Lecture 20
Coref eval and Lexical Semantics

Intro to NLP, CS585, Fall 2014

http://people.cs.umass.edu/~brenocon/inlp2014/

Brendan O'Connor

Coreference evaluation

- Ideally, downstream tasks
- Direct coref evaluation: compare mention clusterings

gold

[Harry Potter]1 was a [wizard]1.
[Voldemort]2 shook [his]1 hand.

prediction examples

[Harry Potter]A was a [wizard]B.
[Voldemort]C shook [his]D hand.

[Harry Potter]A was a [wizard]A.
[Voldemort]A shook [his]A hand.

[Harry Potter]A was a [wizard]A.
[Voldemort]B shook [his]B hand.

[Harry Potter]A was a [wizard]A.
[Voldemort]B shook [his]A hand.

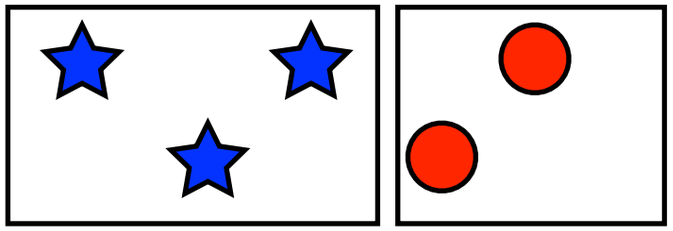
- Two possible metrics
  - 1. Pairwise P/R/F
  - 2. B-cubed P/R/F

Pairwise prec/rec

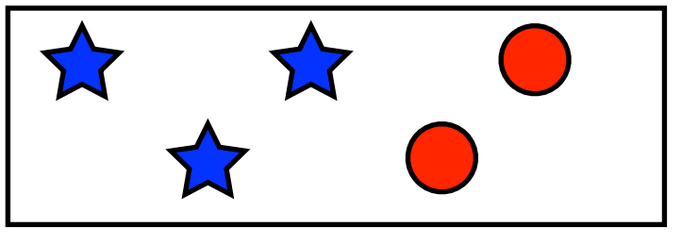
- Entity clustering as a classification task among all mention pairs

$$\text{prec} = \frac{\text{Num TP links}}{\text{Num pred links}} \qquad \text{rec} = \frac{\text{Num TP links}}{\text{Num gold links}}$$

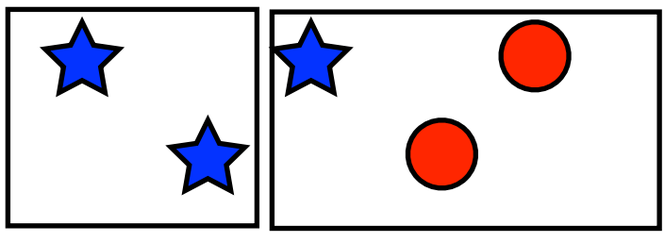
Gold entity1 Gold entity2



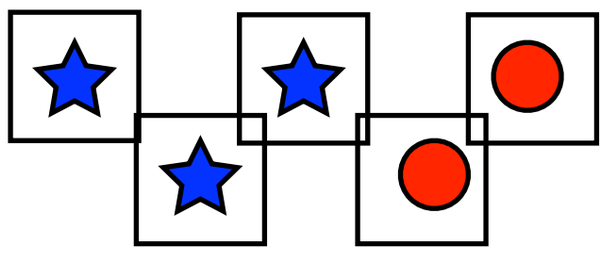
$$\text{prec} = \frac{4}{4} \qquad \text{rec} = \frac{4}{4}$$



$$\text{prec} = \frac{4}{10} \qquad \text{rec} = \frac{4}{4}$$



$$\text{prec} = \frac{2}{5} \qquad \text{rec} = \frac{2}{4}$$



$$\text{prec} = \frac{0}{0} = 100\% \text{ (I guess)} \qquad \text{rec} = \frac{0}{4}$$

B^3 prec/rec

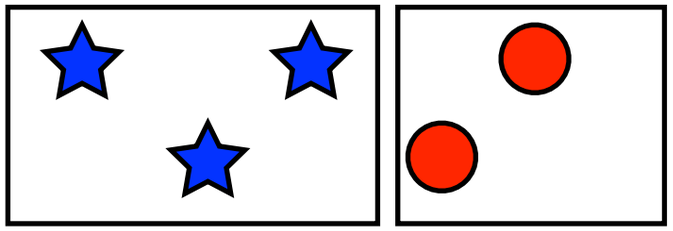
$$\text{prec}_{\text{ment}} = \frac{\text{Num coreferent TP (incl self)}}{\text{Num predicted coreferents (incl self)}}$$

- Mention-averaged versions
  Prec: pick a mention at random.
  Execpted proportion of predicted coreferents are actually coreferent?

