Administrivia

Assignment 0

Assignment 1 out
- due Monday
- no code submitted, but will require coding
- will require some command-line work

Reading

Pronouns

he/him/his
NLP models

How do people learn/acquire language?

A lot of debate about how human's learn language
- Rationalist (e.g. Chomsky)
- Empiricist

From my perspective (and many people who study NLP)... I don't care :)

Strong AI vs. weak AI: don’t need to accomplish the task the same way people do, just the same task
- Machine learning
- Statistical NLP

Vocabulary

Word
- a unit of language that native speakers can identify
- words are the blocks from which sentences are made

Sentence
- a string of words satisfying the grammatical rules of a language

Document
- A collection of sentences

Corpus
- A collection of related texts

Corpus examples

Any you’ve seen or played with before?
Corpus characteristics

What are some defining characteristics of corpora?

- Monolingual vs. parallel language
- Annotated (e.g., parts of speech, classifications, etc.)
- Source (where it came from)
- Size

Corpus examples

- Linguistic Data Consortium
  - http://www.ldc.upenn.edu/Catalog/byType.jsp
- Dictionaries
  - WordNet — 206K English words
  - CELEX2 — 365K German words
- Monolingual text
  - Gigaword corpus
    - 4M documents (mostly news articles)
    - 1.7 trillion words
    - 11GB of data (4GB compressed)
  - Enron e-mails
    - 517K e-mails

- Parallel data
  - ~10M sentences of Chinese-English and Arabic-English
  - Europarl
    - ~25M sentence pairs with English with 21 different languages

Monolingual text continued
- Twitter
- Chatroom
- Many non-English resources
Corpus examples

Annotated
- Brown Corpus
  - 1M words with part of speech tag
- Penn Treebank
  - 1M words with full parse trees annotated
- Other treebanks
  - Treebank refers to a corpus annotated with trees (usually syntactic)
  - Chinese: 51K sentences
  - Arabic: 145K words
  - many other languages...
  - BLIPP: 300M words (automatically annotated)

Corpora examples

Many others...
- Spam and other text classification
- Google n-grams
  - 2006 (24GB compressed!)
  - 13M unigrams
  - 300M bigrams
  - ~1B 3, 4 and 5-grams
- Speech
- Video (with transcripts)

Corpus analysis

Corpora are important resources

Often give examples of an NLP task we’d like to accomplish

Much of NLP is data-driven!

A common and important first step to tackling many problems is analyzing the data you’ll be processing

Corpus analysis

What types of questions might we want to ask?

How many...
- documents, sentences, words

On average, how long are the:
- documents, sentences, words

What are the most frequent words? pairs of words?

How many different words are used?

Data set specifics, e.g. proportion of different classes?

...
Corpora issues

Somebody gives you a file and says there’s text in it

Issues with obtaining the text?
- text encoding
- language recognition
- formatting (e.g. web, xml, …)
- misc. information to be removed
  - header information
  - tables, figures
  - footnotes

A rose by any other name…

Word
- a unit of language that native speakers can identify
- words are the blocks from which sentences are made

Concretely:
- We have a stream of characters
- We need to break into words
- What is a word?
- Issues/problem cases?
- Word segmentation/tokenization?

Tokenization issues:

Finland's capital…

What are the benefits/drawbacks?
<table>
<thead>
<tr>
<th>Tokenization issues: '</th>
<th>Tokenization issues: '</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aren't we ...</td>
<td>Aren't we ...</td>
</tr>
<tr>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>21</td>
<td>22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tokenization issues: hyphens</th>
<th>Tokenization issues: hyphens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hewlett-Packard</td>
<td>state-of-the-art</td>
</tr>
<tr>
<td>co-education</td>
<td>lower-case</td>
</tr>
<tr>
<td>take-it-or-leave-it</td>
<td>26-year-old</td>
</tr>
<tr>
<td>?</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>24</td>
</tr>
</tbody>
</table>

What are the benefits/drawbacks?
More tokenization issues

- Compound nouns: San Francisco, Los Angelos, …
  - One token or two?

- Numbers
  - Examples
    - Dates: 3/12/91
    - Model numbers: B-52
    - Domain specific numbers: PGP key - 324a3df234cb23e
    - Phone numbers: (800) 234-2333
    - Scientific notation: 1.456 e-10

Tokenization: language issues

- Lebensversicherungsgesellschaftsangestellter
  - ‘life insurance company employee’

- Opposite problem we saw with English (San Francisco)
- German compound nouns are not segmented
- German retrieval systems frequently use a compound splitter module

Word counts: Tom Sawyer

- How many words?
  - 71,370 total
  - 8,018 unique

- Is this a lot or a little? How might we find this out?
  - Random sample of news articles: 11K unique words

- What does this say about Tom Sawyer?
  - Simpler vocabulary (colloquial, audience target, etc.)
Word counts

<table>
<thead>
<tr>
<th>Word</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>the</td>
<td>3332</td>
</tr>
<tr>
<td>and</td>
<td>2972</td>
</tr>
<tr>
<td>a</td>
<td>1725</td>
</tr>
<tr>
<td>to</td>
<td>1440</td>
</tr>
<tr>
<td>of</td>
<td>1161</td>
</tr>
<tr>
<td>was</td>
<td>1027</td>
</tr>
<tr>
<td>it</td>
<td>906</td>
</tr>
<tr>
<td>in</td>
<td>877</td>
</tr>
<tr>
<td>that</td>
<td>877</td>
</tr>
<tr>
<td>he</td>
<td>783</td>
</tr>
<tr>
<td>his</td>
<td>772</td>
</tr>
<tr>
<td>you</td>
<td>686</td>
</tr>
<tr>
<td>Tom</td>
<td>679</td>
</tr>
<tr>
<td>with</td>
<td>642</td>
</tr>
</tbody>
</table>

What are the most frequent words?

