Tidy text and sentiment analysis

JHU Data Science

Data Cleaning

In general, data cleaning is a process of investigating your data for inaccuracies, or recoding it in a way that makes it more manageable.

⚠️ MOST IMPORTANT RULE - LOOK 👀 AT YOUR DATA! ⚠️

String functions

Pasting strings with `paste` and `paste0`

Paste can be very useful for joining vectors together:

```
paste("Visit", 1:5, sep = "_")
```

```
[1] "Visit_1" "Visit_2" "Visit_3" "Visit_4" "Visit_5"
```

```
paste("Visit", 1:5, sep = "_", collapse = " ")
```

```
[1] "Visit_1 Visit_2 Visit_3 Visit_4 Visit_5"
```

```
paste("To", "is going be the ", "we go to the store!", sep = "day ")
```

```
[1] "Today is going be the day we go to the store!"
```

```
# and paste0 can be even simpler see ?paste0
paste0("Visit",1:5)
```

```
[1] "Visit1" "Visit2" "Visit3" "Visit4" "Visit5"
```

Paste Depicting How Collapse Works

```r
paste(1:5)
```

```
[1] "1" "2" "3" "4" "5"
```

```r
paste(1:5, collapse = " ")
```

```
[1] "1 2 3 4 5"
```

Useful String Functions

Useful String functions

- `toupper()`, `tolower()` - uppercase or lowercase your data:
- `str_trim()` (in the `stringr` package) or `trimws` in base
- will trim whitespace on ends
- `stringr::str_squish` - trims and replaces double spaces
- `nchar` - get the number of characters in a string

The `stringr` package

Like `dplyr`, the `stringr` package:

- Makes some things more intuitive
- Is different than base R
- Is used on forums for answers
- Has a standard format for most functions
- the first argument is a string like first argument is a `data.frame` in `dplyr`

‘Find’ functions: `stringr`

`str_detect`, `str_subset`, `str_replace`, and `str_replace_all` search for matches to argument pattern within each element of a character vector: they differ in the format of and amount of detail in the results.

- `str_detect` - returns `TRUE` if `pattern` is found
- `str_subset` - returns only the strings which pattern were detected
- convenient wrapper around `x[str_detect(x, pattern)]`
- `str_extract` - returns only strings which pattern were detected, but ONLY the pattern
- `str_replace` - replaces `pattern` with `replacement` the first time
- `str_replace_all` - replaces `pattern` with `replacement` as many times matched

Let’s look at modifier for `stringr`

```
?modifiers
```

- `fixed` - match everything exactly
- `regexp` - default - uses **reg**ular **exp**ressions
- `ignore_case` is an option to not have to use `tolower`
- `boundary` - Match boundaries between things (e.g. words, sentences, characters).

Substringing

Very similar:

Base R

- `substr(x, start, stop)` - substrings from position start to position stop
- `strsplit(x, split)` - splits strings up - returns list!

`stringr`

- `str_sub(x, start, end)` - substrings from position start to position end
- `str_split(string, pattern)` - splits strings up - returns list!

Splitting String: base R

In base R, `strsplit` splits a vector on a string into a `list`

```
x = c("I really", "like writing", "R code programs")
(y = strsplit(x, split = " ")) # returns a list
```

```
[[1]]
[1] "I"      "really"

[[2]]
[1] "like"    "writing"

[[3]]
[1] "R"        "code"     "programs"
```

```
(y2 = stringr::str_split(x, " ")) # returns a list
```

```
[[1]]
[1] "I"      "really"

[[2]]
[1] "like"    "writing"

[[3]]
[1] "R"        "code"     "programs"
```

Using a fixed expression

One example case is when you want to split on a period “ `.` ”. In regular expressions `.` means **ANY** character, so

```
str_split("I.like.strings", ".")
```

```
[[1]]
 [1] "" "" "" "" "" "" "" "" "" "" "" "" "" "" ""
```

```
str_split("I.like.strings", fixed("."))
```

```
[[1]]
[1] "I"       "like"    "strings"
```

Use `purrr` or `apply*` to extract from string lists

```r
sapply(y, dplyr::first) # on the fly
```

```
[1] "I"    "like" "R"
```

```r
purrr::map_chr(y, nth, 2) # on the fly
```

```
[1] "really"  "writing" "code"
```

```r
sapply(y, dplyr::last) # on the fly
```

```
[1] "really"   "writing"  "programs"
```

Boundary

We can use `boundary` in the case of `str_split` as well:

```
words = c("These are   some words.")
str_count(words, boundary("word"))
```

```
[1] 4
```

```
# split with space
str_split(words, " ")[[1]]
```

```
[1] "These"  "are"    ""       ""       "some"   "words."
```

```
# split between word
str_split(words, boundary("word"))[[1]]
```

```
[1] "These" "are"   "some"  "words"
```

Splitting/Find/Replace and Regular Expressions

- R can do much more than find exact matches for a whole string
- Like Perl and other languages, it can use regular expressions.
- What are regular expressions?
- Ways to search for specific strings
- Can be very complicated or simple
- Highly Useful - think “Find” on steroids

A bit on Regular Expressions

- http://www.regular-expressions.info/reference.html
- They can use to match a large number of strings in one statement
- `.` matches any single character
- `*` means repeat as many (even if 0) more times the last character
- `?` makes the last thing optional
- `^` matches start of vector `^a` - starts with “a”
- `$` matches end of vector `b$` - ends with “b”

Beginning of line with ^

```r
x = c("i think we all rule for participating",
      "i think i have been outed",
      "i think this will be quite fun actually",
      "it will be fun, i think")

str_detect(x, "^i think")
```

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

End of line with $

```
x = c("well they had something this morning",
      "then had to catch a tram home in the morning",
      "dog obedience school in the morning",
      "this morning I'll go for a run")

str_detect(x, "morning$")
```

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

Character list with [ ]

```
x = c("Name the worst thing about Bush!",
      "I saw a green bush",
      "BBQ and bushwalking at Molonglo Gorge",
      "BUSH!!")

str_detect(x,"[Bb][Uu][Ss][Hh]")
```

```
[1] TRUE TRUE TRUE TRUE
```

Sets of letters and numbers

```
x = c("7th inning stretch",
      "2nd half soon to begin. OSU did just win.",
      "3am - cant sleep - too hot still.. :(",
      "5ft 7 sent from heaven")

str_detect(x,"^[0-9][a-zA-Z]")
```

```
[1] TRUE TRUE TRUE TRUE
```

Negative Classes

I want to match NOT a `?` or `.` at the end of line (fixed with `[ ]`).

```
x = c("are you there?",
      "2nd half soon to begin. OSU did just win.",
      "6 and 9",
      "dont worry... we all die anyway!")

str_detect(x,"[^?.]$")
```

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

. means anything

```
x = c("these are post 9-11 rules",
      "NetBios: scanning ip 203.169.114.66",
      "Front Door 9:11:46 AM",
      "Sings: 0118999881999119725...3 !")

str_detect(x, "9.11")
```

```
[1] TRUE TRUE TRUE TRUE
```

means or

```
x = c("Not a whole lot of hurricanes.",
      "We do have floods nearly every day",
      "hurricanes swirl in the other direction",
      "coldfire is STRAIGHT!")

str_detect(x,"flood|earthquake|hurricane|coldfire")
```

```
[1] TRUE TRUE TRUE TRUE
```

Detecting phone numbers

```r
x = c("206-555-1122","206-332","4545","test")

phone = "([2-9][0-9]{2})[- .]([0-9]{3})[- .]([0-9]{4})"

str_detect(x,phone)
```

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

Read in Salary Data

```
suppressMessages({
  raw_salary_data = Sal = readr::read_csv(
    "https://raw.githubusercontent.com/muschellij2/adv_data_sci_2023/main/exam
    progress = FALSE)
})
head(Sal)
```

```
# A tibble: 6 × 7
  Name                JobTitle     AgencyID Agency HireDate AnnualSalary GrossP
  <chr>               <chr>        <chr>    <chr>  <chr>    <chr>        <chr>
1 Aaron,Keontae E     AIDE BLUE C… W02200   Youth… 06/10/2… $11310.00    $873.6
2 Aaron,Patricia G    Facilities/… A03031   OED-E… 10/24/1… $53428.00    $52868
3 Aaron,Petra L       ASSISTANT S… A29005   State… 09/25/2… $68300.00    $67439
4 Abaineh,Yohannes T EPIDEMIOLOG… A65026   HLTH-… 07/23/2… $62000.00    $58654
5 Abbene,Anthony M    POLICE OFFI… A99416   Polic… 07/24/2… $43999.00    $39686
6 Abbey,Emmanuel      CONTRACT SE… A40001   M-R I… 05/01/2… $52000.00    $47019
```

‘Find’ functions: finding values, **stringr** and **dplyr**

```
str_subset(Sal$Name, "Rawlings")
```

```
[1] "Rawlings,Kellye A"           "Rawlings,MarqWell D"
[3] "Rawlings,Paula M"            "Rawlings-Blake,Stephanie C"
```

```
Sal %>% filter(str_detect(Name, "Rawlings"))
```

```
# A tibble: 4 × 7
  Name                     JobTitle AgencyID Agency HireDate AnnualSalary GrossP
  <chr>                    <chr>    <chr>    <chr>  <chr>    <chr>        <chr>
1 Rawlings,Kellye A        EMERGEN… A40302   M-R I… 01/06/2… $47980.00    $68426
2 Rawlings,MarqWell D      AIDE BL… W02384   Youth… 06/15/2… $11310.00    $507.5
3 Rawlings,Paula M         COMMUNI… A04015   R&P-R… 12/10/2… $19802.00    $8195.
4 Rawlings-Blake,Stepha… MAYOR    A01001   Mayor… 12/07/1… $163365.00   $16121
```

Replacing and subbing: `stringr`

We can do the same thing (with 2 piping operations!) in dplyr

```
dplyr_sal = Sal %>% mutate(
  AnnualSalary = AnnualSalary %>%
    str_replace(fixed("$"), "") %>%
    as.numeric) %>%
  arrange(desc(AnnualSalary))
```

Showing difference in `str_extract` and `str_extract_all`

`str_extract_all` extracts all the matched strings - `\\d` searches for DIGITS/numbers

```r
head(str_extract(Sal$AgencyID, "\\d"))
```

```
[1] "0" "0" "2" "6" "9" "4"
```

```r
head(str_extract_all(Sal$AgencyID, "\\d"), 2)
```

```
[[1]]
[1] "0" "2" "2" "0" "0"

[[2]]
[1] "0" "3" "0" "3" "1"
```

‘Find’ functions: base R

`grep`: `grep`, `grepl`, `regexpr` and `gregexpr` search for matches to argument pattern within each element of a character vector: they differ in the format of and amount of detail in the results.

