Sharat_Sripada_HW4

```r
# install.packages('tm')
# install.packages('tmap')
# install.packages('quanteda')
# install.packages('philentropy')
# install.packages('factoextra')

library(tm)

## Loading required package: NLP

library(tmap)
library(quanteda)

## Package version: 2.1.1

## Parallel computing: 2 of 4 threads used.

## See https://quanteda.io for tutorials and examples.

##
## Attaching package: 'quanteda'

## The following objects are masked from 'package:tm':
##
##     as.DocumentTermMatrix, stopwords

## The following objects are masked from 'package:NLP':
##
##     meta, meta<-

## The following object is masked from 'package:utils':
##
##     View

library(RColorBrewer)
library(wordcloud)
library(philentropy)
library(factoextra)

## Loading required package: ggplot2

##
## Attaching package: 'ggplot2'

## The following object is masked from 'package:NLP':
##
##     annotate
## Welcome! Want to learn more? See two factoextra-related books at
https://goo.gl/ve3WBa
```

Introduction

This week delves on concepts of clustering viz. k-means, HAC and various distance measurements that aid in the process namely, Eucledian and cosine methods. In particular, the home-work will attempt to solve the problem of classifying disputed papers between authors Hamilton and Madison.

We begin our analysis by ingesting a corpus of documents and running through the following pipelines:

- loading the documents using the R Corpus function
- build a document term matrix (DTM)
- visualize wordclouds
- dive into the core concepts of clustering
- classify disputed documents from results of clustering

```
#load the data/corpus
FedPapersCorpus <-
Corpus(DirSource("/Users/venkatasharatsripada/Downloads/IST707repo-
master/FedPapersCorpus"))
numFedPapers <- length(FedPapersCorpus)

summary(FedPapersCorpus)
```

```
##                      Length Class             Mode
## dispt_fed_49.txt     2      PlainTextDocument list
## dispt_fed_50.txt     2      PlainTextDocument list
## dispt_fed_51.txt     2      PlainTextDocument list
## dispt_fed_52.txt     2      PlainTextDocument list
## dispt_fed_53.txt     2      PlainTextDocument list
## dispt_fed_54.txt     2      PlainTextDocument list
## dispt_fed_55.txt     2      PlainTextDocument list
## dispt_fed_56.txt     2      PlainTextDocument list
## dispt_fed_57.txt     2      PlainTextDocument list
## dispt_fed_62.txt     2      PlainTextDocument list
## dispt_fed_63.txt     2      PlainTextDocument list
## Hamilton_fed_1.txt   2      PlainTextDocument list
## Hamilton_fed_11.txt 2      PlainTextDocument list
## Hamilton_fed_12.txt 2      PlainTextDocument list
## Hamilton_fed_13.txt 2      PlainTextDocument list
## Hamilton_fed_15.txt 2      PlainTextDocument list
## Hamilton_fed_16.txt 2      PlainTextDocument list
## Hamilton_fed_17.txt 2      PlainTextDocument list
## Hamilton_fed_21.txt 2      PlainTextDocument list
## Hamilton_fed_22.txt 2      PlainTextDocument list
## Hamilton_fed_23.txt 2      PlainTextDocument list
## Hamilton_fed_24.txt 2      PlainTextDocument list
## Hamilton_fed_25.txt 2      PlainTextDocument list
## Hamilton_fed_26.txt 2      PlainTextDocument list
## Hamilton_fed_27.txt 2      PlainTextDocument list
## Hamilton_fed_28.txt 2      PlainTextDocument list
## Hamilton_fed_29.txt 2      PlainTextDocument list
## Hamilton_fed_30.txt 2      PlainTextDocument list
## Hamilton_fed_31.txt 2      PlainTextDocument list
## Hamilton_fed_32.txt 2      PlainTextDocument list
## Hamilton_fed_33.txt 2      PlainTextDocument list
## Hamilton_fed_34.txt 2      PlainTextDocument list
## Hamilton_fed_35.txt 2      PlainTextDocument list
## Hamilton_fed_36.txt 2      PlainTextDocument list
## Hamilton_fed_59.txt 2      PlainTextDocument list
## Hamilton_fed_6.txt  2      PlainTextDocument list
## Hamilton_fed_60.txt 2      PlainTextDocument list
## Hamilton_fed_61.txt 2      PlainTextDocument list
## Hamilton_fed_65.txt 2      PlainTextDocument list
## Hamilton_fed_66.txt 2      PlainTextDocument list
## Hamilton_fed_67.txt 2      PlainTextDocument list
## Hamilton_fed_68.txt 2      PlainTextDocument list
## Hamilton_fed_69.txt 2      PlainTextDocument list
## Hamilton_fed_7.txt  2      PlainTextDocument list
## Hamilton_fed_70.txt 2      PlainTextDocument list
## Hamilton_fed_71.txt 2      PlainTextDocument list
## Hamilton_fed_72.txt 2      PlainTextDocument list
## Hamilton_fed_73.txt 2      PlainTextDocument list
## Hamilton_fed_74.txt 2      PlainTextDocument list
## Hamilton_fed_75.txt 2      PlainTextDocument list
## Hamilton_fed_76.txt 2      PlainTextDocument list
## Hamilton_fed_77.txt 2      PlainTextDocument list
## Hamilton_fed_78.txt 2      PlainTextDocument list
## Hamilton_fed_79.txt 2      PlainTextDocument list
## Hamilton_fed_8.txt  2      PlainTextDocument list
## Hamilton_fed_80.txt 2      PlainTextDocument list
## Hamilton_fed_81.txt 2      PlainTextDocument list
## Hamilton_fed_82.txt 2      PlainTextDocument list
## Hamilton_fed_83.txt 2      PlainTextDocument list
## Hamilton_fed_84.txt 2      PlainTextDocument list
## Hamilton_fed_85.txt 2      PlainTextDocument list
## Hamilton_fed_9.txt  2      PlainTextDocument list
## HM_fed_18.txt       2      PlainTextDocument list
## HM_fed_19.txt       2      PlainTextDocument list
## HM_fed_20.txt       2      PlainTextDocument list
## Jay_fed_2.txt       2      PlainTextDocument list
## Jay_fed_3.txt       2      PlainTextDocument list
## Jay_fed_4.txt       2      PlainTextDocument list
## Jay_fed_5.txt       2      PlainTextDocument list
## Jay_fed_64.txt      2      PlainTextDocument list
## Madison_fed_10.txt  2      PlainTextDocument list
## Madison_fed_14.txt  2      PlainTextDocument list
## Madison_fed_37.txt  2      PlainTextDocument list
## Madison_fed_38.txt  2      PlainTextDocument list
## Madison_fed_39.txt  2      PlainTextDocument list
## Madison_fed_40.txt  2      PlainTextDocument list
## Madison_fed_41.txt  2      PlainTextDocument list
## Madison_fed_42.txt  2      PlainTextDocument list
## Madison_fed_43.txt  2      PlainTextDocument list
## Madison_fed_44.txt  2      PlainTextDocument list
## Madison_fed_45.txt  2      PlainTextDocument list
## Madison_fed_46.txt  2      PlainTextDocument list
## Madison_fed_47.txt  2      PlainTextDocument list
## Madison_fed_48.txt  2      PlainTextDocument list
## Madison_fed_58.txt  2      PlainTextDocument list
```

```
# meta(FedPapersCorpus[[1]])

#Ignore extremely rare words - <2% of documents
(minTermFreq <- 0.02 * numFedPapers)
```

```
## [1] 1.7
```

```
#Also, ignore common words - >75%-95% of documents
(maxTermFreq <- 0.95 * numFedPapers)
```

```
## [1] 80.75
```

```
#
Papers_DTM <- DocumentTermMatrix(FedPapersCorpus,
                                 control=list(
                                   stopwords=TRUE,
                                   wordLengths=c(3,15),
                                   removePunctuation=T,
                                   removeNumbers=T,
                                   tolower=T,
                                   stemming=T,
                                   remove_separators=T,
                                   bounds=list(global=c(minTermFreq,
maxTermFreq))
                                 ))
DTM <- as.matrix(Papers_DTM)
(DTM[1:11,1:10])
```

```
##                   Terms
## Docs               abandon abat abb abet abil abl ablest abolish abolit
abort
##   dispt_fed_49.txt       0    0   0    0    0   2      0       0      0
0
##   dispt_fed_50.txt       0    0   0    0    0   0      0       0      0
```

```
0
##   dispt_fed_51.txt       0    0   0    0    0   1      0       0      0
0
##   dispt_fed_52.txt       0    0   0    0    1   1      0       0      0
0
##   dispt_fed_53.txt       0    1   0    0    0   0      0       0      0
0
##   dispt_fed_54.txt       0    0   0    0    0   0      0       0      0
0
##   dispt_fed_55.txt       0    0   0    0    0   0      0       0      0
0
##   dispt_fed_56.txt       0    0   0    0    0   0      0       0      0
0
##   dispt_fed_57.txt       0    0   0    0    0   0      0       0      0
0
##   dispt_fed_62.txt       0    0   0    0    0   1      0       0      0
0
##   dispt_fed_63.txt       0    0   0    0    0   4      0       0      0
0

col_WordFreq <- colSums(as.matrix(Papers_DTM))
(head(col_WordFreq))

## abandon    abat     abb    abet    abil     abl
##       9       2       5       2      15      74

#Length of all words
(length(col_WordFreq))

## [1] 3370

(row_WordFreq <- rowSums(as.matrix(Papers_DTM)))

##    dispt_fed_49.txt    dispt_fed_50.txt    dispt_fed_51.txt
dispt_fed_52.txt
##                 677                 480                 783
743
##    dispt_fed_53.txt    dispt_fed_54.txt    dispt_fed_55.txt
dispt_fed_56.txt
##                 903                 766                 865
649
##    dispt_fed_57.txt    dispt_fed_62.txt    dispt_fed_63.txt
Hamilton_fed_1.txt
##                 889                 983                1244
659
## Hamilton_fed_11.txt Hamilton_fed_12.txt Hamilton_fed_13.txt
Hamilton_fed_15.txt
##                1020                 901                 400
1256
## Hamilton_fed_16.txt Hamilton_fed_17.txt Hamilton_fed_21.txt
Hamilton_fed_22.txt
```

```
##                 814                 663                 823
1494
## Hamilton_fed_23.txt Hamilton_fed_24.txt Hamilton_fed_25.txt
Hamilton_fed_26.txt
##                 717                 826                 825
983
## Hamilton_fed_27.txt Hamilton_fed_28.txt Hamilton_fed_29.txt
Hamilton_fed_30.txt
##                 573                 639                 876
819
## Hamilton_fed_31.txt Hamilton_fed_32.txt Hamilton_fed_33.txt
Hamilton_fed_34.txt
##                 673                 589                 640
883
## Hamilton_fed_35.txt Hamilton_fed_36.txt Hamilton_fed_59.txt
Hamilton_fed_6.txt
##                 942                1095                 720
868
## Hamilton_fed_60.txt Hamilton_fed_61.txt Hamilton_fed_65.txt
Hamilton_fed_66.txt
##                 892                 591                 816
899
## Hamilton_fed_67.txt Hamilton_fed_68.txt Hamilton_fed_69.txt
Hamilton_fed_7.txt
##                 688                 604                1174
952
## Hamilton_fed_70.txt Hamilton_fed_71.txt Hamilton_fed_72.txt
Hamilton_fed_73.txt
##                1295                 677                 842
941
## Hamilton_fed_74.txt Hamilton_fed_75.txt Hamilton_fed_76.txt
Hamilton_fed_77.txt
##                 422                 822                 796
798
## Hamilton_fed_78.txt Hamilton_fed_79.txt  Hamilton_fed_8.txt
Hamilton_fed_80.txt
##                1245                 421                 892
974
## Hamilton_fed_81.txt Hamilton_fed_82.txt Hamilton_fed_83.txt
Hamilton_fed_84.txt
##                1581                 642                2374
1656
## Hamilton_fed_85.txt  Hamilton_fed_9.txt       HM_fed_18.txt
HM_fed_19.txt
##                1114                 808                 926
907
##       HM_fed_20.txt       Jay_fed_2.txt       Jay_fed_3.txt
Jay_fed_4.txt
##                 692                 709                 622
663
```

```
##        Jay_fed_5.txt       Jay_fed_64.txt  Madison_fed_10.txt 
Madison_fed_14.txt 
##                  605                  966                1316 
882 
##  Madison_fed_37.txt  Madison_fed_38.txt  Madison_fed_39.txt 
Madison_fed_40.txt 
##                 1122                1348                 981 
1132 
##  Madison_fed_41.txt  Madison_fed_42.txt  Madison_fed_43.txt 
Madison_fed_44.txt 
##                 1479                1140                1344 
1178 
##  Madison_fed_45.txt  Madison_fed_46.txt  Madison_fed_47.txt 
Madison_fed_48.txt 
##                  810                 980                1167 
738 
##  Madison_fed_58.txt 
##                  847
```

