

# LANGUAGE DISAMBIGUATION VIA IMAGES

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# Language is often ambiguous.

We all saw her duck under the doorway.



## Noun

- **S: (n) interruption, break** (some abrupt occurrence that interrupts an ongoing activity) *"the telephone is an annoying interruption"; "there was a break in the action when a player was hurt"*
- **S: (n) break, good luck, happy chance** (an unexpected piece of good luck) *"he finally got his big break"*
- **S: (n) fault, faulting, geological fault, shift, fracture, break** ((geology) a crack in the earth's crust resulting from the displacement of one side with respect to the other) *"they built it right over a geological fault"; "he studied the faulting of the earth's crust"*
- **S: (n) rupture, breach, break, severance, rift, falling out** (a personal or social separation (as between opposing factions)) *"they hoped to avoid a break in relations"*
- **S: (n) respite, recess, break, time out** (a pause from doing something (as work)) *"we took a 10-minute break"; "he took time out to recuperate"*
- **S: (n) breakage, break, breaking** (the act of breaking something) *"the breakage was unavoidable"*
- **S: (n) pause, intermission, break, interruption, suspension** (a time interval during which there is a temporary cessation of something)
- **S: (n) fracture, break** (breaking of hard tissue such as bone) *"it was a nasty fracture"; "the break seems to have been caused by a fall"*
- **S: (n) break** (the occurrence of breaking) *"the break in the dam threatened the valley"*
- **S: (n) break** (an abrupt change in the tone or register of the voice (as at puberty or due to emotion)) *"then there was a break in her voice"*
- **S: (n) break** (the opening shot that scatters the balls in billiards or pool)
- **S: (n) break, break of serve** ((tennis) a score consisting of winning a game when your opponent was serving) *"he was up two breaks in the second set"*
- **S: (n) break, interruption, disruption, gap** (an act of delaying or interrupting the continuity) *"it was presented without commercial breaks"; "there was a gap in his account"*
- **S: (n) break** (a sudden dash) *"he made a break for the open door"*
- **S: (n) open frame, break** (any frame in which a bowler fails to make a strike or spare) *"the break in the eighth frame cost him the match"*
- **S: (n) break, breakout, jailbreak, gaolbreak, prisonbreak, prison-breaking** (an escape from jail) *"the breakout was carefully planned"*