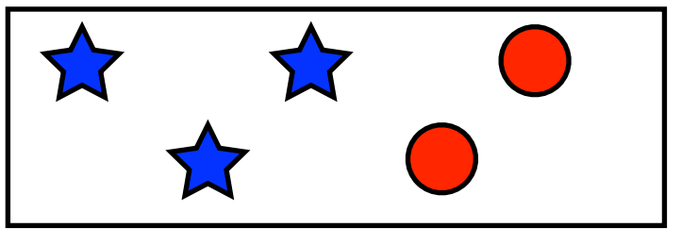
$$B^3\text{-prec} = \frac{1}{\text{Num mentions}} \sum_m \text{prec}_m$$

and analogously for recall

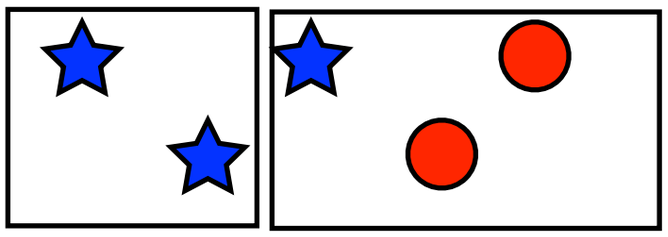
Gold entity1 Gold entity2



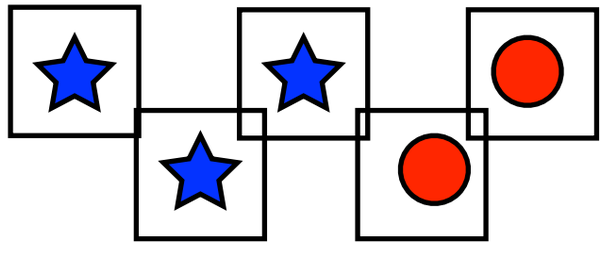
$$\text{prec} = \frac{3/3+3/3+3/3 + 2/2+2/2}{5} \qquad \text{rec} = \frac{3/3+3/3+3/3 + 2/2+2/2}{5}$$



$$\text{prec} = \frac{3/5+3/5+3/5 + 2/5+2/5}{5} \qquad \text{rec} = \frac{3/3+3/3+3/3 + 2/2+2/2}{5}$$



$$\text{prec} = \frac{2/2+2/2 \;+\; 1/3+2/3+2/3}{5} \qquad \text{rec} = \frac{2/3+2/3+1/3+1/2+1/2}{5}$$



$$\text{prec} = \frac{1/1+1/1+1/1+1/1+1/1}{5} \qquad \text{rec} = \frac{1/3+1/3+1/3+1/2+1/2}{5}$$