`grep(pattern, x, fixed=FALSE)`, where:

- pattern = character string containing a regular expression to be matched in the given character vector.
- x = a character vector where matches are sought, or an object which can be coerced by as.character to a character vector.
- If fixed=TRUE, it will do exact matching for the phrase anywhere in the vector (regular find)

'Find' functions: stringr compared to base R

Base R does not use these functions. Here is a "translator" of the `stringr` function to base R functions

- `str_detect` - similar to `grepl` (return logical)
- `grep(value = FALSE)` is similar to `which(str_detect())`
- `str_subset` - similar to `grep(value = TRUE)` - return value of matched
- `str_replace` - similar to `sub` - replace one time
- `str_replace_all` - similar to `gsub` - replace many times

Important Comparisons

Base R:

- Argument order is `(pattern, x)`
- Uses option `(fixed = TRUE)`

`stringr`

- Argument order is `(string, pattern)` aka `(x, pattern)`
- Uses function `fixed(pattern)`

‘Find’ functions: Finding Indices

These are the indices where the pattern match occurs:

```
grep("Rawlings",Sal$Name)
```

```
[1] 13832 13833 13834 13835
```

```
which(grepl("Rawlings", Sal$Name))
```

```
[1] 13832 13833 13834 13835
```

```
which(str_detect(Sal$Name, "Rawlings"))
```

```
[1] 13832 13833 13834 13835
```

‘Find’ functions: Finding Logicals

These are the indices where the pattern match occurs:

```
head(grepl("Rawlings",Sal$Name))
```

```
[1] FALSE FALSE FALSE FALSE FALSE FALSE
```

```
head(str_detect(Sal$Name, "Rawlings"))
```

```
[1] FALSE FALSE FALSE FALSE FALSE FALSE
```

‘Find’ functions: finding values, base R

```
grep("Rawlings", Sal$Name, value=TRUE)
```

```
[1] "Rawlings,Kellye A"             "Rawlings,MarqWell D"
[3] "Rawlings,Paula M"              "Rawlings-Blake,Stephanie C"
```

```
Sal[grep("Rawlings", Sal$Name), ]
```

```
# A tibble: 4 × 7
  Name                       JobTitle AgencyID Agency HireDate AnnualSalary GrossP
  <chr>                      <chr>    <chr>    <chr>  <chr>    <chr>        <chr>
1 Rawlings,Kellye A          EMERGEN… A40302   M-R I… 01/06/2… $47980.00    $68426
2 Rawlings,MarqWell D        AIDE BL… W02384   Youth… 06/15/2… $11310.00    $507.5
3 Rawlings,Paula M           COMMUNI… A04015   R&P-R… 12/10/2… $19802.00    $8195.
4 Rawlings-Blake,Stepha… MAYOR    A01001   Mayor… 12/07/1… $163365.00   $16121
```

Showing differnce in `str_extract`

`str_extract` extracts just the matched string

```
ss = str_extract(Sal$Name, "Rawling")
head(ss)
```

```
[1] NA NA NA NA NA NA
```

```
ss[!is.na(ss)]
```

```
[1] "Rawling" "Rawling" "Rawling" "Rawling"
```

Showing differnce in `str_extract` and `str_extract_all`

`str_extract_all` extracts all the matched strings

```
head(str_extract(Sal$AgencyID, "\\d"))
```

```
[1] "0" "0" "2" "6" "9" "4"
```

```
head(str_extract_all(Sal$AgencyID, "\\d"), 2)
```

```
[[1]]
[1] "0" "2" "2" "0" "0"

[[2]]
[1] "0" "3" "0" "3" "1"
```

Using Regular Expressions

- Look for any name that starts with:
- Payne at the beginning,
- Leonard and then an S
- Spence then capital C

```
head(grep("^Payne.*", x = Sal$Name, value = TRUE), 3)
```

```
[1] "Payne El,Jackie"          "Payne Johnson,Nickole A"
[3] "Payne,Chanel"
```

```
head(grep("Leonard.?S", x = Sal$Name, value = TRUE))
```

```
[1] "Payne,Leonard S"      "Szumlanski,Leonard S"
```

```
head(grep("Spence.*C.*", x = Sal$Name, value = TRUE))
```

```
[1] "Greene,Spencer C"    "Spencer,Charles A"   "Spencer,Christian O"
[4] "Spencer,Clarence W"  "Spencer,Michael C"
```

Using Regular Expressions: **stringr**

```
head(str_subset(Sal$Name, "^Payne.*"), 3)
```

```
[1] "Payne El,Jackie"         "Payne Johnson,Nickole A"
[3] "Payne,Chanel"
```

```
head(str_subset(Sal$Name, "Leonard.?S"))
```

```
[1] "Payne,Leonard S"      "Szumlanski,Leonard S"
```

```
head(str_subset(Sal$Name, "Spence.*C.*"))
```

```
[1] "Greene,Spencer C"    "Spencer,Charles A"   "Spencer,Christian O"
[4] "Spencer,Clarence W"  "Spencer,Michael C"
```

Replace

Let’s say we wanted to sort the data set by Annual Salary:

```r
class(Sal$AnnualSalary)
```

```
[1] "character"
```

```r
sort(c("1", "2", "10")) #  not sort correctly (order simply ranks the data)
```

```
[1] "1"  "10" "2"
```

```r
order(c("1", "2", "10"))
```

```
[1] 1 3 2
```

Replace

So we must change the annual pay into a numeric:

```
head(Sal$AnnualSalary, 4)
```

```
[1] "$11310.00" "$53428.00" "$68300.00" "$62000.00"
```

```
head(as.numeric(Sal$AnnualSalary), 4)
```

```
Warning in head(as.numeric(Sal$AnnualSalary), 4): NAs introduced by coercion
```

```
[1] NA NA NA NA
```

R didn’t like the `$` so it thought turned them all to `NA`.

`sub()` and `gsub()` can do the replacing part in base R.

Replacing and subbing

Now we can replace the `$` with nothing (used `fixed=TRUE` because `$` means ending):

```
Sal$AnnualSalary = as.numeric(gsub(pattern = "$", replacement="",
                                   Sal$AnnualSalary, fixed=TRUE))
Sal = Sal %>% arrange(desc(AnnualSalary))
Sal %>% select(Name, AnnualSalary, JobTitle)
```

```
# A tibble: 18,981 × 3
   Name                       AnnualSalary JobTitle
   <chr>                             <dbl> <chr>
 1 Bernstein,Gregg L                238772 STATE'S ATTORNEY
 2 Charles,Ronnie E                 200000 EXECUTIVE LEVEL III
 3 Batts,Anthony W                  193800 EXECUTIVE LEVEL III
 4 Black,Harry E                    190000 EXECUTIVE LEVEL III
 5 Swift,Michael                    187200 CONTRACT SERV SPEC II
 6 Parthemos,Kaliope                172000 EXECUTIVE LEVEL III
 7 Ford,Niles R                     165000 EXECUTIVE LEVEL III
 8 Rawlings-Blake,Stephanie C       163365 MAYOR
 9 Chow,Rudolph S                   163200 DIRECTOR PUBLIC WORKS
10 Nilson,George A                  163200 CITY SOLICITOR
# ℹ 18,971 more rows
```

Replacing and subbing: `stringr`

We can do the same thing (with 2 piping operations!) in dplyr

```
dplyr_sal = Sal %>% mutate(
  AnnualSalary = AnnualSalary %>%
    str_replace(
      fixed("$"),
      "") %>%
    as.numeric) %>%
  arrange(desc(AnnualSalary))
check_Sal = Sal
rownames(check_Sal) = NULL
all.equal(check_Sal, dplyr_sal) # they are the same
```

```
[1] "Attributes: < Names: 1 string mismatch >"
[2] "Attributes: < Length mismatch: comparison on first 2 components >"
[3] "Attributes: < Component \"class\": Lengths (4, 3) differ (string compare
[4] "Attributes: < Component \"class\": 3 string mismatches >"
[5] "Attributes: < Component 2: target is externalptr, current is numeric >"
```

