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Text Analytics

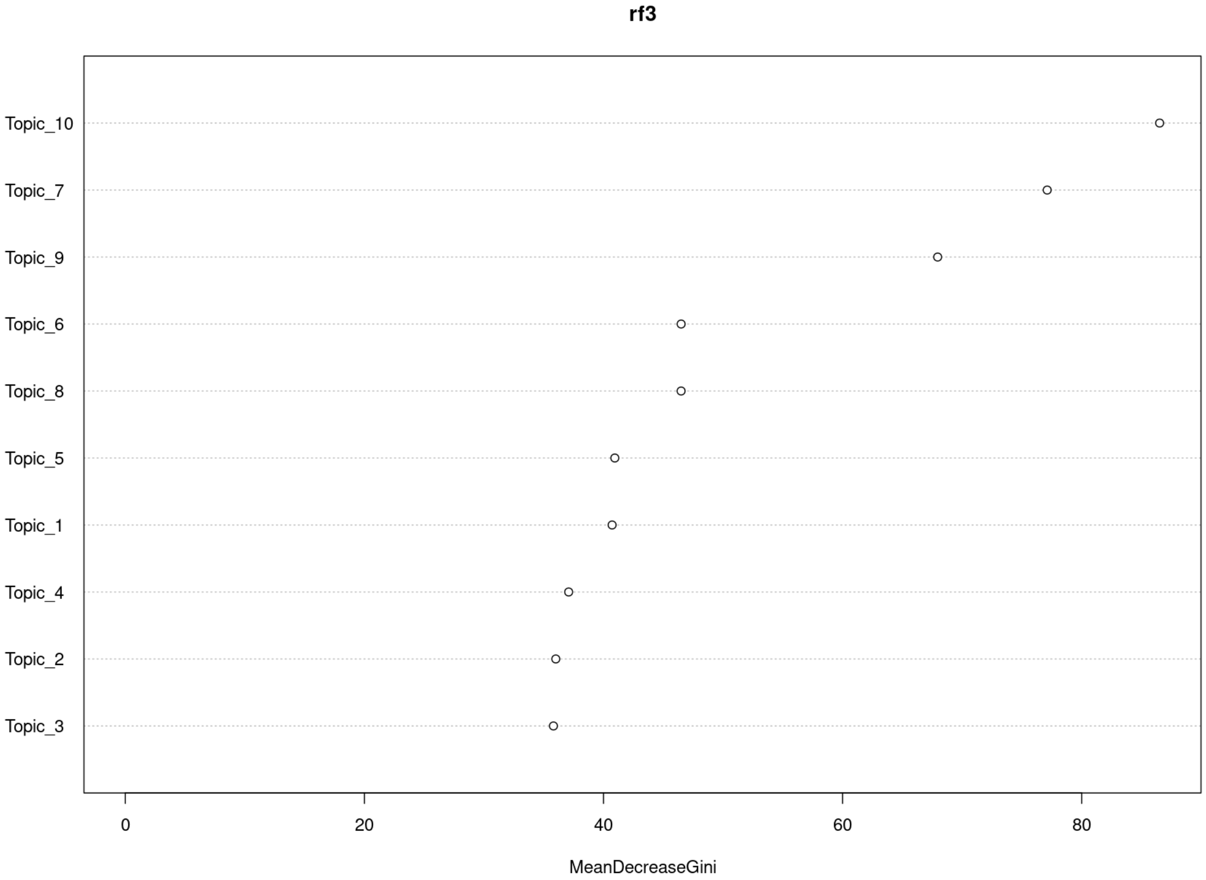
Week 08-BEM2031

Term2: 2024/25

Assignment:

- Wordcount 300-500 words is an estimate – if you go over, that is fine but stay focused and don't go too far over!
- There is no need to try to improve the performance of the model. If you do, you will need to justify your choices, parameters etc! Don't leave me guessing ☺
- You can try some simple changes to the model, plots etc that are easy to explain.
- The purpose is NOT to build a perfect classifier, but to show that you understand what the code is doing and why.
- Come and see me and/or email me if you are having concerns, worries, lacking understanding, stressing out, want reassurance. I'm happy to help.

Assignment:



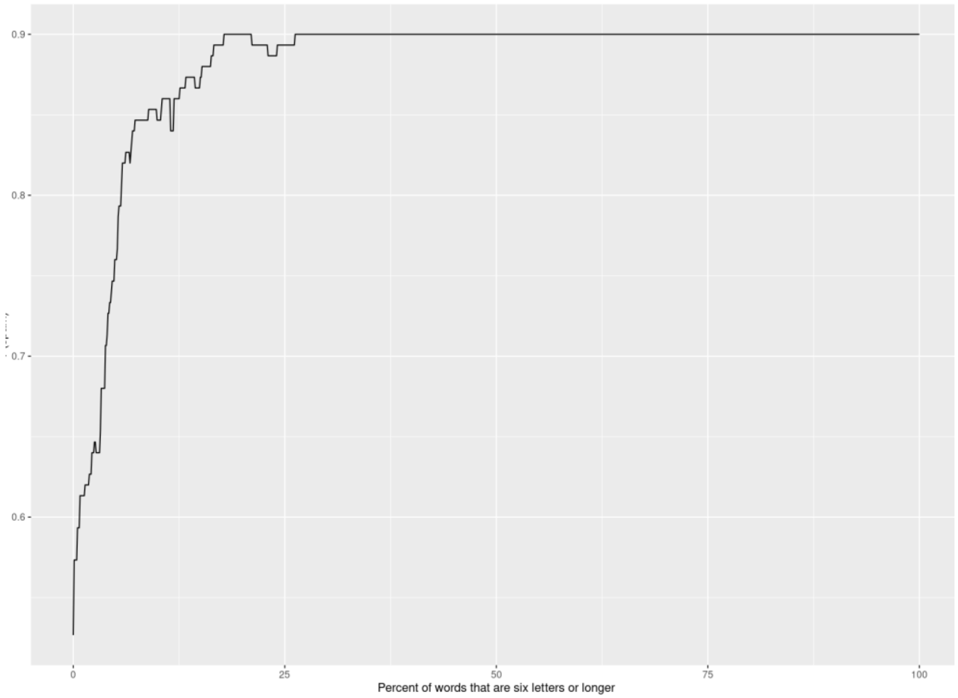
How much a variable contributes to splitting nodes and improving node purity (lowering impurity) across all trees.

Interpretability: You get a sense of which features the model relies on most.

Feature Selection: You can potentially drop less important features to simplify the model.

Insights: Learning that certain variables have a large impact might prompt further investigation into why that's the case.

Assignment:



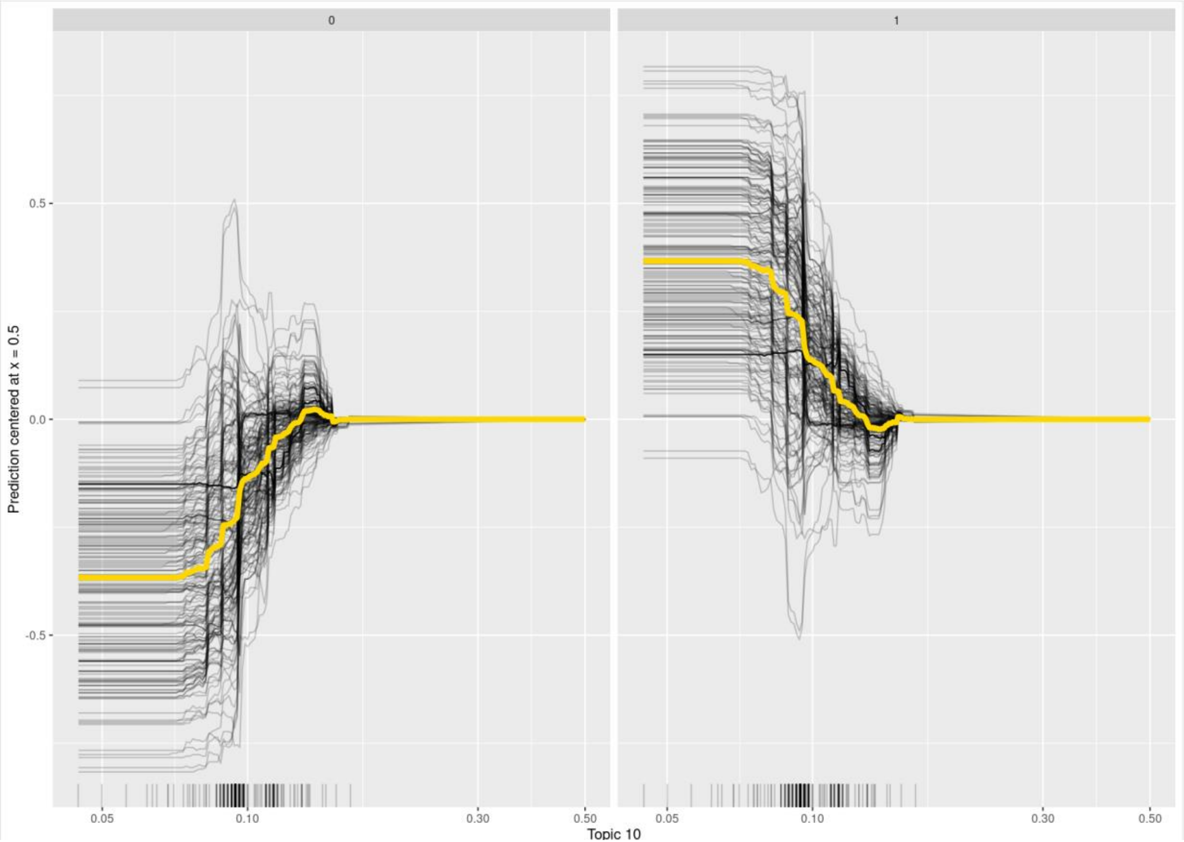
When you select ‘d’ (a single observation) print ‘d’ so I can see the feature values.