Normalization

```
#create a normalized version of Papers_DTM
Papers_M <- as.matrix(Papers_DTM)
Papers_M_N1 <- apply(Papers_M, 1, function(i) round(i/sum(i),3))
Papers_Matrix_Norm <- t(Papers_M_N1)

#compare the original and normalized version
(Papers_M[c(1:11),c(1000:1010)])
```

```
##                    Terms
## Docs               edit effect effectu efficaci effici effort eight eighth
##   dispt_fed_49.txt    0      1       1        0      0      0     0      0
##   dispt_fed_50.txt    0      3       0        0      0      0     0      0
##   dispt_fed_51.txt    0      0       0        0      0      0     0      0
##   dispt_fed_52.txt    0      1       1        0      0      0     0      0
##   dispt_fed_53.txt    0      2       1        0      0      0     0      0
##   dispt_fed_54.txt    0      3       0        2      0      0     0      0
##   dispt_fed_55.txt    0      0       0        0      0      0     1      0
##   dispt_fed_56.txt    0      2       0        0      0      0     3      0
##   dispt_fed_57.txt    0      0       2        0      0      0     0      0
##   dispt_fed_62.txt    0      4       0        0      0      0     0      0
##   dispt_fed_63.txt    0      2       2        0      0      0     0      0
##                    Terms
## Docs               either elaps elect
##   dispt_fed_49.txt      1     0     1
##   dispt_fed_50.txt      3     0     2
##   dispt_fed_51.txt      0     0     1
##   dispt_fed_52.txt      0     0    21
##   dispt_fed_53.txt      2     1    20
##   dispt_fed_54.txt      0     0     1
##   dispt_fed_55.txt      2     0     3
##   dispt_fed_56.txt      2     0     3
##   dispt_fed_57.txt      0     0    10
##   dispt_fed_62.txt      0     0     2
##   dispt_fed_63.txt      0     0    14
```

```r
(Papers_Matrix_Norm[c(1:11),c(1000:1010)])
```

```
##                    Terms
## Docs               edit effect effectu efficaci effici effort eight eighth
##   dispt_fed_49.txt    0  0.001   0.001    0.000      0      0 0.000      0
##   dispt_fed_50.txt    0  0.006   0.000    0.000      0      0 0.000      0
##   dispt_fed_51.txt    0  0.000   0.000    0.000      0      0 0.000      0
##   dispt_fed_52.txt    0  0.001   0.001    0.000      0      0 0.000      0
##   dispt_fed_53.txt    0  0.002   0.001    0.000      0      0 0.000      0
##   dispt_fed_54.txt    0  0.004   0.000    0.003      0      0 0.000      0
##   dispt_fed_55.txt    0  0.000   0.000    0.000      0      0 0.001      0
##   dispt_fed_56.txt    0  0.003   0.000    0.000      0      0 0.005      0
##   dispt_fed_57.txt    0  0.000   0.002    0.000      0      0 0.000      0
##   dispt_fed_62.txt    0  0.004   0.000    0.000      0      0 0.000      0
##   dispt_fed_63.txt    0  0.002   0.002    0.000      0      0 0.000      0
##                    Terms
## Docs               either elaps elect
##   dispt_fed_49.txt  0.001 0.000 0.001
##   dispt_fed_50.txt  0.006 0.000 0.004
##   dispt_fed_51.txt  0.000 0.000 0.001
##   dispt_fed_52.txt  0.000 0.000 0.028
##   dispt_fed_53.txt  0.002 0.001 0.022
##   dispt_fed_54.txt  0.000 0.000 0.001
##   dispt_fed_55.txt  0.002 0.000 0.003
##   dispt_fed_56.txt  0.003 0.000 0.005
##   dispt_fed_57.txt  0.000 0.000 0.011
##   dispt_fed_62.txt  0.000 0.000 0.002
##   dispt_fed_63.txt  0.000 0.000 0.011
```

```r
#verify for word 'embarrass' in document 'dispt_fed_62.txt' if the
#normalization math is correct

(row_WordFreq)
```

```
##    dispt_fed_49.txt    dispt_fed_50.txt    dispt_fed_51.txt
dispt_fed_52.txt
##                 677                 480                 783
743
##    dispt_fed_53.txt    dispt_fed_54.txt    dispt_fed_55.txt
dispt_fed_56.txt
##                 903                 766                 865
649
##    dispt_fed_57.txt    dispt_fed_62.txt    dispt_fed_63.txt
Hamilton_fed_1.txt
##                 889                 983                1244
659
```

```
## Hamilton_fed_11.txt Hamilton_fed_12.txt Hamilton_fed_13.txt 
Hamilton_fed_15.txt 
##                1020                 901                 400 
1256 
## Hamilton_fed_16.txt Hamilton_fed_17.txt Hamilton_fed_21.txt 
Hamilton_fed_22.txt 
##                 814                 663                 823 
1494 
## Hamilton_fed_23.txt Hamilton_fed_24.txt Hamilton_fed_25.txt 
Hamilton_fed_26.txt 
##                 717                 826                 825 
983 
## Hamilton_fed_27.txt Hamilton_fed_28.txt Hamilton_fed_29.txt 
Hamilton_fed_30.txt 
##                 573                 639                 876 
819 
## Hamilton_fed_31.txt Hamilton_fed_32.txt Hamilton_fed_33.txt 
Hamilton_fed_34.txt 
##                 673                 589                 640 
883 
## Hamilton_fed_35.txt Hamilton_fed_36.txt Hamilton_fed_59.txt 
Hamilton_fed_6.txt 
##                 942                1095                 720 
868 
## Hamilton_fed_60.txt Hamilton_fed_61.txt Hamilton_fed_65.txt 
Hamilton_fed_66.txt 
##                 892                 591                 816 
899 
## Hamilton_fed_67.txt Hamilton_fed_68.txt Hamilton_fed_69.txt 
Hamilton_fed_7.txt 
##                 688                 604                1174 
952 
## Hamilton_fed_70.txt Hamilton_fed_71.txt Hamilton_fed_72.txt 
Hamilton_fed_73.txt 
##                1295                 677                 842 
941 
## Hamilton_fed_74.txt Hamilton_fed_75.txt Hamilton_fed_76.txt 
Hamilton_fed_77.txt 
##                 422                 822                 796 
798 
## Hamilton_fed_78.txt Hamilton_fed_79.txt  Hamilton_fed_8.txt 
Hamilton_fed_80.txt 
##                1245                 421                 892 
974 
## Hamilton_fed_81.txt Hamilton_fed_82.txt Hamilton_fed_83.txt 
Hamilton_fed_84.txt 
##                1581                 642                2374 
1656 
## Hamilton_fed_85.txt  Hamilton_fed_9.txt       HM_fed_18.txt 
HM_fed_19.txt
```

```
##                1114                808                926
907
##       HM_fed_20.txt       Jay_fed_2.txt       Jay_fed_3.txt
Jay_fed_4.txt
##                 692                 709                 622
663
##       Jay_fed_5.txt      Jay_fed_64.txt  Madison_fed_10.txt
Madison_fed_14.txt
##                 605                 966                1316
882
##  Madison_fed_37.txt  Madison_fed_38.txt  Madison_fed_39.txt
Madison_fed_40.txt
##                1122                1348                 981
1132
##  Madison_fed_41.txt  Madison_fed_42.txt  Madison_fed_43.txt
Madison_fed_44.txt
##                1479                1140                1344
1178
##  Madison_fed_45.txt  Madison_fed_46.txt  Madison_fed_47.txt
Madison_fed_48.txt
##                 810                 980                1167
738
##  Madison_fed_58.txt
##                 847

#dispt_fed_62 has 798 words in total
#there are 2x words of 'embarrass' so, 2/798 = 0.0025 ~0.003 (3 places after
decimal)
```