Removing $ and , in Practice

readr::parse_* is a number of useful helper functions for parsing columns

```
head(readr::parse_number(raw_salary_data$AnnualSalary))
```

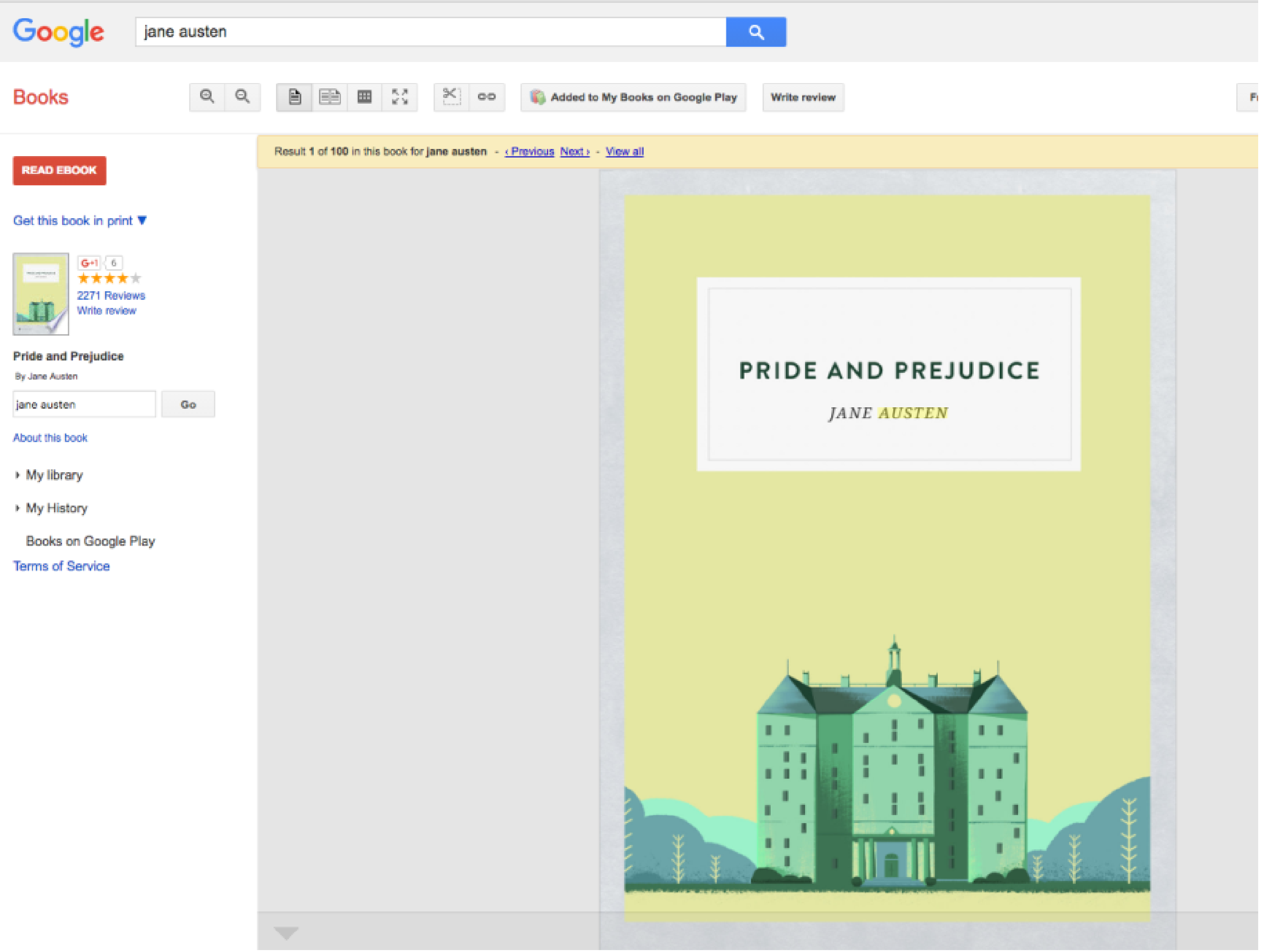
```
[1] 11310 53428 68300 62000 43999 52000
```

```
raw_salary_data %>%
  mutate(across(matches("Salary|Pay"), readr::parse_number)) %>%
  select(matches("Salary|Pay"))
```

```
# A tibble: 18,981 × 2
   AnnualSalary GrossPay
          <dbl>    <dbl>
 1        11310     874.
 2        53428   52868.
 3        68300   67439.
 4        62000   58655.
 5        43999   39687.
 6        52000   47020.
 7        62175   61452.
 8        70918   87900.
 9        42438   53668.
10        11310       NA
# ℹ 18,971 more rows
```

Tidying Text - What about all of Jane Austen’s Novels?

Jane Austen



Result 1 of 100 in this book for jane austen - ‹ Previous Next › - View all

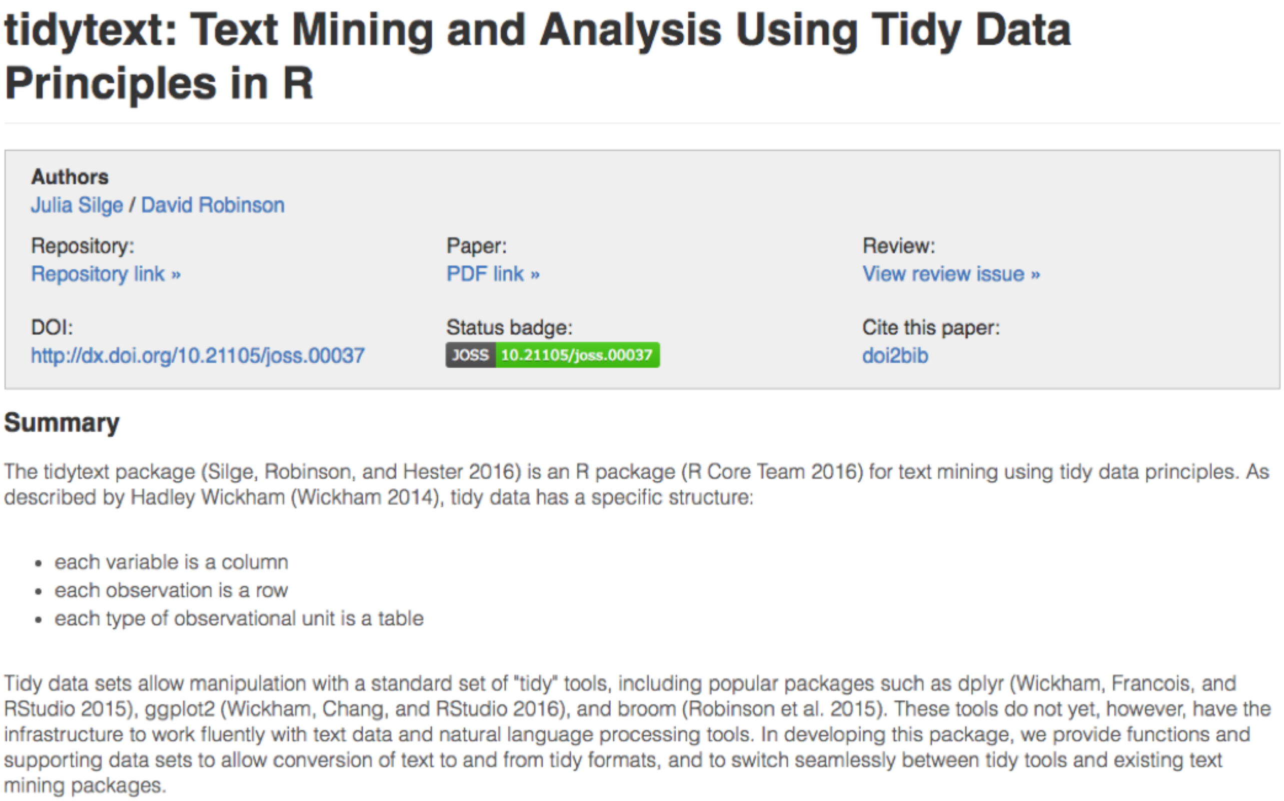
Data Available via: `janeaustenr`

Attached with row numbers (by book).

```
library(janeaustenr)
original_books = austen_books() %>%
  group_by(book) %>%
  mutate(linenumber = row_number()) %>%
  ungroup()
head(original_books)
```

```
# A tibble: 6 × 3
  text                     book                linenumber
  <chr>                    <fct>                    <int>
1 "SENSE AND SENSIBILITY" Sense & Sensibility           1
2 ""                       Sense & Sensibility           2
3 "by Jane Austen"         Sense & Sensibility           3
4 ""                       Sense & Sensibility           4
5 "(1811)"                 Sense & Sensibility           5
6 ""                       Sense & Sensibility           6
```

