PREDICTING ONLINE NEWS POPULARITY

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Content

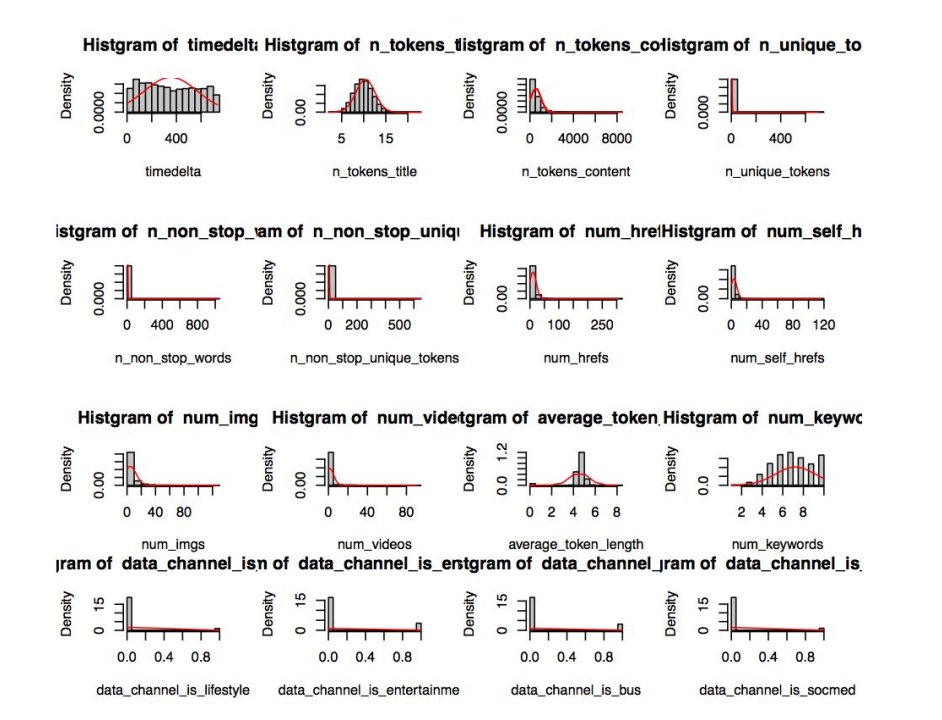
- Data & Features
- Exploratory Data Analysis
- Features Selection
- Machine Learning Models Comparison

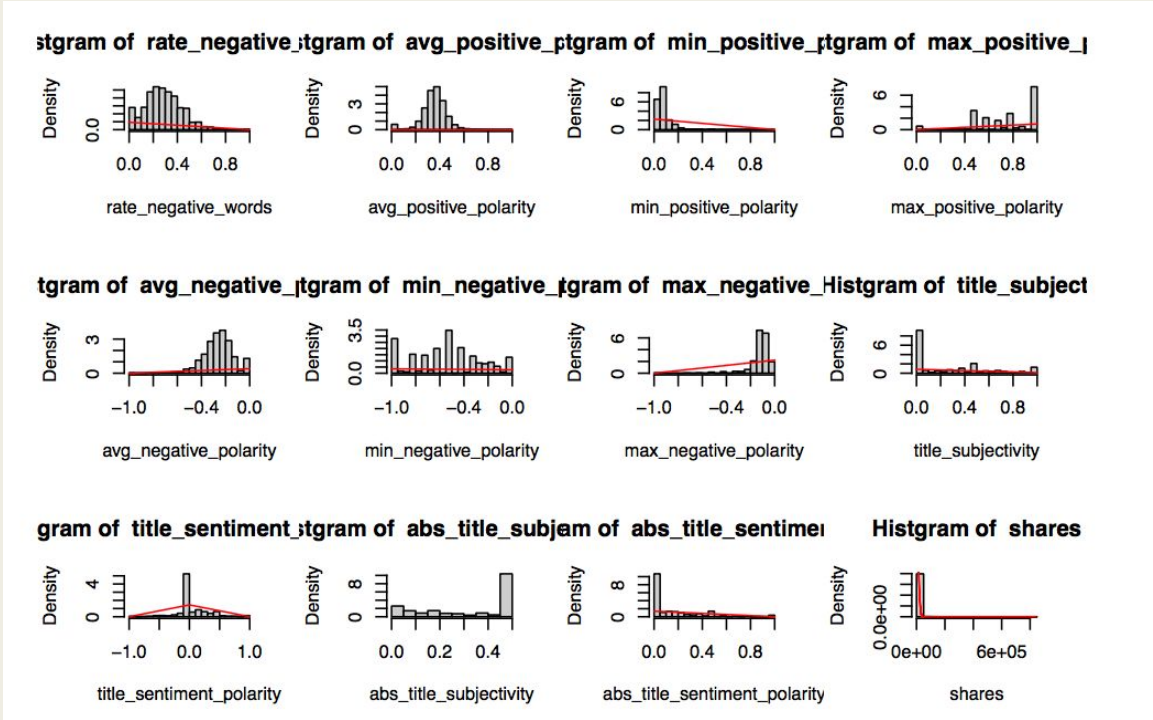
Aspects	Features	
Words	• Number of words in the title • Number of words in the article • Average words length	• Rate of non-stop words • Rate of unique words • Rate of unique non-stop words
Links	• Number of links • Number of Mashable article links	• Minimum, average and maximum number of shares of Mashable links
Digital Media	• Number of images • Number of videos	
Publication Time	• Day of the week • Published on a weekend	
Key Words	• Number of key words • Worst keyword • Average keyword	• Best keywords • Article category
NLP	• Closeness to top 5 LDA topics • Title subjectivity • Article text subjectivity score and its absolute difference to 0.5 • Title sentiment polarity • Rate of positive and negative words	• Rate of positive and negative words • Neg. words rate among non-neutral words • Polarity of positive words (min./avg./max.) • Polarity of negative words (min./avg./max.) • Article text polarity score and its absolute difference to 0.5
Response	Number of article shares	