Data-structures

```
Papers_dtm_matrix <- as.matrix(Papers_DTM)
str(Papers_dtm_matrix)

##  num [1:85, 1:3370] 0 0 0 0 0 0 0 0 0 0 ...
##  - attr(*, "dimnames")=List of 2
##   ..$ Docs : chr [1:85] "dispt_fed_49.txt" "dispt_fed_50.txt"
"dispt_fed_51.txt" "dispt_fed_52.txt" ...
##   ..$ Terms: chr [1:3370] "abandon" "abat" "abb" "abet" ...

Papers_dtm_matrix[c(1:11),c(2:10)]

##                    Terms
## Docs               abat abb abet abil abl ablest abolish abolit abort
##   dispt_fed_49.txt    0   0    0    0   2      0       0      0     0
##   dispt_fed_50.txt    0   0    0    0   0      0       0      0     0
##   dispt_fed_51.txt    0   0    0    0   1      0       0      0     0
##   dispt_fed_52.txt    0   0    0    1   1      0       0      0     0
##   dispt_fed_53.txt    1   0    0    0   0      0       0      0     0
##   dispt_fed_54.txt    0   0    0    0   0      0       0      0     0
##   dispt_fed_55.txt    0   0    0    0   0      0       0      0     0
##   dispt_fed_56.txt    0   0    0    0   0      0       0      0     0
##   dispt_fed_57.txt    0   0    0    0   0      0       0      0     0
##   dispt_fed_62.txt    0   0    0    0   1      0       0      0     0
##   dispt_fed_63.txt    0   0    0    0   4      0       0      0     0
```

