Introduction to

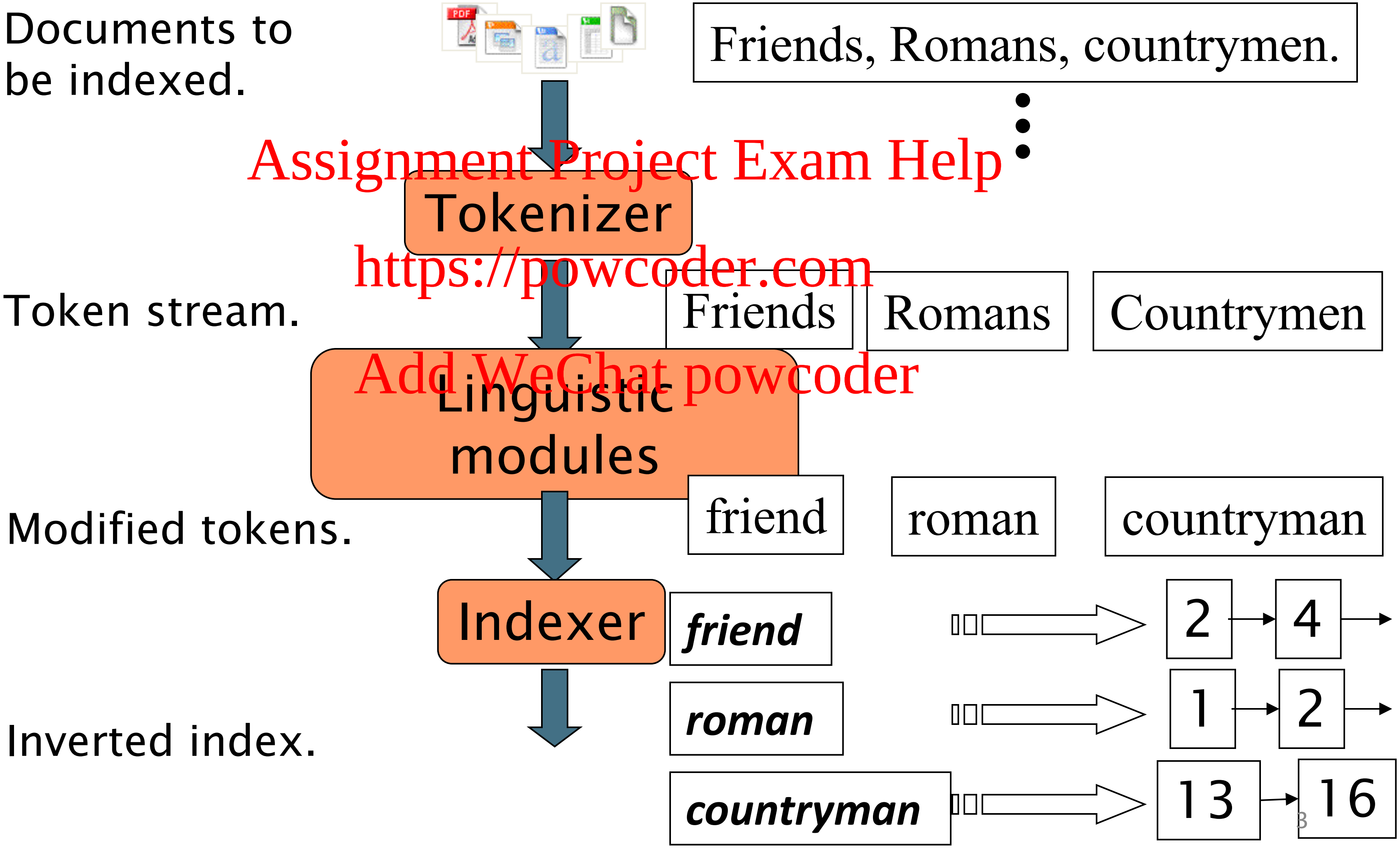
Information Retrieval

Lecture 2: Preprocessing

Plan for this lecture

- Preprocessing to form the term vocabulary
  - Documents
  - Tokenization
  - What *terms* do we put in the index?

