Pattern Analysis In Natural Language Texts

English for Computer Science 1

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Overview

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- Motivation
- Applications
- Introduction to Pattern Analysis
- Take-Home-Messages
- References

Motivation

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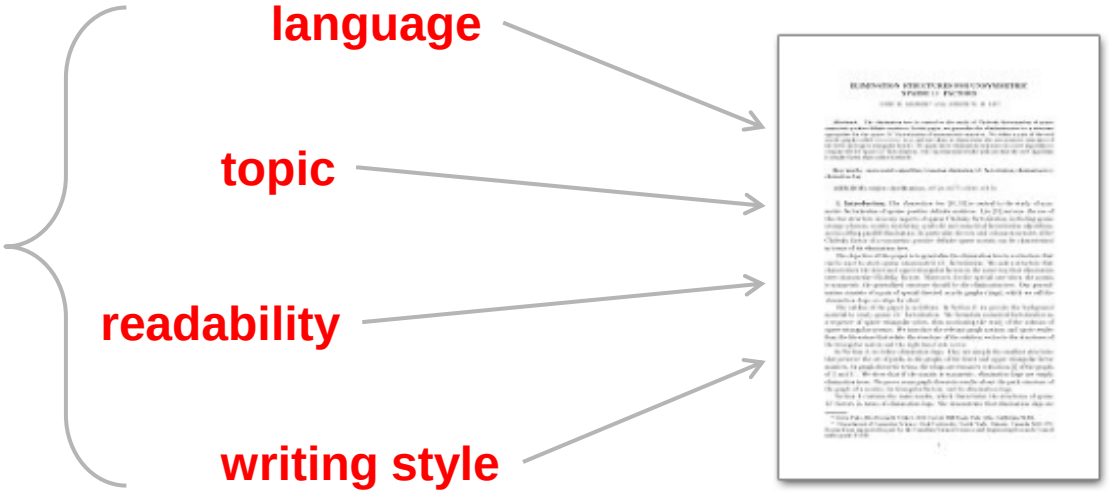
- Natural language texts often provide valuable information (beyond the semantics of the text)
- What does it mean?
- Texts typically consists of many “surface properties”, e.g.

Such properties are usefull for further investigation…



Motivation

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- How difficult is the task of retrieving such properties?
  - For humans: easy (just "read" the text…)
  - For machines: even more easier… (why?)

As far as we know: "Machines don't understand language"

However, they don't have to in order to solve the task…

→ focus of this presentation !

Applications

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- Author identification (e.g. forensic related documents)
- Measuring level of education (readability tests…)
- Cryptanalysis (for simple substitution ciphers)
- Reconstruct fragmentary texts (known as „Noisy Channel Model“)
- Finding similarities between texts (duplicate detection / plagiarism)
- …and many more ;-)

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- Differences between humans and machines for the task

→ Humans: slow but higher precision

→ Machines: fast but error-prone

- Who should solve the task?

  Depends on the task…

  - Analyzing few (critical) texts should be judged by humans
  - Analyzing billions of (harmless) texts should be done automaticaly

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Sample text:

After being released from prison in 2009, Levi fulfilled a promise to himself to visit Israel. He arrived in September, underwent a formal conversion and began to study Judaism with rabbis associated with the more stringent ultra-orthodox sects of the faith. He says he wanted to learn more about the religion and the meaning behind its many rituals…

What kind of properties can you infer from this text?

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Sample text:

After being released from prison in 2009, Levi fulfilled a promise to himself to visit Israel. He arrived in September, underwent a formal conversion and began to study Judaism with rabbis associated with the more stringent ultra-orthodox sects of the faith. He says he wanted to learn more about the religion and the meaning behind its many rituals…

- We can observe several properties, e.g.

  Language: english

  Topic: religion

  Type: news text (what is the indicator?)

