Counting Words, Corpus Statistics, Encoding

Sprachverarbeitung (VL + Ü)

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Recap

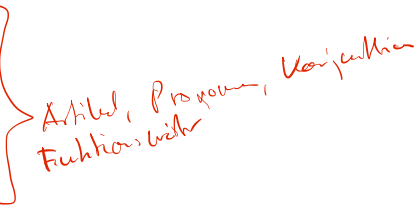
- Computational Linguistics as a discipline between computer science and linguistics
  - also known as »natural language processing«, (NLP)
  - Experiments are important way of making progress in CL
- Corpora
- Tokenization
- Counting words on the command line, extracting word frequencies

Section 1

Corpora

Word Counts

Count	Word
585	die
584	und
407	er
404	der
348	zu
311	sich
259	nicht
250	sie
243	in
243	den
233	war
218	Gregor
189	mit
178	das
176	auf
171	es
162	dem
155	hatte
137	ein
136	aber
133	daß
123	als
110	auch
107	Schwester
	...



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- Number of words in a text
- Most frequent words (MFW) are function words
- ›Content words‹ that appear often indicate text content

Zipf's Law

Manning/Schütze, 1999, 23 ff.

- George Kingsley Zipf (1902-1950): American Linguist
- Basic property of human language
  - Frequency distribution of words (in a corpus) is stable
  - Word frequency is inversely proportional to its position in the ranking

$$f \propto \frac{1}{r}$$

(there is a constant k, such that $f \times r = k$)

Zipf's Law

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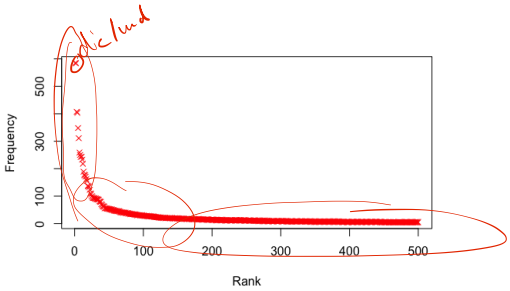

Figure: Words sorted after their frequency (red). Text: Kafka's »Die Verwandlung«.

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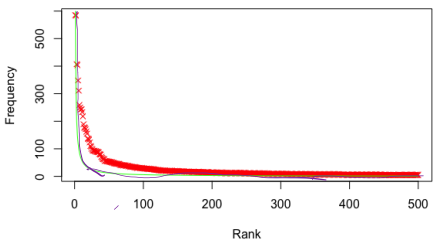

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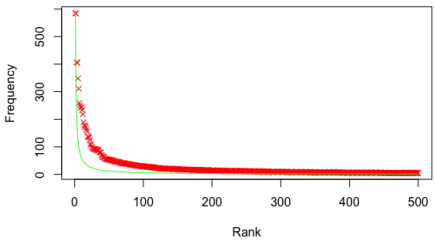

Figure: Words sorted after their frequency (red). Zipf distribution: $y = 600\frac{1}{x}$ (green). Text: Kafka's »Die Verwandlung«.

Consequences

- Very few words appear with very high frequency
- The vast majority of words appear only once
  - It's difficult to learn something about these words!

Counting Words

- Absolute numbers are not that interesting
- Insights are only generated through comparison

Abs. number	Word form
20	women
67	woman
31	men
79	family
82	sister
83	friend
99	bath
117	father
133	man
144	sir

Table: Austens's *Persuasion* (nouns)

Abs. number	Word form
0	friend
2	bath
11	women
23	men
30	father
68	woman
83	family
113	sir
121	man
282	sister

Table: Austens's *Sense and Sensibility* (nouns)

Absolute Numbers

Word	Persuasion	Sense
woman	67	68
women	20	11
man	133	121
men	31	23
sister	82	282

...does it make sense to compare absolute numbers? No.

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- The texts/corpora do not have the same size
- Scaling using their length: Division by the total number of words

Absolute Numbers

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woman	67	0.000 79 %	68	0.000 55 %
women	20	0.000 24 %	11	0.000 09 %
man	133	0.001 58 %	121	0.001 00 %
men	31	0.000 37 %	23	0.000 19 %
sister	82	0.000 97 %	282	0.002 33 %

...does it make sense to compare absolute numbers? No.

- The texts/corpora do not have the same size
- Scaling using their length: Division by the total number of words
- Visible changes: Proportion of »sister«: $3.4 \rightarrow 2.4$

Scaling

- Number of words: Result of a measurement
- If measuring in different scenarios, it's important to scale the results
  - »In a text that is much shorter, there are much less chances for a certain word to be used.«

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Recipe

- Divide the result of the measurement by the theoretical maximum
- How many chances are there for »sister« to be used?
  - As many as there are words in the text
- Thus, we divide by the total number of words

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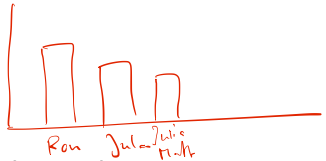

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- It's not always obvious how to scaled
- When reading research: Was it scaled, and how?

Types and Tokens

Manning/Schütze, 1999, 21 f.