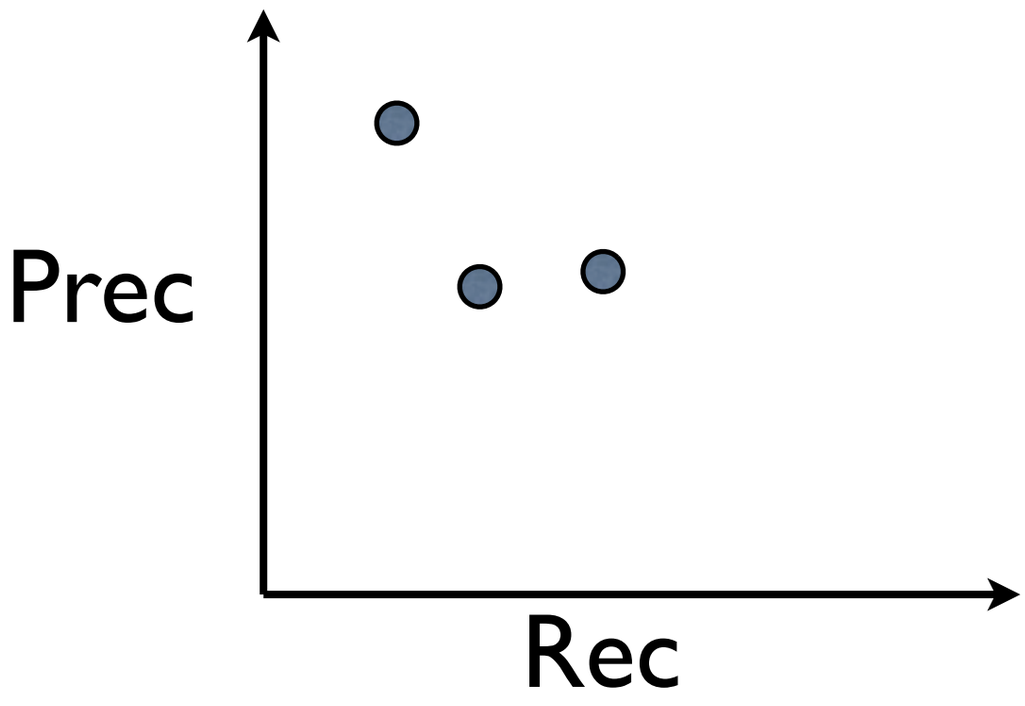
Precision/Recall tradeoffs

- F-score: a very common but somewhat meaningless way to combine precision and recall into one number
  - My prec went up but rec went down. Was it a good change? Without downstream eval, can only answer this in an arbitrary way.
  - Uses a harmonic mean, so if one number is really low, the whole thing is bad

$$F = \frac{2 \times P \times R}{P + R}$$

- Making P/R tradeoffs
  - Rule-based system: Match on anything? Only match if gender and number match?
  - Machine-learning system: say confidence must be at least *t* in order to select a match. Tune *t*?

Visualizing P/R tradeoffs: P-R curve



Semantics and Lexical semantics

Levels of meaning

- 1. Lexical semantics
  - The meaning of words
- 2. Compositional semantics
  - How do word meanings combine to create the meaning of sentences/utterances?
- 3. Discourse/pragmatics
  - How do meanings combine with context to create meaning for an entire text / conversation?

- Entities / coreference: a discourse problem over relatively "simple" concepts (entities...)

Word senses

- What about word meanings that aren't specific entities?
- A single word (word form) can have different *senses*.
  - I went to my bank today.
  - I saw the bank of a river.
- A language dictionary identify these as different senses, e.g. bank#1, bank#2
- What *is* a word meaning?
  One arguable definition:
  a reference to a set of things in the world

