ACCT 420: Textual analysis

Session 7

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Front matter



Learning objectives



- Theory:
 - Natural Language
 Processing
- Application:
 - Analyzing a Citigroup annual report
- Methodology:
 - Text analysis
 - Machine learning





Datacamp

- Sentiment analysis in R the Tidy way
 - Just the first chapter is required
 - You are welcome to do more, of course
- I will generally follow the same "tidy text" principles as the Datacamp course does – the structure keeps things easy to manage
 - We will sometimes deviate to make use of certain libraries, which, while less tidy, make our work easier than the corresponding tidyoriented packages (if they even exist!)

Textual data and textual analysis



Review of Session 6

- Last session we saw that textual measures can help improve our fraud detection algorithm
- We actually looked at a bunch of textual measures:
 - Sentiment
 - Readability
 - Topic/content
- We didn't see how to make these though...
 - Instead, we had a nice premade dataset with everything already done

We'll get started on these today – sentiment and readability

We'll cover topic modeling next session

Why is textual analysis harder?

- Thus far, everything we've worked with is what is known as structured data
 - Structured data is numeric, nicely indexed, and easy to use
- Text data is *unstructured*
 - If we get an annual report with 200 pages of text...
 - Where is the information we want?
 - What do we want?
 - How do we crunch 200 pages into something that is...
 - 1. Manageable? (Structured)
 - 2. Meaningful?

This is what we will work on today, and we will revist some of this in the remaining class sessions

Structured data

• Our long or wide format data

Wide format

##	#	A tibble	e: 3 x 3	
##		quarter	level_3	value
##		<chr></chr>	<chr></chr>	<chr></chr>
##	1	1995-Q1	Wholesale Trade	17
##	2	1995-Q1	Retail Trade	-18
##	3	1995-Q1	Accommodation	16

Long format

##	#	A tibble:	3 x 4	
##		RegionID	`1996-04`	`
##		<dbl></dbl>	<dbl></dbl>	
##	1	84654	334200	
##	2	90668	235700	
##	3	91982	210400	

The structure is given by the IDs, dates, and variables

1996-05``19 <dbl> 335400 236900 212200

Unstructured data

- Text
 - Open responses to question, reports, etc.
 - What it isn't:
 - "JANUARY", "ONE", "FEMALE"
 - Months, numbers
 - Anything with clear and concise categories
- Images
 - Satellite imagery
- Audio
 - Phone call recordings
- Video
 - Security camera footage

All of these require us to determine and *impose* structure



Some ideas of what we can do

- 1. Text extraction
 - Find all references to the CEO
 - Find if the company talked about global warming
 - Pull all telephone numbers or emails from a document
- 2. Text characteristics
 - How varied is the vocabulary?
 - Is it positive or negative (sentiment)
 - Is it written in a strong manner?
- 3. Text summarization or meaning
 - What is the content of the document?
 - What is the most important content of the document?
 - What other documents discuss similar issues?

Where might we encounter text data in business

- 1. Business contracts
- 2. Legal documents
- 3. Any paperwork
- 4. News
- 5. Customer reviews or feedback
 - Including transcription (call centers)
- 6. Consumer social media posts
- 7. Chatbots and AI assistants



Natural Language Processing (NLP)

- NLP is the subfield of computer science focused on analyzing large amounts of unstructured textual information
 - Much of the work builds from computer science, linguistics, and statistics
- Unstructured text actually has some structure derived from language itself
 - Word selection
 - Grammar
 - Phrases
 - Implicit orderings
- NLP utilizes this implicit structure to better understand textual data

NLP in everyday life

- Autocomplete of the next word in phone keyboards
 - Demo below from Google's blog
- Voice assistants like Google Assistant, Siri, Cortana, and Alexa
- Article suggestions on websites
- Search engine queries
- Email features like missing attachment detection

Dinner next week	- 2
Evan Brown, Maalika Patel	8
Dinner next week	

Gartner Hype Cycle for Artificial Intelligence, 2019



gartner.com/SmarterWithGartner

Source: Gartner © 2019 Gartner, Inc. and/or its affiliates. All rights reserved.



As of July 2019

3.10

Case: How leveraging NLP helps call centers

- Natural Language Processing in Call Centres
- Short link: rmc.link/420class7

What are call centers using NLP for?

How does NLP help call centers with their business?







Consider

Where an we make use of NLP in business?

- We can use it for call centers
- We can make products out of it (like Google Duplex and other tech firms)
- Where else?