Recall the basic indexing pipeline



Documents to be indexed.

Friends, Romans, countrymen.

Tokenizer

Token stream.

Friends | Romans | Countrymen

Linguistic modules

Modified tokens.

friend | roman | countryman

Indexer

Inverted index.

friend → 2 → 4 →

roman → 1 → 2 →

countryman → 13 → 16

Parsing a document

- What format is it in?
  - pdf/word/excel/html?
- What language is it in?
- What character set is in use?

Each of these is a classification problem

But these tasks are often done heuristically …

Complications: Format/language

- Documents being indexed can include docs from many different languages
  - A single index may have to contain terms of several languages.
- Sometimes a document or its components can contain multiple languages/formats
  - French email with a German pdf attachment.
- What is a unit document?
  - A file?
  - An email? (Perhaps one of many in an mbox.)
  - An email with 5 attachments?
  - A group of files (PPT or LaTeX as HTML pages)

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Tokens

Tokenization

- Input: "***Friends, Romans and Countrymen***"
- Output: Tokens
  - ***Friends***
  - ***Romans***
  - ***Countrymen***

- A token is an instance of a sequence of characters
- Each such token is now a candidate for an index entry, after further processing
  - Described below
- But what are valid tokens to emit?

Tokenization

- Issues in tokenization:
  - ***Finland's capital*** → ***Finland? Finlands? Finland's***?
    - ***How about O'Neil?***
  - ***Hewlett-Packard*** → ***Hewlett*** and ***Packard*** as two tokens?
    - ***state-of-the-art***: break up hyphenated sequence.
    - ***co-education***
    - ***lowercase***, ***lower-case***, ***lower case*** ?
  - ***San Francisco***: one token or two?
    - York University? New York University?

Numbers

- ***3/20/91   Mar. 20, 1991   20/3/91***
- ***55 B.C.***
- ***B-52***
- ***My PGP key is 324a3df234cb23e***
- ***(800) 234-2333***
  - Often have embedded spaces
  - Older IR systems may not index numbers
    - But often very useful: think about things like looking up error codes/stacktraces on the web
  - Will often index “meta-data” separately
    - Creation date, format, etc.

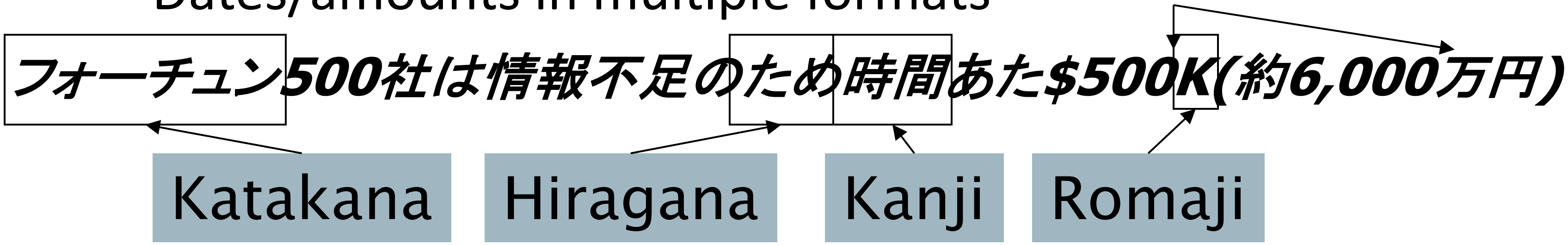
Tokenization: language issues

- French
  - ***L'ensemble*** → one token or two?
    - ***L*** ? ***L'*** ? ***Le*** ?
    - Want ***l'ensemble*** to match with ***un ensemble***
      - Until at least 2003, it didn't on Google
        - Internationalization!
- German noun compounds are not segmented
  - ***Lebensversicherungsgesellschaftsangestellter***
  - 'life insurance company employee'
  - German retrieval systems benefit greatly from a **compound splitter** module
      - Can give a 15% performance boost for German

南京市长江大桥

Tokenization: language issues

- Chinese and Japanese have no spaces between words:
  - 莎拉波娃现在居住在美国东南部的佛罗里达。
  - Not always guaranteed a unique tokenization
- Further complicated in Japanese, with multiple alphabets intermingled
  - Dates/amounts in multiple formats



End-user can express query entirely in hiragana!