## Verb

- **S: (v) interrupt, break** (terminate) *"She interrupted her pregnancy"; "break a lucky streak"; "break the cycle of poverty"*
- **S: (v) break, separate, split up, fall apart, come apart** (become separated into pieces or fragments) *"The figurine broke"; "The freshly baked loaf fell apart"*
- **S: (v) break** (render inoperable or ineffective) *"You broke the alarm clock when you took it apart!"*
- **S: (v) break, bust** (ruin completely) *"He busted my radio!"*
- **S: (v) break** (destroy the integrity of, usually by force: cause to separate into pieces or fragments) *"He broke the glass plate"; "She broke the match"*
- **S: (v) transgress, offend, infract, violate, go against, breach, break** (act in disregard of laws, rules, contracts, or promises) *"offend all laws of humanity"; "violate the basic laws of human civilization"; "break a law"; "break a promise"*
- **S: (v) break, break out, break away** (move away or escape suddenly) *"The horses broke from the stable"; "Three inmates broke jail"; "Nobody can break out—this prison is high security"*
- **S: (v) break** (scatter or part) *"The clouds broke after the heavy downpour"*
- **S: (v) break, burst, erupt** (force out or release suddenly and often violently something pent up) *"break into tears"; "erupt in anger"*
- **S: (v) break, break off, discontinue, stop** (prevent completion) *"stop the project"; "break off the negotiations"*
- **S: (v) break in, break** (enter someone's (virtual or real) property in an unauthorized manner, usually with the intent to steal or commit a violent act) *"Someone broke in while I was on vacation"; "They broke into my car and stole my radio!"; "who broke into my account last night?"*
- **S: (v) break in, break** (make submissive, obedient, or useful) *"The horse was tough to break"; "I broke in the new intern"*
- **S: (v) violate, go against, break** (fail to agree with; be in violation of; as of rules or patterns) *"This sentence violates the rules of syntax"*
- **S: (v) better, break** (surpass in excellence) *"She bettered her own record"; "break a record"*
- **S: (v) unwrap, disclose, let on, bring out, reveal, discover, expose, divulge, break, give away, let out, uncover** (make known to the public information that was previously known only to a few people or that was meant to be kept a secret) *"The auction house would not disclose the price at which the van Gogh had sold"; "The actress won't reveal how old she is"; "bring out the truth"; "he broke the news to her"; "unwrap the evidence in the murder case"; "The newspaper uncovered the President's illegal dealings"*
- **S: (v) break** (come into being) *"light broke over the horizon"; "Voices broke in the air"*
- **S: (v) fail, go bad, give way, die, give out, conk out, go, break, break down** (stop operating or functioning) *"The engine finally went"; "The car died on the road"; "The bus we travelled in broke down on the way to town"; "The coffee maker broke"; "The engine failed on the way to town"; "her eyesight went after the accident"*
- **S: (v) break, break away** (interrupt a continued activity) *"She had broken with the traditional patterns"*
- **S: (v) break** (make a rupture in the ranks of the enemy or one's own by quitting or fleeing) *"The ranks broke"*
- **S: (v) break** (curl over and fall apart in surf or foam, of waves) *"The surf broke"*
- **S: (v) dampen, damp, soften, weaken, break** (lessen in force or effect) *"soften a shock"; "break a fall"*
- **S: (v) break** (be broken in) *"If the new teacher won't break, we'll add some stress"*
- **S: (v) break** (come to an end) *"The heat wave finally broke yesterday"*
- **S: (v) break** (vary or interrupt a uniformity or continuity) *"The flat plain was broken by tall mesas"*
- **S: (v) break** (cause to give up a habit) *"She finally broke herself of smoking cigarettes"*
- **S: (v) break** (give up) *"break cigarette smoking"*
- **S: (v) break** (come forth or begin from a state of latency) *"The first winter storm broke over New York"*
- **S: (v) break** (happen or take place) *"Things have been breaking pretty well for us in the past few months"*
- **S: (v) break** (cause the failure or ruin of) *"His peccadilloes finally broke his marriage"; "This play will either make or break the playwright"*
- **S: (v) break** (invalidate by judicial action) *"The will was broken"*
- **S: (v) separate, part, split up, split, break, break up** (discontinue an association or relation; go different ways) *"The business partners broke over a tax question"; "The couple separated after 25 years of marriage"; "My friend and I split up"*
- **S: (v) demote, bump, relegate, break, kick downstairs** (assign to a lower position; reduce in rank) *"She was demoted because she always speaks up"; "He was broken down to Sergeant"*
- **S: (v) bankrupt, ruin, break, smash** (reduce to bankruptcy) *"My daughter's fancy wedding is going to break me!"; "The slump in the financial markets smashed him"*

- **S: (v) break** (change directions suddenly)
- **S: (v) break** (emerge from the surface of a body of water) *"The whales broke"*
- **S: (v) collapse, fall in, cave in, give, give way, break, founder** (break down, literally or metaphorically) *"The wall collapsed"; "The business collapsed"; "The dam broke"; "The roof collapsed"; "The wall gave in"; "The roof finally gave under the weight of the ice"*
- **S: (v) break dance, break-dance, break** (do a break dance) *"Kids were break-dancing at the street corner"*
- **S: (v) break** (exchange for smaller units of money) *"I had to break a \$100 bill just to buy the candy"*
- **S: (v) break, break up** (destroy the completeness of a set of related items) *"The book dealer would not break the set"*
- **S: (v) break** (make the opening shot that scatters the balls)
- **S: (v) break** (separate from a clinch, in boxing) *"The referee broke the boxers"*
- **S: (v) break, wear, wear out, bust, fall apart** (go to pieces) *"The lawn mower finally broke"; "The gears wore out"; "The old chair finally fell apart completely"*
- **S: (v) break, break off, snap off** (break a piece from a whole) *"break a branch from a tree"*
- **S: (v) break** (become punctured or penetrated) *"The skin broke"*
- **S: (v) break** (pierce or penetrate) *"The blade broke her skin"*
- **S: (v) break, get out, get around** (be released or become known; of news) *"News of her death broke in the morning"*
- **S: (v) pause, intermit, break** (cease an action temporarily) *"We pause for station identification"; "let's break for lunch"*
- **S: (v) break** (interrupt the flow of current in) *"break a circuit"*
- **S: (v) break** (undergo breaking) *"The simple vowels broke in many Germanic languages"*
- **S: (v) break** (find a flaw in) *"break an alibi"; "break down a proof"*
- **S: (v) break** (find the solution or key to) *"break the code"*
- **S: (v) break** (change suddenly from one tone quality or register to another) *"Her voice broke to a whisper when she started to talk about her children"*
- **S: (v) break, recrudescence, develop** (happen) *"Report the news as it develops"; "These political movements recrudescence from time to time"*
- **S: (v) crack, check, break** (become fractured: break or crack on the surface only) *"The glass cracked when it was heated"*
- **S: (v) break** (crack; of the male voice in puberty) *"His voice is breaking—he should no longer sing in the choir"*
- **S: (v) break** (fall sharply) *"Stock prices broke"*
- **S: (v) fracture, break** (fracture a bone of) *"I broke my foot while playing hockey"*
- **S: (v) break** (diminish or discontinue abruptly) *"The patient's fever broke last night"*
- **S: (v) break** (weaken or destroy in spirit or body) *"His resistance was broken"; "a man broken by the terrible experience of near-death"*

This is generally because many words have multiple valid senses.