TidyText



tidytext: Text Mining and Analysis Using Tidy Data Principles in R

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

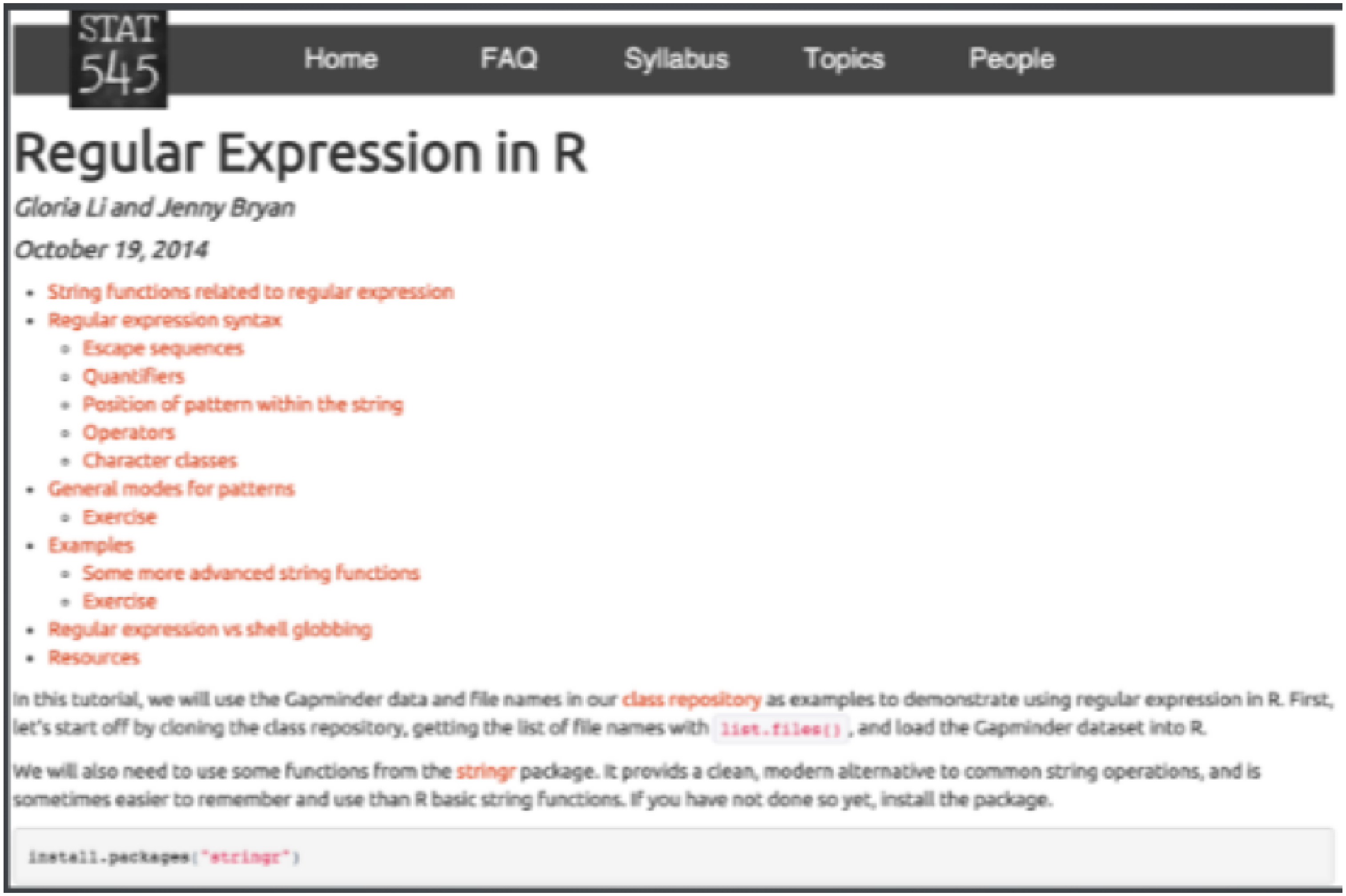
The tidytext package (Silge, Robinson, and Hester 2016) is an R package (R Core Team 2016) for text mining using tidy data principles. As described by Hadley Wickham (Wickham 2014), tidy data has a specific structure:

- 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.

http://joss.theoj.org/papers/89fd1099620268fe0342ffdcdf66776f

A nice tutorial



Regular Expression in R

Gloria Li and Jenny Bryan

October 19, 2014

In this tutorial, we will use the Gapminder data and file names in our class repository as examples to demonstrate using regular expression in R. First, let's start off by cloning the class repository, getting the list of file names with `list.files()`, and load the Gapminder dataset into R.

We will also need to use some functions from the stringr package. It provids a clean, modern alternative to common string operations, and is sometimes easier to remember and use than R basic string functions. If you have not done so yet, install the package.

```
install.packages("stringr")
```

http://stat545-ubc.github.io/block022_regular-expression.html

Large workhorse function: `unnest_tokens`

```
library(tidytext)
txt = c("These are words", "so are these", "this is running on")
sentence = c(1, 2, 3)
dat = tibble(txt, sentence)
unnest_tokens(dat, tok, txt)
```

```
# A tibble: 10 × 2
   sentence tok
      <dbl> <chr>
 1        1 these
 2        1 are
 3        1 words
 4        2 so
 5        2 are
 6        2 these
 7        3 this
 8        3 is
 9        3 running
10        3 on
```

What is tokenization?

“The process of segmenting running text into words and sentences.”

- Split on white space/punctuation
- Make lower case
- Keep contractions together
- Maybe put quoted words together (not in unnest_tokens)

One token per row

```
tidy_books = original_books %>% unnest_tokens(word, text)
head(tidy_books)
```

```
# A tibble: 6 × 3
  book                linenumber word
  <fct>                    <int> <chr>
1 Sense & Sensibility          1 sense
2 Sense & Sensibility          1 and
3 Sense & Sensibility          1 sensibility
4 Sense & Sensibility          3 by
5 Sense & Sensibility          3 jane
6 Sense & Sensibility          3 austen
```

Stop words/words to filter

be
as
much
about
Publication
mensen
Bangalore
Citation
organization
some
page
zie
Twitter
@laikas
OR
or
too
up
it
PubMed
blood
clinic
box
later
As
bericht
when
ago
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Blasts

http://xpo6.com/list-of-english-stop-words/

Stop words/words to filter

```
tidy_books %>%
  group_by(word) %>%
  tally() %>%
  arrange(desc(n))
```

```
# A tibble: 14,520 × 2
   word      n
   <chr> <int>
 1 the   26351
 2 to    24044
 3 and   22515
 4 of    21178
 5 a     13408
 6 her   13055
 7 i     12006
 8 in    11217
 9 was   11204
10 it    10234
# ℹ 14,510 more rows
```

Top Words by Book

```
tidy_books %>%
  count(book, word) %>%
  arrange(desc(n)) %>%
  group_by(book) %>%
  slice(1L)
```

```
# A tibble: 6 × 3
# Groups:   book [6]
  book                word      n
  <fct>               <chr> <int>
1 Sense & Sensibility to     4116
2 Pride & Prejudice   the    4331
3 Mansfield Park      the    6206
4 Emma                to     5239
5 Northanger Abbey    the    3179
6 Persuasion          the    3329
```

Filtering with joins

```
head(stop_words)
```

```
# A tibble: 6 × 2
  word      lexicon
  <chr>     <chr>  
1 a         SMART  
2 a's       SMART  
3 able      SMART  
4 about     SMART  
5 above     SMART  
6 according SMART  
```

```
tidy_books = tidy_books %>% anti_join(stop_words, by = "word")
head(tidy_books)
```

```
# A tibble: 6 × 3
  book                linenumber word       
  <fct>                    <int> <chr>      
1 Sense & Sensibility          1 sense      
2 Sense & Sensibility          1 sensibility
3 Sense & Sensibility          3 jane       
4 Sense & Sensibility          3 austen     
5 Sense & Sensibility          5 1811       
6 Sense & Sensibility         10 chapter    
```

Top Words after joining

```
tidy_books %>%
  count(word) %>%
  arrange(desc(n))
```

```
# A tibble: 13,914 × 2
   word       n
   <chr>  <int>
 1 miss    1855
 2 time    1337
 3 fanny    862
 4 dear     822
 5 lady     817
 6 sir      806
 7 day      797
 8 emma     787
 9 sister   727
10 house    699
# ℹ 13,904 more rows
```

Top Words by Book after joining

```
top_book_words = tidy_books %>%
  count(word, book) %>%
  arrange(desc(n)) %>%
  group_by(book)
(top_book_words %>% slice(1:2))
```

```
# A tibble: 12 × 3
# Groups:   book [6]
   word      book                    n
   <chr>     <fct>               <int>
 1 elinor    Sense & Sensibility   623
 2 marianne  Sense & Sensibility   492
 3 elizabeth Pride & Prejudice     597
 4 darcy     Pride & Prejudice     373
 5 fanny     Mansfield Park        816
 6 crawford  Mansfield Park        493
 7 emma      Emma                  786
 8 miss      Emma                  599
 9 catherine Northanger Abbey      428
10 miss      Northanger Abbey      206
11 anne      Persuasion            447
12 captain   Persuasion            303
```

Sentiment analysis

“I hate this stupid class. But I love the work”

Sentiment analysis

“I hate this stupid class. But I love the work”

Sentiment analysis

“I hate this stupid class. But I love the work”

“Oh yeah, I totally love doing coding sessions”

Sentiments

```
bing = tidytext::sentiments
head(bing)
```

```
# A tibble: 6 × 2
  word       sentiment
  <chr>      <chr>    
1 2-faces    negative 
2 abnormal   negative 
3 abolish    negative 
4 abominable negative 
5 abominably negative 
6 abominate  negative 
```

```
(dupes = bing %>% janitor::get_dupes(word))
```

```
# A tibble: 6 × 3
  word        dupe_count sentiment
  <chr>            <int> <chr>    
1 envious              2 positive 
2 envious              2 negative 
3 enviously            2 positive 
4 enviously            2 negative 
5 enviousness          2 positive 
6 enviousness          2 negative 
```