http://archive.ics.uci.edu/ml/datasets/Online+News+Popularity

Exploratory Data Analysis

1. Data Distribution : Plot the histograms to check distributions.





EDA continues

2. Data Transformation: Transform heavily skewed data using log and square root transformation.

```
skew(newsdata)
```

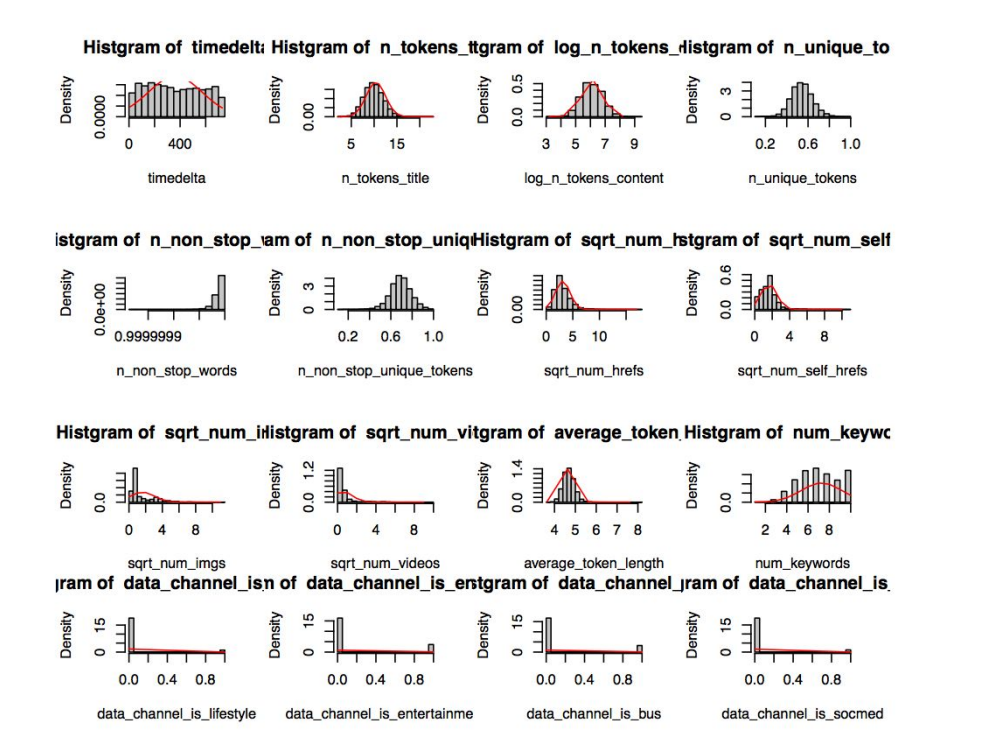
```
##  [1]  0.0830803  0.1752837  3.0410252  0.1288882 -2.5111968 -0.3878504
##  [7]  4.0439504  5.2074614  3.9169496  6.8220500  0.5903815 -0.1219901
## [13]  3.9166129  1.6530398  1.8430331  3.7202444  1.5785427  1.4252588
## [19]  2.3292246 35.5555405 31.4588084 11.5086367 -2.6343728  0.5679786
## [25]  0.4739891 16.4911435  6.2652723 26.1280440 13.5521851 17.6032619
## [31]  1.7862973  1.6108400  1.5969048  1.6298812  2.0373025  3.6333313
## [37]  3.3881444  2.1821695  1.5290735  2.0828705  1.3192205  1.2964337
## [43]  1.1436402  0.1442169 -0.1334362  0.5978480  1.8468719 -0.6822992
## [49]  0.6822992  0.4979651  3.2752169 -0.4627280 -1.2543966 -0.2232372
## [55] -3.6999467  0.8226038  0.4023800 -0.6343757  1.7016601 34.7130340
```