Working with 1 text file



Before we begin: Special characters

- Some characters in R have special meanings for string functions
 - \ | () [{ } ^ \$ * + ? . !
- To type a special character, we need to precede it with a \
 - Since \ is a special character, we'll need to put \ before \...
 - To type \$, we would use \\\$
- Also, some spacing characters have special symbols:
 - It is tab
 - \r is newline (files from Macs)
 - \r\n is newline (files from Windows)
 - In is newline (files from Unix, Linux, etc.)
 - You'll need to write \ \ to get the backslashes though



Loading in text data from files

- Use read file() from tidyverse's readr package to read in text data
- We'll use Citigroup's annual report from 2014
 - Note that there is a full text link at the bottom which is a .txt file
 - I will instead use a cleaner version derived from the linked file
 - The cleaner version can be made using the same techniques we will discuss today

```
# Read text from a .txt file using read file()
doc <- read file("../../Data/0001104659-14-015152.txt")</pre>
# str wrap is from stringr from tidyverse
cat(str wrap(substring(doc, 1, 500), 80))
```

UNITED STATES SECURITIES AND EXCHANGE COMMISSION WASHINGTON, D.C. 20549 FORM ## 10-K ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ## ACT OF 1934 For the fiscal year ended December 31, 2013 Commission file number ## 1-9924 Citigroup Inc. (Exact name of registrant as specified in its charter) ## Securities registered pursuant to Section 12(b) of the Act: See Exhibit 99.01 ## Securities registered pursuant to Section 12(g) of the Act: none Indicate by ## check mark if the registrant is a

Loading from other file types

- Ideally you have a .txt file already such files are generally just the text of the documents
- Other common file types:
 - HTML files (particularly common from web data)
 - You can load it as a text file just note that there are html tags embedded in it
 - Things like <a>, , , etc.
 - You can load from a URL using httr or RCurl
 - In R, you can use XML or rvest to parse out specific pieces of html files
 - If you use python, use lxml or BeautifulSoup 4 (bs4) to quickly turn these into structured documents
 - In R, you can process JSON data using jsonlite

Loading from other file types

- Ideally you have a .txt file already such files are generally just the text of the documents
- Other common file types:
 - PDF files
 - Use pdftools to extract text into a vector of pages of text
 - Use tabulizer to extract tables straight from PDF files!
 - This is very painful to code by hand without this package
 - The package itself is a bit difficult to install, requiring Java and rJava, though



Example using html

library(httr)
library(XML)

httpResponse <- GET('https://coinmarketcap.com/currencies/ethereum/')
html = httr::content(httpResponse, "text")
paste0('...', str_wrap(substring(html, 135418, 135480), 80), '...')</pre>

[1] "...div>\$349.36 USD /</div><div>\$352.16 USD</div><th..."

[1] "Ethereum was priced at \$\$349.39 when these slides were compiled"





Automating crypto pricing in a document

```
# The actual version I use (with caching to avoid repeated lookups) is in the appe
cryptoMC <- function(name) {</pre>
 httpResponse <- GET(paste('https://coinmarketcap.com/currencies/',name,'/',sep='</pre>
 xpath <- '//*[@id=" next"]/div[1]/div[2]/div[1]/div[2]/div[1]/div[2]/span[1</pre>
 hdoc = htmlParse(html, asText=TRUE)
 plain.text <- xpathSApply(hdoc, xpath, xmlValue)</pre>
 plain.text
```

paste("Ethereum was priced at", cryptoMC("ethereum"))

[1] "Ethereum was priced at \$349.39"

paste("Litecoin was priced at", cryptoMC("litecoin"))

[1] "Litecoin was priced at \$349.39"



Basic text functions in R

- Subsetting text
- Transformation
 - Changing case
 - Adding or combining text
 - Replacing text
 - Breaking text apart
- Finding text



We will cover these using stringr as opposed to base R – stringr's commands are much more consistent

 Every function in stringr can take a vector of strings for the first argument, which is *tidy*

Subsetting text



Transforming text

- Commonly used functions:
 - tolower() or str to lower(): make the text lowercase
 - toupper() or str to lower(): MAKE THE TEXT UPPERCASE
 - str to title(): Make the Text Titlecase
- paste() to combine text
 - It puts spaces between by default
 - You can change this with the sep= option
 - If everything to combine is in 1 vector, use collapse = with the desired separator
 - paste0() is paste with sep=""

Examples: Case

```
sentence <- str_sub(doc, 9896, 9929)
str_to lower(sentence)</pre>
```

[1] "citis net income was \$13.5 billion"

str to upper(sentence)

[1] "CITIS NET INCOME WAS \$13.5 BILLION"

str to title(sentence)

[1] "Citis Net Income Was \$13.5 Billion"

The str prefixed functions support non-English languages as well

You can run this in an R terminal! (It doesn't work in Rmarkdown though)
str to upper("Citis net income was \$13.5 billion", locale='tr') # Turkish

Examples: paste

board is a list of director names
titles is a list of the director's titles
paste(board, titles, sep=", ")