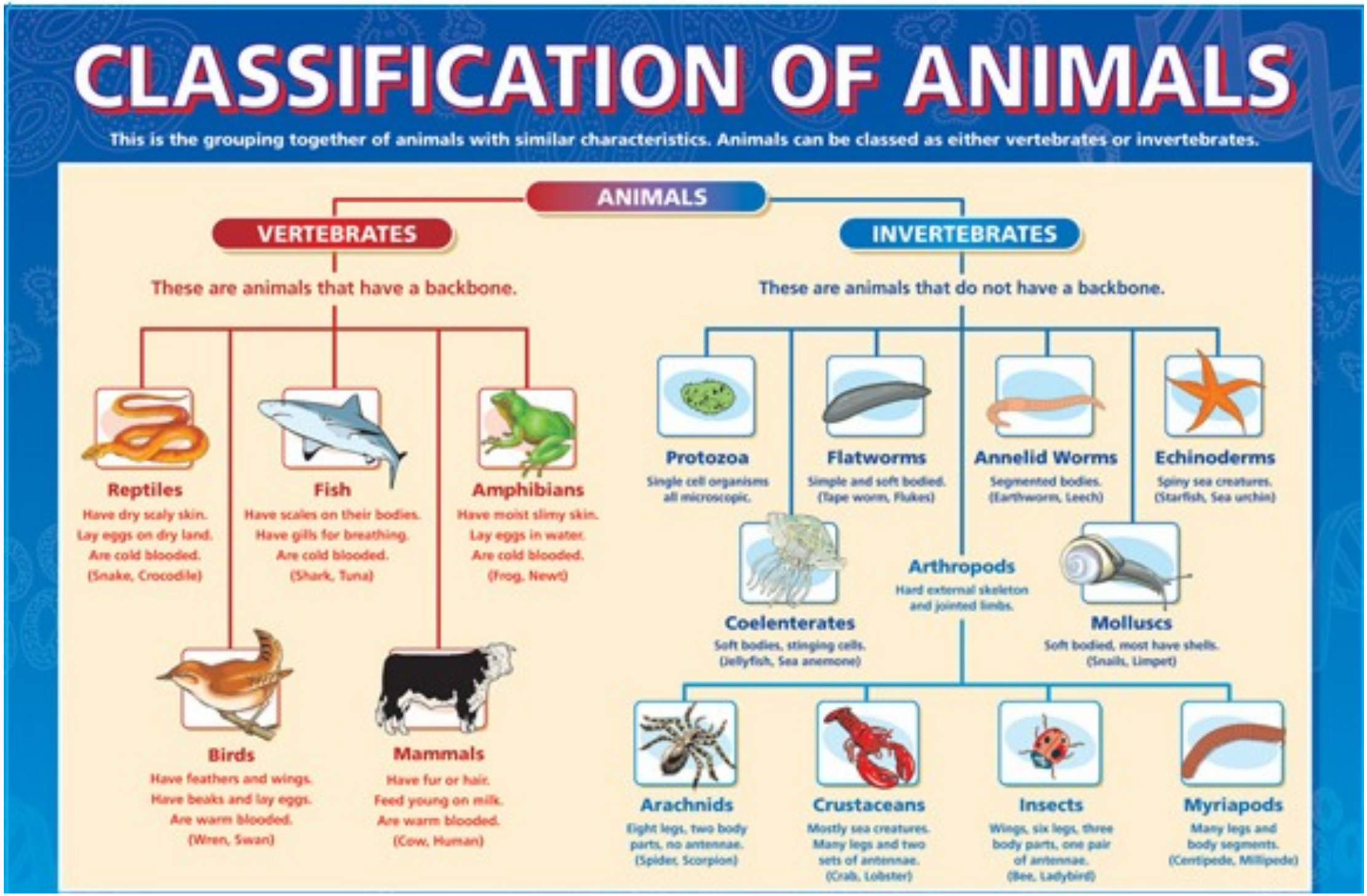
Word sense relations

- Synonymy: bidirectional entailment under substitution (in simple contexts...)
  - I drank cocoa <==> I drank hot chocolate
- Hypernymy: directional entailment under substitution (in simple contexts...)
  - I went to my bank ==> I went to my financial institution
- These relations hold at the sense, not word, level
  - I saw the river bank =/=> I saw the river financial institution

