Text Mining in R

Section: Exploratory Text Analysis

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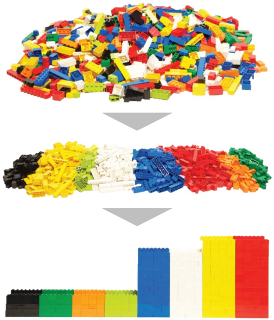
Agenda

1. **Exploratory text analyis:** Learn how to gain an initial understanding of text data
2. **Tidy text analysis:** Learn how to perform text analysis in a “tidy” way using `tidytext`
3. **Corpus analyis:** Understand how to explore text corpora and perform tf-idf document weighting in R

Exploratory text analysis

- Text mining
  - **Extracting relevant information** or knowledge from text data
  - Not always sure what we are looking for (until we find it)!
- Exploratory text analysis
  - Gain an **initial understanding** of the text data
  - **Clean and preprocess** the texts
  - Identify **patterns** and **data characteristics**



Exploratory text analysis serves as a first step towards further statistical analysis (e. g. sentiment analysis, text classification, . . .)

Working with text

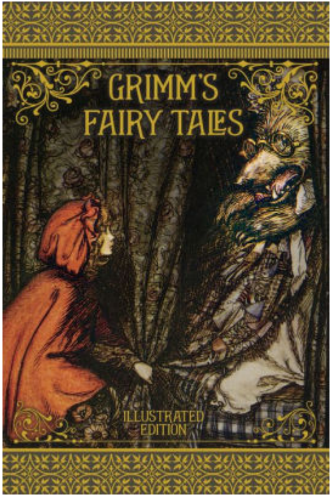
- Text data can come from **various sources**:
  - Websites
  - Books
  - Social media
  - Databases
  - Digital scans of printed materials
  - ...
- Typically in **unstructured format** (data without a pre-defined data model)

Approximately 90% of the world's data is held in unstructured formats (Source: Oracle)

This is text data


```
## <div class="js-tweet-text-container">
## <p class="TweetTextSize
TweetTextSize--normal js-tweet-text
tweet-text" lang="en"
data-aria-label-part="0">The Economy is
doing really well. The Federal Reserve can
easily make it Record Setting! The question
is being asked, why are we paying much more
in interest than Germany and certain other
countries? Be early (for a change), not
late. Let America win big, rather than just
win!</p>
## </div>
```

This is text data too




```
## The Project Gutenberg EBook of Household
Tales by Brothers Grimm
##
## Copyright laws are changing all over the
world. Be sure to check the
## copyright laws for your country before
downloading or redistributing
## this or any other Project Gutenberg
eBook.
##
## This header should be the first thing
seen when viewing this Project
## Gutenberg file.  Please do not remove it.
Do not change or edit the
## header without written permission.
##
## Please read the "legal small print," and
other information about the
## ...
```

Text data

- **Texts** are stored as **raw character strings**
- Text string contains **tokens**, which is a **semantically meaningful** unit of text
- Tokens can be words, sentences, paragraphs, etc.
- Example: Peter Pan by J. M. Barrie

Token type	**Count**
Documents	1
Paragraphs	4464
Sentences	6044
Words	47707

Need to transform the raw string into tokens to perform meaningful text analysis

Tidytext R-package

- Contains **tidy tools** for quantitative text analysis, including tokenization, basic text summarization, sentiment analysis, and text modeling

Authors
Julia Silge / David Robinson

Repository:	Paper:	Review:
Repository link »	PDF link »	View review issue »
DOI:	Status badge:	Cite this paper:
http://dx.doi.org/10.21105/joss.00037	JOSS 10.21105/joss.00037	doi2bib

Summary

The tidytext package (Silge, Robinson, and Hester 2016) is an R package (R Core Team 2016) for text mining using tidy data principles. As described by Hadley Wickham (Wickham 2014), tidy data has a specific structure:

- each variable is a column
- each observation is a row
- each type of observational unit is a table

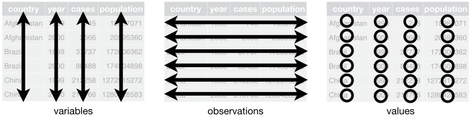
Tidy data sets allow manipulation with a standard set of "tidy" tools, including popular packages such as dplyr (Wickham, Francois, and RStudio 2015), ggplot2 (Wickham, Chang, and RStudio 2016), and broom (Robinson et al. 2015). These tools do not yet, however, have the infrastructure to work fluently with text data and natural language processing tools. In developing this package, we provide functions and supporting data sets to allow conversion of text to and from tidy formats, and to switch seamlessly between tidy tools and existing text mining packages.