##	[1]	"Michael L. Corbat, CEO"
##	[2]	"Michael E. O'Neill, Chairman"
##	[3]	"Anthony M. Santomero, Former president, Fed (Philidelphia)"
##	[4]	"William S. Thompson, Jr., CEO, Retired, PIMCO"
##	[5]	"Duncan P. Hennes, Co-Founder/Partner, Atrevida Partners"
##	[6]	"Gary M. Reiner, Operating Partner, General Atlantic"
##	[7]	"Joan E. Spero, Senior Research Scholar, Columbia University"
##	[8]	"James S. Turley, Former Chairman & CEO, E&Y"
##	[9]	"Franz B. Humer, Chairman, Roche"
##	[10]	"Judith Rodin, President, Rockefeller Foundation"
##	[11]	"Robert L. Ryan, CFO, Retired, Medtronic"
##	[12]	"Diana L. Taylor, MD, Wolfensohn Fund Management"
##	[13]	"Ernesto Zedillo Ponce de Leon, Professor, Yale University"
##	[14]	"Robert L. Joss, Professor/Dean Emeritus, Stanford GSB"

Citi's board consists of: Michael L. Corbat, Michael E. O'Neill, Anthony M. ## Santomero, William S. Thompson, Jr., Duncan P. Hennes, Gary M. Reiner, Joan E. ## Spero, James S. Turley, Franz B. Humer, Judith Rodin, Robert L. Ryan, Diana L. ## Taylor, Ernesto Zedillo Ponce de Leon, and Robert L. Joss.

Transforming text

- Replace text with str_replace_all()
 - First argument is text data
 - Second argument is what you want to remove
 - Third argument is the replacement
- If you only want to replace the first occurrence, use str_replace() instead

sentence

[1] "Citis net income was \$13.5 billion"

str_replace_all(sentence, "\\\$13.5", "over \$10")

[1] "Citis net income was over \$10 billion"

Transforming text

- Split text using str_split()
 - This function returns a list of vectors!
 - This is because it will turn every string passed to it into a vector, and R can't have a vector of vectors
 - [[1]] can extract the first vector
- You can also limit the number of splits using n=
 - A bit more elegant solution is using str_split_fixed() with n=
 - Returns a character matrix (nicer than a list)

Example: Splitting text

paragraphs <- str_split(doc, '\n')[[1]]</pre>

number of paragraphs
length(paragraphs)

[1] 206

Last paragraph
cat(str_wrap(paragraphs[206], 80))

The total amount of securities authorized pursuant to any instrument defining ## rights of holders of long-term debt of the Company does not exceed 10% of the ## total assets of the Company and its consolidated subsidiaries. The Company ## will furnish copies of any such instrument to the SEC upon request. Copies of ## any of the exhibits referred to above will be furnished at a cost of \$0.25 per ## page (although no charge will be made for the 2013 Annual Report on Form 10-## K) to security holders who make written request to Citigroup Inc., Corporate ## Governance, 153 East 53 rd Street, 19 th Floor, New York, New York 10022. * ## Denotes a management contract or compensatory plan or arrangement. + Filed ## herewith.

Finding phrases in text

• How did I find the previous examples?

<pre>str_locate_all(tolower(doc), "net income") ## [[1]] ## start end ## [1,] 8508 8517 ## [2,] 9902 9911 ## [3,] 16549 16558 ## [4,] 17562 17571 ## [5,] 28900 28909 ## [6,] 32197 32206 ## [6,] 32197 32206 ## [7,] 35077 35086 ## [1,] 43257 43266 ## [1,] 43257 43266 ## [11,] 45345 45354 ## [12,] 47618 47627 ## [13,] 51865 51874 ## [14,] 51953 51962 ## [14,] 51953 51962 ## [16,] 52748 52757 ## [16,] 52748 52757 ## [18,] 58817 58826 ## [19,] 96022 96031</pre>							
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## [19,] 96022 96031	ŧ#	[18,]	58817	58826			
	ŧ#	[19,]	96022	96031			

Finding phrases in text

- 4 primary functions:
 - 1. str detect(): Reports TRUE or FALSE for the presence of a string in the text
 - 2. str count(): Reports the number of times a string is in the text
 - 3. str locate(): Reports the first location of a string in the text
 - str locate all(): Reports every location as a list of matrices
 - 4. str extract(): Reports the matched phrases
- All take a character vector as the first argument, and something to match for the second argument

Example: Finding phrases

How many paragraphs mention net income in any case?

x <- str detect(str to lower(paragraphs), "net income")</pre> x[1:10]

[1] FALSE FALSE FALSE FALSE FALSE TRUE FALSE FALSE TRUE TRUE

sum(X)

[1] 13

What is the most net income is mentioned in any paragraph

x <- str_count(str_to_lower(paragraphs), "net income")</pre> x[1:10]

[1] 0 0 0 0 0 4 0 0 2 2

max(X)