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Example

the cat chases (the) mouse

1 2 3 4 5

5 Tokens
4 Types

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- We are often also interested in different tokens: Types

Example

the cat chases the mouse

- Tokens: the, cat, chases, the, mouse
- Types: the, cat, chases, mouse

Type-Token-Ratio (TTR)

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- Construct a sentence with 5 tokens and 4 types!
  - »the cat loves the mouse«
- Construct a sentence with 5 tokens and 1 type!
  - »dog dog dog dog dog« (not really a sentence ...)
  - It's not possible to create a ›proper‹ sentence with 1 type

Type-Token-Ratio (TTR)

- Measure for ›lexical variability‹

$$TTR = \frac{\text{number of types}}{\text{number of tokens}}$$

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- Max value: 1 (there cannot be more types than tokens)
- Min value: $\epsilon = \frac{1}{\text{very large number}}$
- Real (German) texts
  - $10\,000$ words (Wikipedia): $\frac{4021}{10\,000} = 0.4021$

TTR and Text Length

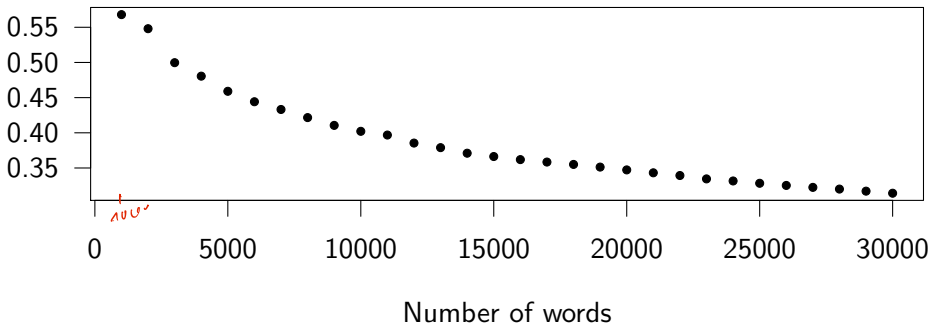
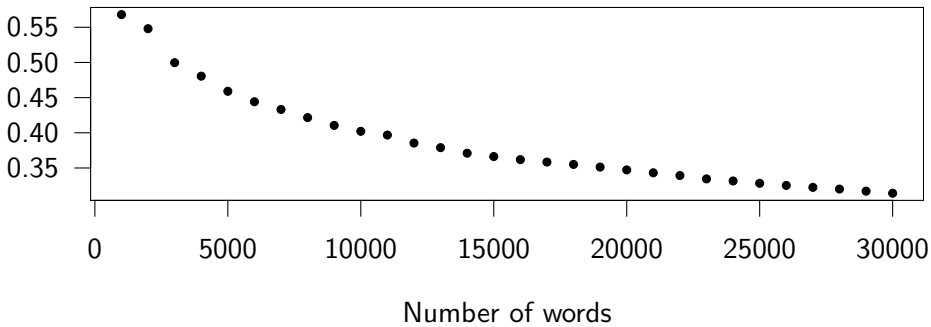


Figure: Type-Token-Ratio for increasing text lengths

TTR and Text Length



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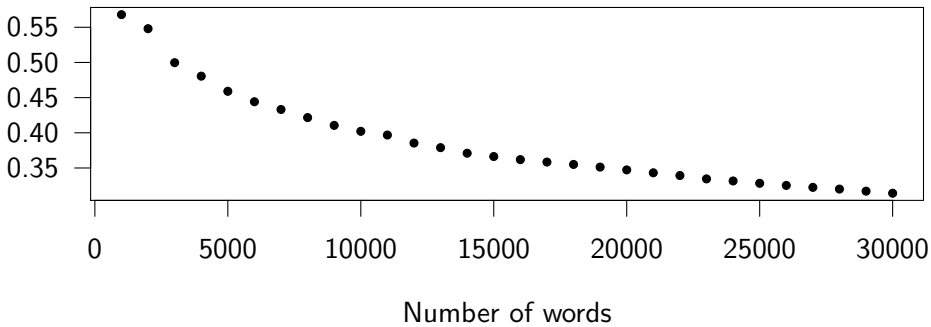
- Increasing length → lower TTR!
- Why?

TTR and Text Length



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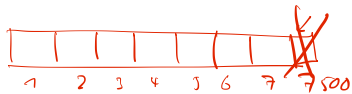

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- Calculate arithmetic mean over TTR values

$$TTR_n = \frac{\text{number of types in } n\text{th window}}{\text{number of tokens in } n\text{th window}}$$

$$STTR = \frac{1}{w} \sum_{i=0}^{w} TTR_i$$

for(int i=0; i<w; i++)

TTR_i

n-grams

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  - Popular choices for n: 2 to 4

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Example

The dog barks.

- 1-grams: »the«, »dog«, »barks«, ».«
- 2-grams (bigrams): »the dog«, »dog barks«, »barks .«
- 3-grams (trigrams): »the dog barks«, »dog barks .«

Section 2

Encoding

Introduction

- How to represent text data in a computer
- Enumeration: Each character is assigned a number
- American Standard Code for Information Interchange (ASCII) Wikipedia: ASCII
  - $128 = 2^7$ characters, including control symbols for telegraphy
  - No German Umlauts etc.