Tokenization: language issues

- Arabic (or Hebrew) is basically written right to left, but with certain items like numbers written left to right
- Words are separated, but letter forms within a word form complex **ligatures**

استقلت الجزائر في سنة 1962 بعد 132 عاما من الاحتلال الفرنسي.

- ← → ← → ← start
- ‘Algeria achieved its independence in 1962 after 132 years of French occupation.’
- With Unicode, the surface presentation is complex, but the stored form is straightforward

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Terms

The things indexed in an IR system

Stop words

- With a stop list, you exclude from the dictionary entirely the commonest words. Intuition:
  - They have little semantic content: *the, a, and, to, be*
  - There are a lot of them: ~30% of postings for top 30 words
- But the trend is away from doing this:
  - Good compression techniques (lecture 5) means the space for including stopwords in a system is very small
  - Good query optimization techniques (lecture 7) mean you pay little at query time for including stop words.
  - You need them for:
    - Phrase queries: “King of Denmark”
    - Various song titles, etc.: “Let it be”, “To be or not to be”
    - “Relational” queries: “flights to London” vs. “flights from London”

Normalization to terms

- We need to "normalize" words in indexed text as well as query words into the same form
  - We want to match ***U.S.A.*** and ***USA***
- Result is terms: a term is a (normalized) word type, which is an entry in our IR system dictionary
- We most commonly implicitly define equivalence classes of terms by, e.g.,
  - deleting periods to form a term
    - ***U.S.A., USA → USA***
  - deleting hyphens to form a term
    - ***anti-discriminatory, antidiscriminatory → antidiscriminatory***

Normalization: other languages

- Accents: e.g., French ***résumé*** vs. ***resume*.**
- Umlauts: e.g., German: ***Tuebingen*** vs. ***Tübingen***
  - Should be equivalent

- Most important criterion:
  - How are your users like to write their queries for these words?

- Even in languages that standardly have accents, users often may not type them
  - Often best to normalize to a de-accented term
    - ***Tuebingen, Tübingen, Tubingen*** ⎝ ***Tubingen***

Normalization: other languages

- Normalization of things like date forms
  - ***7月30日 vs. 7/30***
  - ***Japanese use of kana vs. Chinese characters***

- Tokenization and normalization may depend on the language and so is intertwined with language detection

Morgen will ich in MIT …

Is this German “mit”?

- Crucial: Need to “normalize” indexed text as well as query terms into the same form

Case folding

- Reduce all letters to lower case
  - exception: upper case in mid-sentence?
    - e.g., ***General Motors***
    - ***Fed*** vs. ***fed***
    - ***SAIL*** vs. ***sail***
  - Often best to lower case everything, since users will use lowercase regardless of 'correct' capitalization…

- Google example:
  - Query ***C.A.T.***
  - #1 result is for "cat" (well, Lolcats) *not* Caterpillar Inc.

Normalization to terms

- An alternative to equivalence classing is to do asymmetric expansion
- An example of where this may be useful
  - Enter: ***window*** Search: ***window, windows***
  - Enter: ***windows*** Search: ***Windows, windows, window***
  - Enter: ***Windows*** Search: ***Windows***
- Potentially more powerful, but less efficient

Thesauri and soundex

- Do we handle synonyms and homonyms?
  - E.g., by hand-constructed equivalence classes
    - ***car*** = ***automobile*** ***color*** = ***colour***

  - We can rewrite to form equivalence-class terms
    - When the document contains ***automobile***, index it under ***car-automobile*** (and vice-versa)

  - Or we can expand a query

    - When the query contains ***automobile***, look under ***car*** as well
- What about spelling mistakes?
  - One approach is soundex, which forms equivalence classes of words based on phonetic heuristics
- More in later lectures