[1] 4

Example: Finding phrases

• Where is net income first mentioned in the document?

```
str locate(str to lower(doc), "net income")
```

start end ## [1,] 8508 8517

- First mention of net income
 - This function may look useless now, but it'll be on of the most useful later

```
str extract(str to lower(doc), "net income")
## [1] "net income"
```


R Practice

- Text data is already loaded, as if it was loaded using read file()
- Try:
 - Subsetting the text data
 - Transforming the text data
 - To all upper case
 - Replacing a phrase
 - Finding specific text in the document
- Do exercises 1 through 3 in today's practice file
 - **R** Practice
 - Shortlink: rmc.link/420r7

Pattern matching



Finding *patterns* in the text (regex)

- Regular expressions, aka regex or regexp, are ways of finding patterns in text
- This means that instead of looking for a specific phrase, we can match a set of phrases
- Most of the functions we discussed accept regexes for matching
 - str replace(),str split(),str detect(), str count(),str locate(),and str extract(),plus their variants
- This is why str extract() is so great we can extract anything from a document with it!



Regex example

- Breaking down an email
 - 1. A local name
 - 2. An @ sign
 - 3. A domain, which will have a . in it
- Local names can have many different characters in them
 - Match it with [:graph:]+
- The domain is pretty restrictive, generally just alphanumeric and .
 - There can be multiple . though
 - Match it with [:alnum:]+\\.[.[:alnum:]]+

```
# Extract all emails from the annual report
str_extract_all(doc, '[:graph:]+@[:alnum:]+\\.[.[:alnum:]]+')
```

```
## [[1]]
```

- ## [1] "shareholder@computershare.com" "shareholder@computershare.com"
- ## [3] "docserve@citi.com"

"shareholderrelations@citi.com"

Breaking down the example

- @ was itself it isn't a special character in strings in R
- $\setminus \setminus$ is just a period we need to escape . because it is special
- Anything in brackets with colons, [: :], is a set of characters
 - [:graph:] means any letter, number, or punctuation
 - [:alnum:] means any letter or number
- + is used to indicate that we want 1 or more of the preceding element
 - as many as it can match
 - [:graph:] + meant "Give us every letter, number, and punctuation you can, but make sure there is at least 1."
- Brackets with no colons, [], ask for anything inside
 - [.[:alnum:]] + meant "Give us every letter, number, and . you can, but make sure there is at least 1."

Breaking down the example

- Let's examine the output shareholder@computershare.com
- Our regex was [:graph:]+@[:alnum:]+\\.[.[:alnum:]]+
- Matching regex components to output:
 - $[:graph:] + \Rightarrow$ shareholder
 - $a \Rightarrow a$
 - $[:alnum:] + \Rightarrow$ computershare
 - $\backslash \backslash . \Rightarrow$.
 - [.[:alnum:]] + \Rightarrow com



Useful regex components: Content

- There's a nice cheat sheet here
 - More detailed documentation here
- Matching collections of characters
 - . matches everything
 - [:alpha:] matches all letters
 - [:lower:] matches all lowercase letters
 - [:upper:] matches all UPPERCASE letters
 - [:digit:] matches all numbers 0 through 9
 - [:alnum:] matches all letters and numbers
 - [:punct:] matches all punctuation
 - [:graph:] matches all letters, numbers, and punctuation
 - [:space:] or \s match ANY whitespace
 - S is the exact opposite
 - [:blank:] matches whitespace except newlines



Example: Regex content

```
text <- c("abcde", 'ABCDE', '12345', '!?!?.', 'ABC123?', "With space", "New\nline"
html_df(data.frame(
  text=text,
  alpha=str_detect(text, '[:alpha:]'),
  lower=str detect(text, '[:lower:]'),
  upper=str_detect(text, '[:upper:]'),
  digit=str_detect(text, '[:digit:]'),
  alnum=str_detect(text, '[:alnum:]')
))
```

text	alpha	lower	upper	digit	alnum
abcde	TRUE	TRUE	FALSE	FALSE	TRUE
ABCDE	TRUE	FALSE	TRUE	FALSE	TRUE
12345	FALSE	FALSE	FALSE	TRUE	TRUE
!?!?.	FALSE	FALSE	FALSE	FALSE	FALSE
ABC123?	TRUE	FALSE	TRUE	TRUE	TRUE
With space	TRUE	TRUE	TRUE	FALSE	TRUE
New line	TRUE	TRUE	TRUE	FALSE	TRUE

