Pre-Processing

(COSC 488)

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Document Processing

Facts:

- Documents may belong to various languages.
  Web: ~ 60% in English

- A given document may have foreign language terms and phrases.

- Skewed term frequency distribution

Outline

- Tokenizing single terms
- Stop terms
- Special terms
- Normalization of tokens
- Phrasing
- Stemming
- n-grams
- links

Parsing Single Terms

- Splitting on white spaces
  - "parsing single terms"

    "Parsing" , "single", "terms"

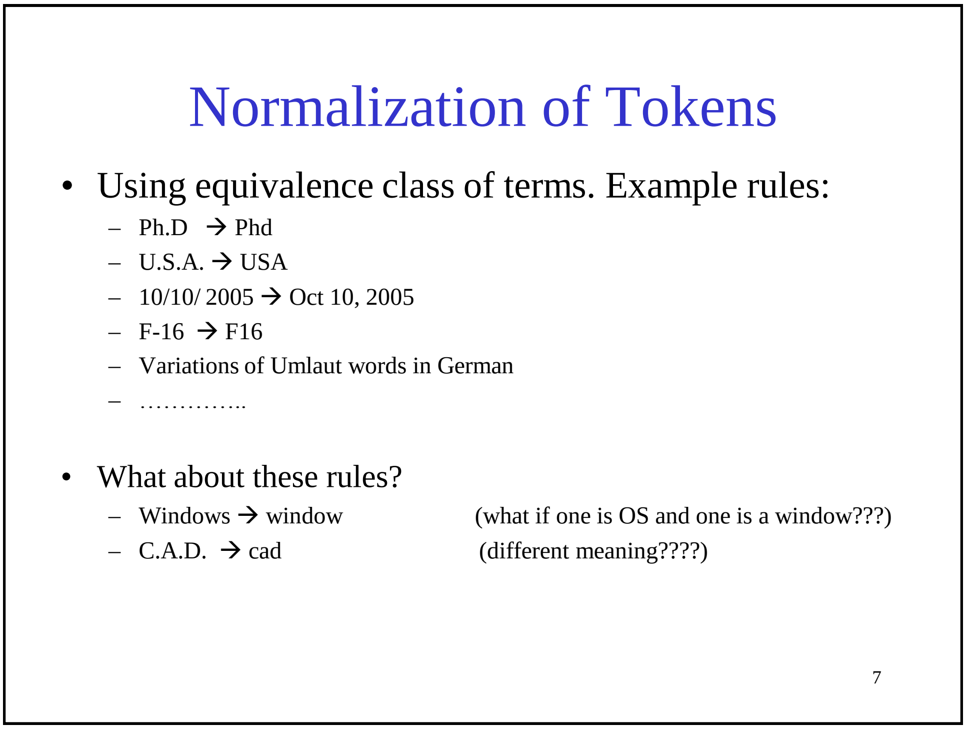
  Problem:
  - "whitespaces" or "white spaces"
  - month day, year "Aug 28, 2008"
  - "Washington DC"
- Each language has somewhat its own conventions as to word boundaries.
  - Some languages use a compound splitter or segmentation software.

Stop Words

- Terms that occur too many times in a collection and hence are not discriminating:
  - to, a, the, of, from,…..
  - Evaluate the stop terms for a domain
  - Stop word lists are maintained
    - Reduces the index size
    - Problem: some search are not successful: “to be or not to be”
    - It is a lossy compression.
  - General trend in IR has been to reduce the size of stop word list or eliminate the use of it.
    - Using a good index compression
    - Weighting stop terms accordingly for query processing (query-based)

Special Tokens

• Dates	2005; Oct 10, 2005; 10/10/2005; 10/10/05
• Digit-alphabet	1-hour
• Alphabet-digit	F-16; I-20
• Hyphenation	co-existence; black-tie party
• All caps	CNN, BBC
• Cap period (initial)	N.
• Digit.digit	8.00
• Digit,digit	8,000
• Currency symbol	$, ….
• Cultural known names	M*A*S*H
• Email address	mouse@hotmail.com
• URLs	http://www.cnn.com
• IP address	123.67.65.870
• Names	New York; Los Angles (Los Angles-New York flights ????)