In natural language processing, we refer to the act of deciding which sense to assign to a given word as *word sense disambiguation*.

S: (n) **duck** (small wild or domesticated web-footed broad-billed swimming bird usually having a depressed body and short legs)

↑  
duck

↓  
S: (v) **duck** (to move (the head or body) quickly downwards or away) “*Before he could duck, another stone struck him*”

How has word  
sense  
disambiguation  
traditionally  
been  
performed?

## Statistical approaches

- *Supervised machine learning*

## Rule-based approaches

- *Dictionary or thesaurus lookup*

# Statistical Approaches to Word Sense Disambiguation

- Basic premise: Given a corpus of words and their contexts, with each word labeled with its appropriate sense, learn how to predict the correct sense for new test words and their contexts.

There was a duck in the lake. → duck1

She has a pet duck. → duck1

She had to duck underneath the low-hanging beam. → duck2

Quick, duck for cover! → duck2

# Statistical Approaches to Word Sense Disambiguation

- What features are useful for this?
  - *Collocational features*
    - What words are directly before and after the target word? How about two words before and after the target word?
    - What are the POS tags for those words?
    - How do those words relate to the target word in a syntactic parse tree?
  - *Bag of words features*
    - What words occur anywhere within a given context window around the target word?
    - How often do they occur within that window?

There was a duck in the lake.

She had to duck underneath the low-hanging beam.

# Rule-based Approaches to Word Sense Disambiguation

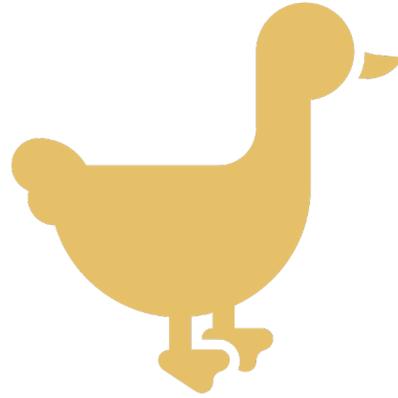
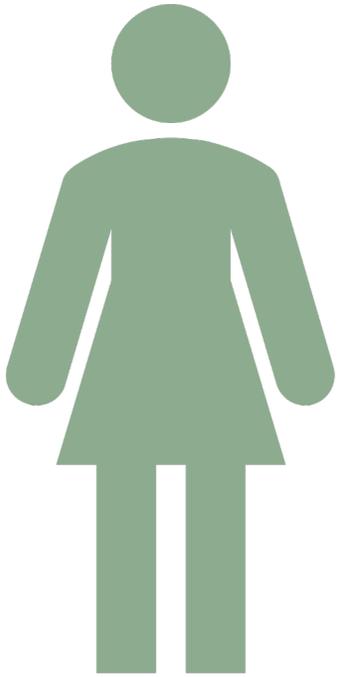
- Most frequent sense in WordNet or other large dictionary
- Lesk algorithm
  - *Select the sense with the most content word overlap between its WordNet entry and the test word/context*

A **duck** was **swimming** in the lake.

S: (n) **duck** (small wild or domesticated web-footed broad-billed **swimming** bird usually having a depressed body and short legs)

She had to **duck** her **head** to avoid hitting it on the beam.

S: (v) **duck** (to move (the **head** or body) quickly downwards or away) “*Before he could **duck**, another stone struck him*”



How can the inclusion of visual features be useful for word sense disambiguation?

Imagery can be useful for disambiguating unclear language

Images are present in many dialogue contexts!