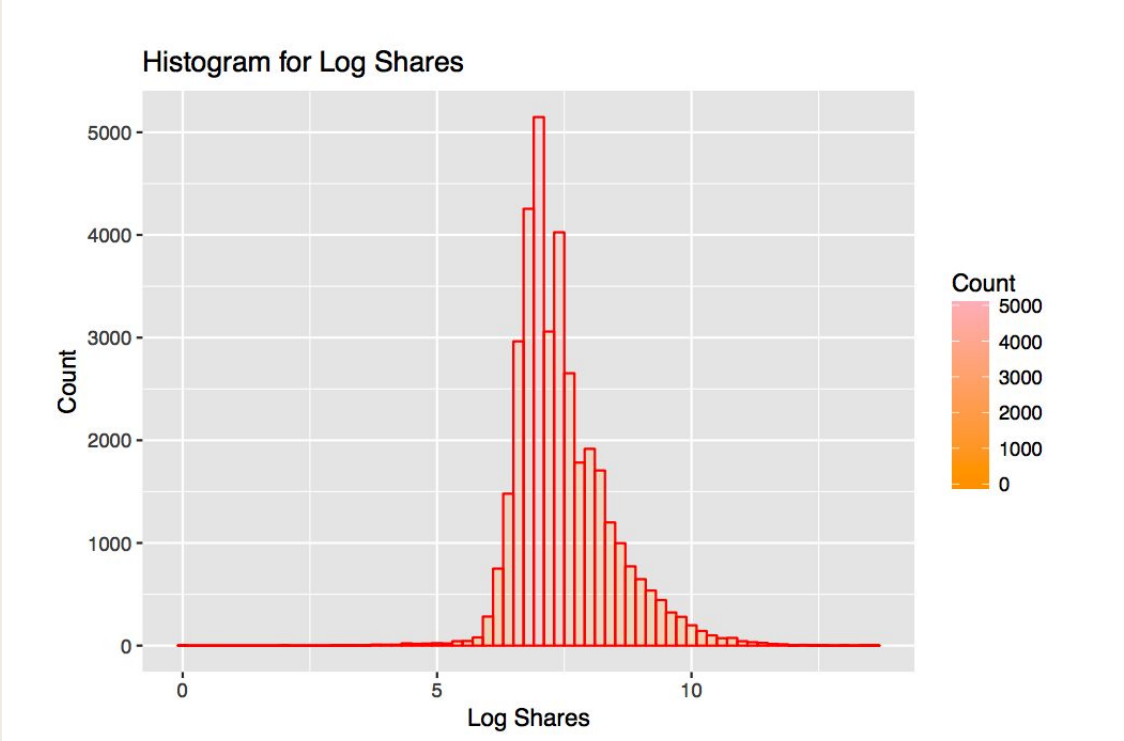
```
which(skew(newsdata)>1)
```

```
##  [1]  3  7  8  9 10 13 14 15 16 17 18 19 20 21 22 26 27 28 29 30 31 32 33
## [24] 34 35 36 37 38 39 40 41 42 43 47 51 59 60
```

EDA continues

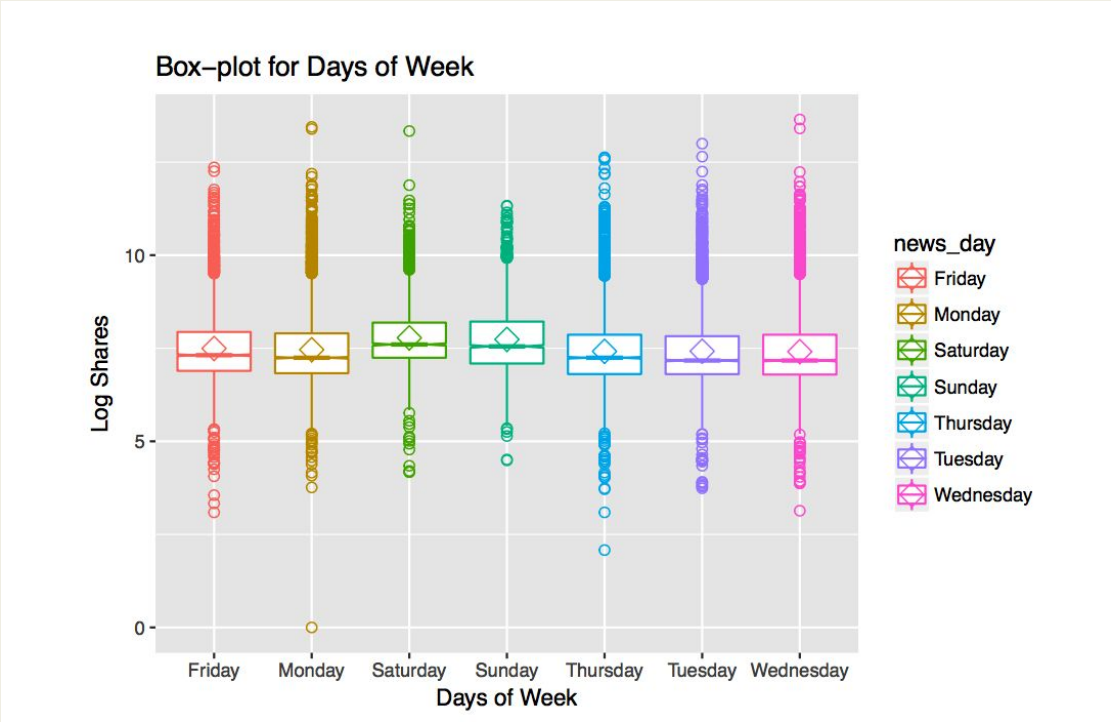
3. Data Distribution : Plot the histograms after transformation