- Load necessary libraries `tidyverse` and `tidytext` to do text analysis

```r
library(tidyverse)
library(tiytext)
```

Tidy data

- Tidy format
  - Each variable forms a column
  - Each observation forms a row
  - Each type of observational unit forms a table



- Why?
  - **Standardized** consistent data structure
  - Makes it **easier to manipulate, model and visualize data**

We can easily switch between tidy format and other formats if needed

Tokenization

- Need to **organize text data around tokens**
  - If the data contains whole documents as a variable and the tokens are words, the data isn't *tidy*
- Common steps before text analysis
  - Split on white space/punctuation
  - Make lower case
  - Handling abbreviations
  - Maybe put named entities together
  - ...

Tokenization is the process of segmenting running text into a list of tokens (e.g. words or sentences)

Creating some text data

- Creating a text corpus consisting of three documents

```
txt <- c("These are words", "so are these", "this is running on")
document <- c(1, 2, 3)
dat <- tibble(txt, document)
dat
```

```
## # A tibble: 3 x 2
##   txt                document
##   <chr>                 <dbl>
## 1 These are words           1
## 2 so are these              2
## 3 this is running on        3
```

The `unnest_tokens()` function

- The function `unnest_tokens(tbl, output, input, ...)` converts a text column of a dataframe into tokens
- Parameters:
  - `tbl` is a dataframe
  - `output` is the name of the column to be generated
  - `input` is the column in the dataframe that gets split

```
unnest_tokens(tbl = dat, output = "tok", input = txt)
```

`unnest_tokens()` supports tokenization of words (default), sentences, ngrams, characters, and regular expressions

Example: `unnest_tokens()`

```
## # A tibble: 10 x 2
##   document tok
##      <dbl> <chr>
## 1        1 these
## 2        1 are
## 3        1 words
## 4        2 so
## 5        2 are
## # ... with 5 more rows
```

- One-token-per-row format
- Punctuation has been stripped
- Words have been converted to lowercase

Our text is **tidy** now!

Gathering more data

- **Project Gutenberg** provides access to the full text of many public domain works
- Access the library via the `gutenbergr` R-package

```
library(gutenbergr)
gutenberg_metadata %>%
  filter(author == "Shakespeare, William")
```

```
## # A tibble: 317 x 8
##   gutenberg_id title author gutenberg_autho~ language gutenberg_books~
##          <int> <chr> <chr>                  <int> <chr>    <chr>
## 1          100 The ~ Shake~                    65 en       Plays
## 2         1041 Shak~ Shake~                    65 en       <NA>
## 3         1045 Venu~ Shake~                    65 en       <NA>
## 4         1100 The ~ Shake~                    65 en       <NA>
## 5         1101 The ~ Shake~                    65 en       <NA>
## # ... with 312 more rows, and 2 more variables: rights <chr>,
## #   has_text <lgl>
```

Gathering more data

- Download book 5314 (“Household Tales by Brothers Grimm”)

```
full_text <- gutenberg_download(5314)
```

- Take a glimpse at the book via `slice(rows)`

```
full_text %>% slice(1000:1005)
```

```
## # A tibble: 6 x 2
##   gutenberg_id text
##          <int> <chr>
## 1         5314 "    \"What rumbles and tumbles"
## 2         5314 "    Against my poor bones?"
## 3         5314 "    I thought 't was six kids,"
## 4         5314 "    But it's naught but big stones.\""
## 5         5314 ""
## # ... with 1 more row
```

Time to tidy your text!

- Word tokenization using `unnest_tokens()`

```
tidy_book <- full_text %>%
    unnest_tokens(word, text)
tidy_book
```

```
## # A tibble: 287,073 x 2
##   gutenberg_id word
##          <int> <chr>
## 1         5314 the
## 2         5314 e
## 3         5314 book
## 4         5314 was
## 5         5314 prepared
## # ... with 2.871e+05 more rows
```

- The book contains 287,073 words

What are the most common words?

- Calculate word counts via `count(var)`
- Ouput is a new column `n`
- If `sort = TRUE`, the output is sorted in descending order

```
tidy_book %>%
    count(word, sort = TRUE)
```

```
## # A tibble: 8,288 x 2
##   word      n
##   <chr> <int>
## 1 the   20176
## 2 and   14740
## 3 to     7454
## 4 he     5954
## 5 a      5436
## # ... with 8,283 more rows
```