Convert to a data-frame

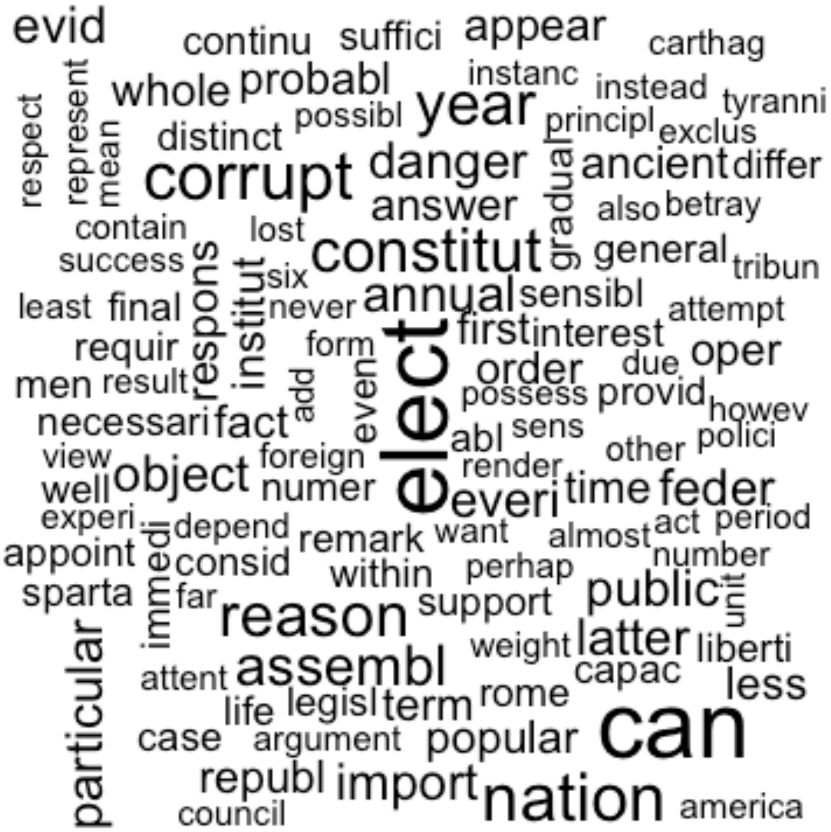
```
Papers_DF <- as.data.frame(as.matrix(Papers_DTM))
str(Papers_DF)
```

```
## 'data.frame':    85 obs. of  3370 variables:
##  $ abandon        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abat           : num  0 0 0 0 1 0 0 0 0 0 ...
##  $ abb            : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abet           : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abil           : num  0 0 0 1 0 0 0 0 0 0 ...
##  $ abl            : num  2 0 1 1 0 0 0 0 0 1 ...
##  $ ablest         : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abolish        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abolit         : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abort          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abound         : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abridg         : num  0 0 0 1 0 0 0 0 0 0 ...
##  $ abroad         : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ absolut        : num  0 2 2 1 0 0 0 0 0 0 ...
##  $ absorb         : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abstain        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abstract       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ absurd         : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abund          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ abus           : num  1 1 2 1 1 0 0 0 0 0 ...
##  $ abyss          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ acced          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ accept         : num  0 0 0 0 0 0 0 0 0 1 ...
##  $ access         : num  0 0 0 2 0 0 0 0 0 0 ...
##  $ accid          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ accident       : num  0 0 0 1 0 0 0 0 0 0 ...
##  $ accommod       : num  0 0 0 0 1 0 0 0 0 0 ...
##  $ accompani      : num  0 0 0 0 0 0 0 1 0 0 ...
##  $ accomplic      : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ accomplish     : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ accord         : num  0 0 0 0 1 2 2 1 1 0 ...
##  $ account        : num  0 0 0 0 0 0 1 0 0 0 ...
##  $ accumul        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ accur          : num  1 0 0 0 1 0 0 0 0 1 ...
##  $ accuraci       : num  0 0 0 0 0 1 0 0 0 0 ...
##  $ accus          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ accustom       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ achaean        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ acknowledg     : num  0 1 0 0 0 0 0 0 0 1 ...
##  $ acquaint       : num  1 0 0 0 2 0 0 2 0 1 ...
##  $ acquiesc       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ acquir         : num  1 0 0 0 5 0 0 2 0 0 ...
##  $ acquisit       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ act            : num  0 0 0 1 2 1 0 1 0 1 ...
##  $ action         : num  0 0 1 0 0 0 0 0 0 1 ...
##  $ activ          : num  0 4 0 0 0 0 0 0 0 0 ...
##  $ actor          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ actual         : num  1 2 0 0 4 0 0 0 1 0 ...
##  $ actuat         : num  0 0 0 0 0 0 1 0 1 0 ...
##  $ adapt          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ add            : num  0 0 0 0 1 0 0 1 1 0 ...
##  $ addict         : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ addit          : num  0 0 1 1 0 0 0 0 1 1 ...
##  $ address        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ adduc          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ adept          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ adequ          : num  1 1 0 0 0 0 0 0 0 0 ...
##  $ adher          : num  0 0 1 0 0 1 0 0 0 0 ...
##  $ adjourn        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ adjud          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ adjust         : num  0 0 0 0 0 1 0 0 0 0 ...
##  $ administ       : num  0 0 2 0 0 0 0 0 0 1 ...
##  $ administr      : num  1 2 1 0 0 0 0 0 1 0 ...
##  $ admir          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ admiralti      : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ admiss         : num  0 0 0 0 0 1 0 0 1 1 ...
##  $ admit          : num  1 0 3 0 1 5 2 0 1 0 ...
##  $ admitt         : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ admonish       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ admonit        : num  0 0 0 0 0 0 0 0 0 1 ...
##  $ adopt          : num  0 0 0 1 0 1 0 0 0 1 ...
##  $ advanc         : num  0 0 0 0 1 0 0 1 1 2 ...
##  $ advantag       : num  4 1 0 2 2 4 0 1 0 7 ...
##  $ adventiti      : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ adventur       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ advers         : num  2 0 0 0 0 0 0 0 0 0 ...
##  $ adversari      : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ advert         : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ advertis       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ advic          : num  0 0 0 0 0 0 0 0 0 1 ...
##  $ advis          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ advoc          : num  0 0 0 0 0 1 0 1 0 0 ...
##  $ affair         : num  0 0 1 0 9 0 1 5 0 4 ...
##  $ affect         : num  0 0 0 1 0 0 0 0 1 1 ...
##  $ affin          : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ affirm         : num  0 0 0 0 2 0 0 0 0 1 ...
##  $ afford         : num  0 0 0 0 1 0 0 0 0 0 ...
##  $ affront        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ afraid         : num  0 0 0 0 0 0 1 0 0 0 ...
##  $ afterward      : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ age            : num  0 0 0 1 0 0 0 0 0 2 ...
##  $ agenc          : num  0 0 1 0 0 0 0 0 0 1 ...
##  $ agent          : num  1 1 0 0 0 0 0 0 0 0 ...
##  $ aggrand        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ aggrandiz      : num  1 0 0 0 0 0 0 0 1 0 ...
##  $ aggreg         : num  0 0 0 0 0 2 0 0 0 0 ...
##  $ aggress        : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ aggressor      : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ agit           : num  0 0 0 0 0 0 0 0 0 0 ...
##   [list output truncated]
```

Example word cloud

Breaking the word clouds based on the document list: - 1:11 -> disputed papers - 12:62 -> Hamilton papers - 63:70 -> Ignoring HM_fed*, Jay_fed* papers - 71:85 -> Madison papers

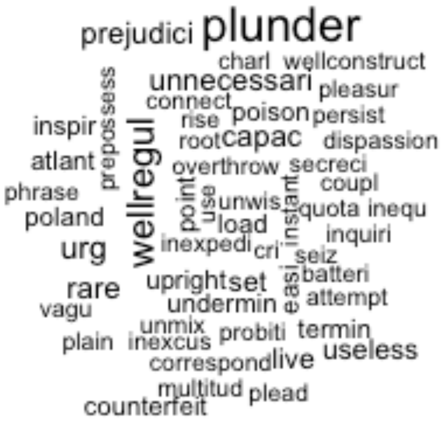
```
disputedpaperswc <- wordcloud(colnames(Papers_dtm_matrix),
Papers_dtm_matrix[11,])

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
repres
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
branch
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
bodi
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
exampl
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
small
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
## american could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
member
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
senat
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
## maryland could not be fit on page. It will not be plotted.
## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
## charact could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
## passion could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
## advantag could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
## independ could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
hous
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
former
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
## without could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
might
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
mani
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
known
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
defect
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
measur
## could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
## legislatur could not be fit on page. It will not be plotted.

## Warning in wordcloud(colnames(Papers_dtm_matrix), Papers_dtm_matrix[11, :
two
## could not be fit on page. It will not be plotted.
```



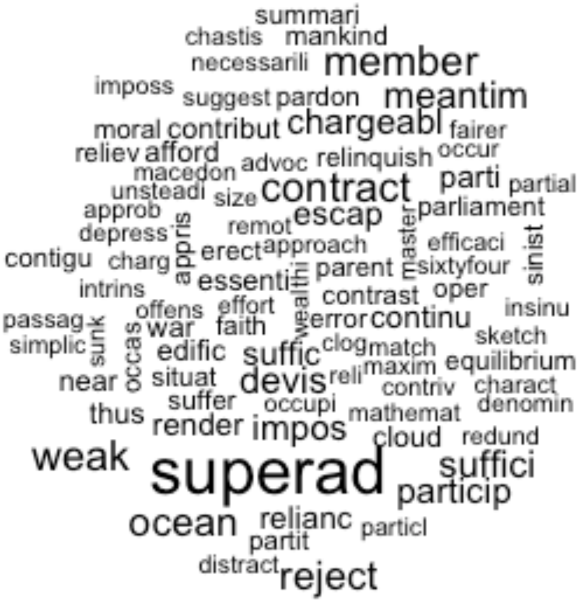
```
(head(sort(as.matrix(Papers_DTM)[11,], decreasing = TRUE), n=50))
```

```
##      senat      repres        bodi         can       elect      measur
corrupt
##         24          18          15          14          14          11
9
##     nation  constitut      former      reason        year     assembl
exampl
##          9           8           8           8           8           7
7
##        two      annual      danger       everi        evid       feder
import
##          7           6           6           6           6           6
6
##     latter      object particular      public    advantag     ancient
answer
##          6           6           6           6           5           5
5
##     appear     charact        fact       first        hous    institut
less
##          5           5           5           5           5           5
5
##       mani      member       might        oper       order     popular
```

```
probabl
##          5           5           5           5           5           5
5
##     republ    respons       small        term        time       whole
without
##          5           5           5           5           5           5
5
##        abl
##          4

HamiltonPapersWC <- wordcloud(colnames(Papers_dtm_matrix),
Papers_dtm_matrix[12:62, ])
```