The effect of a feature on a *per-instance* basis.

When you vary a feature for ‘d’ print it again, so it is easy to compare the predictions for ‘d’ and ‘d varied’. What did you vary and why?

When you plot ‘d’ with the full range of a feature, remember this is only a single observation.

Assignment:



You pdp+ice plot shows all of the ‘d’s (in your sample).

What can we learn from this?

pdp:
The *average effect* of one (or two) features on the model’s prediction, while theoretically holding other features constant.

ice:
Shows whether the “average effect” from the PD plot holds for everyone, or if there are *subgroups* (or individual cases) that behave differently.

Today:

- Understand how to transform text into features for predictive analytics
- Become familiar with concepts such as n-grams, term frequency, sentiment analysis, and topic modelling
- Appreciate the value of analysing unstructured data

Natural Language Processing (NLP)

- Understanding unstructured language – human generated content
  - Syntax – the grammar of text
  - Semantics – the meaning of text
  - Pragmatics – what the text is trying to achieve

✓ Profanity detection (e.g. did the post contain any profanity?)
✓ Sentiment detection (e.g. did a customer provide a positive or negative review)
✓ Topic identification (e.g. what is this email about?)
✓ Entity detection (e.g. what locations are referenced in this text message?)

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Natural Language Processing (NLP)

- Machine translation
  - Google translate, Duolingo, Watson
- Sentiment analysis
  - Predator/troll detection, customer experience management, speech analysis..
- Predictive text
  - Keyboards, google search
- Speech to text translation
  - Google assistant, Alexa, Siri, call bots
- Q&A
  - Chatbots etc
- Spam detection

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NLP → Text analytics → Unstructured data

- Un-understandable by machines

- 80% of the world's data is unstructured – blogs, social media, free text boxes, medical records, emails, texts, comments, customer feedback, discussion forums, press releases, literary texts, academic papers…..

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NLP → Text analytics → Unstructured data

jomatthews123

Basingstoke, UK • 108 contributions

👍 0 •••

Underground Passages

Good place to visit.

Feb 2024 • Couples

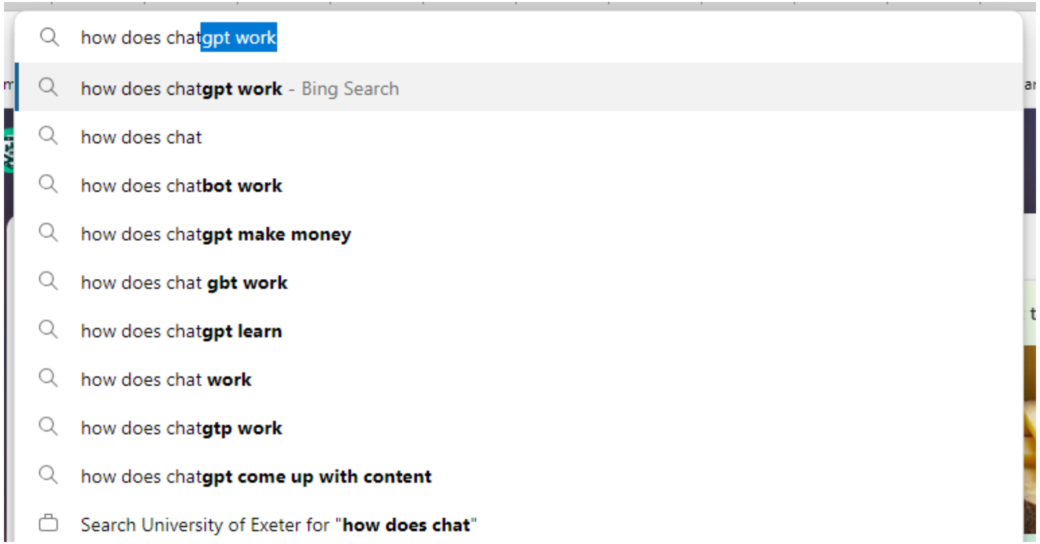
Really enjoyed the tour here. Our tour guide, Dimitrios, was very friendly and polite, and was great at explaining the history of the passages. And he was patient with me as I couldn't walk very fast.

There are some parts (optional to visit) which require crouching low to go through. I have a disabled knee, so I managed to slowly crawl on all fours through those parts. If you don't want to do that, you can skip that section to get back to the entrance point.

...

Read more

Written 3 February 2024



“ **Autocomplete predictions** reflect searches that have been done on Google. To determine what predictions to show, our systems begin by looking at common and trending queries that match what someone starts to enter into the search box”.

“DeepText is a deep learning-based text understanding engine designed to analyze vast amounts of text data processed across Facebook’s platforms, including Facebook, Messenger, and Instagram.

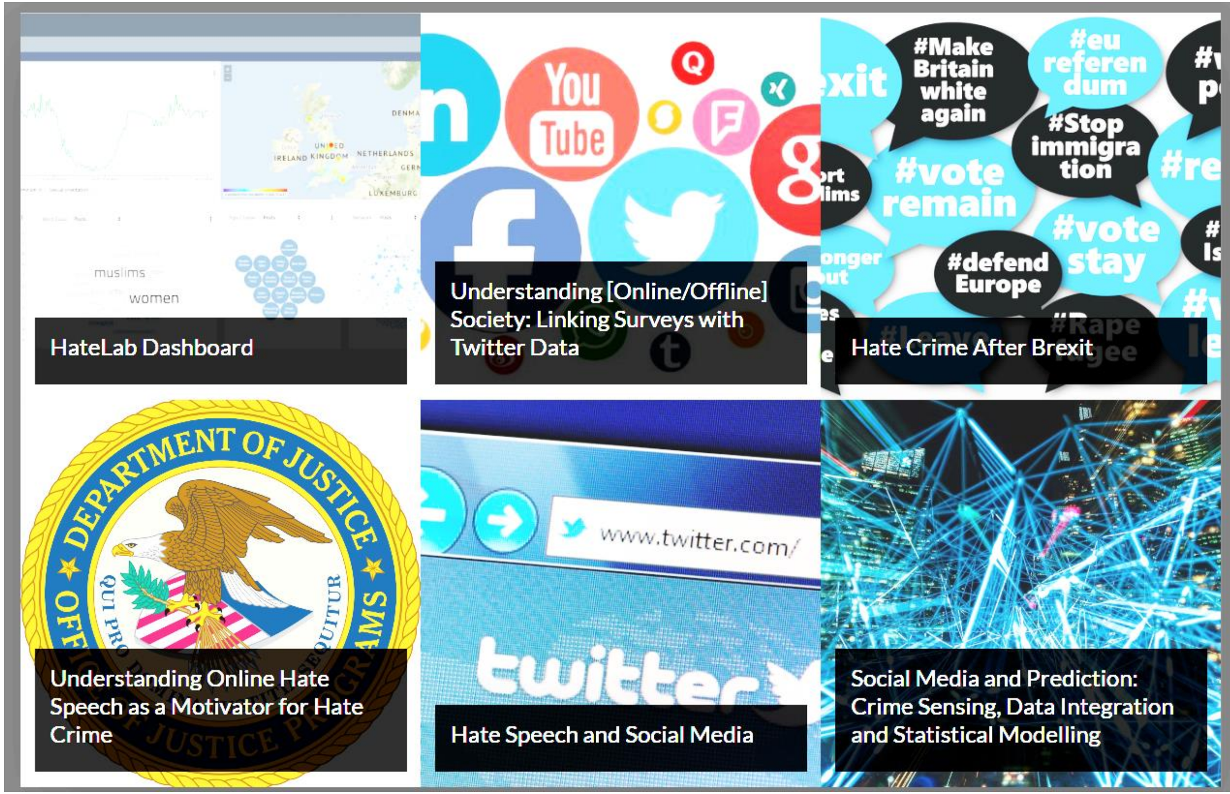
In the realm of artificial intelligence, few developments have garnered as much attention as natural language processing (NLP). Among the leading innovations in this space is DeepText, an AI-powered text understanding engine developed by Facebook..”