Stopwords

- **Stopwords** are short function words occurring **frequently** but with **no deep meaning**
- Removal of stopwords in order to concentrate on more important words (that are specific to the text)
- Common approach is to use **predefined list** of stopwords (Examples: *the*, *is*, *at*, *which*, *and*)
- Get such a built-in list via `get_stopwords()`

```r
get_stopwords()
```

```
## # A tibble: 175 x 2
##    word   lexicon
##    <chr>  <chr>
## 1 i       snowball
## 2 me      snowball
## 3 my      snowball
## 4 myself snowball
## 5 we      snowball
## # ... with 170 more rows
```

Filtering stopwords

- Filter stopwords via `anti_join()`

```
tidy_book %>%
    anti_join(get_stopwords()) %>%
    count(word, sort = TRUE)
```

```
## # A tibble: 8,141 x 2
##   word      n
##   <chr> <int>
## 1 said   3025
## 2 thou   1525
## 3 one    1369
## 4 went   1181
## 5 came   1044
## # ... with 8,136 more rows
```

Handling contractions

- The function `unnest_tokens()` does **not** replace contractions

```
tidy_book %>% filter(word == "can't")
```

```
## # A tibble: 26 x 2
##   gutenberg_id word
##          <int> <chr>
## 1         5314 can't
## 2         5314 can't
## 3         5314 can't
## 4         5314 can't
## 5         5314 can't
## # ... with 21 more rows
```

- Load package `textclean`

```
library(textclean)
```

Example: Handling contractions

- Example: Replace contractions using `replace_contraction()`

```r
text <- "I'll go home"
replace_contraction(text, contraction.key = lexicon::key_contractions)
```

```
## [1] "I will go home"
```

- `replace_contraction()` uses a predefined list of contractions

```r
head(lexicon::key_contractions, 5)
```

```
##   contraction expanded
## 1      'cause  because
## 2        'tis    it is
## 3       'twas   it was
## 4       ain't   am not
## 5      aren't  are not
```

Handling contractions

- Replace contractions in our book

```
tidy_book <- full_text %>%
  mutate(text = replace_contraction(text)) %>%
  unnest_tokens(word, text)

  tidy_book %>% filter(word == "can't")
```

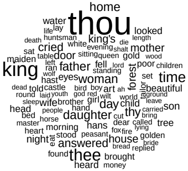
```
## # A tibble: 0 x 2
## # ... with 2 variables: gutenberg_id <int>, word <chr>
```

The `textclean` package provides additional functions for replacing dates, emojis, emoticons, etc.

Word clouds

- The `wordcloud` R-package allows one to easily visualize the most common words in a word cloud

```
library(wordcloud)

wc_data <- tidy_book %>%
  anti_join(stop_words) %>%
  count(word)
wordcloud(wc_data$word, wc_data$n, max.words = 100)
```



Zipf's law

- Zipf's law states that the **frequency that a word appears** is **inversely proportional to its rank**

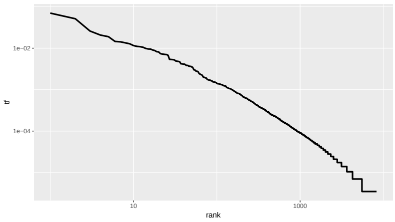
```
term_freq <- tidy_book %>%
  count(word, sort = TRUE) %>%
  mutate(TotalWords = sum(n),
         rank = row_number(),
         tf = n / TotalWords)

term_freq
```

```
## # A tibble: 8,267 x 5
##   word       n TotalWords  rank     tf
##   <chr> <int>      <int> <int>  <dbl>
## 1 the   20176     287331     1 0.0702
## 2 and   14740     287331     2 0.0513
## 3 to     7454     287331     3 0.0259
## 4 he     5955     287331     4 0.0207
## 5 a      5436     287331     5 0.0189
## # ... with 8,262 more rows
```

Zipf's law

- We indeed observe a constant, negative slope indicating an inversely proportional relationship

```
term_freq %>%
  ggplot(aes(rank, tf)) +
  geom_line(size = 1.1, show.legend = FALSE) +
  scale_x_log10() +
  scale_y_log10()
```



Analysis text corpora

- A text corpus is a **structured set of texts** (e. g. a collection of articles)
- Example: Loading a collection of physics classics

```
gutenberg_metadata %>% filter(gutenberg_id %in% c(37729, 14725, 13476, 7333))
```

```
## # A tibble: 4 x 8
##   gutenberg_id title author gutenberg_autho~ language gutenberg_books~
##          <int> <chr> <chr>             <int> <chr>    <chr>
## 1         7333 Side~ Einst~             1630 en       <NA>
## 2        13476 "Exp~ Tesla~             5067 en       <NA>
## 3        14725 "Tre~ Huyge~             5648 en       <NA>
## 4        37729 A Di~ Galil~            39014 en       <NA>
## # ... with 2 more variables: rights <chr>, has_text <lgl>
```

```
physics <- gutenberg_download(c(37729,14725,13476,7333), meta_fields = "author")
```