Example: Regex content

```
text <- c("abcde", 'ABCDE', '12345', '!?!?.', 'ABC123?', "With space", "New\nline"
html_df(data.frame(
  text=text,
  punct=str_detect(text, '[:punct:]'),
  graph=str_detect(text, '[:graph:]'),
  space=str_detect(text, '[:space:]'),
  blank=str_detect(text, '[:blank:]'),
  period=str_detect(text, '.')
))
```

text	punct	graph	space	blank	period
abcde	FALSE	TRUE	FALSE	FALSE	TRUE
ABCDE	FALSE	TRUE	FALSE	FALSE	TRUE
12345	FALSE	TRUE	FALSE	FALSE	TRUE
!?!?.	TRUE	TRUE	FALSE	FALSE	TRUE
ABC123?	TRUE	TRUE	FALSE	FALSE	TRUE
With space	FALSE	TRUE	TRUE	TRUE	TRUE
New line	FALSE	TRUE	TRUE	FALSE	TRUE

Useful regex components: Form

- [] can be used to create a class of characters to look for
 - [abc] matches anything that is a, b, c •
- [^] can be used to create a class of everything else
 - [^abc] matches anything that isn't a, b, or c
- Quantity, where x is some element
 - x? looks for 0 or 1 of x
 - x* looks for 0 or more of x
 - x+ looks for 1 or more of x
 - x{n} looks for n (a number) of x
 - x {n, } looks for at least n of x
 - x{n,m} looks for at least n and at most m of x
- Lazy operators
 - Regexes always prefer the longest match by default
 - Append ? to any quantity operator to make it prefer the shortest match possible

Useful regex components: Form

- Position
 - ^ indicates the start of the string
 - \$ indicates the end of the string
- Grouping
 - () can be used to group components
 - can be used within groups as a logical or
 - Groups can be referenced later using the position of the group within the regex
 - \\1 refers to the first group
 - \\2 refers to the second group





Example: Regexes on real estate firm names

Real estate firm names with 3 vowels in a row str_subset(RE names, '[AEIOU]{3}')

[1] "STADLAUER MALZFABRIK" "JOAO FORTES ENGENHARIA SA"

Real estate firm names with no vowels str_subset(RE names, '^[^AEIOU]+\$')

##	[1]	"FGP LTD"	"MBK PCL"	"MYP LTD"	"MCT BHD"	"R T C I
----	-----	-----------	-----------	-----------	-----------	----------

Real estate firm names with at least 12 vowels str subset(RE names, '([^AEIOU] * [AEIOU]) {11, }')

[1] "INTERNATIONAL ENTERTAINMENT" "PREMIERE HORIZON ALLIANCE" ## [3] "JOAO FORTES ENGENHARIA SA" "OVERSEAS CHINESE TOWN (ASIA)" ## [5] "COOPERATIVE CONSTRUCTION CO" "FRANCE TOURISME IMMOBILIER" ## [7] "BONEI HATICHON CIVIL ENGINE"

Real estate firm names with a repeated 4 letter pattern str subset(RE names, '([:upper:]{4}).*\\1')

[1] "INTERNATIONAL ENTERTAINMENT" "CHONG HONG CONSTRUCTION CO" ## [3] "ZHONGHONG HOLDING CO LTD"

"DEUTSCHE GEOTHERMISCHE IMMOB"

LTD"

Why is regex so important?

- Regex can be used to match anything in text
 - Simple things like phone numbers
 - More complex things like addresses
- It can be used to parse through large markup documents
 - HTML, XML, LaTeX, etc.
- Very good for validating the format of text
 - For birthday in the format YYYYMMDD, you could validate with:
 - YYYY: [12] [90] [:digit:] [:digit:]
 - MM: [01] [:digit:]
 - DD: [0123] [:digit:]

Cavaet: Regexes are generally slow. If you can code something to avoid them, that is often better. But often that may be infeasible.

Some extras

- While the str *() functions use regex by default, they actually have four modes
 - 1. You can specify a regex normally
 - Or you can use regex () to construct more customized ones, such as regexes that operate by line in a string
 - 2. You can specify an exact string to match using fixed() fast but fragile
 - 3. You can specify an exact string to match using coll() slow but robust; recognizes characters that are equivalent
 - Important when dealing with non-English words, since certain characters can be encoded in multiple ways
 - 4. You can ask for boundaries with boundary () such as words, using boundary("word")



Expanding usage

- Anything covered so far can be used for text in data
 - Ex.: Firm names or addresses in Compustat

```
## # A tibble: 2 x 2
## SG_firm pct_SG
## 
<dbl> <dbl>
## 1 0 0.369
## 2 1 4.76
```



Expanding usage

library(DT)
df_RE_names %>%
 group_by(fic) %>%
 mutate(avg_name_length = mean(name_length)) %>%
 slice(1) %>%
 ungroup() %>%
 select(fic, avg_name_length) %>%
 arrange(desc(avg_name_length), fic) %>%
 datatable(options = list(pageLength = 5))

1

Show entries

	fic		av
1	TUR		
2	VNM		
3	EGY		
4	CHN		24.57
5	ISR		24.33
Show	ving 1 to 5 of	41 entries	