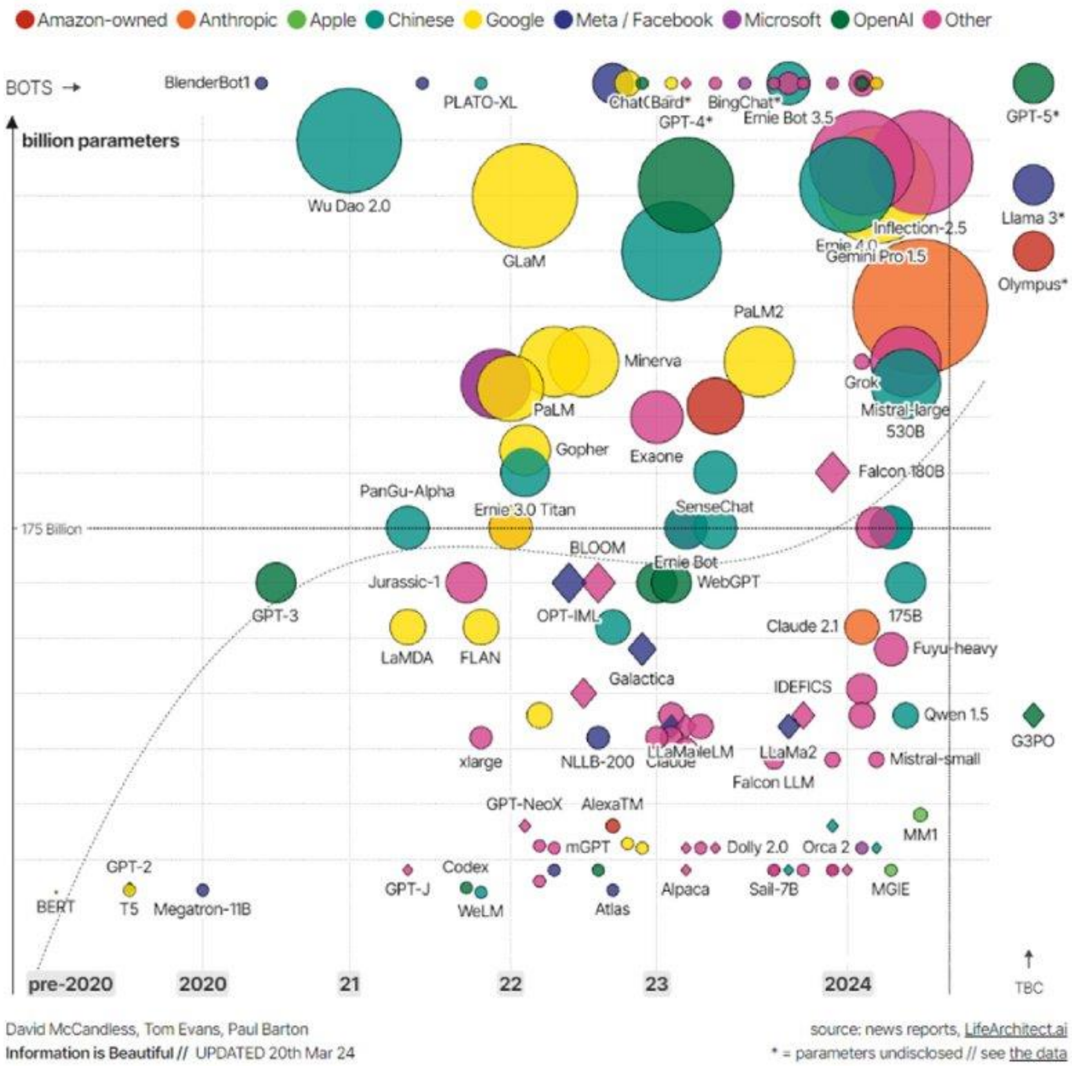
Introducing DeepText: Facebook's text understanding engine - Engineering at Meta (fb.com)

HateLab – A global repository for data and insight into hate crime and speech

How prejudice becomes hate, and what we can do about it.

“We use data science methods, including ethical forms of AI, to measure and counter the problem of hate both online and offline.”





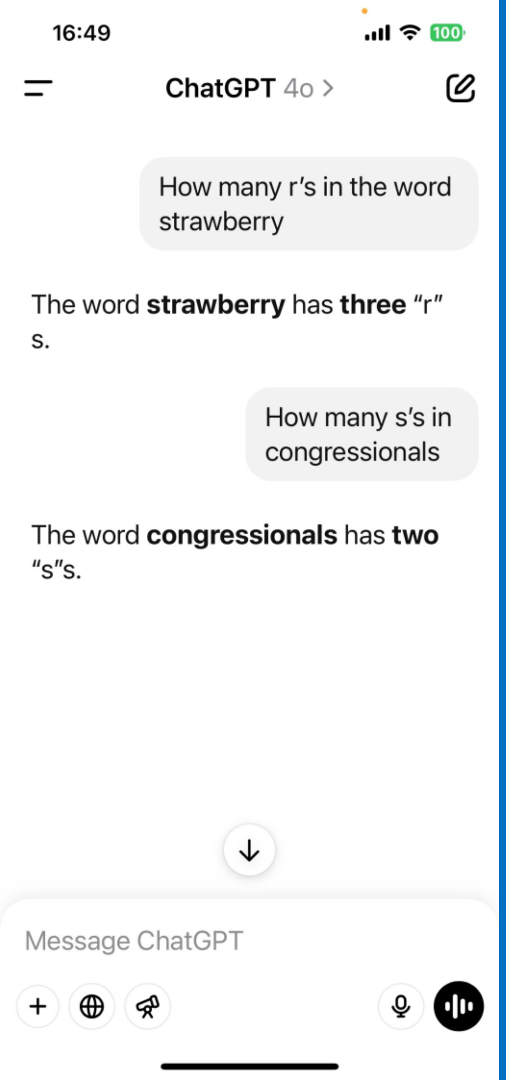
Words are converted into high-dimensional vectors so that similar meanings cluster together. Because context matters, a single word can have different vectors—or, conversely, two identical words may mean different things.

These vectors feed into layers that learn syntax, resolve ambiguity, and form a high-level understanding (e.g., to answer a prompt). Large language models (LLMs) learn by predicting the next word from huge text collections (billions of words), and more training data usually improves their accuracy.

Why not use LLMs to analyse text?

- **Inconsistency**
- **Prediction model – not reproducible or transparent**
- **Sample from probability distribution**
- **Generates text sequentially.**

- **Hallucination**
- **Optimise for text plausibility rather than factual accuracy.**
- **Imperfect / biased training data**
- **Heavily dependent upon prompts**



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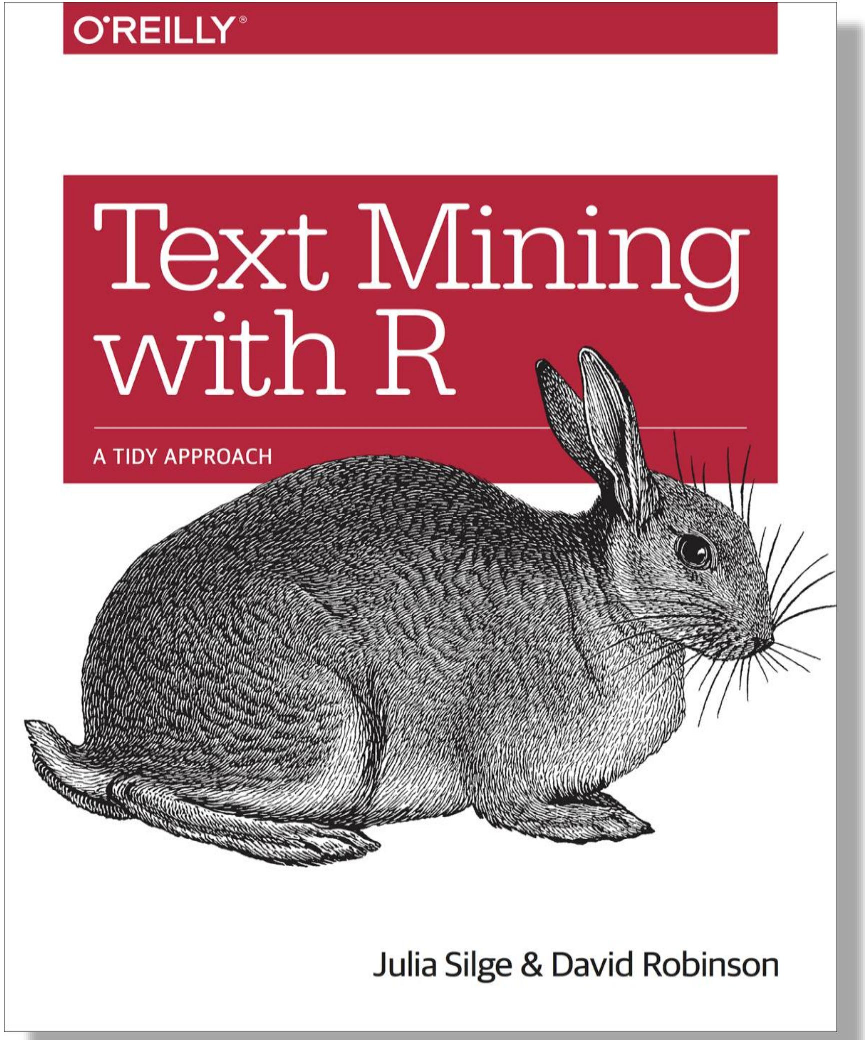
https://www.tidytextmining.com/