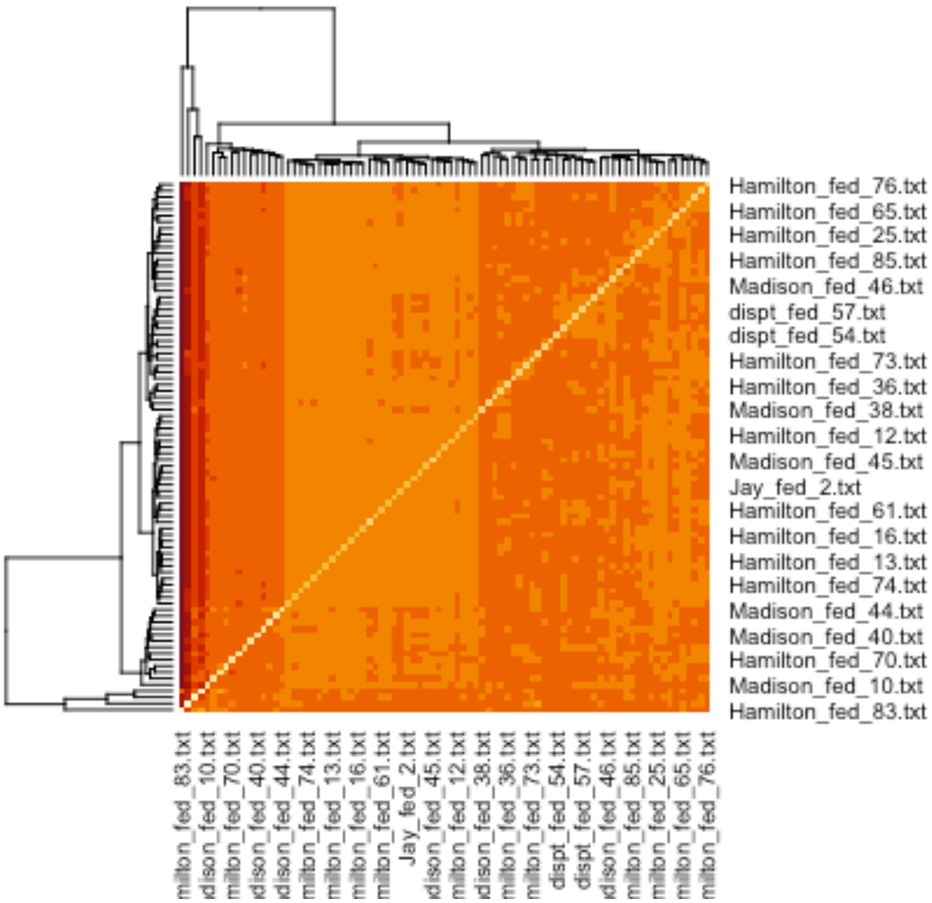
```
MadisonPapersWC <- wordcloud(colnames(Papers_dtm_matrix),
Papers_dtm_matrix[71:85, ])
```



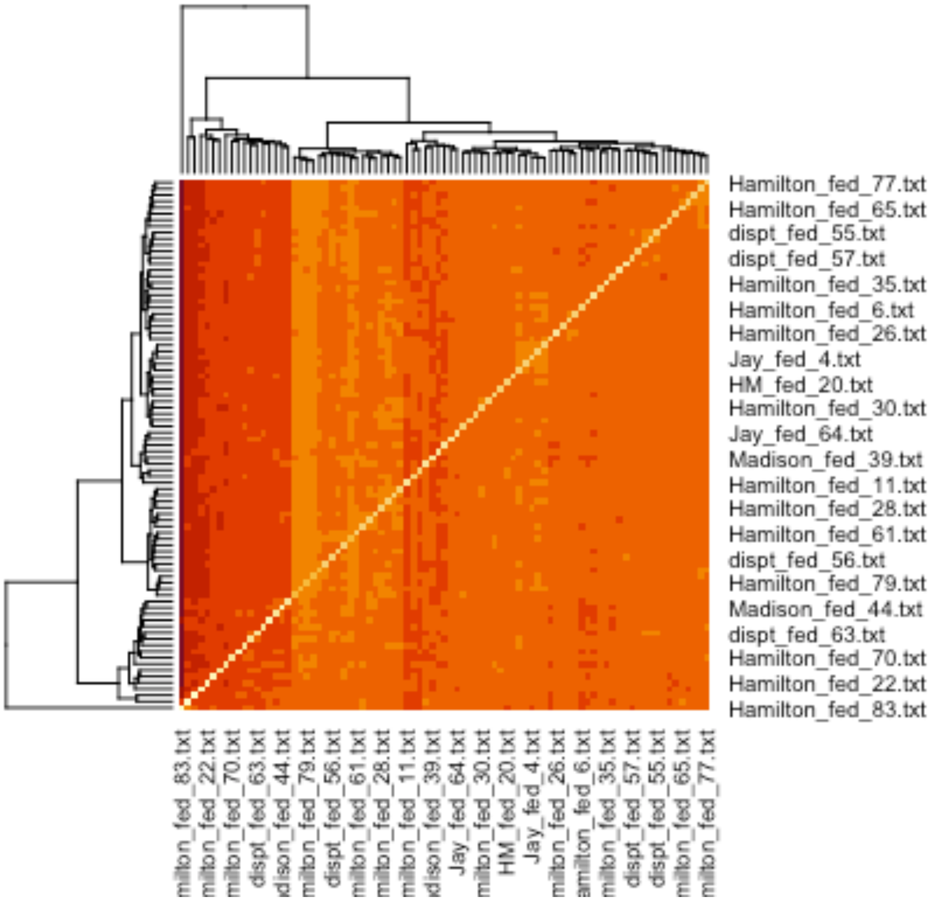
Analysis

Distance metrics

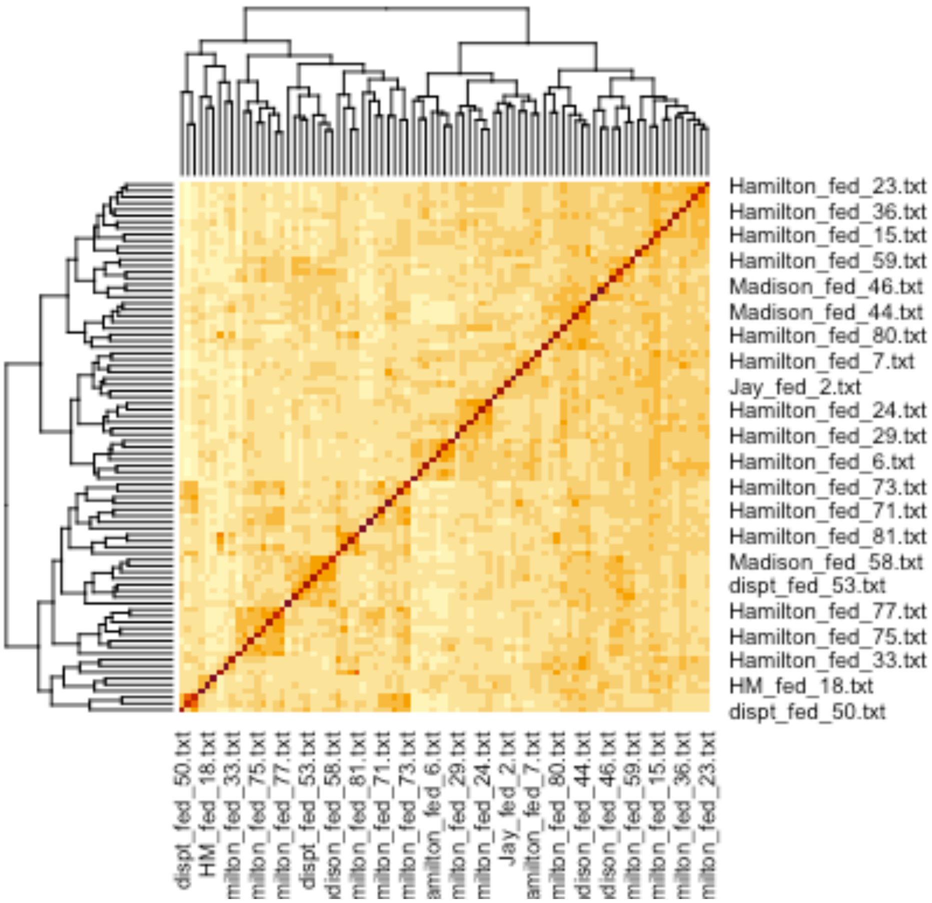
```
m <- Papers_dtm_matrix
m_norm <- Papers_Matrix_Norm

distMatrix_E <- distance(m, method='euclidean', use.row.names = TRUE)

## Metric: 'euclidean'; comparing: 85 vectors.

# print(distMatrix_E)
heatmap(distMatrix_E)
```