  Readability: easy, but requires background knowledge (rabbis, Judaism, …)

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Example (I) Identify language of a given text

Statistical approach: determine the most frequent n-gram‘s in the text…

Sample word: “cats”

Name	**n**	**n-gram‘s**
Unigram	n = 1	{ c, a, t, s }
Bigram	n = 2	{ ca, at, ts }
Trigram	n = 3	{ cat, ats }
Tetragram	n = 4	{ cats }

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Consider again the sample text:

After being released from prison in 2009, Levi fulfilled a promise to himself to visit Israel. He arrived in September, underwent a formal conversion and began to study Judaism with rabbis associated with the more stringent ultra-orthodox sects of the faith. He says he wanted to learn more about the religion and the meaning behind its many rituals…

The 5 frequent bigrams here are: { th, he, an, in, is }

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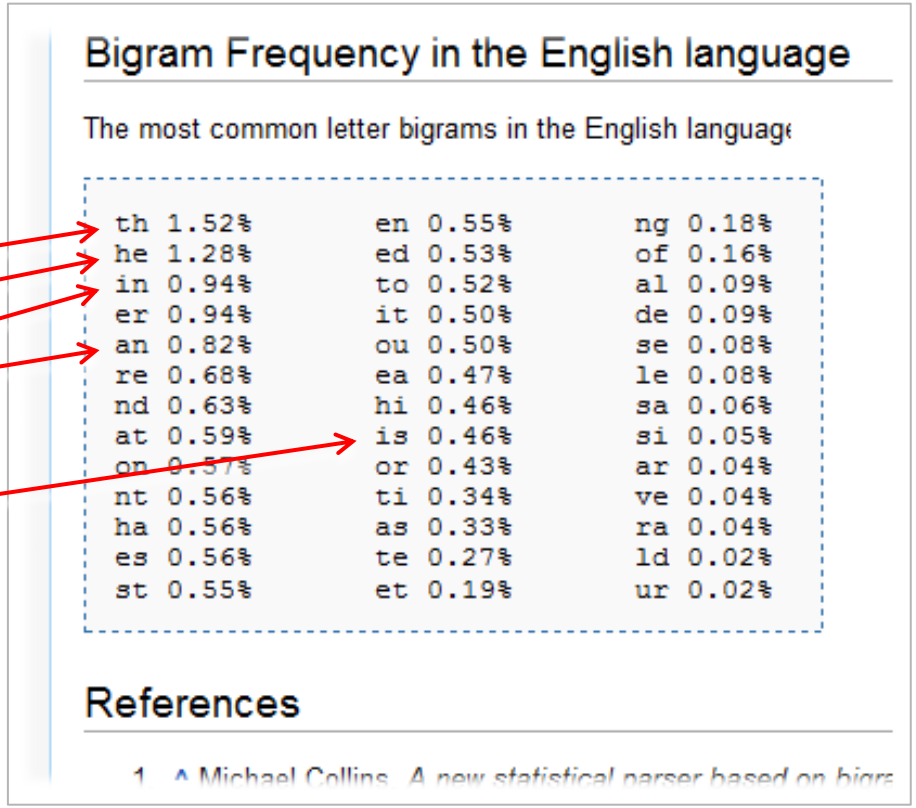
The 5 frequent bigrams:

{
th,
he,
an,
in,
is
}



Bigram Frequency in the English language

The most common letter bigrams in the English languag

th 1.52%	en 0.55%	ng 0.18%
he 1.28%	ed 0.53%	of 0.16%
in 0.94%	to 0.52%	al 0.09%
er 0.94%	it 0.50%	de 0.09%
an 0.82%	ou 0.50%	se 0.08%
re 0.68%	ea 0.47%	le 0.08%
nd 0.63%	hi 0.46%	sa 0.06%
at 0.59%	is 0.46%	si 0.05%
on 0.57%	or 0.43%	ar 0.04%
nt 0.56%	ti 0.34%	ve 0.04%
ha 0.56%	as 0.33%	ra 0.04%
es 0.56%	te 0.27%	ld 0.02%
st 0.55%	et 0.19%	ur 0.02%

References

1. ^ Michael Collins. *A new statistical parser based on bigra*

Source: [http://en.wikipedia.org/wiki/Bigram]