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Text Mining with R: A Tidy Approach

Search

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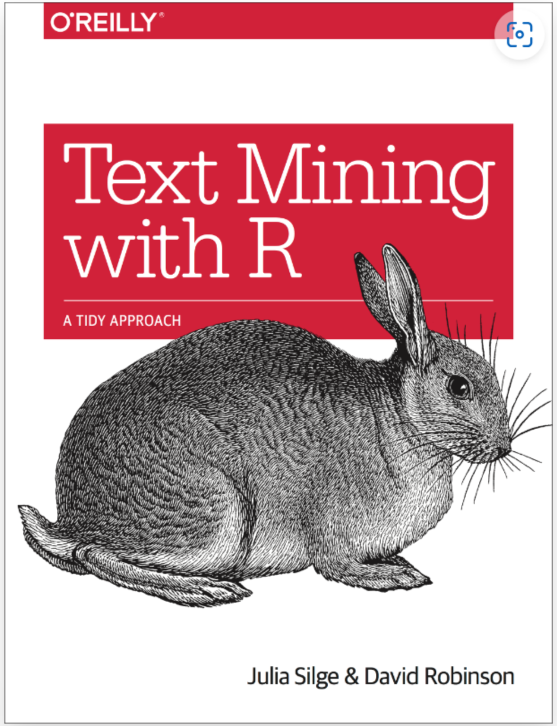
View book source

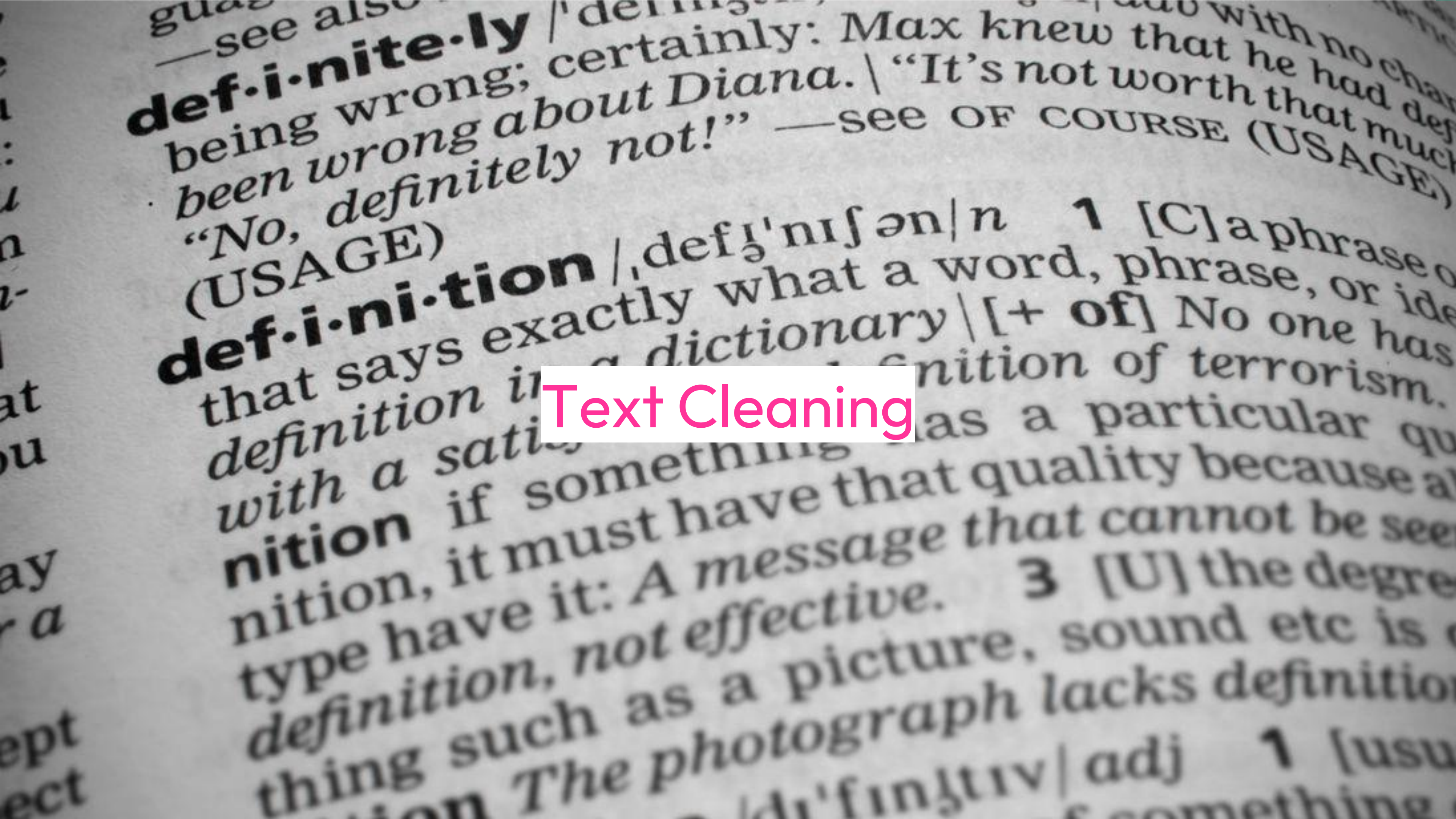
Welcome to Text Mining with R

This is the website for *Text Mining with R*! Visit the GitHub repository for this site, find the book at O'Reilly, or buy it on Amazon.



Preface »

Text Cleaning



Text analytics: NLP analysis pipeline

Data:

Speech communication
Speech-to-text communication
Text communication

Data pre-processing

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Text analytics: cleaning

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Noise removal

- Stopwords, URLs, special characters, punctuation
- Case normalisation

Segmentation and tokenisation

- Paragraph/sentence segmentation
- Tokenisation

Normalisation

- Stemming
- Lemmatisation

Stopwords are noisy words with high frequency that a search engine is programmed to ignore, e.g. 'the' 'an' 'is'.
Convert to lower case.

Break a corpus of text into smaller segments: paragraphs, sentences.

Token: a meaningful unit of text, e.g a word, that can be used for analysis. Tokenisation splits text into tokens.

n-grams: words or phrases cut out of sentences as a set of *n* co-occurring words within a given window.
[I] [have] [an] [essay] [due] [today] (n=1)
[I have] [an essay] [due today] (n=2)

Stemming: stripping affixes.
Fished, fishing, fisher → fish
Thinking → think

Lemmatisation: ensures the output word is an existing normalized form of the word
Studies, studying, studied → study

Text analytics: stopwords

	poem	cleaned	filtered
0	Deep in the shady sadness of a vale	[deep, in, the, shady, sadness, of, a, vale]	[deep, shady, sadness, vale]
1	Far sunken from the healthy breath of morn	[far, sunken, from, the, healthy, breath, of, ...	[far, sunken, healthy, breath, morn]
2	Far from the fiery noon, and eve's one star	[far, from, the, fiery, noon,, and, eve's, one...	[far, fiery, noon,, eve's, one, star]
3	Sat gray-hair'd Saturn, quiet as a stone	[sat, gray-hair'd, saturn,, quiet, as, a, stone]	[sat, gray-hair'd, saturn,, quiet, stone]
4	Still as the silence round about his lair	[still, as, the, silence, round, about, his, l...	[still, silence, round, lair]
5	Forest on forest hung about his head	[forest, on, forest, hung, about, his, head]	[forest, forest, hung, head]
6	Like cloud on cloud. No stir of air was there	[like, cloud, on, cloud., no, stir, of, air, w...	[like, cloud, cloud., stir, air]
7	Not so much life as on a summer's day	[not, so, much, life, as, on, a, summer's, day]	[much, life, summer's, day]
8	Robs not one light seed from the feather'd grass	[robs, not, one, light, seed, from, the, feath...	[robs, one, light, seed, feather'd, grass]
9	But where the dead leaf fell, there did it rest	[but, where, the, dead, leaf, fell,, there, di...	[dead, leaf, fell,, rest]
10	A stream went voiceless by, still deadened more	[a, stream, went, voiceless, by,, still, deade...	[stream, went, voiceless, by,, still, deadened]
11	By reason of his fallen divinity	[by, reason, of, his, fallen, divinity]	[reason, fallen, divinity]
12	Spreading a shade: the Naiad 'mid her reeds	[spreading, a, shade:, the, naiad, 'mid, her, ...	[spreading, shade:, naiad, 'mid, reeds]
13	Press'd her cold finger closer to her lips	[press'd, her, cold, finger, closer, to, her, ...	[press'd, cold, finger, closer, lips]

Text analytics: tokenisation

Token: A meaningful unit of text, such as a word, that we are interested in further analysis
Tokenisation: The process of splitting text into tokens

Unigrams, bigrams, n-grams (e.g. words, sentences, paragraphs)

N-grams: are words or phrases cut out of sentences that co-occur within a given window

[I] [have] [an] [essay] [due] [today] (n=1) unigram
[I have] [have an] [an essay] [essay due] [due today] (n=2) bigram
[I have an] [have an essay] [essay due today] (n=3) trigram
etc.