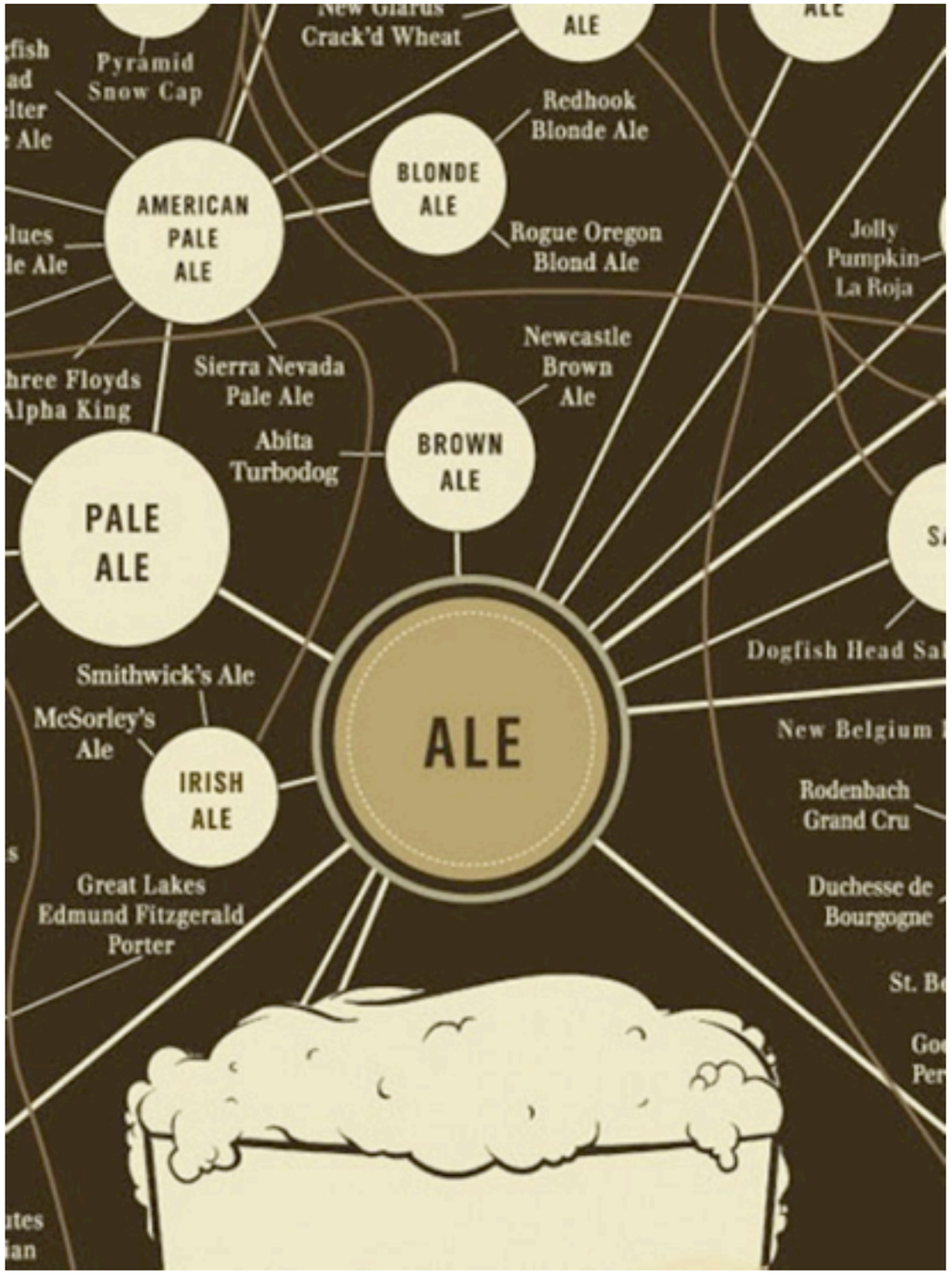
Taxonomies

- Hierarchies of concepts or word meanings
  - For a class, a list of things within that class
- Simple example: word/concept lists
  - List of all baseball teams in the US
  - List of all sports teams in the US

Taxonomy: complex example



Taxonomy: complex example



Wordnet

- One of the biggest lexical resources out there.
- Hand-curated database of word senses for English.
- Each concept ("synset") has
  - A set of words it corresponds to (one-many relationship)
    - A word/lexeme is a (lemma, POS) pair
    - A wordsense is a (lemma,POS,concept) tuple
  - Synonym undirected links b/w concepts
  - Hypernym/Hyponym directed links b/w concepts
- Hyponyms are a DAG (not quite a tree)

Wordnet

POS	#
Noun	117,097
Adjective	22,141
Verb	11,488
Adverb	4,601

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

What's Wordnet good for?

- Going beyond individual words to more general meanings
  - Especially helpful if you can't use supervised ML (no or little training data)
- But WN doesn't always have the right granularity or coverage -- it's hand-built, for better or worse
- WN trick: only use most-frequent-sense

Hyponyms of "person"

7588 total -- with MFS restriction. *[from Michael Heilman]*

- vintager
- matrisib
- horseback rider
- ceo
- seeker
- fieldhand
- radiologist
- captain
- moujik
- research director
- damsel
- nibbler
- nailer
- nude person
- seismologist
- oddball
- prankster
- radiotherapist
- nebraskan
- cupbearer
- psychic
- accompanist
- plagiariser
- timberman
- photographer's model
- lombard
- debaser
- courtier
- dutch uncle
- schlemiel
- dizygotic twin
- mental case
- matriarch
- vocalist
- internist
- transplanter
- techie
- sniffler
- marrano
- first baseman
- government man
- child prodigy
- athenian
- hospital chaplain
- dominatrix
- bibliopole
- hombre
- east indian
- ballet master
- bad person
- rock 'n' roll musician
- flack catcher
- telephoner
- dominus
- cheater
- groveler
- accomplice
- herb doctor
- schoolfriend
- preteen
- gastronome
- concierge
- shogun
- flutist
- bottom dog
- imperialist
- emir
- libeler
- manichaean
- abnegator
- cousin-german
- masorite
- trouble maker
- villainess
- rajpoot
- calapooya
- overlord
- bank guard
- tumbler
- polycarp
- radiographer
- slave owner
- stick-in-the-mud
- audile
- deadbeat
- maltman
- jeweler

Word sense disambiguation

- Say you have a concept database -- has word forms paired with concept entries
- Given "I saw the bank", is it bank#1 or bank#2?
  - "Most frequent sense" baseline
- Given text "Michael Jordan", is it...

- For an entity DB, this is called "entity linking" A form of cross-document coreference
- In all cases: context features are critical

From hierarchy to attributes

- Can a single hierarchy capture all semantic attributes?

- Borges' "Celestial Emporium of Benevolent Knowledge"
  Animals are divided into ...
  - (a) those that belong to the Emperor,
  - (b) embalmed ones,
  - (c) those that are trained,
  - (d) suckling pigs,
  - (e) mermaids,
  - (f) fabulous ones,
  - (g) stray dogs,
  - (h) those that are included in this classification,
  - (i) those that tremble as if they were mad,
  - (j) innumerable ones,
  - (k) those drawn with a very fine camel brush,
  - (l) others,
  - (m) those that have just broken a flower vase,
  - (n) those that resemble flies from a distance.