

# 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 game when a player was hurt"
- S: (n) **meal**, **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) **rutture**, **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**, **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**, **intermission**, **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" "the bank funds irretrievable or ineffective) You broke the alarm clock when you took it apart"
- S: (v) **break**, **burst** (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**, **infraet**, **violate**, **go against**, **breach**, **break** (act in disregard of laws, rules, contracts, or promises) "offend all laws of humanity"; "violate the basic laws or 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"; "What was the account last night?"
- S: (v) **break**, **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) "soaked in a shock"; "break a fall"
- S: (v) **break** (the broken) "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) **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**, **recrudesce**, **develop** (happen) "Report the news as it develops"; "These problems break out from time to time"
- S: (v) **break**, **crack**, **break** (become fractured or 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 soccer"
- 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

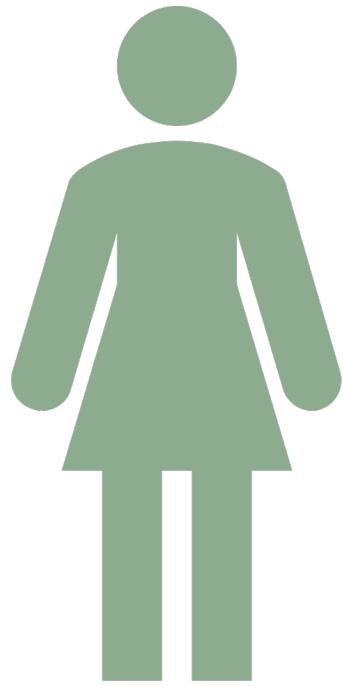
- Most frequent sense in WordNet or other large dictionary
- Lesk algorithm
  - Select the sense with the most content word overlap between its WordNet entry and the test word/context

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)

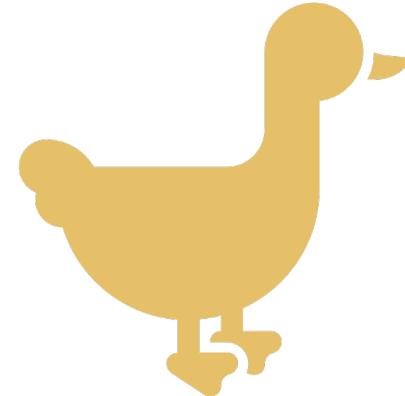
She had to **duck** her **head** to avoid hitting it on the beam.

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

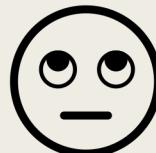
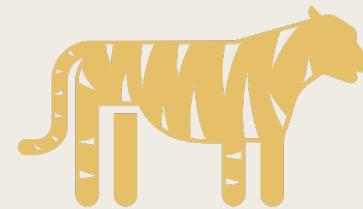
The image shows a screenshot of a news card from ESPN. The card has a black border. In the top left corner is the ESPN logo (a red square with a white 'E'). To its right is the word 'ESPN'. Below that is the main headline: 'He's back -- Tiger wins first Masters since 2005'. Underneath the headline is the timestamp '3 hours ago'. In the bottom right corner of the card is a small thumbnail image showing a crowd of people at a golf tournament, with a yellow flag visible in the background.

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

 ESPN

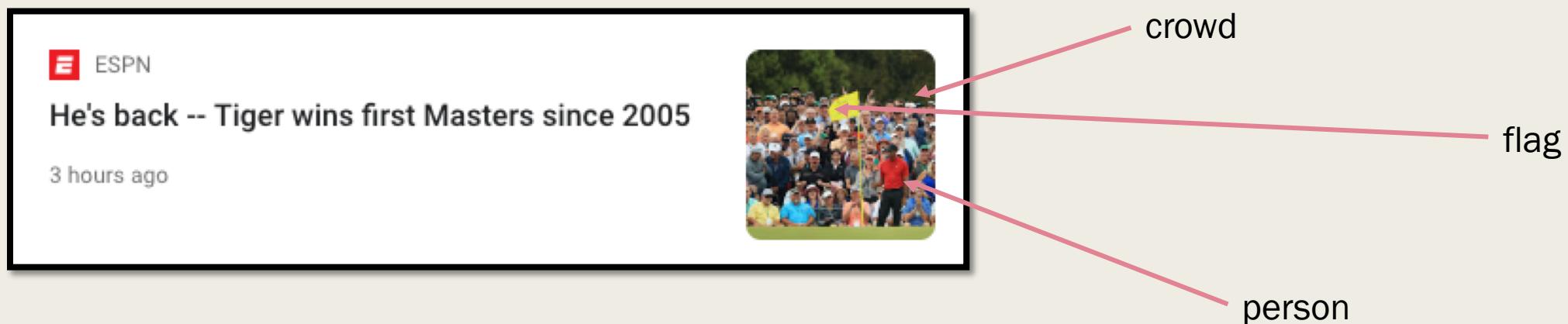
He's back -- Tiger wins first Masters since 2005

3 hours ago



# 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*



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