What types of words are most frequent?

8K words in vocab
71K total occurrences

Zipf’s “Law”

The frequency of the occurrence of a word is inversely proportional to its frequency of occurrence ranking.

Their relationship is log-linear, i.e. when both are plotted on a log scale, the graph is a straight line.

Zipf’s law

At a high level:
- a few words occur very frequently
- a medium number of elements have medium frequency
- many words occur very infrequently
Zipf’s law

\[ f = C \frac{1}{r} \]

The product of the frequency of words \((f)\) and their rank \((r)\) is approximately constant.

Constant is corpus dependent, but generally grows roughly linearly with the amount of data.

Zipf’s law: Brown corpus

Zipf’s law: Tom Sawyer

<table>
<thead>
<tr>
<th>Word</th>
<th>Frequency</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>the</td>
<td>3332</td>
<td>1</td>
</tr>
<tr>
<td>end</td>
<td>?</td>
<td>2</td>
</tr>
</tbody>
</table>

\[ C = f \cdot r \]

\[ f = C \cdot \frac{1}{r} \]

\[ f = 3332 \cdot \frac{1}{2} = 1666 \]
### Zipf's Law: Tom Sawyer

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</tr>
<tr>
<td>end</td>
<td>2972</td>
<td>2</td>
</tr>
</tbody>
</table>

\[ f = C \frac{1}{r} \]

\[ C = f^*r \]

\[ C = 3332 \times \frac{1}{2} = 1666 \]

<table>
<thead>
<tr>
<th>Word</th>
<th>Frequency</th>
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</tr>
</thead>
<tbody>
<tr>
<td>he</td>
<td>877</td>
<td>10</td>
</tr>
<tr>
<td>friends</td>
<td>1775</td>
<td>800</td>
</tr>
</tbody>
</table>

\[ f = C \frac{1}{r} \]

\[ C = f^*r \]

\[ C = 2972 \times 2 = 5944 \]

\[ \approx 1981 \]

<table>
<thead>
<tr>
<th>Word</th>
<th>Frequency</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>he</td>
<td>877</td>
<td>10</td>
</tr>
<tr>
<td>friends</td>
<td>8770</td>
<td>800</td>
</tr>
</tbody>
</table>

\[ f = C \frac{1}{r} \]

\[ C = f^*r \]

\[ C = 8770 \times \frac{1}{800} = 10.96 \]
Zipf’s law: Tom Sawyer

<table>
<thead>
<tr>
<th>Word</th>
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<td>he</td>
<td>877</td>
<td>10</td>
</tr>
<tr>
<td>friends</td>
<td>10</td>
<td>800</td>
</tr>
</tbody>
</table>

\[
f = C \frac{1}{r}
\]

\[
C = f \times r = 877 \times 10 = 8770
\]

What does this imply about \( C/\text{zipf’s law} \)? How would you pick \( C? \)

Sentences

Sentence
- a string of words satisfying the grammatical rules of a language

Sentence segmentation
- How do we identify a sentence?
- Issues/problem cases?
- Approach?

Sentence segmentation: issues

A first answer:
- something ending in . ? !
- gets 90% accuracy

Dr. Dave gives us just the right amount of homework.

Abbreviations can cause problems
Sentence segmentation: issues

A first answer:
- something ending in a: . ? !
- gets 90% accuracy

The scene is written with a combination of unbridled passion and sure-handed control. In the exchanges of the three characters and the rise and fall of emotions, Mr. Weller has captured the heartbreaking inexorability of separation.

sometimes: ; and – might also denote a sentence split

"You remind me," she remarked, "of your mother."

Quotes often appear outside the ending marks

Sentence segmentation

Place initial boundaries after: . ? !

Move the boundaries after the quotation marks, if they follow a break

Remove a boundary following a period if:
- it is a known abbreviation that doesn’t tend to occur at the end of a sentence (Prof., vs.)
- it is preceded by a known abbreviation and not followed by an uppercase word

Sentence length

What is the average sentence length, say for news text?

<table>
<thead>
<tr>
<th>Length</th>
<th>percent</th>
<th>cumul. percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>6-10</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>11-15</td>
<td>14</td>
<td>25</td>
</tr>
<tr>
<td>16-20</td>
<td>17</td>
<td>42</td>
</tr>
<tr>
<td>21-25</td>
<td>17</td>
<td>59</td>
</tr>
<tr>
<td>26-30</td>
<td>15</td>
<td>74</td>
</tr>
<tr>
<td>31-35</td>
<td>11</td>
<td>86</td>
</tr>
<tr>
<td>36-40</td>
<td>7</td>
<td>92</td>
</tr>
<tr>
<td>41-45</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>46-50</td>
<td>2</td>
<td>98</td>
</tr>
<tr>
<td>51-100</td>
<td>1</td>
<td>99.99</td>
</tr>
<tr>
<td>101+</td>
<td>0.01</td>
<td>100</td>
</tr>
</tbody>
</table>
A real-world example