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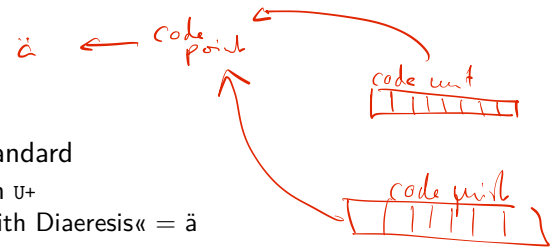
- Unicode: A single standard to represent *all* characters from all languages — unicode.org
  - $149\,186$ characters, including CJK ideographs — Unicode 15.0 charts
  - Complex enumeration scheme

Unicode

- Code point: An integer in the Unicode standard
  - Written in hexadecimal and prefixed with U+
  - E.g.: `U+00E4` = »Latin Small Letter a with Diaeresis« = ä

Unicode



- Code point: An integer in the Unicode standard
  - Written in hexadecimal and prefixed with `U+`
  - E.g.: `U+00E4` = »Latin Small Letter a with Diaeresis« = ä
- Mapping methods used to map each code point onto a code unit
  - Code unit: A sequence of bytes that represent some character
- Unicode transformation format (UTF): Most common mapping
  - UTF-8: uses one to four bytes for each code point, maximizes compatibility with ASCII
  - UTF-16, uses one or two 16-bit code units per code point
    - Strings in Java!
  - UTF-32, uses one 32-bit code unit per code point

Unicode

UTF-8

- Code points U+0000 to U+007F (128) represented in ASCII way, with a leading zero
  - E.g.: A_{ASCII} =U+0041 $= 65_{10} = 41_{16} = 1000001_2 =$ | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |

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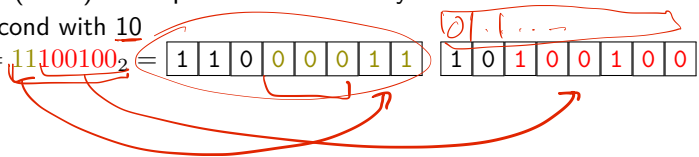
- Code points U+0080 to U+07FF (1920) are represented in two bytes
  - First byte starts with 110, second with 10
  - E.g.: ä $= \texttt{U+00E4} = 228_{10} = 11100100_2 =$ | 1 | 1 | 0 | 0 | 0 | 1 | 1 | | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |



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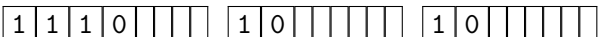
- U+0800 to U+FFFF:  (three bytes)
- U+10000 to U+10FFFF: 4 Bytes, first one starting with 11110, others with 10

Unicode

Parsing UTF-8

- If a byte starts with a 0: The character is one byte long
- If a byte starts with a 1:
  - The number of 1s before the first 0 determine how many bytes belong to this character
  - Check that they start with 10
  - Take them together as a single character

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Determining Encoding

- It is difficult to (automatically) determine the encoding of a text
- »11000011 10100100« is »ä« in UTF-8, but »Ã¤« in ISO Latin 1 – how to know what's correct?

Unicode

Combined Characters

- For flexibility, there is a mechanism for combining characters
- `U+0300` to `U+036F` defines combining diacritical marks
- To be combined with the preceding character
- `U+0041` `U+0308` represent »Ä« in decomposed form

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Normalization

- Normalization Form D (NFD):
  - »Canonical Decomposition«
  - All combined characters are represented in their decomposed form
- Normalization Form C (NFC):
  - »Canonical Decomposition, followed by Canonical Composition«

Unicode

More (Interesting) Oddities

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  - `U+03A9`: The Greek letter
  - `U+2126`: The physical unit for electrical resistance
- Country Flags
  - Emoji support came 2010, including country flags
  - No individual code point for each flag
  - Instead: Regional indicator symbols that represent ISO 3166-1 codes for countries
  - Implementations should render `U+1F1E9` `U+1F1EA` as 🇩🇪
    - If that's not possible, use Roman letters (`U+1F1E9` `U+1F1EA` = DE)

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- Emoji skin color variation: Similar to character combination
  - `U+1F44C U+1F3FB` = 👌🏻 `U+1F44C U+1F3FF` = 👌🏿

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  - `U+1F44C U+1F3FB` = 👌🏻 `U+1F44C U+1F3FF` = 👌🏿
- »a« also represented twice
  - `U+0061`: Latin small letter a
  - `U+0430`: Cyrillic small letter a
  - ⚠ This is/was also a security risk, because `https://mybank.com` and `https://mybank.com` look similar

Section 3

Summary

Summary

- Types and tokens
- Zipf distribution
- Type-Token-Ratio
- Encoding
- Unicode

References I


Manning, Christopher D./Hinrich Schütze (1999). *Foundations of Statistical Natural Language Processing*. Cambridge, Massachusetts and London, England: MIT Press.