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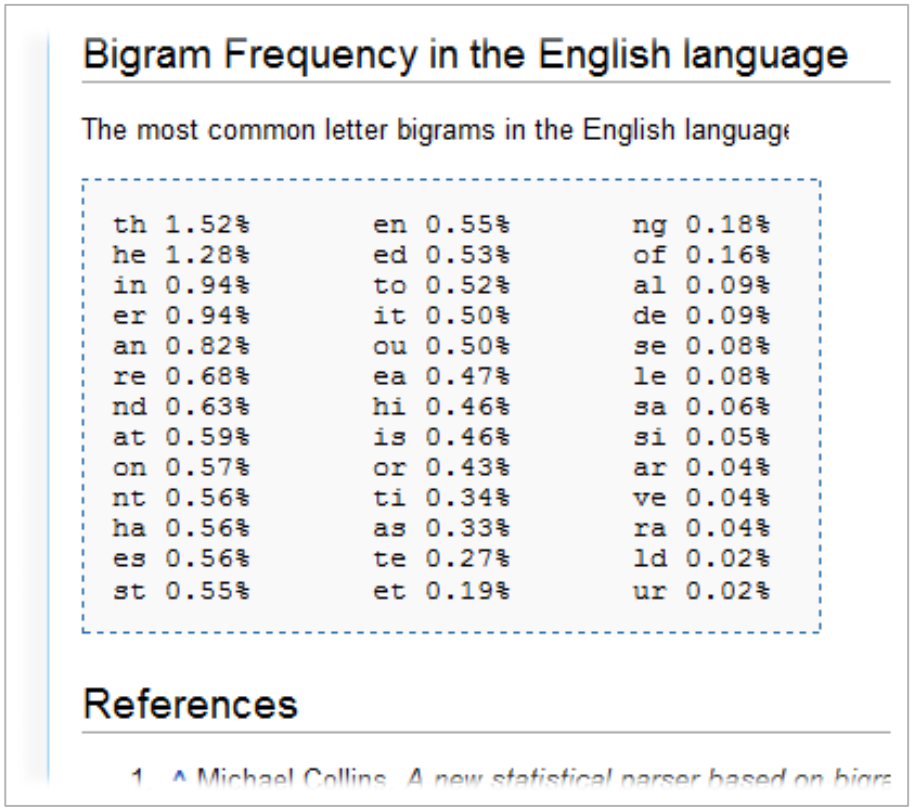
Why is the text assumed to be written in English?



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re 0.68%	ea 0.47%	le 0.08%
nd 0.63%	hi 0.46%	sa 0.06%
at 0.59%	is 0.46%	si 0.05%
on 0.57%	or 0.43%	ar 0.04%
nt 0.56%	ti 0.34%	ve 0.04%
ha 0.56%	as 0.33%	ra 0.04%
es 0.56%	te 0.27%	ld 0.02%
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References

1. ^ Michael Collins. *A new statistical parser based on bigra*

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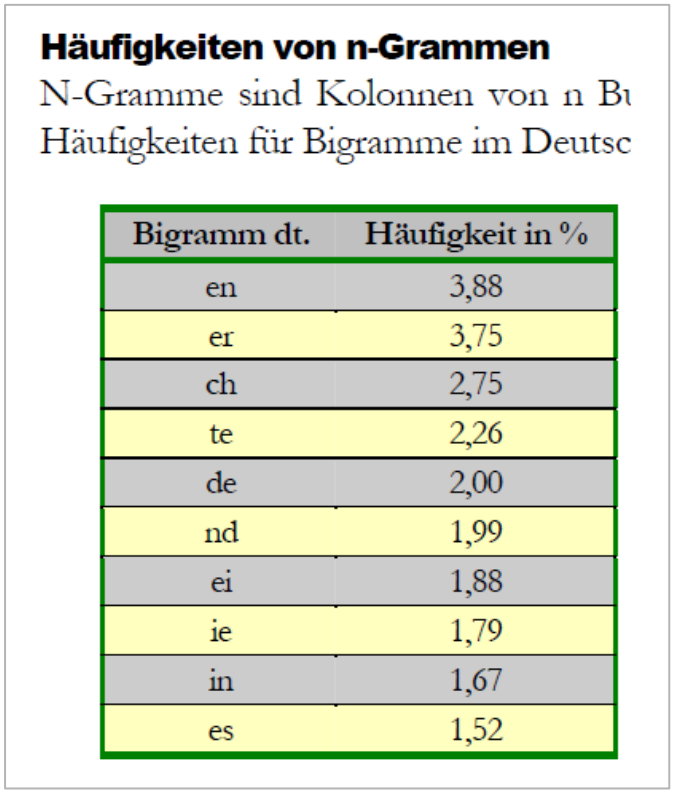