Show the most frequent words

- Show the most frequent words

```
physics_words <- physics %>%
  unnest_tokens(word, text) %>%
  count(author, word, sort = TRUE) %>% print()
```

```
## # A tibble: 11,219 x 3
##   author              word       n
##   <chr>               <chr> <int>
## 1 Galilei, Galileo    the     3760
## 2 Tesla, Nikola       the     3604
## 3 Huygens, Christiaan the     3553
## 4 Galilei, Galileo    of      2049
## 5 Tesla, Nikola       of      1737
## # ... with 1.121e+04 more rows
```

- How can we find the words that are most characteristic for each document?

How can we find characteristic words?

- Example: *relativity* and *the* in the document from Albert Einstein

Word	Document Frequency	Corpus Frequency
relativity	31	31
the	694	11611

- Rare word *relativity*
  - Document containing this term is very likely to be relevant to Albert Einstein
  - High weight for rare terms like *relativity*
- Common word *the*
  - Document containing this term can be about anything
  - Very low weight for common terms like *the*
- **Idea:** Need a numerical **measure** that reflects how **important** a word is to a **document** in a **corpus**

Tf-idf weighting

- Tf-idf weighting
  - Best known weighting scheme in **information retrieval**
  - Increases with the number of **occurrences** of a term in a **document**
  - Increases with the **rarity** of the term in the **collection**
- Calculation
  1. Term Frequency (*tf*): Number of times a term *t* occurs in a document *d*
  2. Document Frequency (*df*): Number of documents *d* that contain each term *t*
  3. Inverse Document Frequency $idf = log(N/df)$, where N is the total number of documents
  4. Term frequency–inverse document frequency $tf - idf = tf \times idf$

Tf-idf weighting is used frequently by search engines

The `bind_tf_idf` function

- `bind_tf_idf(tbl, term, document, n)` adds tf-idf values to a tidy text dataset
- Parameters:
  - `tbl` is a tidy text dataset with one-row-per-term-per-document
  - `term` is the column containing the terms (`word` in this case)
  - `document` is the column containing the document IDs (`author` in this case),
  - `n` is the column containing document-term counts (`n` in this case)
- Add a column tf-idf using the `bind_tf_idf()` function

```
physics_words %>%
  bind_tf_idf(word, author, n) %>%
  arrange(desc(tf_idf))
```

The `bind_tf_idf` function

```
## # A tibble: 11,219 x 6
##   author              word            n      tf   idf  tf_idf
##   <chr>               <chr>       <int>   <dbl> <dbl>   <dbl>
## 1 Huygens, Christiaan refraction    218 0.00569 1.39  0.00789
## 2 Tesla, Nikola       bulb          171 0.00433 1.39  0.00600
## 3 Galilei, Galileo    water         828 0.0206  0.288 0.00593
## 4 Tesla, Nikola       coil          166 0.00420 1.39  0.00583
## 5 Einstein, Albert    theory         67 0.00774 0.693 0.00536
## # ... with 1.121e+04 more rows
```

- Top tf-idf values are intuitively very characteristic to the authors

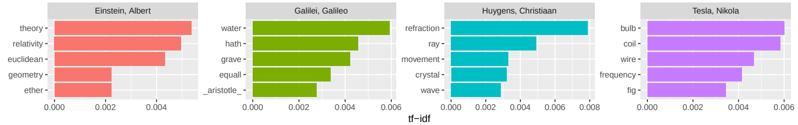
---

Top tf-idf values are not affected by stop words as IDF values of such stop words are very small (due to their presence in almost every document)

Visualizing the results

- Plotting the 5 most characteristic words per author using `ggplot`

```
plot_physics <- physics_words %>%
  bind_tf_idf(word, author, n) %>%
  group_by(author) %>%
  top_n(5, tf_idf) %>%
  ungroup()

ggplot(plot_physics, aes(reorder(word, tf_idf), tf_idf, fill = author)) +
  geom_col(show.legend = FALSE) + labs(x = NULL, y = "tf-idf") +
  facet_wrap( ~ author, ncol = 4, scales = "free") + coord_flip()
```



Wrap-up

- Key takeaways
  - **Text data** typically comes in **unstructed format**
  - **Exploratory text analysis** allows one to gain an **initial understanding** of the data
  - The `tidytext` **R-Package** provides tools to perform **exploratory text analysis** in a "tidy" way
- Advanced topics
  - Sentiment analysis
  - Topic modeling
  - Text classification & text-based forecasting
- Further reading
  - Book: Text Mining with R (O'Reilly, 2017, by J. Silge & D. Robinson)