Normalization of Tokens

- Using equivalence class of terms. Example rules:
  - Ph.D → Phd
  - U.S.A. → USA
  - 10/10/ 2005 → Oct 10, 2005
  - F-16 → F16
  - Variations of Umlaut words in German
  - …………..

- What about these rules?
  - Windows → window (what if one is OS and one is a window???)
  - C.A.D. → cad (different meaning????)

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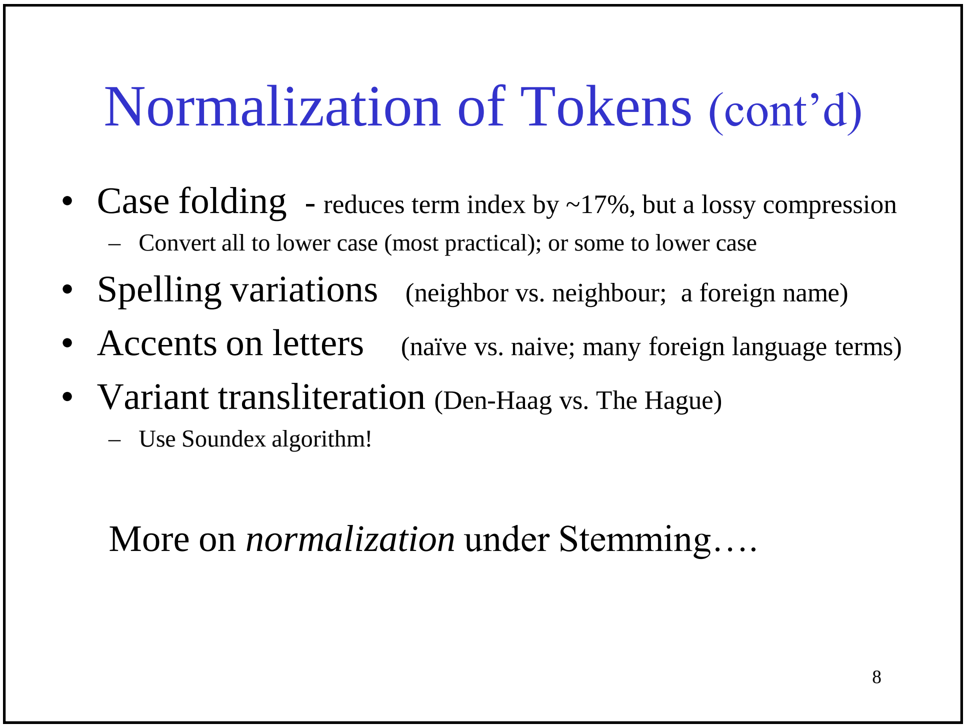

Normalization of Tokens (cont'd)

- Case folding - reduces term index by ~17%, but a lossy compression
  - Convert all to lower case (most practical); or some to lower case
- Spelling variations (neighbor vs. neighbour; a foreign name)
- Accents on letters (naïve vs. naive; many foreign language terms)
- Variant transliteration (Den-Haag vs. The Hague)
  - Use Soundex algorithm!

More on *normalization* under Stemming….

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Phrase processing

- Phrase recognition is based on the goal of indexing meaningful phrases like
  - “Lincoln Town Car”
  - “San Francisco”
  - “apple pie”
- Doing this would use *word order* to assist with effectiveness -- otherwise we are assuming the query and documents are just a “bag of words”
- ~ 10% of web queries are explicit phrase queries

Phrase processing

- Add phrase terms to the query just like other terms
  - This really violates independence assumptions but a lot of people do it anyway
- Give phrase terms a different weight than query terms

Constructing Phrases

using n-gram words

- Using bigrams, trigrams
- Start with all 2-word pairs that are not separated by punctuation, stop words, or special characters
- Only store those that occur more than *x* times
  - Example: New York; Apple Pie;…

Constructing Phrases

using term positions

- Store the term positions
- Identify phrases at the query processing time
- Good flexibility for various window sizes
- May be too slow for large collections