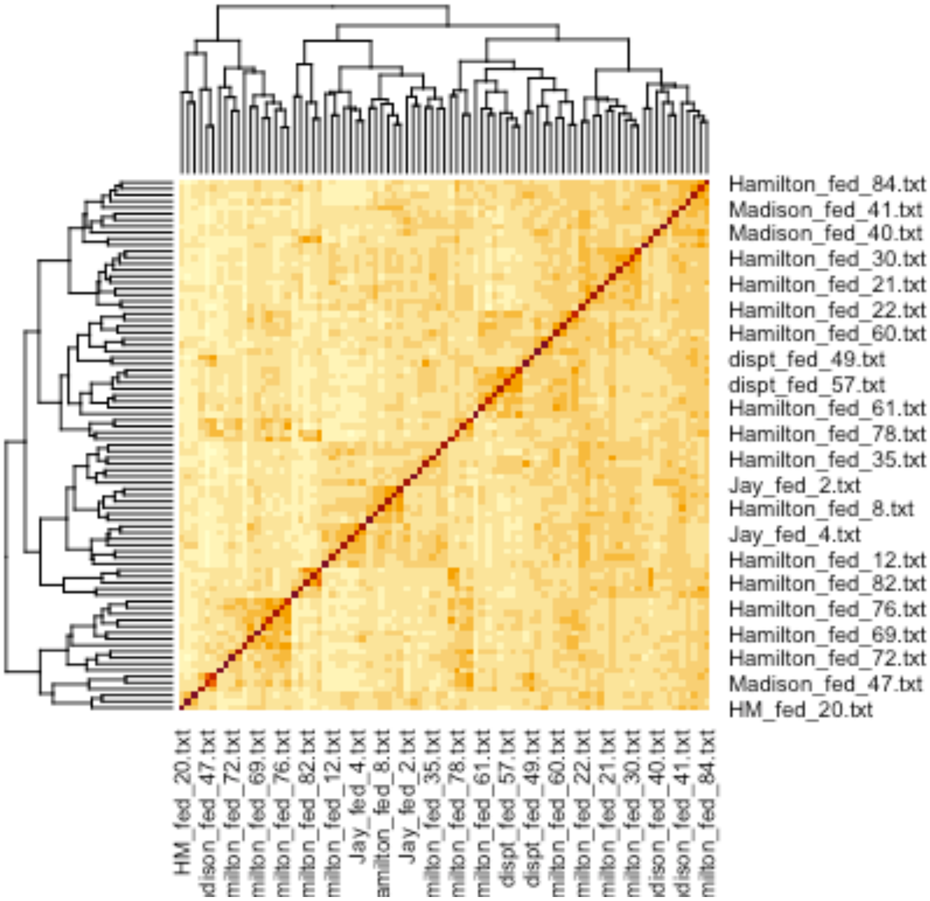
```
distMatrix_M <- distance(m, method='manhattan', use.row.names = TRUE)

## Metric: 'manhattan'; comparing: 85 vectors.

# print(distMatrix_M)
heatmap(distMatrix_M)
```



```r
distMatrix_C <- distance(m, method = 'cosine', use.row.names = TRUE)

## Metric: 'cosine'; comparing: 85 vectors.

# print(distMatrix_C)
heatmap(distMatrix_C)
```



```
distMatrix_C_norm <- distance(m_norm, method='cosine', use.row.names = TRUE)

## Metric: 'cosine'; comparing: 85 vectors.

# print(distMatrix_C_norm)
heatmap(distMatrix_C_norm)
```



The dist() function has issues with 'cosine' methods. Instead, used distance() function and obtain cosine similarity visualization. Heat-maps prove cosine similarity measurements are likely more suitable for document analysis.

Data

We will explore the following two methods to cluster the data and determine an author to the disputed papers:

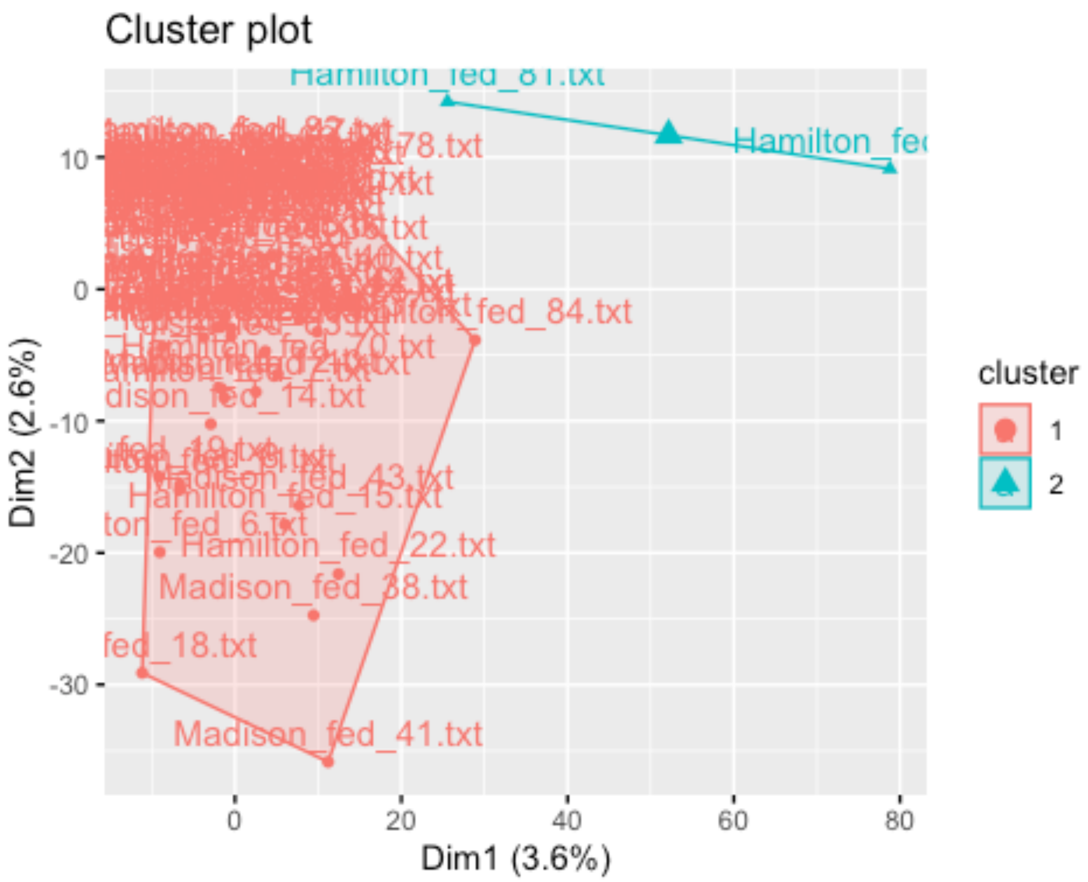
- K-means algorithm
- HAC algorithm

Given that the number of authors here are namely Hamilton and Madison, we will start with choosing number of clusters = 2.