Word Stemming

Word stemming prevents confusion by converting the multiple forms of a word into a new single word.

It helps improve the accuracy of many methods, like sentiment analysis.

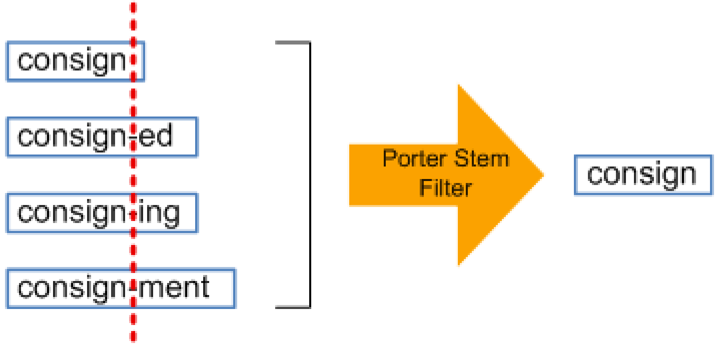
‘I’ ‘run’ ‘he’ ‘ran’ ‘she’ ‘is’ ‘running’ ‘stop’ ‘running’

‘I’ ‘run’ ‘he’ ‘ran’ ‘she’ ‘is’ ‘run’ ‘stop’ ‘run’

Lemmatisation: reduce word to base form

‘I’ ‘run’ ‘he’ ‘run’ ‘she’ ‘is’ ‘run’ ‘stop’ ‘run’

https://leanjavaengineering.wordpress.com/2012/02/24/using-lucene-in-grails/



Text Analytics

Text analytics: terminology

The NLP pipeline:

Speech communication
Speech-to-text communication
Text communication

Data pre-processing

- Lexical analysis (words)
- Syntactic analysis (grammar)
- Semantic analysis (meaning)
- Pragmatic analysis (context)

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1. Bag of Words

This approach ignores the word order and meaning of text in a document.

It simply consider the *frequency* of words and how frequently they co-occur in documents.

It is the simplest method for embedding words as vectors.

But it is not a good representation of language as it ignores word order, word relationships, meanings, context

Figure 1 – Pre-pre-processing

https://scatter.wordpress.com/2020/02/19/doing-things-with-bags-of-words/

Document-term Matrix

Many methods of analysing text, including similarity matching, cluster analysis, topic models, and others rely on the **document term matrix.**

https://stackoverflow.com/questions/46470240/combine-dataframe-column-into-document-term-matrix

Docs	amp	brexit	euref	leav	remain	strongerin	vote	voteleav
738102860454498304	2	1	1	0	0	0	1	1
739933062281187329	0	0	1	2	2	0	1	0
745289444006170624	0	0	0	1	1	0	4	0
745501761289355264	0	0	0	0	7	0	0	0
745621915516149760	0	1	1	1	1	0	2	0
745649059231215616	1	0	0	1	1	1	2	0
745875415839965184	2	0	1	0	1	0	2	0
745922585494429697	1	0	1	0	1	1	2	0
745973624142725120	2	0	0	1	1	1	1	0
746108821479821312	0	0	1	0	4	0	1	0

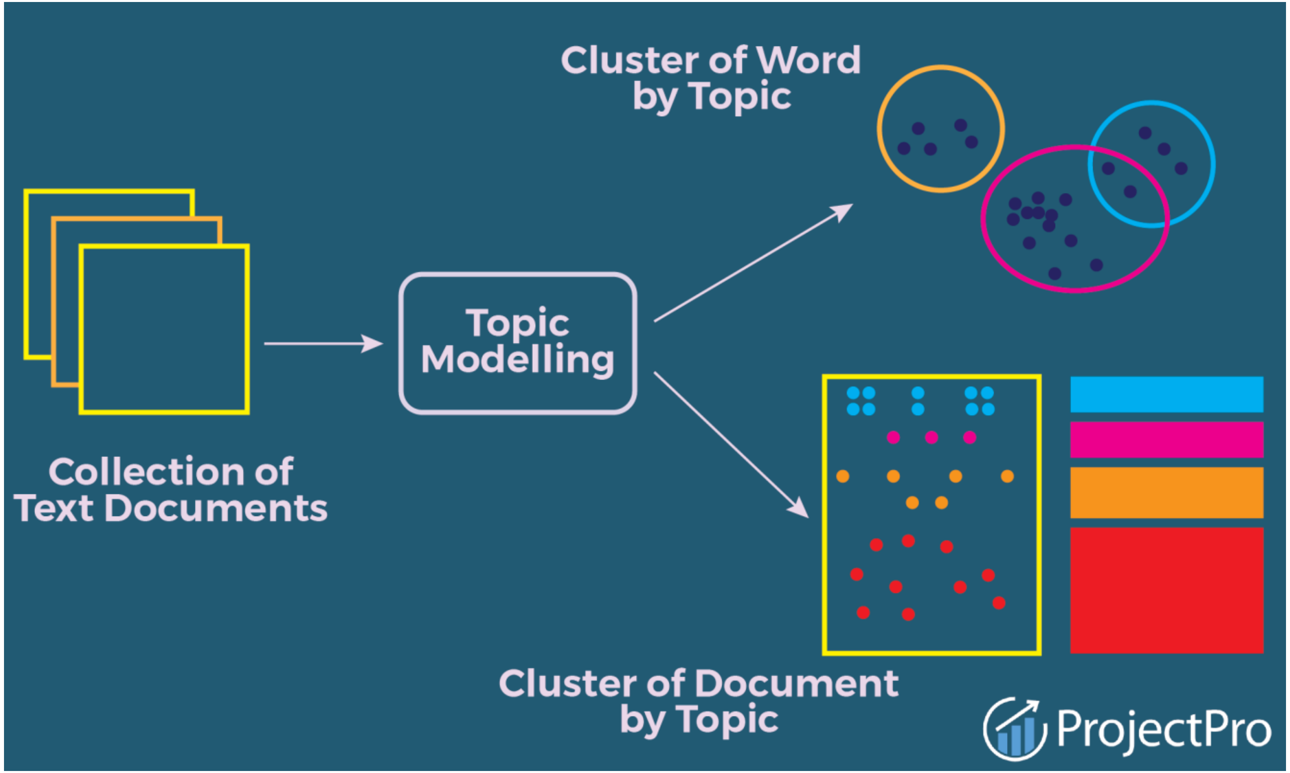
Word Cloud

Nice way to visualise text.

Array of most important words in a document according to frequency, frequency rank, or tf-idf

Can be misleading

2. Topic Models



Probabilistic topic models:

- Each document is a mixture of topics
- Each topic is a mixture of terms.

Scans documents, detects word and phrase patterns, clusters word groups to best characterise a set of documents.

[Topic Modeling In Natural Language Processing – peerdh.com]

Topic Models

Topics are an indication of common patterns of language use in email messages.
Each email is a mixture topics.
Each topic is a mixture of terms.

(Blei, Carin, & Dunson, 2010; Blei et al., 2003)

Hi PERSON_391123,

I saw you were preparing the space for the show in Vegas next week. Let PERSON_318923 know that his bonus will come through after we process the taxes for this quarter. There will be some adjustments we need to make after the show. Let me know how it all goes and we can grab some lunch when you return. Somewhere other than Chinese place this time. lol

V23 (23%)	**V134 (22%)**	**V97 (18%)**
tax (15%)	show (11%)	lunch (22%)
amount (8%)	market (10%)	break (18%)
balance (8%)	vegas (10%)	dinner (5%)
pay (5%)	week (10%)	bring (4%)
bonus (2%)	showroom (7%)	food (3%)
cash (1%)	space (3%)	eat (1%)
paid (1%)	coming (3%)	lol (>1%)
total (>1%)	shows (1%)	grab (>1%)
...	...	...

3. Term Frequency - Inverse Document Frequency TF-IDF

- **TF-IDF (Term Frequency-Inverse Document Frequency) Vectorizer** takes into account the importance of each term to document.

- TF-IDF vectorizes documents by calculating a TF-IDF statistic between the document and each term in the vocabulary.

- Term Document matrix represented by TF-IDF weights.

- TF-IDF accentuates terms that are frequent in the document, but not frequent in general.