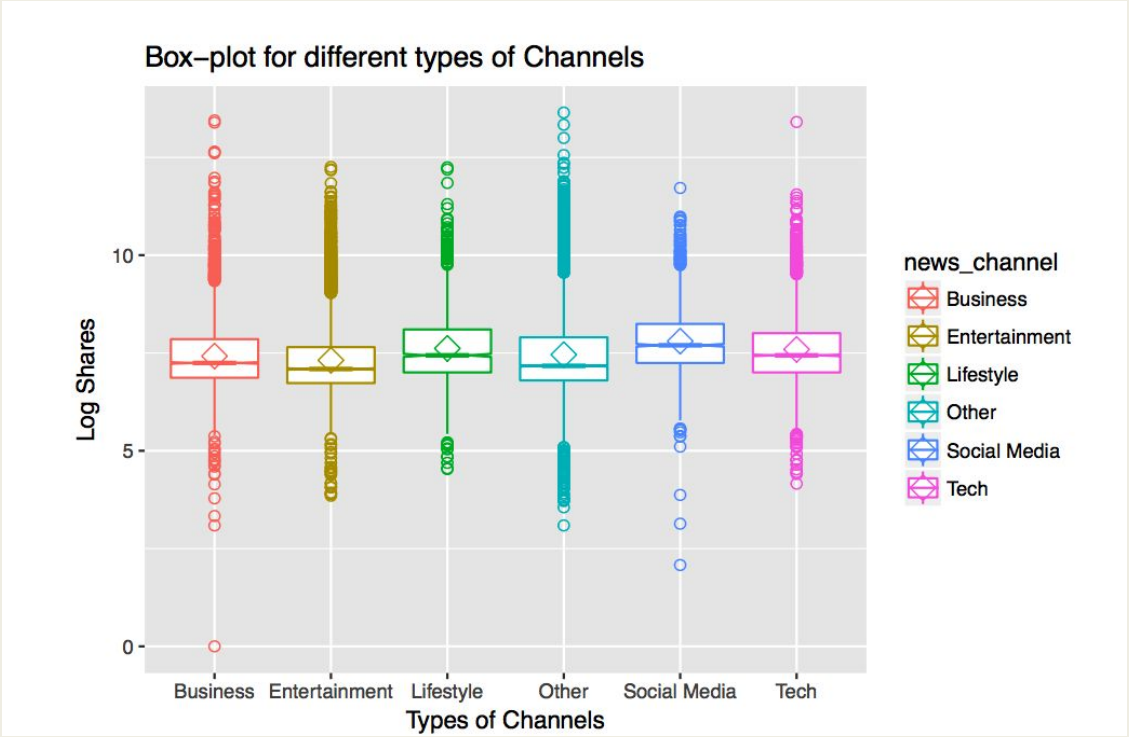




EDA continues

4. Check interesting variables.





EDA continues

5. Other Modifications:

a. 19th, 21st, 23rd, 25th variables contain negative values that cannot be explained by information available, so they will be removed.