In-person conversation



News articles



Social media

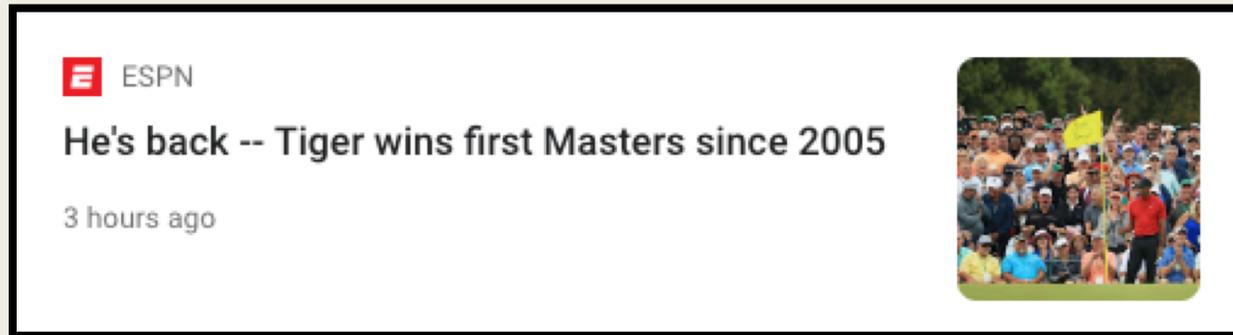


**He's back -- Tiger wins first Masters since 2005**

3 hours ago

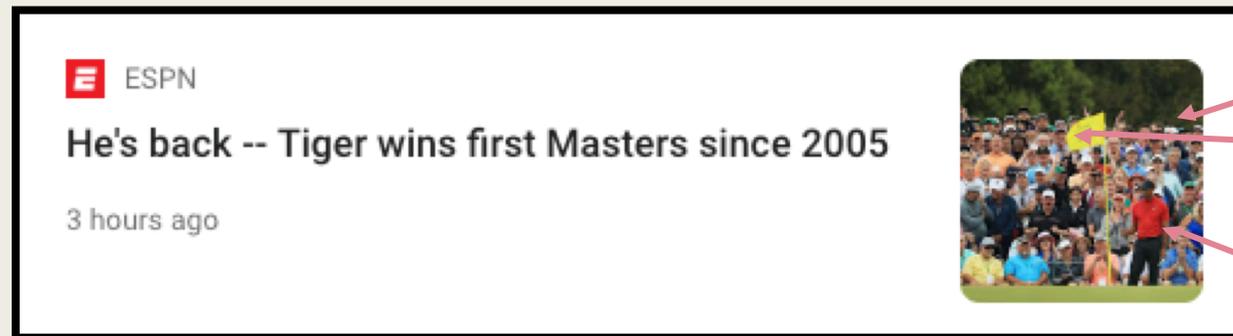


If humans are able to take advantage of multiple modalities to disambiguate language, it makes sense that computers could benefit from this as well.



# Earliest Work on Visually-Informed Language Disambiguation

- Barnard, Kobus, and Matthew Johnson. "Word sense disambiguation with pictures." *Artificial Intelligence* 167.1-2 (2005): 13-30.
  - *Disambiguated nouns using a Bayesian approach that incorporated object labels for image regions as part of the context*



crowd

flag

person

Recent work has  
extended joint  
visual/linguistic language  
disambiguation to special  
cases of semantics.



Sugar has recently fallen from grace.



The world is full of very smart people.

How is  
language  
disambiguation  
evaluated?

## Intrinsic Evaluation

- *Accuracy, precision, recall, and  $F_1$  compared to human labels*

## Extrinsic Evaluation

- *Solution incorporated into one or more downstream tasks, with performance evaluated before and after its inclusion*

# Resources

- Datasets:
  - VerSe Dataset: <https://github.com/spandanagella/verse>
    - Verb sense annotations for images from COCO and TUHOI (<http://disi.unitn.it/~dle/dataset/TUHOI.html>)
  - UIUC Image Sense Discrimination Dataset: <http://vision.cs.uiuc.edu/isd/>
    - Images and the search queries used to find them
  - Visual Word2Vec: <http://satwikkottur.github.io/VisualWord2Vec/>
    - Word embeddings that are grounded in contexts from abstract scenes
- *Learning Abstract Concepts from Multi-Modal Data*, by Felix Hill: [https://youtu.be/K3PB9I\\_AYAE](https://youtu.be/K3PB9I_AYAE)
- (Slides) *Multi-Modal Word Synset Induction*, by Jesse Thomason and Raymond Mooney: [https://jessethomason.com/personal\\_site/www/publication\\_supplements/IJCAI2017\\_slides.pdf](https://jessethomason.com/personal_site/www/publication_supplements/IJCAI2017_slides.pdf)

# Wrapping up....

- Overview of word sense disambiguation
  - *Statistical approaches*
  - *Rule-based approaches*
- Benefits of including visual features when disambiguating language
- Common evaluation metrics
- Resources