First, is the k-means algorithm:

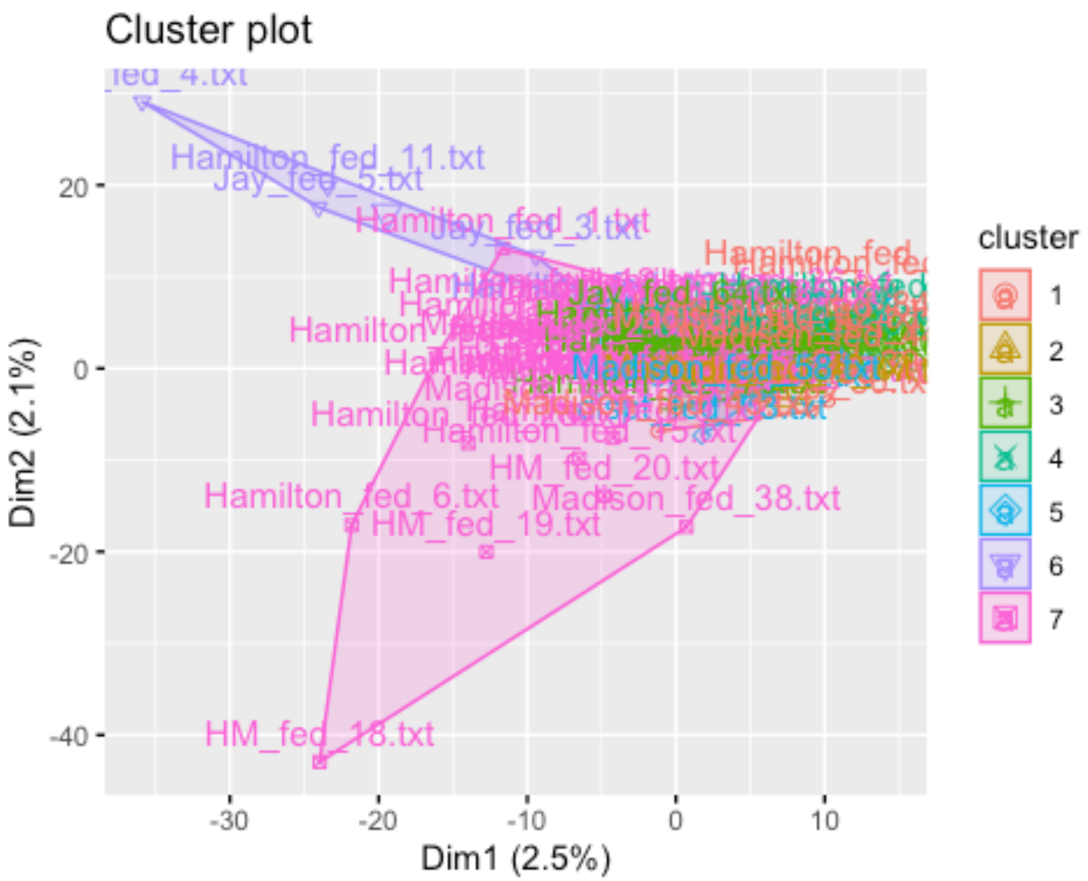
```
k <- 2
set.seed(5)
km.res <- kmeans(Papers_dtm_matrix, k, nstart=100, iter.max=50)
str(km.res)
```

```
## List of 9
##  $ cluster     : Named int [1:85] 1 1 1 1 1 1 1 1 1 1 ...
##   ..- attr(*, "names")= chr [1:85] "dispt_fed_49.txt" "dispt_fed_50.txt"
"dispt_fed_51.txt" "dispt_fed_52.txt" ...
##  $ centers     : num [1:2, 1:3370] 0.1084 0 0.0241 0 0.0602 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : chr [1:2] "1" "2"
##   .. ..$ : chr [1:3370] "abandon" "abat" "abb" "abet" ...
##  $ totss       : num 202176
##  $ withinss    : num [1:2] 174195 6448
##  $ tot.withinss: num 180642
##  $ betweenss   : num 21533
##  $ size        : int [1:2] 83 2
##  $ iter        : int 1
##  $ ifault      : int 0
##  - attr(*, "class")= chr "kmeans"

#plot a visualization
fviz_cluster(km.res, Papers_dtm_matrix)
```



```
k <- 7
km.res <- kmeans(Papers_Matrix_Norm, k, nstart=50, iter.max=50)
str(km.res)
```

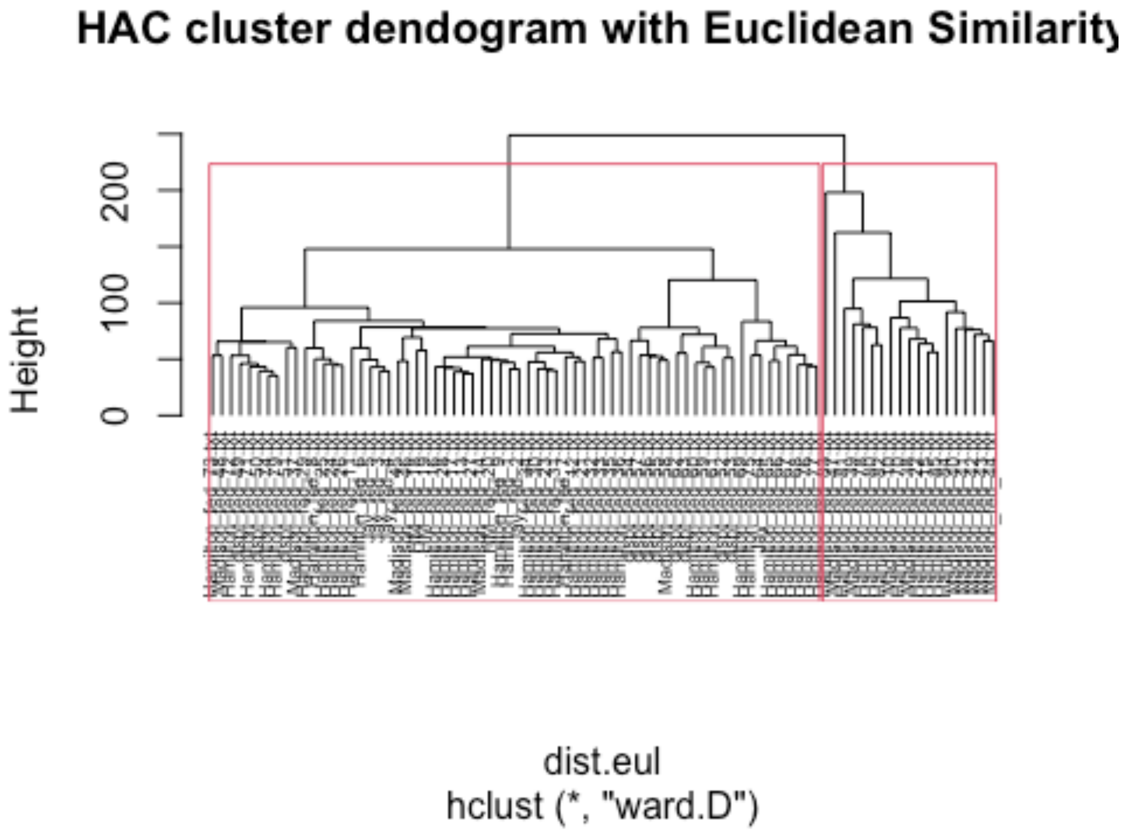
```
## List of 9
##  $ cluster     : Named int [1:85] 1 1 1 5 5 5 5 5 5 7 ...
##   ..- attr(*, "names")= chr [1:85] "dispt_fed_49.txt" "dispt_fed_50.txt"
"dispt_fed_51.txt" "dispt_fed_52.txt" ...
##  $ centers     : num [1:7, 1:3370] 7.69e-05 0.00 7.14e-05 0.00 0.00 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : chr [1:7] "1" "2" "3" "4" ...
##   .. ..$ : chr [1:3370] "abandon" "abat" "abb" "abet" ...
##  $ totss       : num 0.226
##  $ withinss    : num [1:7] 0.03396 0.00231 0.02952 0.00754 0.02239 ...
##  $ tot.withinss: num 0.174
##  $ betweenss   : num 0.0514
##  $ size        : int [1:7] 13 2 14 4 10 5 37
##  $ iter        : int 4
##  $ ifault      : int 0
##  - attr(*, "class")= chr "kmeans"

#plot a visualization
fviz_cluster(km.res, Papers_Matrix_Norm)
```