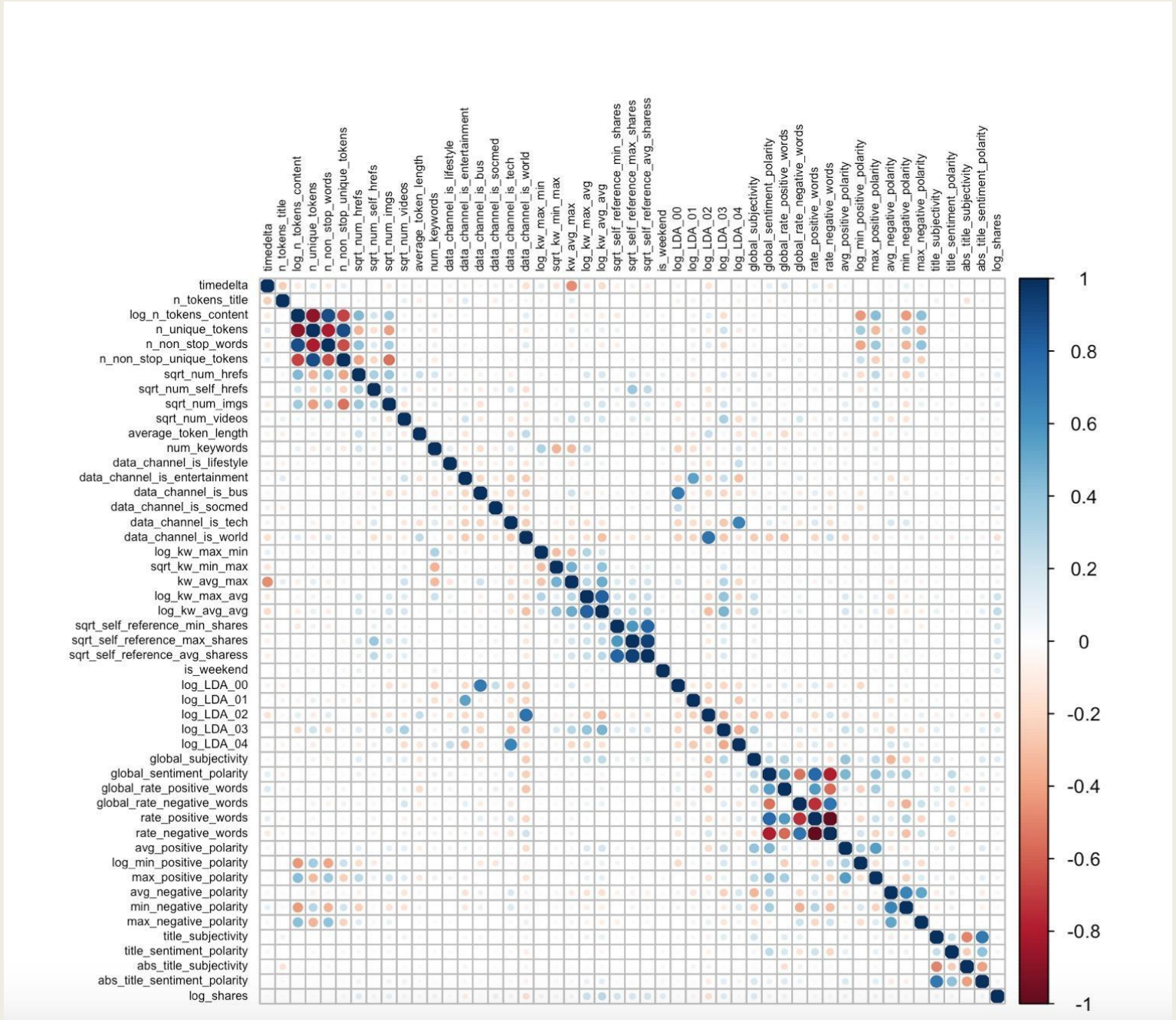
b. Outliers in variable “n_unique_tokens”, “n_non_stop_words”, and “n_non_stop_unique_tokens”, may due to typing error as they are the ratios and should have a value between 0 and 1. We remove those observations.

c. The number of total variables left is 49.

Features Selection

- **Remove redundant variables**
  - We consider pair-wise correlations among predictor variables (cutoff > 0.5)

