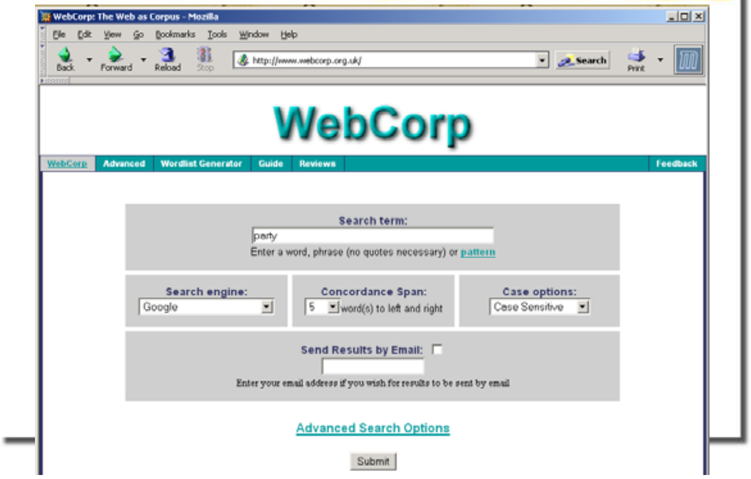
Grouping Words

Linguistic Objects in this Course

- Trees (with strings at the nodes)
  - Syntax, semantics
  - **Algorithms:** Generation, parsing, inside-outside, build semantics
- Sequences (of strings)
  - n-grams, tag sequences
  - morpheme sequences, phoneme sequences
  - **Algorithms:** Finite-state, best-paths, forward-backward
- "Atoms" (unanalyzed strings)
  - Words, morphemes
  - Represent by contexts – other words they occur with
  - **Algorithms:** Grouping similar words, splitting words into senses

A Concordance for "party" from www.webcorp.org.uk



Search term: party

Enter a word, phrase (no quotes necessary) or pattern

Search engine: Google

Concordance Span: 5 word(s) to left and right

Case options: Case Sensitive

Send Results by Email: □

Enter your email address if you wish for results to be sent by email

A Concordance for "party" from www.webcorp.org.uk

- thing. She was talking at a party thrown at Daphne's restaurant in
- have turned it into the hot dinner-party topic. The comedy is the
- selection for the World Cup party, which will be announced on May 1
- in the 1983 general election for a party which, when it could not bear to
- to attack the Scottish National Party, who look set to seize Perth and
- that had been passed to a second party who made a financial decision
- the by-pass there will be a street party. "Then," he says, "we are going
- number-crunchers within the Labour party, there now seems little doubt
- political tradition and the same party. They are both relatively Anglophilic
- he told Tony Blair's modernised party they must not retreat into "warm
- "Oh no, I'm just here for the party," they said. "I think it's terrible
- A future obliges each party to the contract to fulfil it by
- be signed by or on behalf of each party to the contract." Mr David N

What Good are Word Senses?

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What Good are Word Senses?

- John threw a “rain forest” party last December. His living room was full of plants and his box was playing Brazilian music ...

What Good are Word Senses?

- Replace word w with sense s
  - Splits w into senses: distinguishes this token of w from tokens with sense t
  - Groups w with other words: groups this token of w with tokens of x that also have sense s

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- an appearance at the annual awards bash , but feels in no fit state to
- -known families at a fundraising bash on Thursday night for Learning
- Who was paying for the bash? The only clue was the name Asprey,
- Mail, always hosted the annual bash for the Scottish Labour front-
- popular. Their method is to bash sense into criminals with a short,
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What Good are Word Senses?

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What Good are Word Senses?