Sentiments: A little Tidying

Let’s remove those cases that it says these duplicates were positive

```
bing = bing %>% # remove positive envy!
  anti_join(dupes %>% filter(sentiment == "positive"))
```

```
Joining with `by = join_by(word, sentiment)`
```

```
anyDuplicated(bing$word) == 0
```

```
[1] TRUE
```

Aside: `any(duplicated(x))` vs. `anyDuplicated(x) == 0` speed

Functions useful for checking and speed (big data): `anyNA` and `anyDuplicated

```
microbenchmark::microbenchmark(
  anyDup = anyDuplicated(bing$word) == 0,
  any_dup = any(duplicated(bing$word)),
  anyNA = anyNA(bing$word),
  any_is_na = any(is.na(bing$word))
)
```

```
Unit: microseconds
      expr     min       lq      mean  median       uq     max neval  cld
    anyDup 118.113 119.5800 122.57043 120.521 122.4595 220.789   100 a
   any_dup 126.849 130.8715 133.26949 131.990 134.4115 153.465   100  b
     anyNA   4.705   4.9750   5.37510   5.305   5.6430   8.252   100   c
 any_is_na  20.873  21.2895  22.13306  21.832  22.3530  40.653   100    d
```

Top Word Sentiments

Miss - may be misclassified (e.g. “Miss Elizabeth”)

```
top_book_words %>% slice(1:2) %>% left_join(bing, by = join_by(word))
```

```
# A tibble: 12 × 4
# Groups:   book [6]
   word      book                    n sentiment
   <chr>     <fct>               <int> <chr>
 1 elinor    Sense & Sensibility   623 <NA>
 2 marianne  Sense & Sensibility   492 <NA>
 3 elizabeth Pride & Prejudice     597 <NA>
 4 darcy     Pride & Prejudice     373 <NA>
 5 fanny     Mansfield Park        816 <NA>
 6 crawford  Mansfield Park        493 <NA>
 7 emma      Emma                  786 <NA>
 8 miss      Emma                  599 negative
 9 catherine Northanger Abbey      428 <NA>
10 miss      Northanger Abbey      206 negative
11 anne      Persuasion            447 <NA>
12 captain   Persuasion            303 <NA>
```

Top Word Sentiments

```
top_book_words %>% inner_join(bing, by = join_by(word)) %>% slice(1:2)
```

```
# A tibble: 12 × 4
# Groups:   book [6]
   word     book                    n sentiment
   <chr>    <fct>               <int> <chr>    
 1 miss     Sense & Sensibility   210 negative 
 2 happy    Sense & Sensibility   100 positive 
 3 miss     Pride & Prejudice     283 negative 
 4 love     Pride & Prejudice      92 positive 
 5 miss     Mansfield Park        432 negative 
 6 love     Mansfield Park        124 positive 
 7 miss     Emma                  599 negative 
 8 poor     Emma                  136 negative 
 9 miss     Northanger Abbey      206 negative 
10 pleasure Northanger Abbey       48 positive 
11 miss     Persuasion            125 negative 
12 happy    Persuasion             64 positive 
```

Assigning sentiments to words

```
janeaustensentiment = tidy_books %>%
  inner_join(bing, by = join_by(word)) %>%
  count(book, page = linenumber %/% 80, sentiment) %>%
  spread(sentiment, n, fill = 0) %>%
  mutate(sentiment = positive - negative)
head(janeaustensentiment)
```

```
# A tibble: 6 × 5
  book                   page negative positive sentiment
  <fct>                 <dbl>    <dbl>    <dbl>     <dbl>
1 Sense & Sensibility       0       16       26        10
2 Sense & Sensibility       1       19       44        25
3 Sense & Sensibility       2       12       23        11
4 Sense & Sensibility       3       15       22         7
5 Sense & Sensibility       4       16       29        13
6 Sense & Sensibility       5       16       39        23
```

Assigning sentiments to words

```
janeaustensentiment %>%
  group_by(book) %>%
  slice(1:3)
```

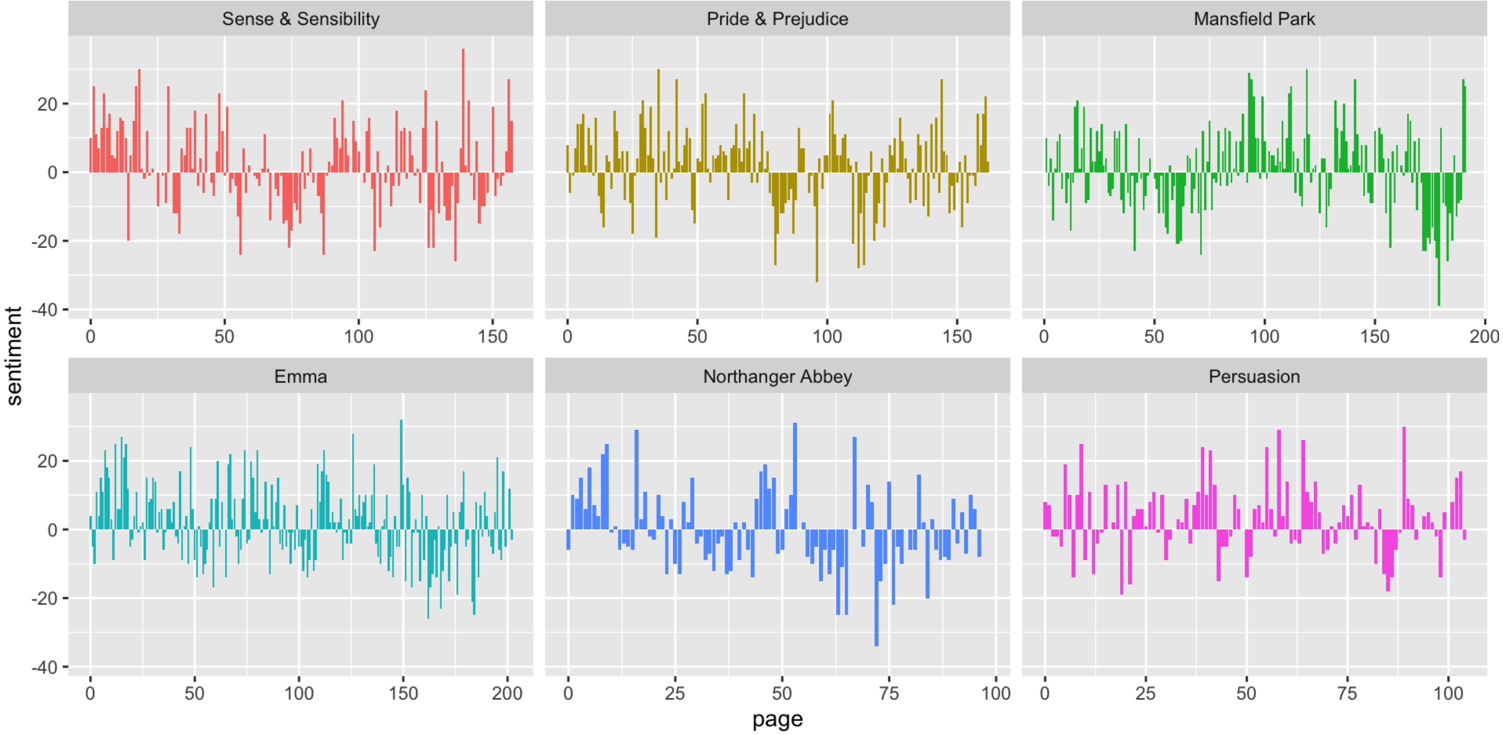
```
# A tibble: 18 × 5
# Groups:   book [6]
   book                 page negative positive sentiment
   <fct>               <dbl>    <dbl>    <dbl>     <dbl>
 1 Sense & Sensibility     0       16       26        10
 2 Sense & Sensibility     1       19       44        25
 3 Sense & Sensibility     2       12       23        11
 4 Pride & Prejudice       0        7       15         8
 5 Pride & Prejudice       1       20       14        -6
 6 Pride & Prejudice       2       15       14        -1
 7 Mansfield Park          0       29       29         0
 8 Mansfield Park          1       20       30        10
 9 Mansfield Park          2       27       23        -4
10 Emma                    0       31       35         4
11 Emma                    1       28       23        -5
12 Emma                    2       30       20       -10
13 Northanger Abbey        0       27       21        -6
14 Northanger Abbey        1       22       32        10
15 Northanger Abbey        2       25       34         9
16 Persuasion              0       20       28         8
17 Persuasion              1       21       28         7
18 Persuasion              2       24       22        -2
```

Assigning sentiments to words: removing “miss”

```
janeaustensentiment_nomiss = tidy_books %>%
  filter(word != "miss") %>%
  inner_join(bing, by = join_by(word)) %>%
  count(book, page = linenumber %/% 80, sentiment) %>%
  spread(sentiment, n, fill = 0) %>%
  mutate(sentiment = positive - negative)
```