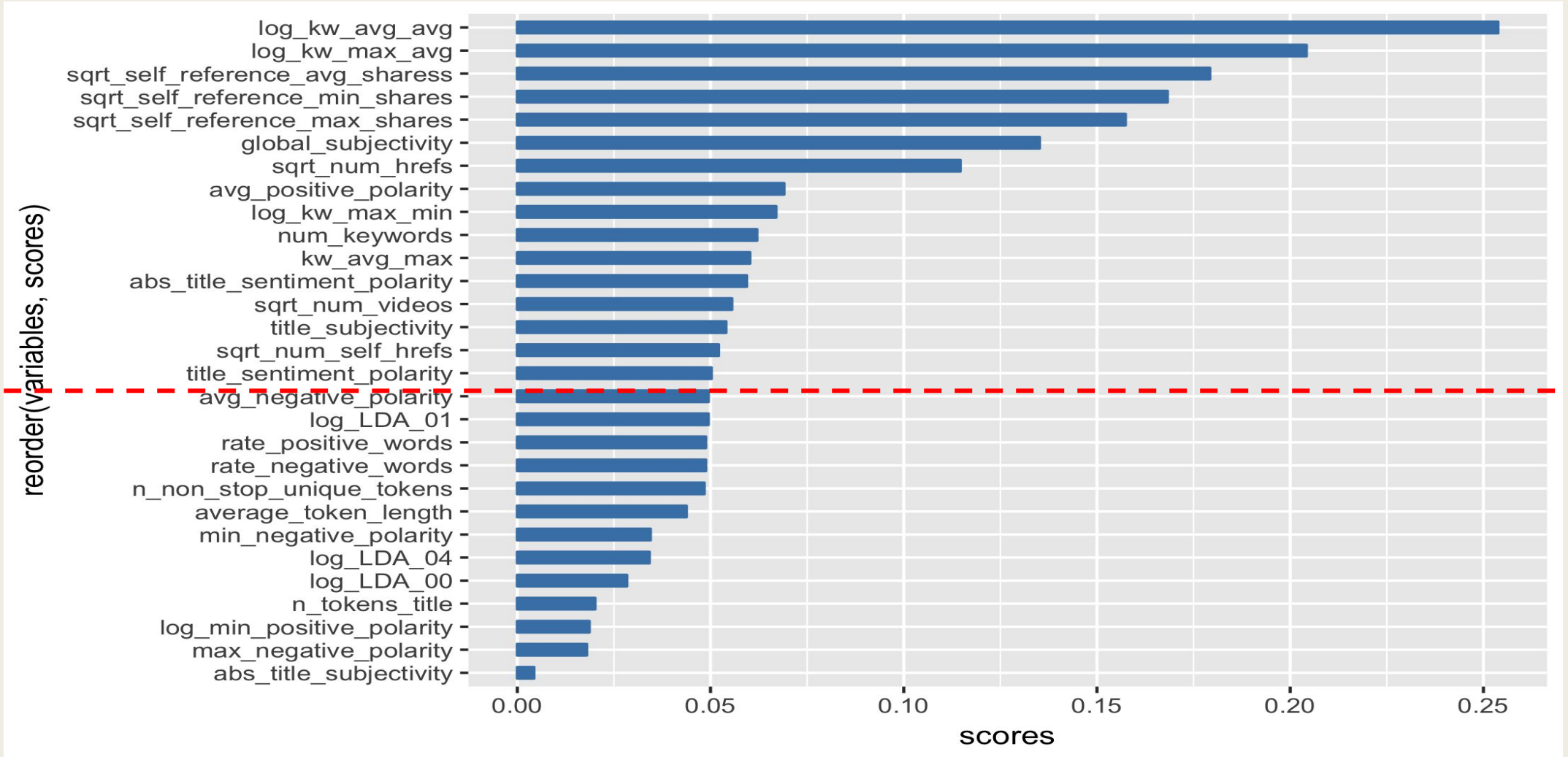
Correlation



Features Selection

- **Rank variables by importance**
  - We use Pearson's correlation as the indicator to measures the linear relationship between continuous variables and the response variable. Then rank them from the highest correlated to the lowest correlated.

Importance rank



Selected Variables

Aspects	Features
Keywords	● kw_avg_avg: Avg. keyword (avg. shares) ● kw_max_avg: Avg. keyword (max. shares) ● kw_avg_max: Best keyword (avg. shares) ● num_keywords: Number of keywords in the metadata ● data_channel_is_lifestyle: Is data channel 'Lifestyle'? ● data_channel_is_entertainment: Is data channel 'Entertainment'? ● data_channel_is_bus: Is data channel 'Business'? ● data_channel_is_socmed: Is data channel 'Social Media'?
Links	● self_reference_avg_sharess: Avg. shares of referenced articles in Mashable ● self_reference_min_shares: Min. shares of referenced articles in Mashable ● self_reference_max_shares: Max. shares of referenced articles in Mashable ● num_hrefs: Number of links ● num_self_hrefs: Number of links to other articles published by Mashable
NLP	● global_subjectivity: Text subjectivity ● avg_positive_polarity: Avg. polarity of positive words ● abs_title_sentiment_polarity: Absolute polarity level ● title_subjectivity: Title subjectivity
Digital Media	● num_videos: Number of videos ● abs_title_sentiment_polarity: Absolute polarity level ● title_sentiment_polarity: Title polarity

Machine Learning Models Comparison

- Linear Regression
- Support Vector Machine
- Random Forest
- Regression Tree
- Gradient Boosting