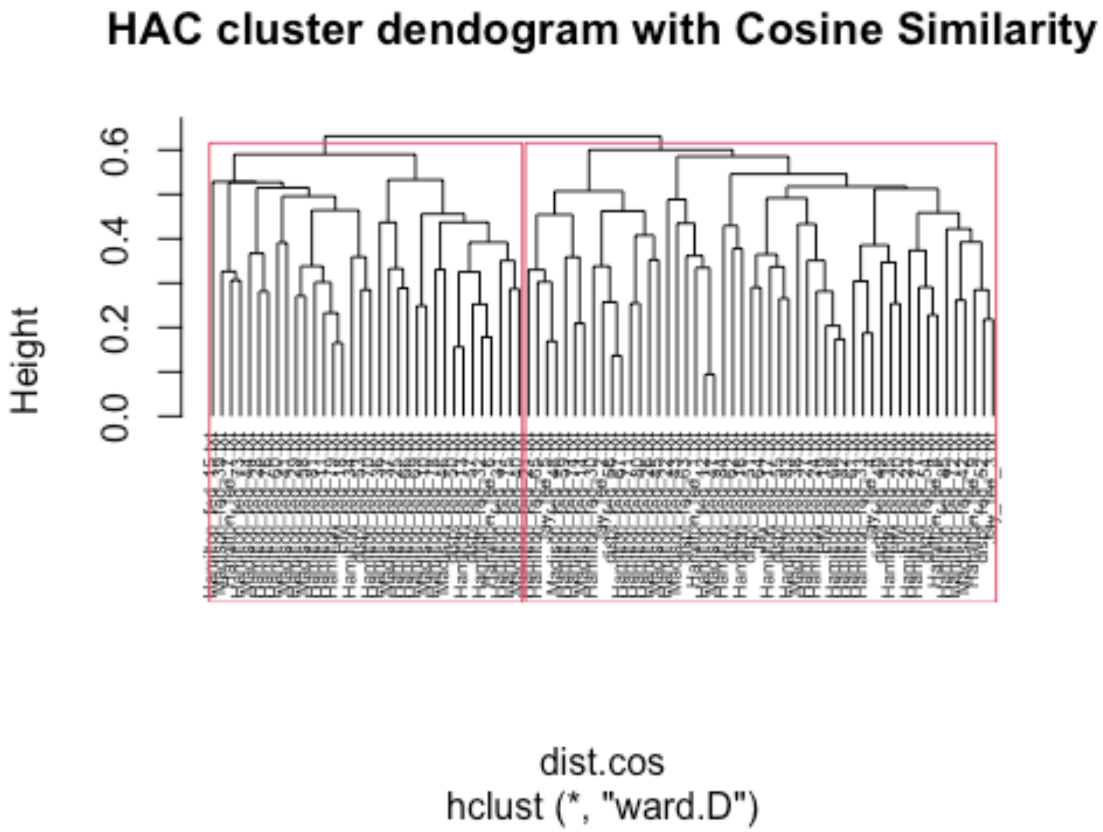
Now, we explore the HAC algorithms

```
#Euclidean distance measure
dist.eul <- as.dist(distMatrix_E)
```

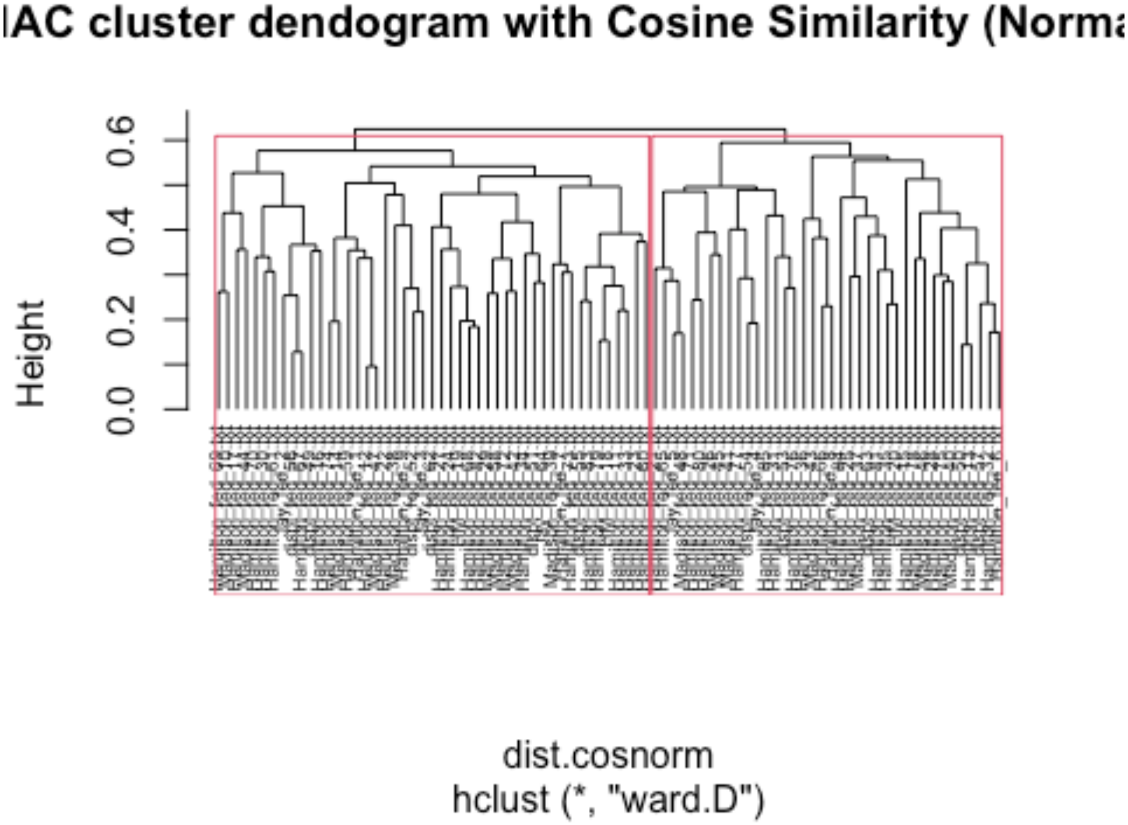
```
groups_E <- hclust(dist.eul, method='ward.D')

#Visualizations
plot(groups_E, cex=0.5, font=22, hang=-1, main="HAC cluster dendogram with
Euclidean Similarity")
rect.hclust(groups_E, k=2)
```



```
#Cosine distance measure
dist.cos <- as.dist(distMatrix_C)
groups_C <- hclust(dist.cos, method='ward.D')

#Visualizations
plot(groups_C, cex=0.5, font=22, hang=-1, main="HAC cluster dendogram with
Cosine Similarity")
rect.hclust(groups_C, k=2)
```



```
#Cosine distance measure (Normalized)
dist.cosnorm <- as.dist(distMatrix_C_norm)
groups_C_norm <- hclust(dist.cosnorm, method='ward.D')

#Visualizations
plot(groups_C_norm, cex=0.5, font=22, hang=-1, main="HAC cluster dendogram
with Cosine Similarity (Normalized")
rect.hclust(groups_C_norm, k=2)
```



Analysis and Results

K-Means

Here are some results/observations with experiments around different cluster sizes:

- cluster-size=2

SSEs

Within cluster sum of squares by cluster is high:

[1] 174194.7 6447.5

This is an indication of high deviation between data-points and the centroid which we would ideally like to be lower. To explore k-means further, we could consider using the k-medoids/expectation-max or PAM algorithms.

Data

Most of the data-points were grouped into cluster-1 and this did not help to clearly determine the author for the disputed papers.

- cluster-size=7

SSE

SSEs look a lot better with increased cluster-size

Within cluster sum of squares by cluster:

```
[1] 0.00754175 0.03396400 0.06862076 0.00231200 0.02952307 0.00990520
0.02239410
```

Data

Disputed papers were placed in clusters - 2, 7, 3:

- Number of disputed papers in cluster-2 = 3
- Number of disputed papers in cluster-7 = 7
- Number of disputed papers in cluster-3 = 1

Cluster-7 that has the highest papers does not have sufficient majority of Hamilton/Madison papers to make a decision.

Overall, k-means does not seem like a good algorithm for document analysis use-cases.

HAC algorithm

In comparison, seems like plotting and analyzing dendograms, seems a plausible means to realize the exercise. To a very large extent we can classify the disputed documents to the corresponding authors.

Conclusions

With Hierarchical Agglomerative Clustering (HAC) techniques (and dendograms to analyze the results) we conclude by analyzing one disputed document dispt_fed_49.txt across:

- Eucledian

In plot 'HAC cluster dendogram with Euclidean Similarity', see document 'dispt_fed_49.txt' present in the first-cluster on the left and is associated by nodes/leafs that belong to Hamilton so, we can conclude it was written by author Hamilton with moderate confidence.

- Cosine

In plot 'HAC cluster dendogram with Cosine Similarity', see document 'dispt_fed_49.txt' belonging to a cluster towards the end. Again, the nodes/leafs around it are documents by author Hamilton.

- Cosine-Normalized

Likewise, in plot 'HAC cluster dendogram with Cosine Similarity (Normalized)' the surrounding nodes/leafs are related to author Hamilton.

In similar lines, we could extend the study to all disputed documents and hence classify them between the two authors.