Term Frequency (TF)

- Measures how frequently a term occurs in a document
- May appear more times in long documents than shorter ones, since every document length is different
- *tf(t,d)* of term *t* in document *d* is defined as the number of times that *t* occurs in *d*.
- Greater when a term is frequent in a document

Inverse Document Frequency (IDF)

- A word is not very informative if it occurs in **all** documents.
- Estimate the rarity of a term in the whole document collection.
- If a term (*t*) occurs in all documents (*d*) in the collection, its IDF is zero.
- IDF is greater when the term is rare in the collection (but more frequent in the document).

$$idf(t) = log(\frac{D}{df_t})$$

D = Number of documents in the collection, i.e. the Document space.

df_t = Number of documents in which term t appears, i.e., document frequency

TF-IDF

The tf-idf weight of a term is the product of its *tf* weight and its *idf* weight, i.e.,

$$w(t) = tf(t,d) * \log(\frac{D}{df_t})$$

Tf-idf increases proportionally to the frequency a term appears in a document (tf) and is offset by the number of documents in the corpus that also contains that term (idf)

Inverse Document Frequency (IDF)

$$idf(t) = log(\frac{D}{df_t})$$

D = Number of documents in the collection, i.e. the Document space.

df_t = Number of documents in which term t appears, i.e., document frequency

The word "example" is more interesting - it occurs three times, but only in the second document:

$$\mathrm{tf}(''\mathrm{example}'', d_1) = \frac{0}{5} = 0$$

$$\mathrm{tf}(''\mathrm{example}'', d_2) = \frac{3}{7} \approx 0.429$$

$$\mathrm{idf}(''\mathrm{example}'', D) = \log\left(\frac{2}{1}\right) = 0.301$$

Finally,

$$\mathrm{tfidf}(''\mathrm{example}'', d_1, D) = \mathrm{tf}(''\mathrm{example}'', d_1) \times \mathrm{idf}(''\mathrm{example}'', D) = 0 \times 0.301 = 0$$
$$\mathrm{tfidf}(''\mathrm{example}'', d_2, D) = \mathrm{tf}(''\mathrm{example}'', d_2) \times \mathrm{idf}(''\mathrm{example}'', D) = 0.429 \times 0.301 \approx 0.129$$

Document 1

Term	Term Count
this	1
is	1
a	2
sample	1

Document 2

Term	Term Count
this	1
is	1
another	2
example	3

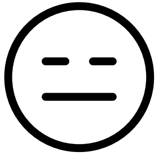
The most common words are meaningless (e.g. ‘a’, ‘the’, ‘this’

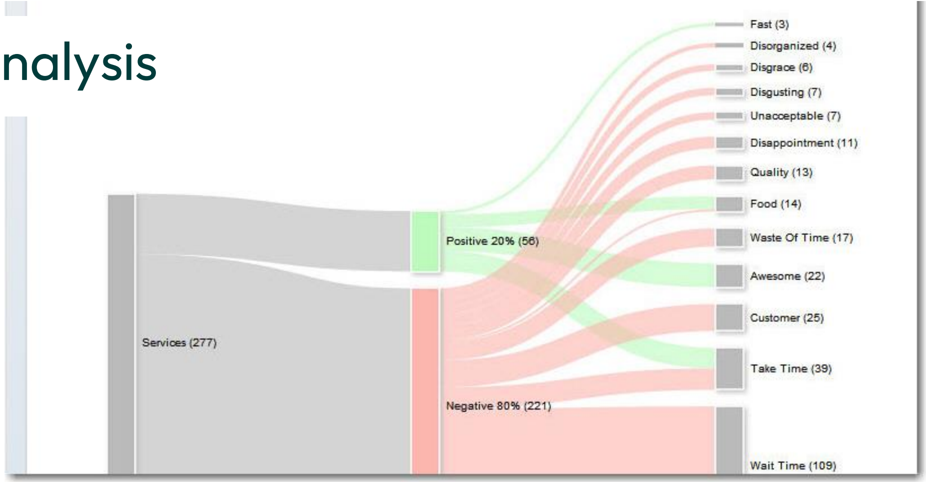
TF-IDF helps to find terms in documents that best characterise the document

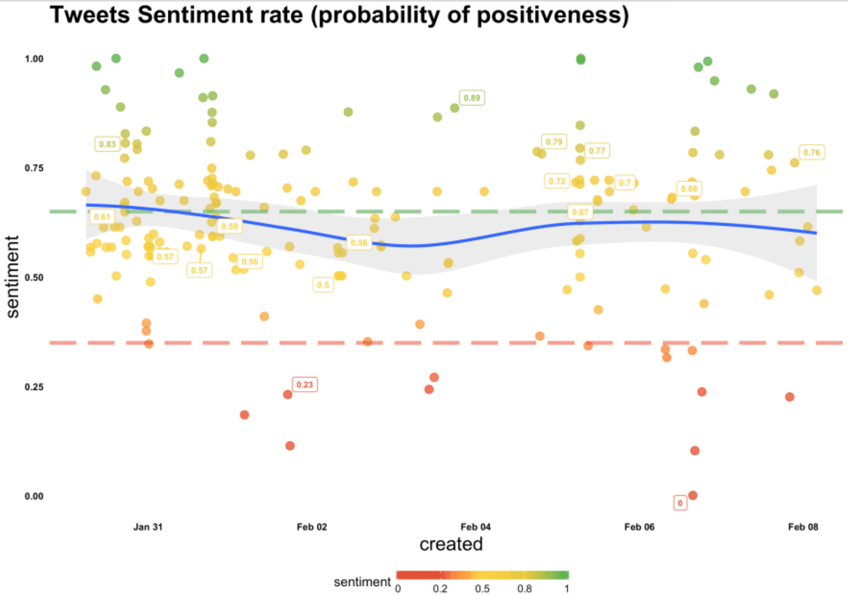
4. Sentiment Analysis

Sentiment analysis is an attempt to measure the emotional tone of a document.

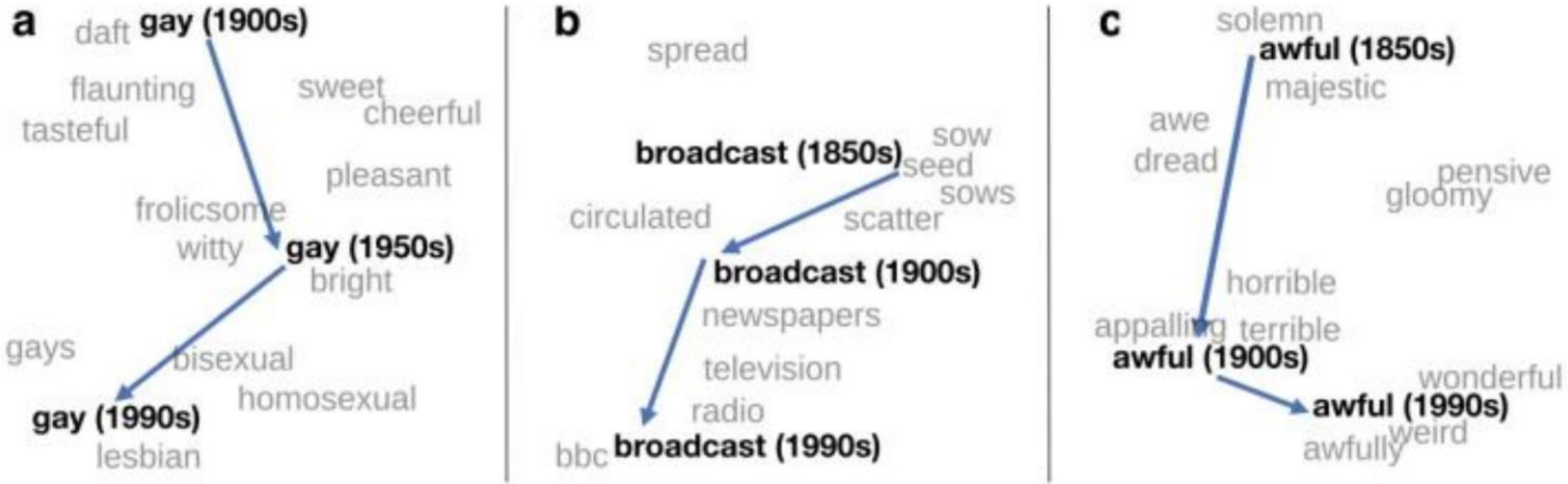
Many cases use a dictionary of words that are either positive or negative. You count the positive or negative words and sum them up.







5. Vectorizing the text



Hamilton, W. L., Leskovec, J., & Jurafsky, D. (2016). Diachronic word embeddings reveal statistical laws of semantic change. arXiv preprint arXiv:1605.09096.