Linear Regression

MSE = 0.7841

```
Residuals:
    Min      1Q  Median      3Q     Max
-8.0883 -0.5541 -0.1601  0.4073  5.6924

Coefficients:
                                 Estimate Std. Error t value Pr(>|t|)
(Intercept)                     1.521e+00  1.505e-01  10.109  < 2e-16 ***
log_kw_avg_avg                  8.571e-01  3.364e-02  25.482  < 2e-16 ***
log_kw_max_avg                 -1.456e-01  2.296e-02  -6.343 2.29e-10 ***
sqrt_self_reference_avg_sharess 1.760e-03  6.231e-04   2.825 0.004734 **
sqrt_self_reference_min_shares  1.010e-03  3.230e-04   3.126 0.001775 **
sqrt_self_reference_max_shares -4.517e-04  3.545e-04  -1.274 0.202580
global_subjectivity             5.527e-01  6.902e-02   8.007 1.22e-15 ***
sqrt_num_hrefs                  3.801e-02  4.339e-03   8.759  < 2e-16 ***
avg_positive_polarity          -8.964e-02  7.006e-02  -1.279 0.200738
log_kw_max_min                 -9.312e-03  6.565e-03  -1.418 0.156109
num_keywords                    1.800e-02  3.311e-03   5.435 5.53e-08 ***
kw_avg_max                     -7.069e-07  5.847e-08 -12.090  < 2e-16 ***
abs_title_sentiment_polarity    1.572e-02  3.587e-02   0.438 0.661133
sqrt_num_videos                 2.448e-02  5.739e-03   4.265 2.01e-05 ***
title_subjectivity              3.482e-02  2.355e-02   1.478 0.139289
sqrt_num_self_hrefs            -4.080e-03  7.043e-03  -0.579 0.562419
title_sentiment_polarity        7.983e-02  2.197e-02   3.634 0.000279 ***
data_channel_is_lifestyle1     -2.853e-02  2.402e-02  -1.188 0.234880
data_channel_is_entertainment1 -2.197e-01  1.486e-02 -14.780  < 2e-16 ***
data_channel_is_bus1            4.306e-02  1.576e-02   2.733 0.006285 **
data_channel_is_socmed1         2.108e-01  2.348e-02   8.980  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.8694 on 27184 degrees of freedom
Multiple R-squared:  0.1111,    Adjusted R-squared:  0.1104
F-statistic: 169.9 on 20 and 27184 DF,  p-value: < 2.2e-16
```

Support Vector Machine

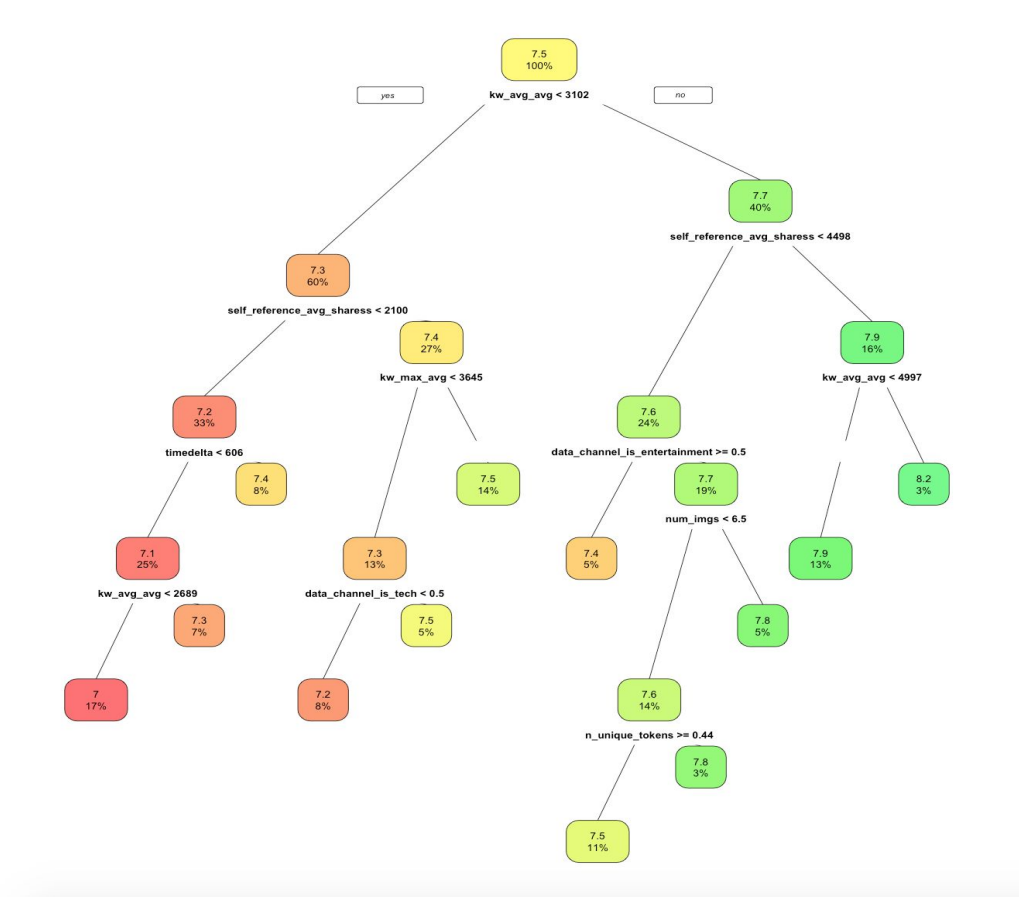
- The value of **epsilon** defines a margin of tolerance where no penalty is given to errors.
- **Cost** is a parameter allows one to trade off training error vs. model complexity.
- **Sigma** determines the width of Gaussian distribution.