Previous

3

4

5

2

g_name_length 27 25.5 25 714285714286 33333333333333 9 Next

Search:

R Practice 2

- This practice explores the previously used practice data using regular expressions for various purposes
- Do exercises 4 and 5 in today's practice file
 - R Practice
 - Shortlink: rmc.link/420r7





Readability and Sentiment



Readability

- Thanks to the quanteda package, readability is very easy to calculate in R
 - Use the textstat readability() function
- There are many readability measures, however
 - Flesch Kinkaid grade level: A measure of readability developed for the U.S. Navy to ensure manuals were written at a level any 15 year old should be able to understand
 - Fog: A grade level index that was commonly used in business and publishing
 - Coleman-Liau: An index with a unique calculation method, relying only on character counts

Readability: Flesch Kincaid

$$0.39\left(\frac{\# \, words}{\# \, sentences}\right) + 11.8\left(\frac{\# \, syllables}{\# \, words}\right)$$

- An approximate grade level required for reading a document
 - Lower is more readable
 - A JC or poly graduate should read at a level of 12
 - New York Times articles are usually around 13
 - A Bachelor's degree could be necessary for anything 16 or above

```
library(quanteda)
textstat readability(doc, "Flesch.Kincaid")
     document Flesch.Kincaid
##
## 1
        text1
                       17.685
```

Readability: Fog

[Mean(Words per sentence)+ $(\% \ of \ words \ > 3 \ syllables)] imes 0.4$

- An approximate grade level required for reading a document
 - Lower is more readable

textstat readability(doc, "FOG")

document FOG ## 1 text1 21.7582

Readability: Coleman-Liau $5.88\left(\frac{\# \, letters}{\# \, words}\right) - 29.6\left(\frac{\# \, sentences}{\# \, words}\right) - 15.8$ An approximate grade level required for reading a document Lower is more readable textstat readability(doc, "Coleman.Liau.short") ## document Coleman.Liau.short ## 1 14.96773 text1



Converting text to words

- Tidy text is when you have one *token* per document per row, in a data frame
- *Token* is the unit of text you are interested in
 - Words: "New"
 - Phrases: "New York Times"
 - Sentences: "The New York Times is a publication."
 - etc.
- The tidytext package can handle this conversion for us!
 - Use the unnest_tokens() function
 - Note: it also converts to lowercase. Use the option
 to lower=FALSE to avoid this if needed

```
# Example of "tokenizing"
library(tidytext)
df_doc <- data.frame(ID=c("0001104659-14-015152"), text=c(doc)) %>%
    unnest_tokens(word, text)
# word is the name for the new column
# text is the name of the string column in the input data
```



The details

html_df(head(df_doc))

	ID	word
1	0001104659-14-015152	united
1.1	0001104659-14-015152	states
1.2	0001104659-14-015152	securities
1.3	0001104659-14-015152	and
1.4	0001104659-14-015152	exchange
1.5	0001104659-14-015152	commission



The details

- tidytext uses the tokenizers package in the backend to do the conversion
 - You can call that package directly instead if you want to
- Available tokenizers include: (specify with token=)
 - "word": The default, individual words
 - "ngram": Collections of words (default of 2, specify with n=)
 - A few other less commonly used tokenizers



Word case

- Why convert to lowercase?
- How much of a difference is there between "The" and "the"?
 - "Singapore" and "singapore" still not much difference
 - Only words like "new" versus "New" matter
 - "New York" versus "new yorkshire terrier"
- Benefit: We get rid of a bunch of distinct words!
 - Helps with the curse of dimensionality



f "the"? rence

The Curse of dimensionality

- There are a lot of words
- A LOT OF WORDS
- At least 171,476 according to Oxford Dictionary
- What happens if we make a matrix of words per document?

For right now, not much

- If we have every publicly available government filed press release in the US?
 - 1,479,068 files through July 2018...
 - ~2TB if we include all English words
 - ~70GB if we restrict just to the 5,884 words in the Citigroup annual report...

Stopwords

- Stopwords words we remove because they have little content
 - the, a, an, and, ...
- Also helps with our curse a bit removes the words entirely
- We'll use the stopword package to remove stopwords

```
# get a list of stopwords
stop_en <- stopwords::stopwords("english") # Snowball English
paste0(length(stop_en), " words: ", paste(stop_en[1:5], collapse=", "))</pre>
```

[1] "175 words: i, me, my, myself, we"

stop_SMART <- stopwords::stopwords(source="smart") # SMART English
paste0(length(stop_SMART), "words: ", paste(stop_SMART[1:5], collapse=", "))</pre>

[1] "571 words: a, a's, able, about, above"

stop_fr <- stopwords::stopwords("french") # Snowball French
paste0(length(stop_fr), " words: ", paste(stop_fr[1:5], collapse=", "))</pre>