Constructing Phrases

using Part-of-Speech Tagging

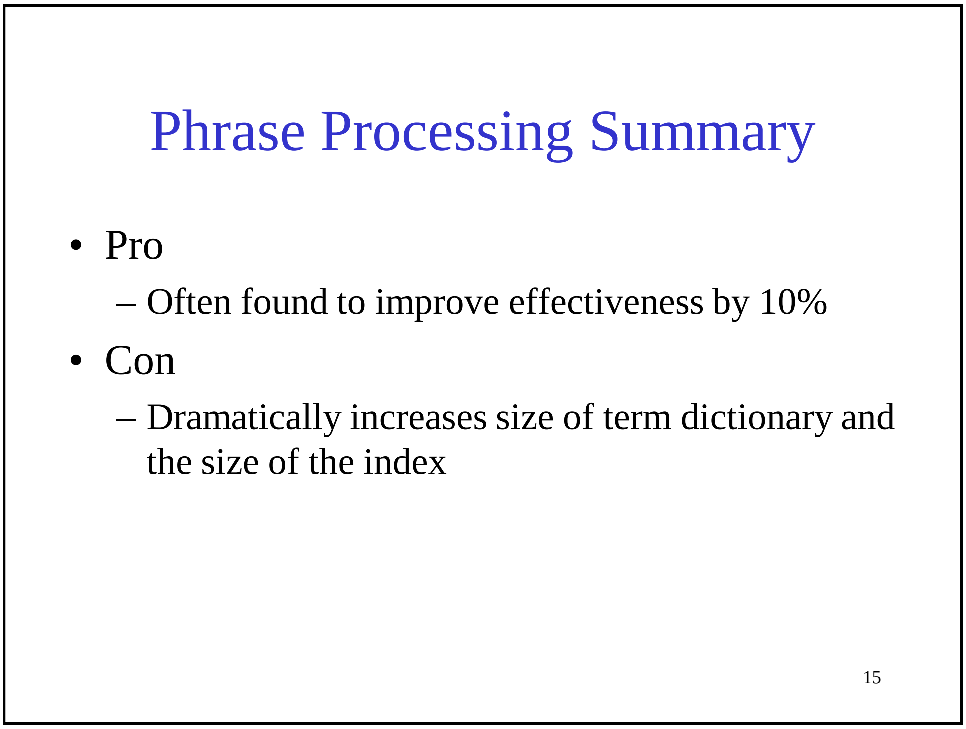
Can take advantage of NLP techniques:

- Using part-of-Speech tagging to identify key components of a sentence (S-V-OBJ, …)
  - store all noun phrases “Republic of China”, or
  - store adjective followed by noun “Red Carpet”
- Problem: too slow!