Häufigkeiten von n-Grammen

N-Gramme sind Kolonnen von n Bu
Häufigkeiten für Bigramme im Deutsc

Bigramm dt.	Häufigkeit in %
en	3,88
er	3,75
ch	2,75
te	2,26
de	2,00
nd	1,99
ei	1,88
ie	1,79
in	1,67
es	1,52

Source: [http://tinyurl.com/296z5wr]

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Example (II) Predict the topic for a given text

- Statistical model: Naïve Bayes classification
- Naïve assumption:

> "All words in a given text are conditionally independent from eachother"

- **Note:** assumption rarely holds in natural language texts…
- Goal:

> Determine the probability p(c|d) that document d belongs to category c

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- How the model works…
  - Precondition: trainingset **D** (labeled sample texts)
  - Anatomy of the model:

Category (e.g. sports, politics, economy,…)

$$c = \arg\max_c \; p(c) \prod_{i=1}^{|\mathbf{d}|} p(t_i|c)$$

Number of all words (t_i's) in the unknown text **d**

Fraction of documents that belongs to category c

Probability that word t_i occurs at a certain position in the document

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Trainingset **D** = {d_1 , d_2, d_3, d_4}

Document d_i	**Contents**	**Category**
d_1	chinese beijing chinese	C
d_2	chinese chinese shanghai	C
d_3	chinese macao	C
d_4	tokyo yapan chinese	J

Vocabulary **V** = { beijing, chinese, macao, shanghai, tokyo, yapan }

New (unknown) document d_5 = "chinese, chinese, chinese, tokyo, yapan"

Predict which category d_5 most likely belongs to…

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New (unknown) document d_5 = "chinese, chinese, chinese, tokyo, yapan"

Model needs to compute: P(C), P(J) and $P(t_i|C)$, $P(t_i|J)$

$$P(C) = \frac{\text{amount of documents of category } C \text{ in } D}{\text{amount of documents in } D} = \frac{3}{4}$$

$$P(J) = \frac{\text{amount of documents of category } J \text{ in } D}{\text{amount of documents in } D} = \frac{1}{4}$$

$$P(chinese \mid C) = \frac{\text{occurrence of "chinese" in } C + 1}{sum(\text{occurrence of each word in } C) + |V|} = \frac{5+1}{8+6} = \frac{3}{7}$$

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All the parameters:

P(chinese|C) = 3/7

P(tokyo|C) = 1/14

P(yapan|C) = 1/14

P(chinese|J) = 2/9

P(tokyo|J) = 2/9

P(yapan|J) = 2/9

$$P(d_5|C) = P(C)\,P(chinese|C)^3 P(tokyo|C) P(yapan|C)$$

$$P(d_5|J) = P(J)\,P(chinese|J)^3 P(tokyo|J) P(yapan|J)$$

$$P(d_5|C) = 0.000301...$$

$$P(d_5|J) = 0.000135...$$

Hence, category C would best fit for d_5

Or with other words: d_5 is labeled with the topic C

Take-Home-Messages

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Pattern Analysis in natural language texts:

- …is very valuable (if you know where and how to use it)
- …becomes very popular in many fields (beyond computer science)
- …doesn't require semantics of text (hence, easy to implement)
- …is not 100% bulletproof, but often the last possibility to gain insights about the text

- Last but not least: it's a  (hot) discussed research topic !!!

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Your turn ;-)

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- Imagine you want to detect plagiarism between two documents (A and B)

  Explain: which of the following 2 ideas would you choose for the detection?

  (1) Overlap in sets of words

  (2) Overlap in sequences of words (n-grams)

- Recall the calculation:

$$P(chinese \mid C) = \frac{\text{occurrence of "chinese" in } C + 1}{sum(\text{occurrence of each word in } C) + |V|}$$

  What can we observe, if we ignore the red part in the fraction?

- The presentation mentioned the "Readability" property, how could a machine compute this?

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Thanks for your attention…

References

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- "**Rap bad boy goes kosher**",

  CNN article (November 18, 2010|By Izzy Lemberg and Kevin Flower),

  http://bit.ly/koW3MM