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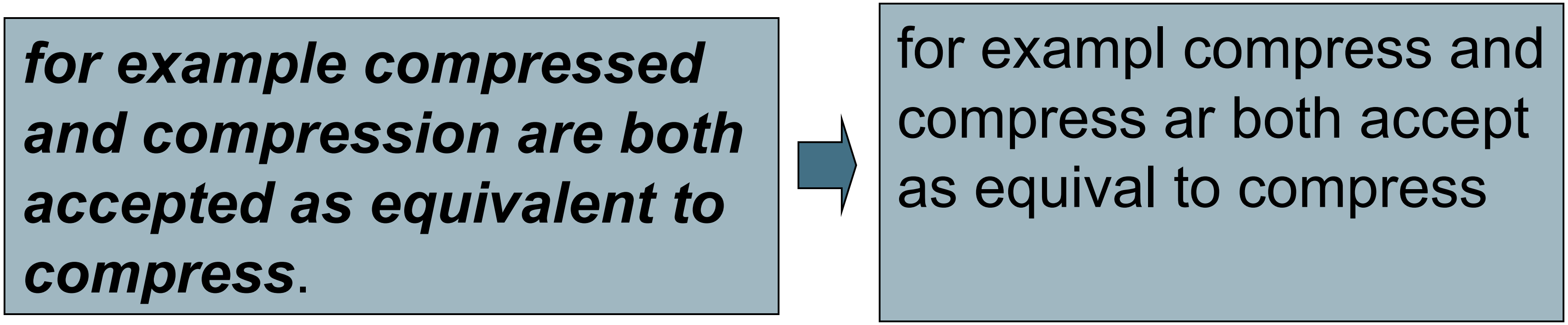
Lemmatization and Stemming

Lemmatization

- Reduce inflectional/variant forms to base form
- E.g.,
  - *am, are, is* → *be*
  - *car, cars, car's, cars'* → *car*
- *the boy's cars are different colors* → *the boy car be different color*
- Lemmatization implies doing “proper” reduction to dictionary headword form

Stemming

- Reduce terms to their “roots” before indexing
- “Stemming” suggest crude affix chopping
  - language dependent
  - e.g., ***automate(s), automatic, automation*** all reduced to ***automat***.



for example compressed and compression are both accepted as equivalent to compress.

for exampl compress and compress ar both accept as equival to compress

Porter’s algorithm

- Commonest algorithm for stemming English
  - Results suggest it’s at least as good as other stemming options
- Conventions + 5 phases of reductions
  - phases applied sequentially
  - each phase consists of a set of commands
  - sample convention: *Of the rules in a compound command, select the one that applies to the longest suffix.*

Typical rules in Porter

- *s* →
- *sses* → *ss*
- *ies* → *i*
- *ational* → *ate*
- *tional* → *tion*

- Weight of word sensitive rules
- *(m>1) EMENT* →
  - *replacement* → *replac*
  - *cement* → *cement*

Other stemmers

- Other stemmers exist, e.g., Lovins stemmer
  - http://www.comp.lancs.ac.uk/computing/research/stemming/general/lovins.htm
  - Single-pass, longest suffix removal (about 250 rules)
- Full morphological analysis – at most modest benefits for retrieval
- Do stemming and other normalizations help?
  - English: very mixed results. Helps recall for some queries but harms precision on others
    - E.g., operative (dentistry) ⇒ oper
  - Definitely useful for Spanish, German, Finnish, …
    - 30% performance gains for Finnish!

Language-specificity

- Many of the above features embody transformations that are
  - Language-specific and
  - Often, application-specific
- These are "plug-in" addenda to the indexing process
- Both open source and commercial plug-ins are available for handling these

Dictionary entries – first cut

ensemble.french
時間.japanese
MIT.english
mit.german
guaranteed.english
entries.english
sometimes.english
tokenization.english

These may be grouped by language (or not…). More on this in ranking/query processing.

Resources for today's lecture

- IIR 2
- MG 3.6, 4.3; MIR 7.2
- Porter's stemmer: http://www.tartarus.org/~martin/PorterStemmer/