Constructing Phrases

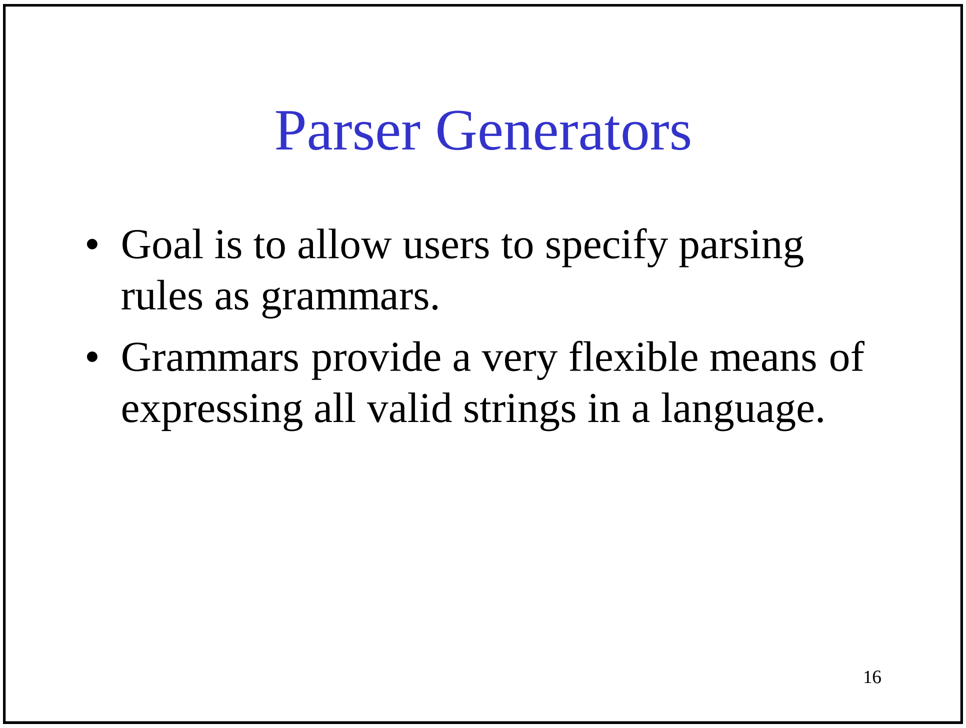
Using Named Entity Tagging

- Finding structured data within an unstructured document
  - People’s names, organizations, locations, amounts, etc.



Phrase Processing Summary

- Pro
  - Often found to improve effectiveness by 10%
- Con
  - Dramatically increases size of term dictionary and the size of the index



Parser Generators

- Goal is to allow users to specify parsing rules as grammars.
- Grammars provide a very flexible means of expressing all valid strings in a language.

Some useful regular expressions

Acronym: (["A"-"Z"]) (["A"-"Z"])*   Ex: NCR, IBM, etc.

Abbreviation: (["A"-"Z"] ".")*   Ex: U.S.A.

Model: ["a"-"z","A"-"Z"] "-" (["0"-"9"])*   Ex: F-16, C-25

Word: ["a"-"z","A"-"Z"] (["a"-"z","A"-"Z"])*   Ex: hippo, Hippo

Integer: ["0"-"9"] (["0"-"9"])*   Ex: 123

Decimal: (["0"-"9"])* "." (["0"-"9"])+   Ex: 123.45

Stemming

- Goal of stemming (Conflation) is to reduce variations of each word due to inflection or derivation to a common stem.
- Improves effectiveness by providing a better match between query and a relevant document.
- User who is searching for “swimming” might be interested in documents with “swim”.
- Reduces the term index by ~17%
- It is a lossy compression.

Stemming

- @ indexing time
  - – Storing only the stems
    - Reduces the flexibility for certain context, improves for some other
    - Reduces index size
  - – Storing both stems and non-stemmed terms
- @ Query processing time
    - Increases the flexibility of not stemming the Q terms
    - Must expand the Q to all term variations (slow)

Stemming Algorithms

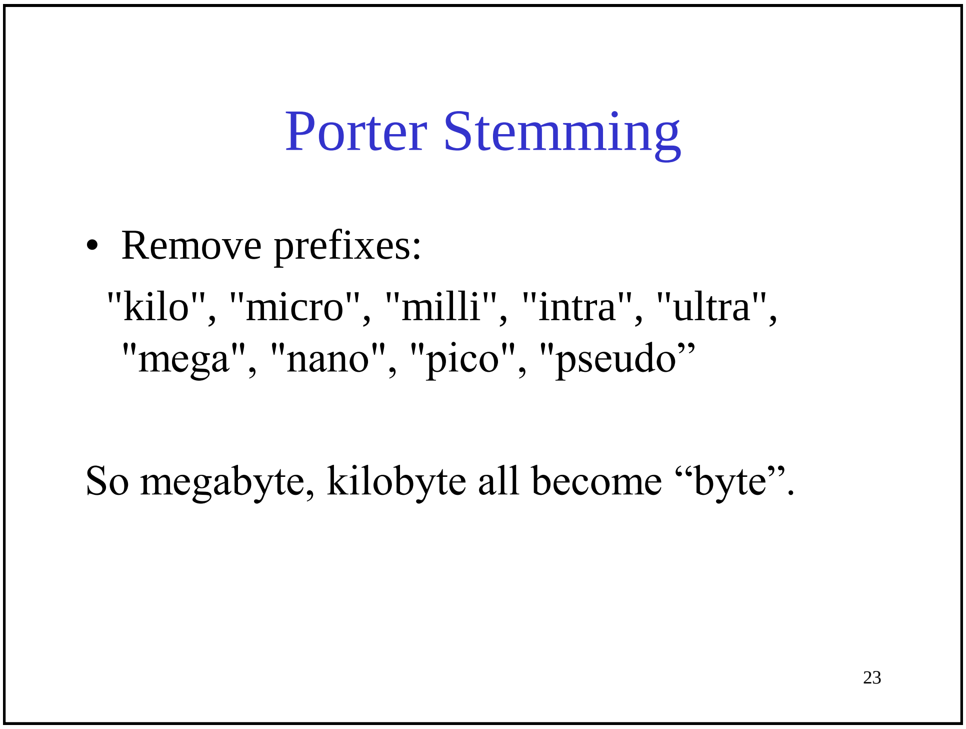
- Stemming algorithms generate *stem classes*.
  - – Rule-Based
    - Porter (1980)
    - Lovins (1968)
  - – Dictionary-based
    - K-stem (1989, 1993)
  - – Corpus/Co-Occurrence-Based (1994)

