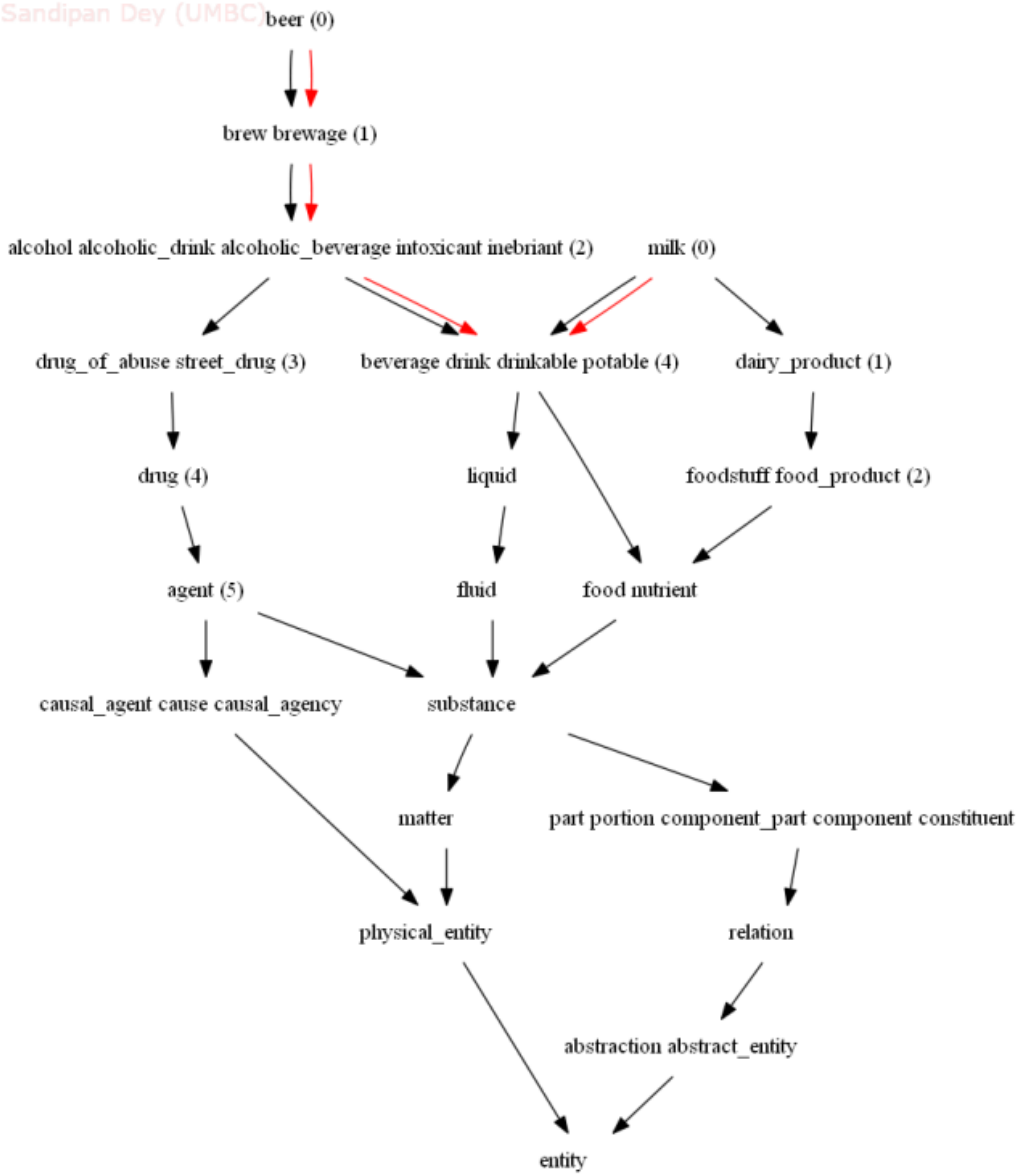
- Synonymy: same meaning. Ex: age - historic_period
- Antonymy: opposite meaning. Ex: dark - light
- Homophome: same sound. Ex: son - sun
- Homograph: same written form. Ex: lead (noun - verb)
- Polysemy: different related meaning. Ex: newspaper (paper - firm)
- Homonymy: different unrelated meaning. Ex: position (place - status)
- Hypernymy: parent. Ex: cat - feline
- Hyponymy: child. Ex: feline - cat
- Holonym: group, whole. Ex: student - class
- Meronym: member, part. Ex: class - student
- Metonymy: substitution of entity. Ex: We ordered many delicious dishes at the restaurant.

Outline

Similarities in WordNet

- Shortest Path Length: $Sim(s_1, s_2) = \frac{1}{SPL(s_1, s_2)}$
  where $SPL(s_1, s_2)$ = Shortest Path Length from s_1 to s_2 as vertex-countings conto i vertici non gli archi
- Leacock & Chodorow: $Sim(s_1, s_2) = -log_2 \frac{SPL(s_1, s_2)}{2 \cdot MaxDepth}$
  where $depth(s)$ = SPL(TopSynset,s) numero di bit necessari
  $MaxDepth = \max_{s \in WN} depth(s)$
- Wu & Palmer: deepest the common ancestor they have more similarity
  $Sim(s_1, s_2) = \frac{2 \cdot depth(LCS(s_1, s_2))}{depth_{LCS(s_1, s_2)}(s_1) + depth_{LCS(s_1, s_2)}(s_2)}$
  where $LCS(s_1, s_2)$ = Lowest Common Subsumer of s_1 and s_2
  $depth_{s'}(s)$ = SPL(TopSynset,s) throw s' through
- 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)

Example / exercise



$spl(beer, milk) = 5$
$Sim_{spl}(beer, milk) = 0.2$

$Sim_{wp}(beer, milk) = 0.75$

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

Outline

Definition

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

Outline

Outline

Sentiment analysis

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>).

Outline

Unsupervised sentiment analysis

Possible simple solution with lexical information:

$$h(D) = \sum_{w \in \hat{D}} word\_score(w) \qquad word\_score(w) = 1/|S(w)| * \sum_{s \in S(w)} score(s))$$

$\hat{D}$ is usually the set of adjectives, or nouns and adjectives, or nouns, verbs, adjectives and adverbs. $S(w)$ is the set of synsets for word w.

- Opinion detection:

$$score(s) = 1 - obj_s \quad or \quad score(s) = obj_s$$

- Polarity classification:

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

Pros:

- no need for training corpora

Cons:

- low results
- need for POS tagger

Supervised sentiment analysis

Possible simple solution with lexical information:

Bag of words with Naïve Bayes

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

where y is the category (positive/negative, subjective/objective), and $w_1, \ldots, w_n$ is the bag of words related to D

- Given a training corpus $C = \{d_i\}$ partitioned into subsets Y_1 and Y_2
  - $P(y) \approx P_{MLE}(y) = \frac{|Y_i|}{|C|}$
  - $P(w_i|y) \approx P_{MLE}(w_i|Y_j) = \frac{c(w_i, Y_j)}{\sum_{w_i \in Y_j} c(w_i, Y_j)}$

Pros:

- higher results
- no need for POS tagger

Cons:

- need for training corpora

Hybrid approach for sentiment analysis

Possible solution with lexical information:

- 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

Annex

- Base on the Bayes' theorem:

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

- Naïve assumption of independence between features:

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

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

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

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