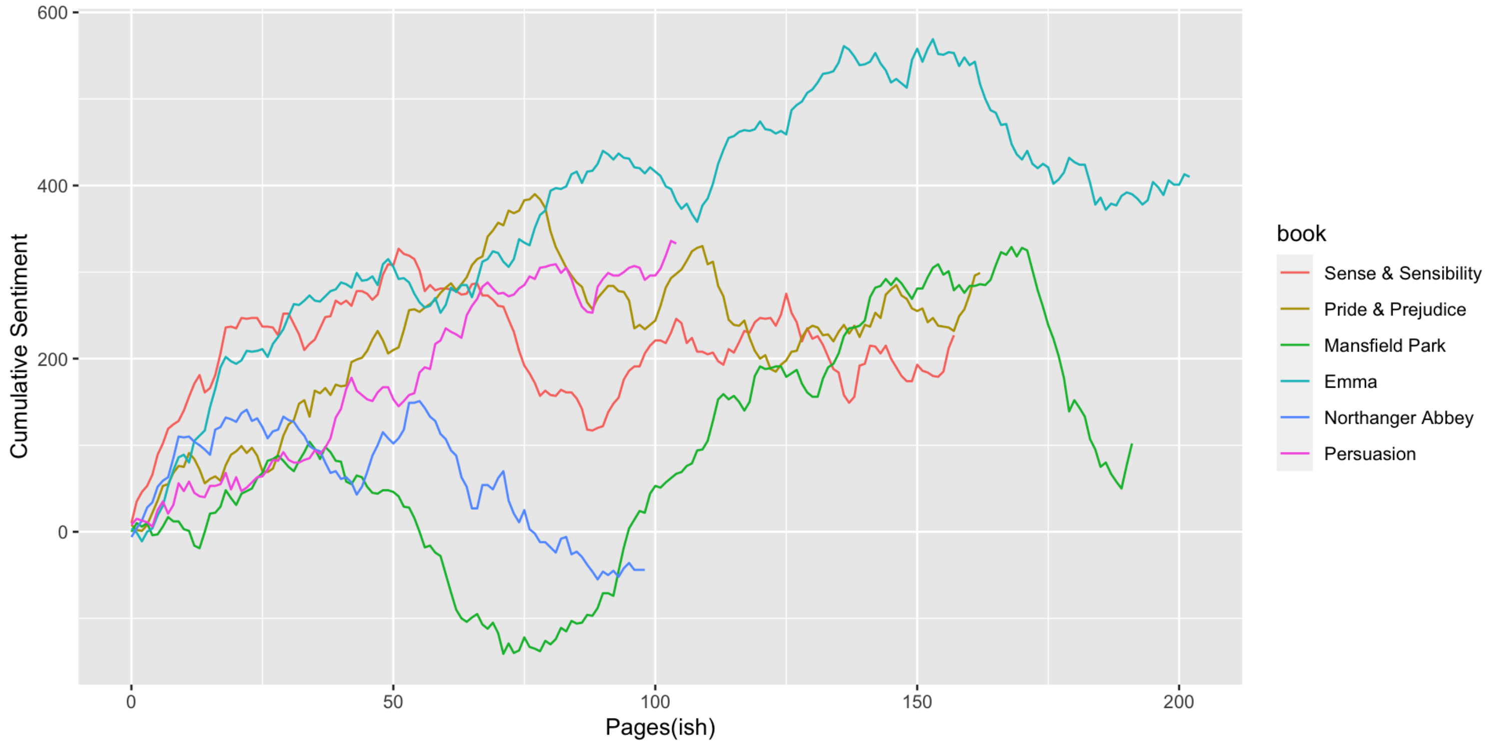
Plotting the sentiment trajectory (ggplot2 loaded)

```
ggplot(janeaustensentiment, aes(page, sentiment, fill = book)) +
  geom_bar(stat = "identity", show.legend = FALSE) +
  facet_wrap(~book, ncol = 3, scales = "free_x")
```



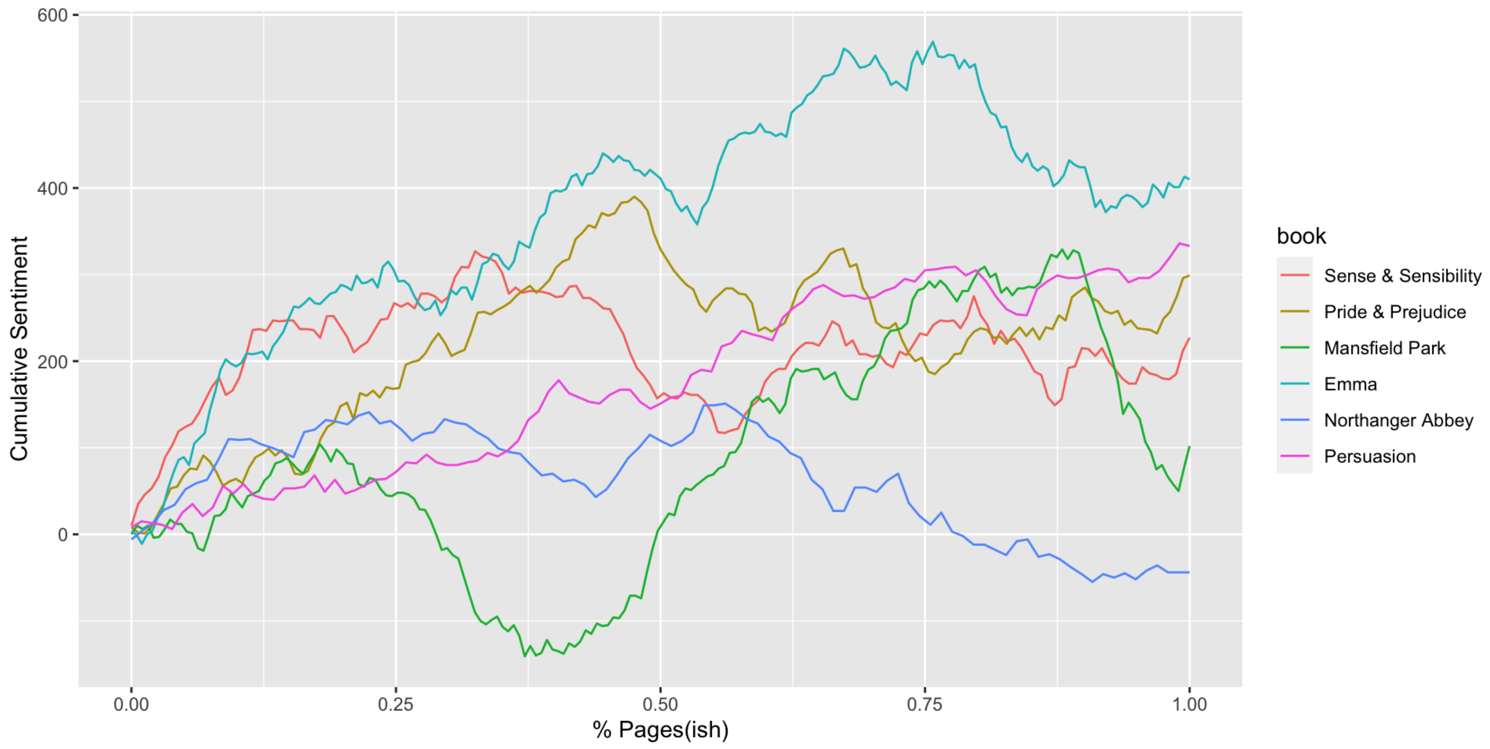
Plotting the cumulative sentiment

```
janeaustensentiment %>%
  group_by(book) %>%
  mutate(sentiment = cumsum(sentiment)) %>%
  ggplot(aes(page, sentiment, colour = book)) +
  geom_line() + ylab("Cumulative Sentiment") + xlab("Pages(ish)")
```



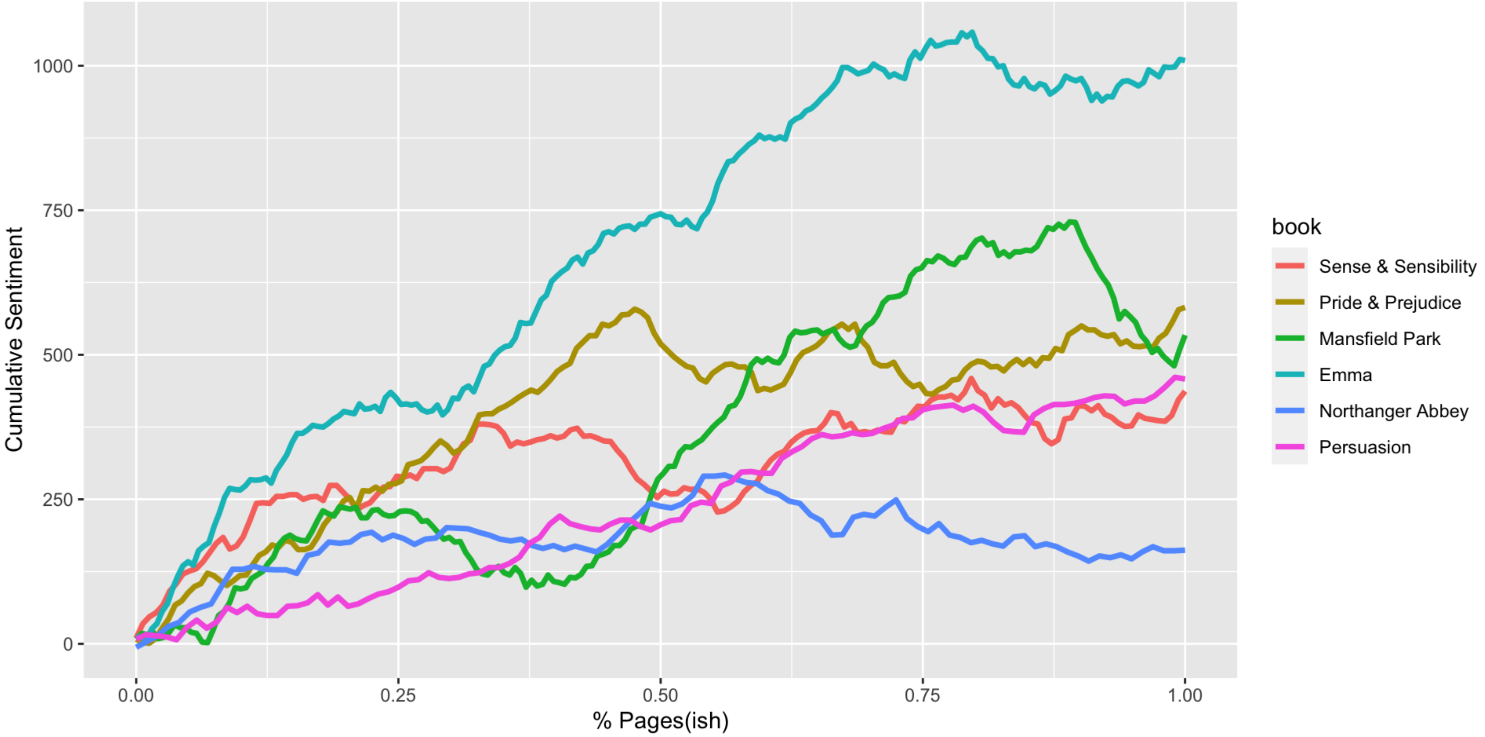
Plotting the cumulative sentiment (normalized book length)

```
janeaustensentiment %>%
  group_by(book) %>%
  mutate(sentiment = cumsum(sentiment),
         page = page/max(page)) %>%
  ggplot(aes(page, sentiment, colour = book)) +
  geom_line() + ylab("Cumulative Sentiment") + xlab("% Pages(ish)")
```

