



Natural Language Processing

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Adapted from Info 256 - David Bamman, UC Berkeley

Word representation

...	...
the	0
a	0
an	0
for	0
in	0
on	0
dog	1
cat	0
...	...

dog is a point in V-dimensional space

dog

4.1
-0.9

dog is a point in 2-dimensional space

Polysemy

the movie is so **bad** , in fact , that it retains that ridiculous tarzan call that was so tirelessly mocked in last summer's comedy " george of the jungle .

the performances are **bad** .



Polysemy

Sense 1

Sense 2

bad	Of poor quality or little worth.	slang (orig. U.S.). Formidable, good.
sick	Suffering from illness of any kind; ill, unwell, ailing.	slang (now esp. Skateboarding and Surfing). Excellent, impressive; risky.
awesome	Inspiring awe; appalling, dreadful, weird.	Expressing enthusiastic approval: great, excellent, highly impressive; fantastic.
wicked	Bad in moral character, disposition, or conduct	Excellent, splendid; remarkable. slang (orig. U.S.).

Word senses

I'm going to the bank

- bank₁ = “financial institution”
- bank₂ = “sloping mound”
- bank₃ = “biological repository”
- bank₄ = “building where a bank₁ does its business”

Word senses

- A word sense is a representation of one **aspect** of a word's meaning.

Word senses

- “Serve”

S: (v) serve, function (serve a purpose, role, or function) *"The tree stump serves as a table"; "The female students served as a control group"; "This table would serve very well"; "His freedom served him well"; "The table functions as a desk"*

S: (v) serve (do duty or hold offices; serve in a specific function) *"He served as head of the department for three years"; "She served in Congress for two terms"*

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S: (v) serve, service (mate with) *"male animals serve the females for breeding purposes"*

S: (v) serve (put the ball into play) *"It was Agassi's turn to serve"*

Word senses

- They rarely **serve** red meat
- He **served** as U.S. ambassador to Norway
- He might have **served** his time.

Jurafsky & Martin (2008)

Zeugma

- Conjunction (“yoke”) of antagonistic readings; one test for whether word senses are distinct.
- Which flights **serve** breakfast?
- Does Midwest Express **serve** Philadelphia?
- Does Midwest Express serve breakfast and Philadelphia?

Word senses

I'm going to the bank

Je vais à la _____

Word senses

I'm going to the bank

Je vais à la banque

(financial institution)

Word senses

I'm going to the bank

Je vais à la rive

(side of the river)

Relationship between senses

- Synonymy/antonymy
- Hypernymy
- Metonymy
- Meronymy

Synonym

- Two senses of different words are synonyms of each other if their meaning is nearly identical*
- Two words are never exactly the same in their meaning, distribution of use, dialect or other contexts in which they're licensed.
- Synonyms can be exchanged for each other without changing the truth conditions of a sentence.

couch	sofa
filbert	hazelnut
car	automobile
fair	impartial
fair	pale

Synonymy

Synonymy holds between word **senses**, not words

- How **big** is that plane?
- Would I be flying on a **large** or small plane?
- Miss Nelson, for instance, became a kind of **big** sister to Benjamin
- ?Miss Nelson, for instance, became a kind of **large** sister to Benjamin

Antonymy

- Two senses of different words are antonyms of each other if their meaning is nearly opposite
- All aspects of meaning are nearly identical between antonyms, **except one** (very much like synonyms in this respect)

long	short	both describe length
big	little	both describe size
fast	slow	both describe speed
cold	hot	both describe temperature
dark	light	both describe luminescence

Hyponymy

hypo = “under”
(e.g., hypothermia)

- Sense A is a hyponym of sense B if A is a subclass of B
- Formally, entailment: for entity x , $A(x) \Rightarrow B(x)$

hyponym/subordinate	hypernym/superordinate
car	vehicle
mango	fruit
chair	furniture
dog	mammal
mammal	animal

Hyponymy

hypo = “under”
(e.g., hypothermia)

- Hyponymy is generally transitive

hyponym/subordinate	hypernym/superordinate
car	vehicle
mango	fruit
chair	furniture
dog	mammal
mammal	animal
dog	animal

Meronymy

- Part-whole relations. A meronym is a part of a holonym.

meronym	holonym
leg	chair
wheel	car
car	automobile

WordNet

- Lexical database for nouns, verbs and adjectives/adverbs.
- Each word sense is arranged in a synset (category of near-synonyms) and each synset is related to others in terms of their sense relations.