[1] "164 words: au, aux, avec, ce, ces"





Applying stopwords to a corpus

- When we have a tidy set of text, we can just use dplyr for this!
 - dplyr's anti_join() function is like a merge, but where all matches are deleted

```
df_doc_stop <- df_doc %>%
    anti_join(data.frame(word=stop_SMART))
```

Joining, by = "word"

nrow(df doc)

[1] 128728

nrow(df_doc_stop)

[1] 74985

[.] this! here all



Converting to term frequency

```
terms <- df_doc_stop %>%
   count(ID, word, sort=TRUE) %>%
   ungroup()
total_terms <- terms %>%
   group_by(ID) %>%
   summarize(total = sum(n))
tf <- left_join(terms, total_terms) %>% mutate(tf=n/total)
tf
```

##		ID	word	n	total	
##	1	0001104659-14-015152	citi	826	74985	0.011015
##	2	0001104659-14-015152	2013	743	74985	0.009908
##	3	0001104659-14-015152	credit	704	74985	0.009388
##	4	0001104659-14-015152	citis	660	74985	0.008801
##	5	0001104659-14-015152	risk	624	74985	0.008321
##	6	0001104659-14-015152	december	523	74985	0.006974
##	7	0001104659-14-015152	financial	513	74985	0.006841
##	8	0001104659-14-015152	31	505	74985	0.006734
##	9	0001104659-14-015152	loans	495	74985	0.006601
##	10	0001104659-14-015152	assets	488	74985	0.006507
##	11	0001104659-14-015152	fair	453	74985	0.006041
##	12	0001104659-14-015152	securities	440	74985	0.005867
##	13	0001104659-14-015152	billion	435	74985	0.005801
##	14	0001104659-14-015152	citigroup	420	74985	0.005601
##	15	0001104659-14-015152	2012	412	74985	0.005494
##	16	0001104659-14-015152	u.s	390	74985	0.005201
##	17	0001104659-14-015152	interest	373	74985	0.004974
##	18	0001104659-14-015152	company	371	74985	0.004947
##	19	0001104659-14-015152	net	324	74985	0.004320
##	20	0001104659-14-015152	related	323	74985	0.004307

Sentiment

- Sentiment works similarly to stopwords, except we are identifying words with specific, useful meanings
 - We can grab off-the-shelf sentiment measures using get sentiments () from tidytext

```
get sentiments("afinn") %>%
                                           get sentiments("bing") %>%
 group by(value) %>%
                                             group by(sentiment) %>%
                                             slice(1) %>%
 slice(1) %>%
 ungroup()
                                             ungroup()
## # A tibble: 11 x 2
                                           ## # A tibble: 2 x 2
##
     word value
                                            ##
                                                word
                                                        sentiment
                                           ## <chr>
##
     <chr> <dbl>
                                                        <chr>
## 1 bastard
                    -5
                                           ## 1 2-faces negative
## 2 ass
                                           ## 2 abound positive
                    -4
## 3 abhor
                    -3
                    -2
## 4 abandon
## 5 absentee
                     -1
## 6 some kind
                     0
## 7 aboard
                      1
## 8 abilities
                      2
## 9 admire
                      3
## 10 amazing
                      4
## 11 breathtaking
                      5
```

Sentiment

get sentiments("nrc") %>% group by(sentiment) %>% **slice**(1) %>% ungroup()

##	# Z	A tibble: 10	x 2
##		word	sentiment
##		<chr></chr>	<chr></chr>
##	1	abandoned	anger
##	2	abundance	anticipation
##	3	aberration	disgust
##	4	abandon	fear
##	5	absolution	јоу
##	6	abandon	negative
##	7	abba	positive
##	8	abandon	sadness
##	9	abandonment	surprise
##	10	abacus	trust

Loughran & McDonald dictionary - finance specific, targeted at annual reports

get_sentiments("loughran") %>% group by(sentiment) %>% **slice**(1) %>% ungroup()

##	#	A tibble: 6 x 2	2
##		word	sentin
##		<chr></chr>	<chr></chr>
##	1	abide	consti
##	2	abovementioned	litigi
##	3	abandon	negati
##	4	able	positi
##	5	aegis	superf
##	6	abeyance	uncert

nent

raining ious ive ive fluous tainty



Merging in sentiment data

tf_sent <- tf %>% left_join(get_sentiments("loughran"))

Joining, by = "word"

tf_sent[1:5,]

##		ID	word	n	total	tf	sentiment
##	1	0001104659-14-015152	citi	826	74985	0.011015536	<na></na>
##	2	0001104659-14-015152	2013	743	74985	0.009908648	<na></na>
##	3	0001104659-14-015152	credit	704	74985	0.009388544	<na></na>
##	4	0001104659-14-015152	citis	660	74985	0.008801760	<na></na>
##	5	0001104659-14-015152	risk	624	74985	0.008321664	uncertainty

tf_sent[!is.na(tf_sent\$sentiment),][1:5,]