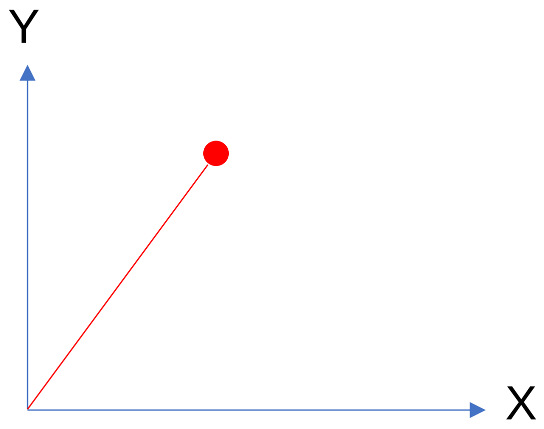
Vectorizing the text

Natural languages are ambiguous.

Machines can be trained to interpret text by transforming it into numerical representation: vectorization, or embedding techniques.

These are mapped onto vectors of real numbers, in a vector space.

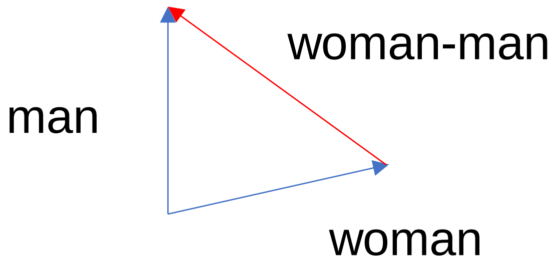
A vector is a point in a vector space that has a length (from the point of origin) and a direction
A 2-dimensional vector can be written as [x, y]

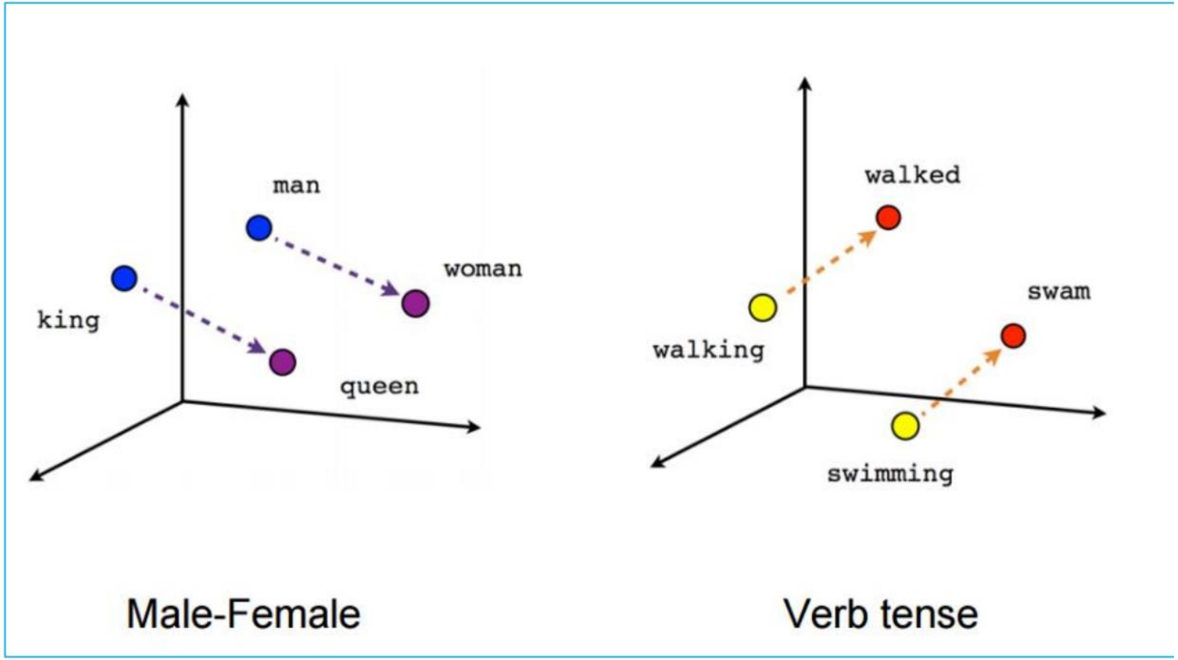


Vectorizing the text

Similar words are found 'closer' in vector space (distance is small, similarity is higher)

Characters, groups of words, or documents can also be mapped as vectors.



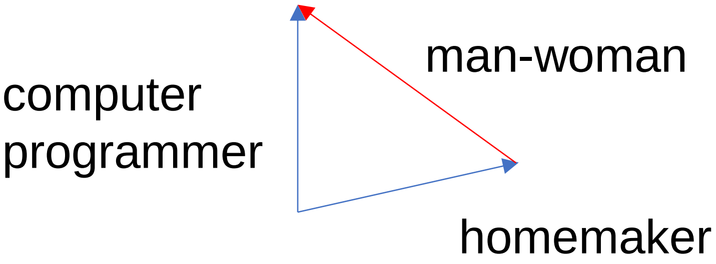


[The Illustrated Word2vec – Jay Alammar – Visualizing machine learning one concept at a time. (jalammar.github.io)](jalammar.github.io)

Vectorizing the text

[Man is to computer programmer as woman is to homemaker? debiasing word embeddings | Proceedings of the 30th International Conference on Neural Information Processing Systems (acm.org)]

$$\overrightarrow{man} - \overrightarrow{woman} \approx \overrightarrow{king} - \overrightarrow{queen}$$



Man is to Computer Programmer as Woman is to Homemaker? Debiasing Word Embeddings

Tolga Bolukbasi[1], **Kai-Wei Chang**[2], **James Zou**[2], **Venkatesh Saligrama**[1,2], **Adam Kalai**[2]
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Abstract

The blind application of machine learning runs the risk of amplifying biases present in data. Such a danger is facing us with *word embedding*, a popular framework to represent text data as vectors which has been used in many machine learning and natural language processing tasks. We show that even word embeddings trained on Google News articles exhibit female/male gender stereotypes to a disturbing extent. This raises concerns because their widespread use, as we describe, often tends to amplify these biases. Geometrically, gender bias is first shown to be captured by a direction in the word embedding. Second, gender neutral words are shown to be linearly separable from gender definition words in the word embedding. Using these properties, we provide a methodology for modifying an embedding to remove gender stereotypes, such as the association between the words *receptionist* and *female*, while maintaining desired associations such as between the words *queen* and *female*. Using crowd-worker evaluation as well as standard benchmarks, we empirically demonstrate that our algorithms significantly reduce gender bias in embeddings while preserving the its useful properties such as the ability to cluster related concepts and to solve analogy tasks. The resulting embeddings can be used in applications without amplifying gender bias.

1 Introduction

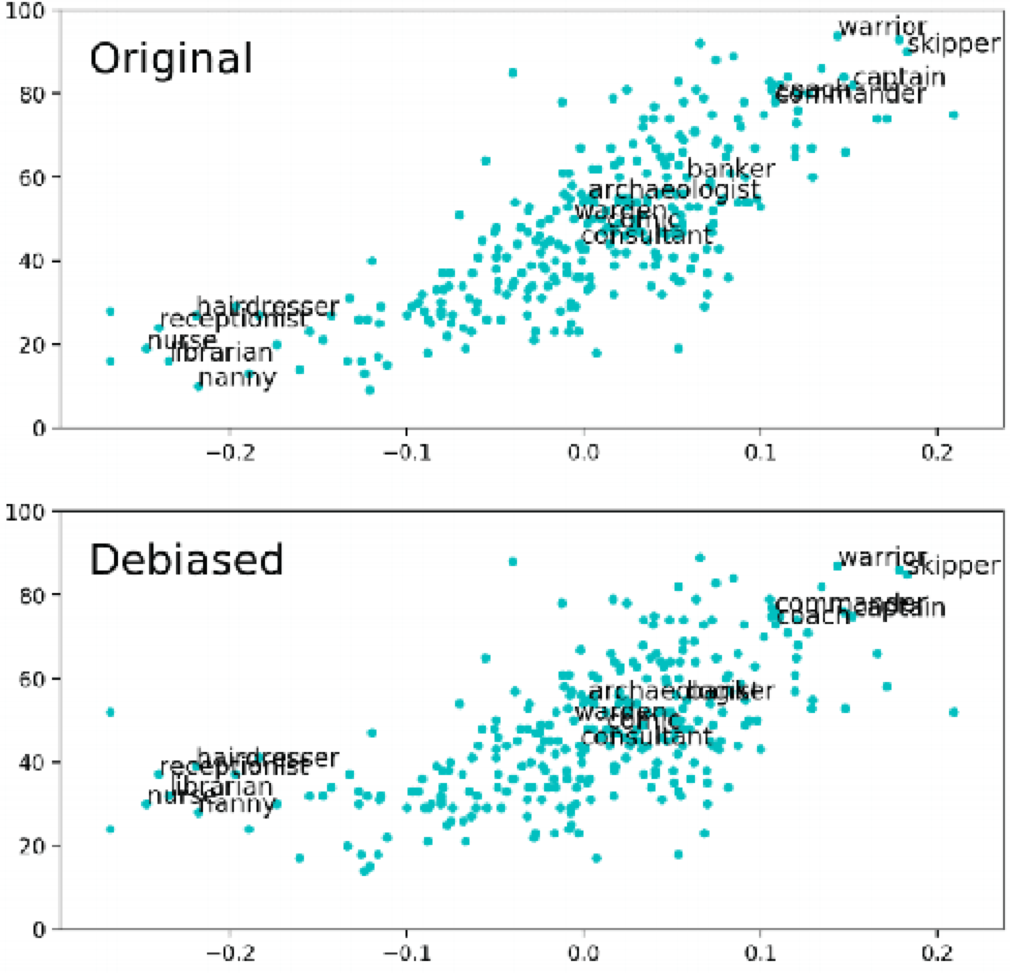
Research on word embeddings has drawn significant interest in machine learning and natural language processing. There have been hundreds of papers written about word embeddings and their applications, from Web search [22] to parsing Curriculum Vitae [12]. However, none of these papers have recognized how blatantly sexist the embeddings are and hence risk introducing biases of various types into real-world systems.