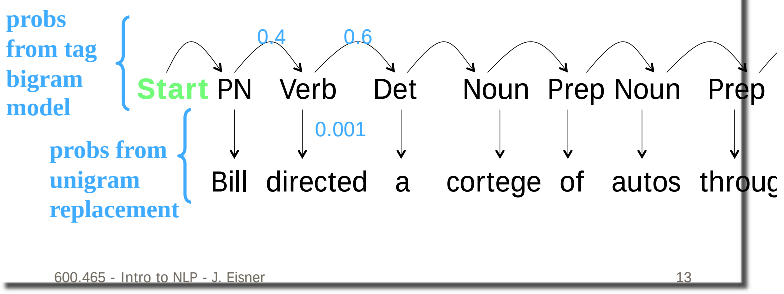
- Semantics / Text understanding
  - Axioms about TRANSFER apply to (some tokens of) `throw`
  - Axioms about BUILDING apply to (some tokens of) `bank`
- Machine translation
- Info retrieval / Question answering / Text categ.
  - Query or pattern might not match document exactly
- Backoff for just about anything
  - what word comes next? (speech recognition, language ID, ...)
    - trigrams are sparse but tri-meanings might not be
  - bilexical PCFGs: p(`S[devour]` → `NP[lion] VP[devour]` | `S[devour]`)
    - approximate by p(S[EAT] → `NP[lion]` VP[EAT] | S[EAT])
- Speaker’s real intention is senses; words are a noisy channel

Cues to Word Sense

- Adjacent words (or their senses)
- Grammatically related words (subject, object, ...)
- Other nearby words
- Topic of document
- Sense of other tokens of the word in the same document

Word Classes by Tagging

- Every tag is a kind of class
- Tagger assigns a class to each word token


probs from tag bigram model
probs from unigram replacement
0.4
0.6
0.001
Start PN Verb Det Noun Prep Noun Prep
Bill directed a cortege of autos throug

Word Classes by Tagging

- Every tag is a kind of class
- Tagger assigns a class to each word token
  - Simultaneously groups and splits words
  - "party" gets split into N and V senses
  - "bash" gets split into N and V senses
  - {party/N, bash/N} vs. {party/V, bash/V}
  - What good are these groupings?

Learning Word Classes

- Every tag is a kind of class
- Tagger assigns a class to each word token
  - {party/N, bash/N} vs. {party/V, bash/V}
  - What good are these groupings?
  - Good for predicting next word or its class!
- Role of forward-backward algorithm?
  - It adjusts classes etc. in order to predict sequence of words better (with lower perplexity)

Words as Vectors

- Represent each word **type** w by a point in k-dimensional space =party
  - e.g., k is size of vocabulary
  - the 17th coordinate of w represents **strength** of w's association with vocabulary word 17

aardvark	abacus	abandoned	abbot	abduct	above		zygote	zymurgy
(0,	0,	3,	1,	0,	7,	. . .	1,	0)

count too high (too influential)

count too low

From corpus:

Jim Jeffords **abandoned** the Republican **party**.
There were lots of **abbots** and nuns dancing at that **party**.
The **party** **above** the art gallery was, **above** all, a laboratory
for synthesizing **zygotes** and beer.

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how might you measure this?

- how often words appear next to each other
- how often words appear near each other
- how often words are syntactically linked
- *should correct for commonness of word (e.g., "above")*

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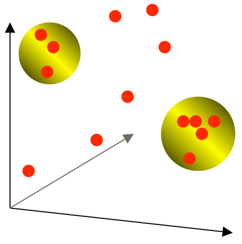
- Plot all word types in k-dimensional space
- Look for **clusters** of close-together types

Learning Classes by Clustering

- Plot all word types in k-dimensional space
- Look for **clusters** of close-together types

Plot in k dimensions (here k=3)

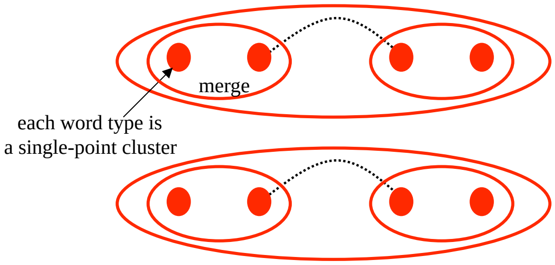


Bottom-Up Clustering

- Start with one cluster per point
- Repeatedly merge 2 closest clusters
  - Single-link: dist(A,B) = min dist(a,b) for a∈A, b∈B
  - Complete-link: dist(A,B) = max dist(a,b) for a∈A, b∈B