##		ID	word	n	total	tf	sentim
##	5	0001104659-14-015152	risk	624	74985	0.008321664	uncertai
##	28	0001104659-14-015152	loss	267	74985	0.003560712	negat
##	29	0001104659-14-015152	losses	265	74985	0.003534040	negat
##	36	0001104659-14-015152	approximately	232	74985	0.003093952	uncertai
##	37	0001104659-14-015152	regulatory	216	74985	0.002880576	litigi



Summarizing document sentiment

tf sent %>%

spread(sentiment, tf, fill=0) %>%

select(constraining, litigious, negative, positive, superfluous, uncertainty) %> colSums()

constraining litigious negative positive superfluous uncertainty ## 0.013242649 0.020750817 0.034780289 0.007054744 0.000373408











Visualizing a document as a word cloud

- quanteda provides textplot_wordcloud()
- cast dfm() converts tidy term frequencies to Quanteda
- There are also the wordcloud and wordcloud2 packages for this

corp <- cast_dfm(tf, ID, word, n)
textplot_wordcloud(dfm(corp), color = RColorBrewer::brewer.pal(9, "Set1"))</pre>

la ages for this



Another reason to use stopwords

Without removing stopwords, the word cloud shows almost nothing useful

corp no stop <- cast dfm(tf no stop, ID, word, n)</pre> textplot_wordcloud(dfm(corp no stop), color = RColorBrewer::brewer.pal(9, "Set1"))




R Practice 3

- Using the same data as before, we will explore
 - Readability
 - Sentiment
 - Word clouds
- Note: Due to missing packages, you will need to run the code in RStudio, not in the DataCamp light console
- Do exercises 6 through 8 in today's practice file
 - R Practice
 - Shortlink: rmc.link/420r7





What's next

- Armed with an understanding of how to process unstructured data, all of the sudden the amount of data available to us is expanding rapidly
- To an extent, anything in the world can be viewed as data, which can get overwhelming pretty fast
- We'll require some better and newer tools to deal with this
- Revisiting last session...
 - Last session we used *topics* in our analysis
 - Topics were derived from the 10-Ks we have been working with







For next week

- For next week:
 - Finish the third assignment
 - Submit on eLearn
 - Datacamp
 - Do the assigned chapter on text analysis
 - Start on the group project





Packages used for these slides

- httr
- kableExtra
- knitr
- magrittr
- quanteda
- RColorBrewer
- readtext
- revealjs
- tidytext
- tidyverse
 - dplyr, readr, stringr
- XML



Custom code

```
library(knitr)
library(kableExtra)
html_df <- function(text, cols=NULL, col1=FALSE, full=F) {
    if(!length(cols)) {
        cols=colnames(text)
    }
    if(!col1) {
        kable(text,"html", col.names = cols, align = c("l",rep('c',length(cols)-1))) %>%
        kable_styling(bootstrap_options = c("striped","hover"), full_width=full)
    } else {
        kable(text,"html", col.names = cols, align = c("l",rep('c',length(cols)-1))) %>%
        kable(text,"html", col.names = cols, align = c("l",rep('c',length(cols)-1))) %>%
        kable(text,"html", col.names = cols, align = c("l",rep('c',length(cols)-1))) %>%
        kable_styling(bootstrap_options = c("striped","hover"), full_width=full) %>%
        column_spec(1,bold=T)
```

```
cryptoMC <- function(name) {
    if (exists(name)) {
        get(name)
    } else{
        html <- getURL(paste('https://coinmarketcap.com/currencies/',name,'/',sep=''))
        xpath <- '//*[@id="__next"]/div[1]/div[2]/div[1]/div[2]/div[1]/div/div[2]/span[1]/span[1]/text()'
        doc = htmlParse(html, asText=TRUE)
        plain.text <- xpathSApply(doc, xpath, xmlValue)
        assign(name, gsub("\n", "", gsub(" ", "", paste(plain.text, collapse = ""), fixed = TRUE), fixed = TRUE),envir = .GlobalEnv)
    get(name)
    }
</pre>
```

```
}
```

```
# Create a plot of the top words by sentiment
tf_sent %>%
filter(!is.na(sentiment)) %>%
group_by(sentiment) %>%
arrange(desc(n)) %>%
arrange(desc(n)) %>%
filter(row = row_number()) %>%
filter(row < 10) %>%
ungroup() %>%
mutate(word = reorder(word, n)) %>%
ggplot(aes(y=n, x=word)) + geom_col() + theme(axis.text.x = element_text(angle=90, hjust=1)) +
facet_wrap(~sentiment, ncol=3, scales="free_x")
```