Porter Stemmer

- An incoming word is cleaned up in the initialization phase, one prefix trimming phase then takes place and then five suffix trimming phases occur.
- Note: The entire algorithm will not be covered -- we will leave out some obscure rules.

Initialization

- First the word is cleaned up. Converted to lower case only letters or digits are kept.
- F-16 is converted to f16.

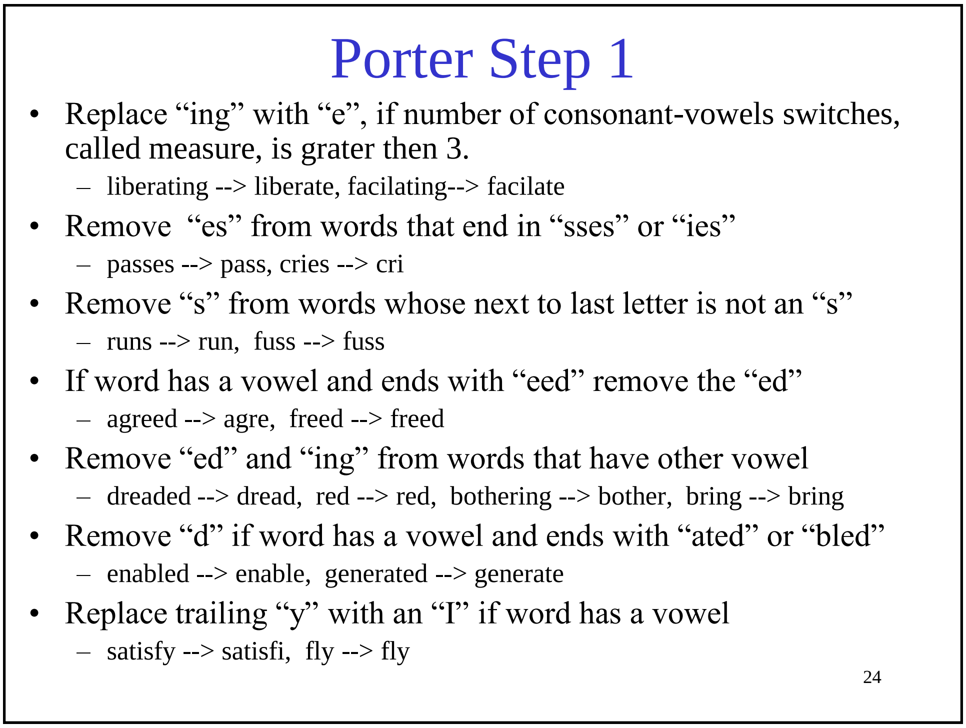


Porter Stemming

- Remove prefixes:

  "kilo", "micro", "milli", "intra", "ultra", "mega", "nano", "pico", "pseudo”

So megabyte, kilobyte all become “byte”.