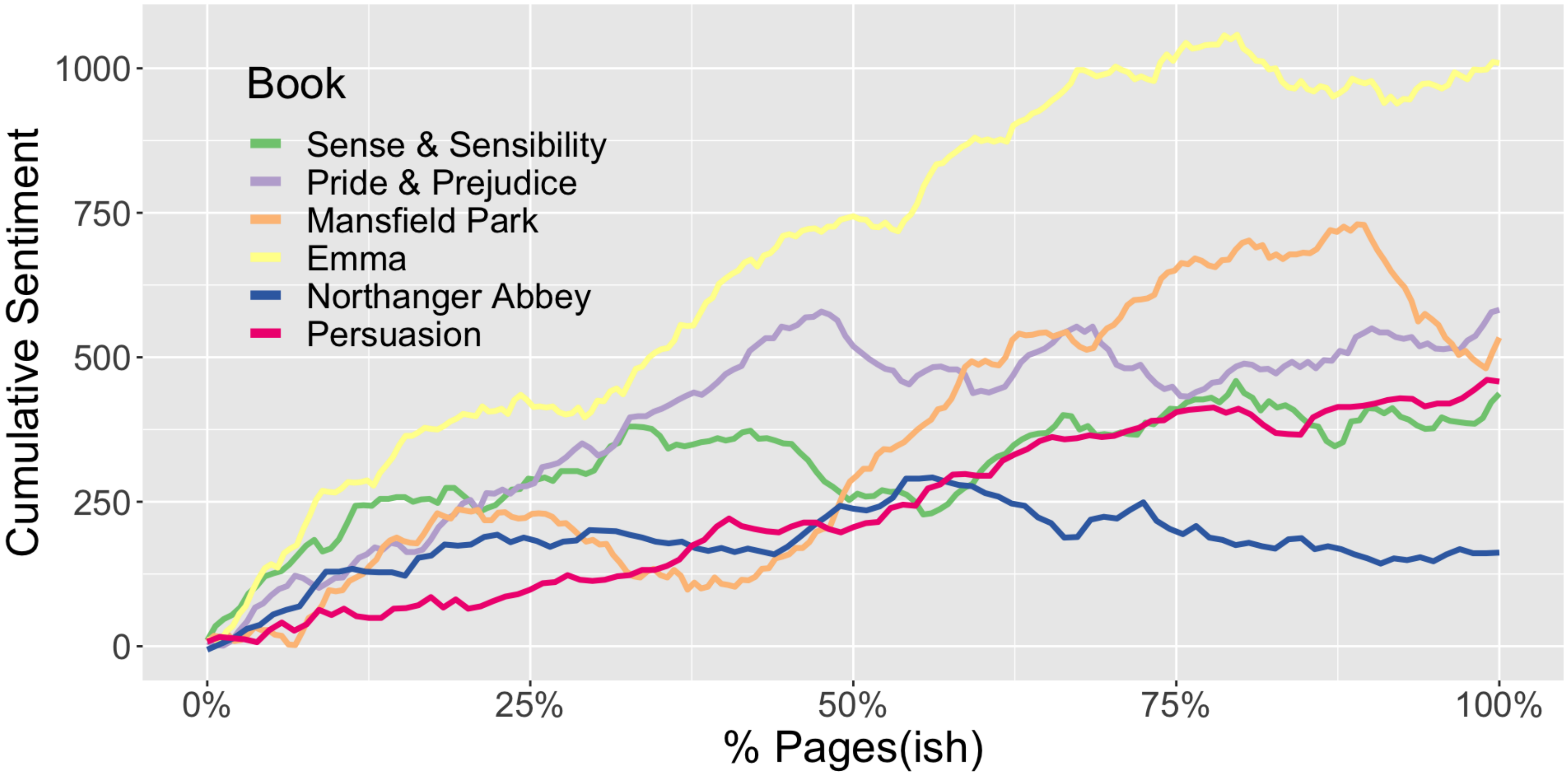


Plotting the cumulative sentiment (normalized book length)

```
(p = janeaustensentiment_nomiss %>%
  group_by(book) %>%
  mutate(sentiment = cumsum(sentiment),
         page = page/max(page)) %>%
  ggplot(aes(page, sentiment, colour = book)) +
  geom_line(linewidth = 1.25) + ylab("Cumulative Sentiment") + xlab("% Pages(i
```



Plotting Aside: Put Legend **Inside** the Figure



Plotting Aside: Put Legend **Inside** the Figure

```
transparent_legend =  theme(
  legend.background = element_rect(fill = "transparent"),
  legend.key = element_rect(fill = "transparent",
                            color = "transparent"))
p +
  transparent_legend +
  scale_color_brewer(type = "qual") +
  scale_x_continuous(labels = scales::percent_format()) +
  theme(legend.position = c(0.2, 0.7), text = element_text(size = 20)) +
  guides(colour = guide_legend(title = "Book",
                               override.aes = list(linewidth = 2)))
```

Example classification

```
library(tm);
data("AssociatedPress", package = "topicmodels"); AssociatedPress
```

```
<<DocumentTermMatrix (documents: 2246, terms: 10473)>>
Non-/sparse entries: 302031/23220327
Sparsity           : 99%
Maximal term length: 18
Weighting          : term frequency (tf)
```

```
class(AssociatedPress)
```

```
[1] "DocumentTermMatrix"    "simple_triplet_matrix"
```

```
head(tidy(AssociatedPress)) # generics::tidy
```

```
# A tibble: 6 × 3
  document term      count
     <int> <chr>     <dbl>
1        1 adding        1
2        1 adult         2
3        1 ago           1
4        1 alcohol       1
5        1 allegedly     1
6        1 allen         1
```

Compare frequencies: Jane Austen vs. the AP

```
comparison = tidy(AssociatedPress) %>%
  count(word = term, name = "AP") %>%
  inner_join(count(tidy_books, word, name = "Austen")) %>%
  mutate(AP = AP / sum(AP),
         Austen = Austen / sum(Austen),
         diff = AP - Austen) %>%
  arrange(desc(abs(diff)))
```

```
Joining with `by = join_by(word)`
```

```
head(comparison)
```

```
# A tibble: 6 × 4
  word             AP  Austen     diff
  <chr>         <dbl>   <dbl>    <dbl>
1 lady      0.000102 0.00580 -0.00569
2 time      0.00382  0.00948 -0.00566
3 sir       0.000120 0.00572 -0.00560
4 sister    0.000216 0.00516 -0.00494
5 elizabeth 0.000162 0.00487 -0.00471
6 friend    0.000288 0.00421 -0.00392
```

Bag of words

```
tidy_freq = tidy_books %>%
  dplyr::ungroup() %>%
  count(book, word, name = "count")
head(tidy_freq)
```

```
# A tibble: 6 × 3
  book                word  count
  <fct>               <chr> <int>
1 Sense & Sensibility 1         2
2 Sense & Sensibility 10        1
3 Sense & Sensibility 11        1
4 Sense & Sensibility 12        1
5 Sense & Sensibility 13        1
6 Sense & Sensibility 14        1
```

Bag of words

`nonum` removes any words that are all numeric (many ways of doing this):

```
nonum = tidy_freq %>%
  filter(is.na(as.numeric(word)))
```

```
Warning: There was 1 warning in `filter()`.
ℹ In argument: `is.na(as.numeric(word))`.
Caused by warning:
! NAs introduced by coercion
```

```
head(nonum)
```

```
# A tibble: 6 × 3
  book                word      count
  <fct>               <chr>     <int>
1 Sense & Sensibility 7000l         1
2 Sense & Sensibility abandoned     1
3 Sense & Sensibility abatement     1
4 Sense & Sensibility abbeyland     1
5 Sense & Sensibility abhor         1
6 Sense & Sensibility abhorred      2
```