example from Manning & Schütze

Bottom-Up Clustering – Single-Link



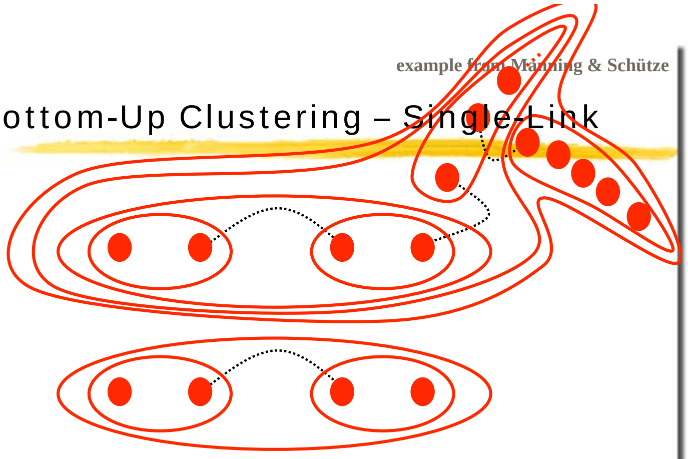
Again, merge closest pair of clusters:

Single-link: clusters are close if any of their points are

dist(A,B) = min dist(a,b) for a∈A, b∈B

example from Manning & Schütze

Bottom-Up Clustering – Single-Link



Again, merge closest pair of clusters:

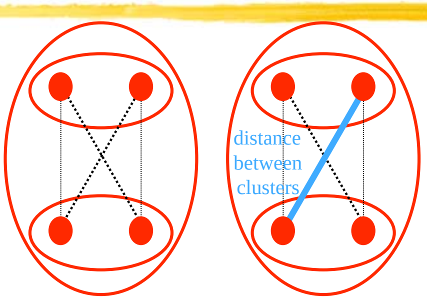
Single-link: clusters are close if any of their points are

dist(A,B) = min dist(a,b) for a∈A, b∈B

Fast, but tend to get long, stringy, meandering clusters

example from Manning & Schütze

Bottom-Up Clustering – Complete-Link



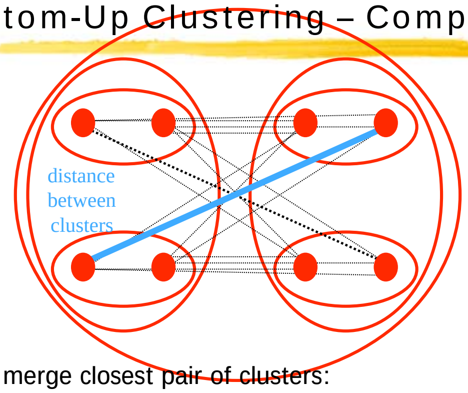
Again, merge closest pair of clusters:

Complete-link: clusters are close only if all of their points are

dist(A,B) = max dist(a,b) for a∈A, b∈B

example from Manning & Schütze

Bottom-Up Clustering – Complete-Link



Again, merge closest pair of clusters:

Complete-link: clusters are close only if all of their points are

dist(A,B) = max dist(a,b) for a∈A, b∈B

Slow to find closest pair – need quadratically many distances

Bottom-Up Clustering

- Start with one cluster per point
- Repeatedly merge 2 closest clusters
  - Single-link: dist(A,B) = min dist(a,b) for a∈A, b∈B
  - Complete-link: dist(A,B) = max dist(a,b) for a∈A, b∈B
    - too slow to update cluster distances after each merge; but ∃ alternatives!
  - Average-link: dist(A,B) = mean dist(a,b) for a∈A, b∈B
  - Centroid-link: dist(A,B) = dist(mean(A),mean(B))
- Stop when clusters are "big enough"
  - e.g., provide adequate support for backoff (on a development corpus)
- Some flexibility in defining dist(a,b)
  - Might not be Euclidean distance; e.g., use vector angle

EM Clustering (for k clusters)

- EM algorithm
  - Viterbi version – called "k-means clustering"
  - Full EM version – called "Gaussian mixtures"

- **Expectation step:** Use current parameters (and observations) to reconstruct hidden structure
- **Maximization step:** Use that hidden structure (and observations) to reestimate parameters

- Parameters: k points representing cluster centers
- Hidden structure: for each data point (word type), which center generated it?

EM Clustering (for k clusters)

- [see spreadsheet animation]