Porter Step 1

- Replace “ing” with “e”, if number of consonant-vowels switches, called measure, is grater then 3.
  - liberating --> liberate, facilating--> facilate
- Remove “es” from words that end in “sses” or “ies”
  - passes --> pass, cries --> cri
- Remove “s” from words whose next to last letter is not an “s”
  - runs --> run, fuss --> fuss
- If word has a vowel and ends with “eed” remove the “ed”
  - agreed --> agre, freed --> freed
- Remove “ed” and “ing” from words that have other vowel
  - dreaded --> dread, red --> red, bothering --> bother, bring --> bring
- Remove “d” if word has a vowel and ends with “ated” or “bled”
  - enabled --> enable, generated --> generate
- Replace trailing “y” with an “I” if word has a vowel
  - satisfy --> satisfi, fly --> fly

Porter Step 2

- With what is left, replace any suffix on the left with suffix on the right- only if the consonant-vowels measure >0

...

tional	tion	conditional --> condition
ization	ize	nationalization --> nationalize
iveness	ive	effectiveness --> effective
fulness	ful	usefulness --> useful
ousness	ous	nervousness --> nervous
ousli	ous	nervously --> nervous
entli	ent	fervently --> fervent
iveness	ive	inventiveness --> inventive
biliti	ble	sensibility --> sensible

...

Step 3

- With what is left, replace any suffix on the left with suffix on the right

...

icate	ic	fabricate --> fabric (*Think about this one*)
ative	--	combativ --> comb (*another good one)*
alize	al	nationalize --> national
iciti	ic	
ical	ic	tropical --> tropic
ful	--	faithful --> faith
iveness	ive	inventiveness --> inventive
ness	--	harness --> har

Step 4

- Remove remaining standard suffixes

al, ance, ence, er, ic, able, ible, ant, ement, ment, ent, sion, tion, ou, ism, ate, iti, ous, ive, ize, ise

Step 5

- Remove trailing “e” if word does not end in a vowel
  - – hinge --> hing
  - – free --> free

Porter Summary

- Con
  - many words with different meanings have common stems (e.g.; *fabricate* and *fabric*)
  - a lot of stems are not words

Dictionary based approaches (K-Stem)

- Using dictionaries to ensure that the generated stem is a valid word.
  - Develop some candidate words by removing the endings
  - Find the longest word that is in the dictionary that matches one of the candidates.
- Pro: This eliminates the Porter problem that many stems are not words.
- Con: Language dependent approach

Corpus-based Co-Occurrence

- Use Porter or other stemmer to stem terms
- Place words in potential classes
- Measure the frequency of co-occurrence of terms in the class
- Eliminate words from a class with a low co-occurrence
- Remaining classes form stemming rules

Corpus-based Co-Occurrence

- Pro
  - Language independent (no need of dictionary)
  - Based on assumption that terms in a class will co-occur with other terms “hippo” will co-occur with “hippos”
  - Improves effectiveness
- Con
  - Computationally expensive to build co-occurrence matrix (but you only do it every now and then)

N-grams

- Noise such as OCR (Optical Character Recognition) errors or misspelling lower the query processing accuracy in a term-based search.
- The premise is:
  - Substrings of a term may help to find a match in the noise cases
- Replace terms with n-grams
- Language-independent -- *no stemming or stop word removal needed*

5-Gram Example

- Q: What technique **work**s **on nois**e and mis**spelled** words?
- D_1: N-grams **work on nois**y mis**pelled** text.

_work
_on_no
on_noi
n_nois

spell
pelle
elled
lled_

- 8 terms are matched
- No stemming of work, noise
- Partial match of misspelled word

N-gram Summary

- Pro
  - Language independent
  - Works on garbled text (OCR, etc.)
- Con
  - There can be a LOT of n-grams, dictionary may not fit in memory anymore *(thus, only some are kept)*
  - Query processing requires more resources

Links

- Web documents contain *link* information that is parsed and used for query processing and ranking (ex: pageRank,…).
  - *Anchor text*
  - *Inlinks* and *outlinks*

Token Processing Summary

- Token Processing can make a difference in effectiveness
- It is often overlooked
- Language independence approach is preferred