A word embedding, trained on word co-occurrence in text corpora, represents each word (or common phrase) w as a d-dimensional *word vector* $\vec{w} \in \mathbb{R}^d$. It serves as a dictionary of sorts for computer programs that would like to use word meaning. First, words with similar semantic meanings tend to have vectors that are close together. Second, the vector differences between words in embeddings have been shown to represent relationships between words [27, 21]. For example given an analogy puzzle, "man is to king as woman is to x" (denoted as *man*:*king* :: *woman*:x), simple arithmetic of the embedding vectors finds that x=*queen* is the best answer because $\overrightarrow{\text{man}} - \overrightarrow{\text{woman}} \approx \overrightarrow{\text{king}} - \overrightarrow{\text{queen}}$. Similarly, x=*Japan* is returned for *Paris*:*France* :: *Tokyo*:x. It is surprising that a simple vector arithmetic can simultaneously capture a variety of relationships. It has also excited practitioners because such a tool could be useful across applications involving natural language. Indeed, they are being studied and used in a variety of downstream applications (e.g., document ranking [22], sentiment analysis [14], and question retrieval [17]).

Vectorizing the text

Similar words are found ‘closer’ in vector space (distance is small, similarity is higher)

Characters, groups of words, or documents can also be mapped as vectors.



Transformers

Transformers (e.g. BERT, GPT) and word vectors (like Word2Vec and GloVe) represent two different approaches to handling language data in natural language processing (NLP).

Both are used to capture the meaning of words and their relationships with other words, but they do so in significantly different ways.

Word vectors:

Are static (e.g. I am **well**; the cat fell in the well will have the same vector).

Use neural networks to learn word vectors.

Can capture semantic relationships (e.g. king-man queen-woman
King – man + woman = queen

Can use PCA (or other dimension reduction) to support visualisations

Transformers:

Vectors are sensitive to context.

Use attention mechanisms – for each word, which word to pay attention to (e.g. over a pronoun, will pay attention to the noun)

Trained to predicted next word, or masked words.

Versatile – classification, sentiment analysis, question/answer etc.

AI

MDPI

University of Exeter

Review

A Comprehensive Review of AI Techniques for Addressing Algorithmic Bias in Job Hiring

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Abstract: The study comprehensively reviews artificial intelligence (AI) techniques for addressing algorithmic bias in job hiring. More businesses are using AI in curriculum vitae (CV) screening. While the move improves efficiency in the recruitment process, it is vulnerable to biases, which have adverse effects on organizations and the broader society. This research aims to analyze case studies on AI hiring to demonstrate both successful implementations and instances of bias. It also seeks to evaluate the impact of algorithmic bias and the strategies to mitigate it. The basic design of the study entails undertaking a systematic review of existing literature and research studies that focus on artificial intelligence techniques employed to mitigate bias in hiring. The results demonstrate that the correction of the vector space and data augmentation are effective natural language processing (NLP) and deep learning techniques for mitigating algorithmic bias in hiring. The findings underscore the potential of artificial intelligence techniques in promoting fairness and diversity in the hiring process with the application of artificial intelligence techniques. The study contributes to human

6. Text similarity measures

Computing similarity between two text pieces (terms/strings/documents etc)

Example Applications:

- Relevance of a document match for a query
- Computing semantic relatedness between strings/terms

Various string metrics available:

- Edit Distance/Levenshtein Distance
- Jaccard Distance
- Cosine Similarity
- ...

Text similarity measures: Edit Distance

Edit distance is the most common.

- aka **Levenshtein distance**

The minimum number of single character deletions, insertions, or substitutions required to transform one string into the other.

kitten → sitten (sub 'k' for 's')
sitten → sittin (sub 'e' for 'i')
sittin → **sitting** (insert 'g' at end)

e.g. The edit distance between good and goodbye is 3.

Useful in spell checking applications, fuzzy matching, plagiarism detection.

```
if (!require("stringdist")) install.packages("stringdist")
library(stringdist)

# Example strings
string1 <- "kitten"
string2 <- "sitting"

# Calculate Levenshtein distance
distance <- stringdist(string1, string2, method = "lv")

# Print the distance
print(distance)
```

```
[1]  3
```

Text similarity measures: Jaccard distance

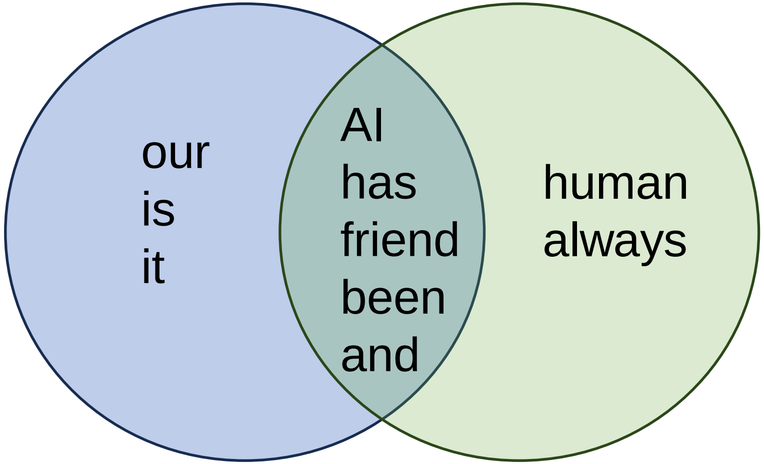
Measure of how dissimilar two sets of strings are. The lower the distance, the stronger the string similarity.

Defined as the intersection divided by the union of two sets.

Perform lemmatisation first to increase the number of size of intersection.

Calculate the edit distance between the strings:

S1 = ‘AI is our friend, and it has been friendly’
S2 = ‘AI and humans have always been friendly’



7. Regular Expressions

A **regular expression** (often referred to as “regex”) is a language for expressing a search pattern of text.

A test bed for some regex
https://regexr.com/

Example: Regular expression for an email address :

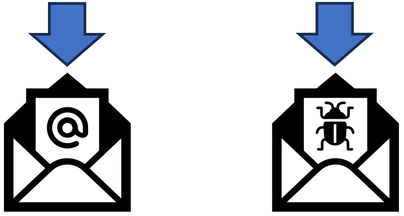
^([a-zA-Z0-9_\-\.]+)@([a-zA-Z0-9_\-\.]+)\.([a-zA-Z]{2,5})$

https://xkcd.com/208/

Seminar tonight and tomorrow: SPAM or HAM?

- Clean data (YouTube comments)
- TF-IDF
- Term document-matrix (raw words)
- Sentiment analysis using a lexicon (dictionary of words classified according to sentiment)
- Topic modelling (clustering) of terms

- Random forest classification on raw words
- Random forest classification of sentiment
- Random forest classification of topics



HAM SPAM

Why is text analysis difficult?

Words are ambiguous. Understanding meaning depends on:

Another
rainy day.
FUN! ☹

He yelled at me for
eating his pizza ☹

Call me a cab!
Can you pass the
salt?

What are the
best restaurants
near me?

I will leave as
soon as the
meeting is over.

Slang, abbreviations, typo’s and grammatical errors

- Hangry!! Super psyched to bounce back for grub.
- OMG. Ths standup is hilarious. I'm dying.
- My dinner was better then yours.

Sarcasm, idioms and metaphors

- You light up my life.
- Time is a thief.
- Been running around like headless chickens tryna get ths assgnmnt sorted.

Body Language (eye roll, side eye, word stress,..)

Context (personal/situational) matters!

- It was a wet, muddy Sunday. The car parks were almost too full, rain was beating down.
- Took my grandma out for a trip to Killerton. She has walking difficulties, but I shouldn’t have worried as the staff were quite helpful and considerate.

Next Week: Week 9

- Read Data Science for Business, chapter 9 and 11

Cohen MC, Guetta CD, Jiao K, Provost F (2018) Data-Driven Investment Strategies for Peer-to-Peer Lending: A Case Study for Teaching Data Science. Big Data 6(3):191– 213

Assignment Due

15 March 2024 Time: 15:00 hours

University of Exeter

Any questions?

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