Relations

Relation	Also Called	Definition	Example
Hypernym	Superordinate	From concepts to superordinates	<i>breakfast</i> ¹ → <i>meal</i> ¹
Hyponym	Subordinate	From concepts to subtypes	<i>meal</i> ¹ → <i>lunch</i> ¹
Instance Hypernym	Instance	From instances to their concepts	<i>Austen</i> ¹ → <i>author</i> ¹
Instance Hyponym	Has-Instance	From concepts to concept instances	<i>composer</i> ¹ → <i>Bach</i> ¹
Member Meronym	Has-Member	From groups to their members	<i>faculty</i> ² → <i>professor</i> ¹
Member Holonym	Member-Of	From members to their groups	<i>copilot</i> ¹ → <i>crew</i> ¹
Part Meronym	Has-Part	From wholes to parts	<i>table</i> ² → <i>leg</i> ³
Part Holonym	Part-Of	From parts to wholes	<i>course</i> ⁷ → <i>meal</i> ¹
Substance Meronym		From substances to their subparts	<i>water</i> ¹ → <i>oxygen</i> ¹
Substance Holonym		From parts of substances to wholes	<i>gin</i> ¹ → <i>martini</i> ¹
Antonym		Semantic opposition between lemmas	<i>leader</i> ¹ ⇔ <i>follower</i> ¹
Derivationally Related Form		Lemmas w/same morphological root	<i>destruction</i> ¹ ⇔ <i>destroy</i> ¹

Figure 17.2 Noun relations in WordNet.

Synsets

synset	gloss
mark, grade, score	a number or letter indicating quality
scratch, scrape, scar, mark	an indication of damage
bell ringer, bull's eye, mark, home run	something that exactly succeeds in achieving its goal
chump, fool, gull, mark, patsy, fall guy, sucker, soft touch, mug	a person who is gullible and easy to take advantage of
mark, stigma, brand, stain	a symbol of disgrace or infamy

Synsets

- S: (n) victim, dupe (a person who is tricked or swindled)
 - S: (n) person, individual, someone, somebody, mortal, soul (a human being) *"there was too much for one person to do"*
 - S: (n) organism, being (a living thing that has (or can develop) the ability to act or function independently)
 - S: (n) living thing, animate thing (a living (or once living) entity)
 - S: (n) whole, unit (an assemblage of parts that is regarded as a single entity) *"how big is that part compared to the whole?"*; *"the team is a unit"*
 - S: (n) object, physical object (a tangible and visible entity; an entity that can cast a shadow) *"it was full of rackets, balls and other objects"*
 - S: (n) physical entity (an entity that has physical existence)
 - S: (n) entity (that which is perceived or known or inferred to have its own distinct existence (living or nonliving))

Hypernyms of {chump, fool, gull, mark, patsy, fall guy, sucker, soft touch, mug} sunset

WordNet

- WordNet encodes human-judged measures of similarity. Learn distributed representations of words that respect WordNet similarities (Faruqui et al. 2015)
- By indexing word senses, we can build annotated resources on top of it for word sense disambiguation.

Semcor

- Semcor: 200K+ words from Brown corpus tagged with Wordnet senses.
 - <http://web.eecs.umich.edu/~mihalcea/downloads/semcor/semcor3.0.tar.gz>

original	It urged that the city take steps to remedy this problem
lemma sense	It urge¹ that the city² take¹ step¹ to remedy¹ this problem²
synset number	It urge^{2:32:00} that the city^{1:15:01} take^{2:41:04} step^{1:04:02} to remedy^{2:30:00} this problem^{1:10:00}

www.bit.ly/wordnet-serve

- They rarely **serve** red meat
- Eisenhower **served** as Supreme Commander of the Allied Expeditionary Forces during WWII.
- He might have **served** his time.

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