Combine “bags”

```
tidy_ap = tidy(AssociatedPress) %>%
  rename(book = document,
         word = term,
         count = count)
dat = rbind(tidy_ap, tidy_freq)
head(dat)
```

```
# A tibble: 6 × 3
  book  word      count
  <chr> <chr>     <dbl>
1 1     adding        1
2 1     adult         2
3 1     ago           1
4 1     alcohol       1
5 1     allegedly     1
6 1     allen         1
```

Term-document matrices

Make a `DocuemntTermMatrix`/reshape the data:

```
dtm = dat %>% cast_dtm(document = book, term = word, value = count)
inspect(dtm[1:6,1:10])
```

```
<<DocumentTermMatrix (documents: 6, terms: 10)>>
Non-/sparse entries: 15/45
Sparsity           : 75%
Maximal term length: 10
Weighting          : term frequency (tf)
Sample             :
    Terms
Docs adding adult ago alcohol allegedly allen apparently appeared arrested
   1      1     2   1       1         1     1          2        1        1
   2      0     0   0       0         0     0          0        1        0
   3      0     0   1       0         0     0          0        1        0
   4      0     0   3       0         0     0          0        0        0
   5      0     0   0       0         0     0          0        0        0
   6      0     0   2       0         0     0          0        0        0
    Terms
Docs assault
   1       1
   2       0
   3       0
   4       0
   5       0
   6       0
```

Normalized Matrices

Here we normalize documents based on number of words:

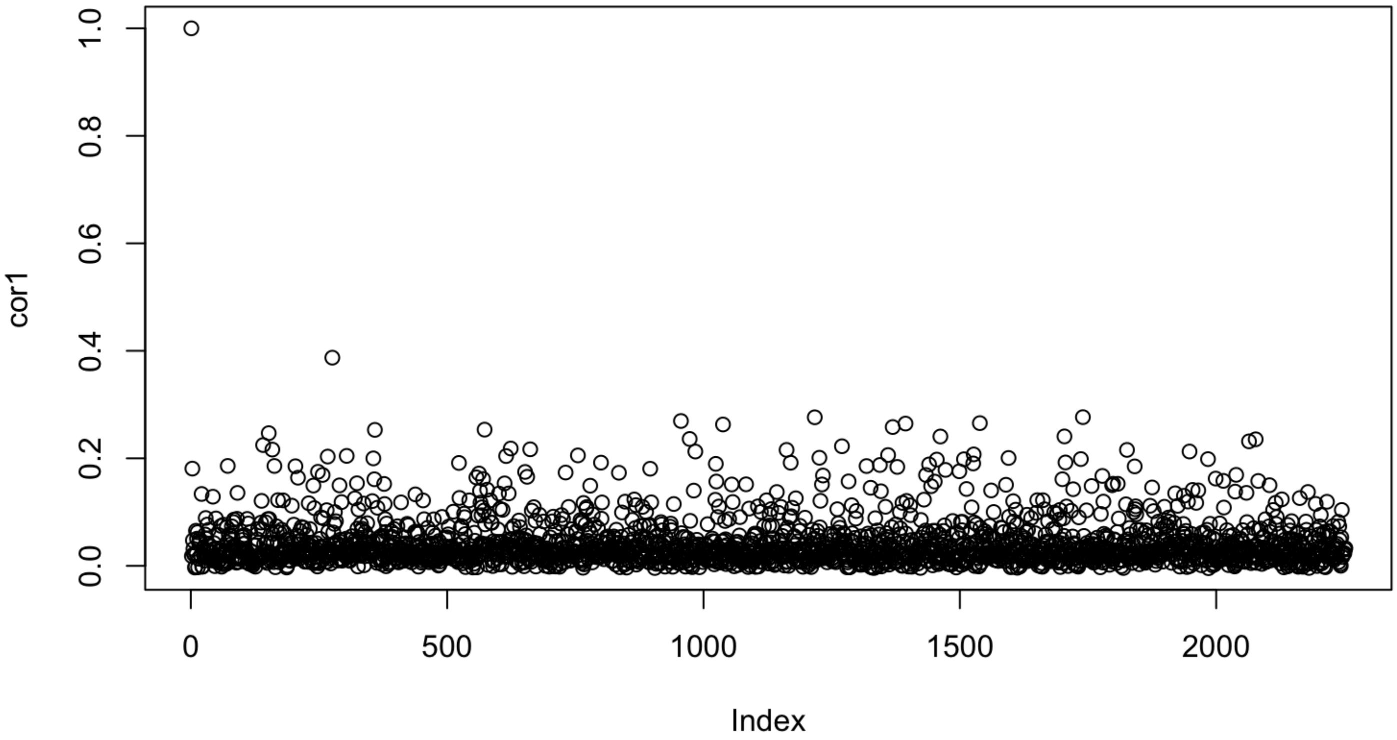
```
dtm = as.matrix(dtm)
dtm = dtm/rowSums(dtm)
```

Classify

Show the similarity (based on count correlations with first document):

```
cor1 = cor(dtm[1,], t(dtm))[1,]; print(cor1[1:5]);
```

```
         1          2          3          4          5 
1.00000000 0.01817799 0.18085240 0.04745425 0.03157564 
```

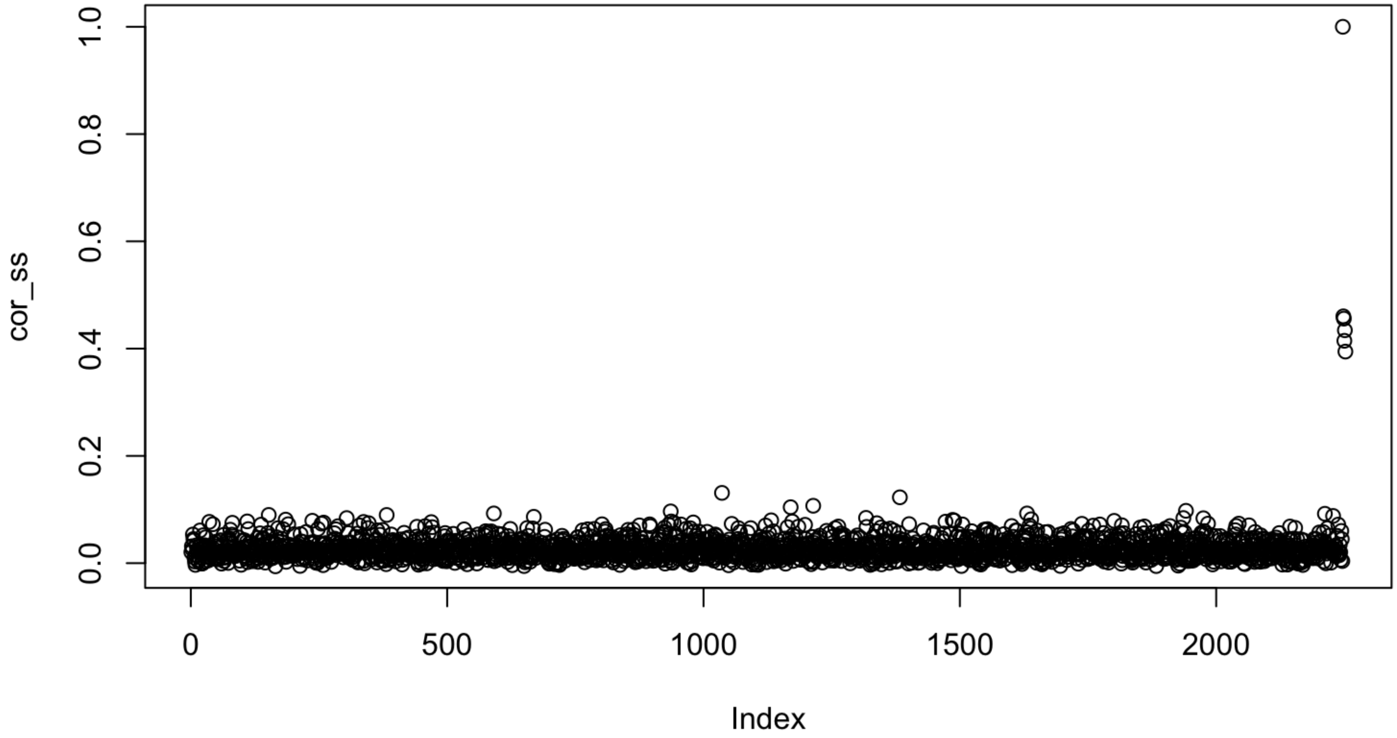


Classify

We see that there is a large clustering of Austen compared to AP:

```
cor_ss = cor(dtm["Sense & Sensibility",], t(dtm))[1,]; print(cor_ss[1:5]);
```

```
         1          2          3          4          5 
0.02056637 0.03157958 0.02608218 0.05342795 0.04504179 
```



Classify

The max similarity is not symmetrical (closest document/book to document 1 does not have document 1 as its closest document/book):

```
(index = which.max(cor1[-1]))
```

```
276
275
```

```
cor_ss = cor(dtm[index,],t(dtm))[1,]
which.max(cor_ss[-index]) # not 1!
```

```
1126
1125
```

Stemming

Can use `wordStem` to reduce certain words to their primary stem (e.g. remove gerunds/tense):

```r
library(SnowballC)
wordStem(c("running","fasted"))
```

```
[1] "run"  "fast"
```