Kernel	Parameters	Expression
Linear	$\epsilon = 0.1,$ $Cost = 1$	$K(u, v) = u^T v$
Gaussian	$\epsilon = 0.1$ $Cost = 0.5,$ $\sigma = 0.04$	$K(u, v) = \exp(\frac{-\lvert u - v\rvert^2}{2\sigma^2})$

Support Vector Machine

Algorithms	**MSE**	**Training Time**
SVM Linear	0.82	550s
SVM Gaussian	0.79	255s

Regression Tree- rpart



A rpart model with a continuous response (an anova model).

Each node shows

- the predicted value
- the percentage of observations in the node.

12 splits, 53 nodes

rpart - CP(complexity parameters)

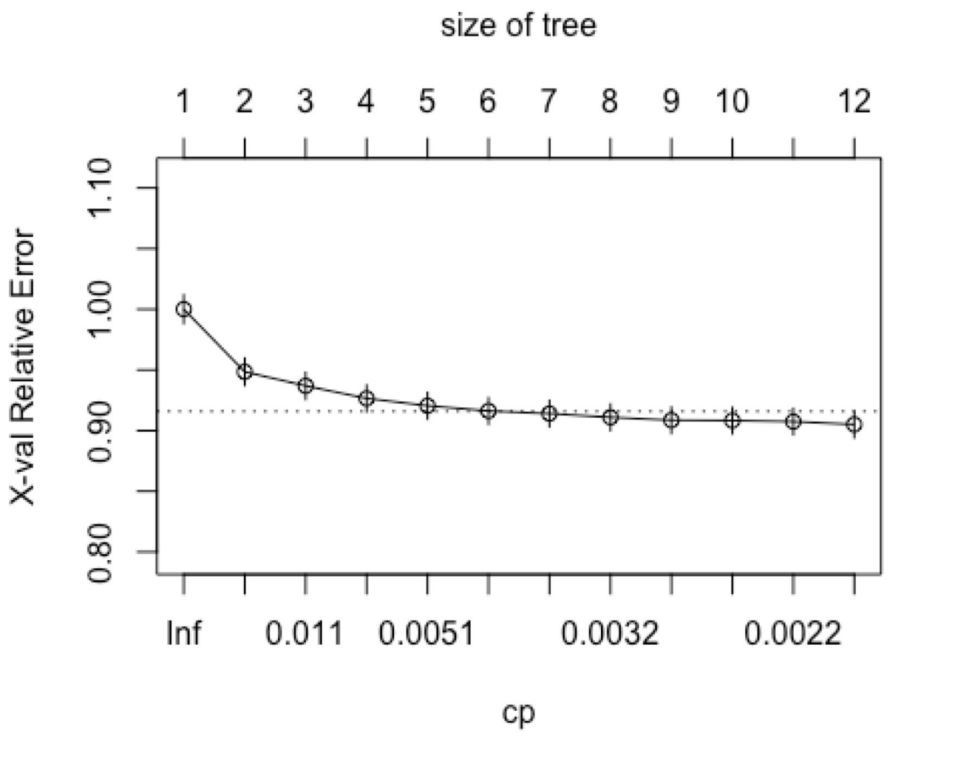
```
> summary(c_fit)
Call:
rpart(formula = log(shares) ~ ., data = cat, method = "anova",
    control = rpart.control(minsplit = 10, minbucket = 4, cp = 0.002))
  n= 31715

           CP nsplit rel error    xerror       xstd
1  0.052938572      0 1.0000000 1.0000200 0.01183431
2  0.011582417      1 0.9470614 0.9495463 0.01126572
3  0.011169415      2 0.9354790 0.9392656 0.01113900
4  0.006287195      3 0.9243096 0.9283532 0.01101877
5  0.004176868      4 0.9180224 0.9224415 0.01096581
6  0.003725943      5 0.9138455 0.9189170 0.01092625
7  0.003407788      6 0.9101196 0.9167224 0.01095825
8  0.003091044      7 0.9067118 0.9140441 0.01093393
9  0.002376130      8 0.9036208 0.9099215 0.01088119
10 0.002374690      9 0.9012446 0.9093941 0.01089503
11 0.002123137     10 0.8988699 0.9092912 0.01089433
12 0.002000000     11 0.8967468 0.9060781 0.01087814
```

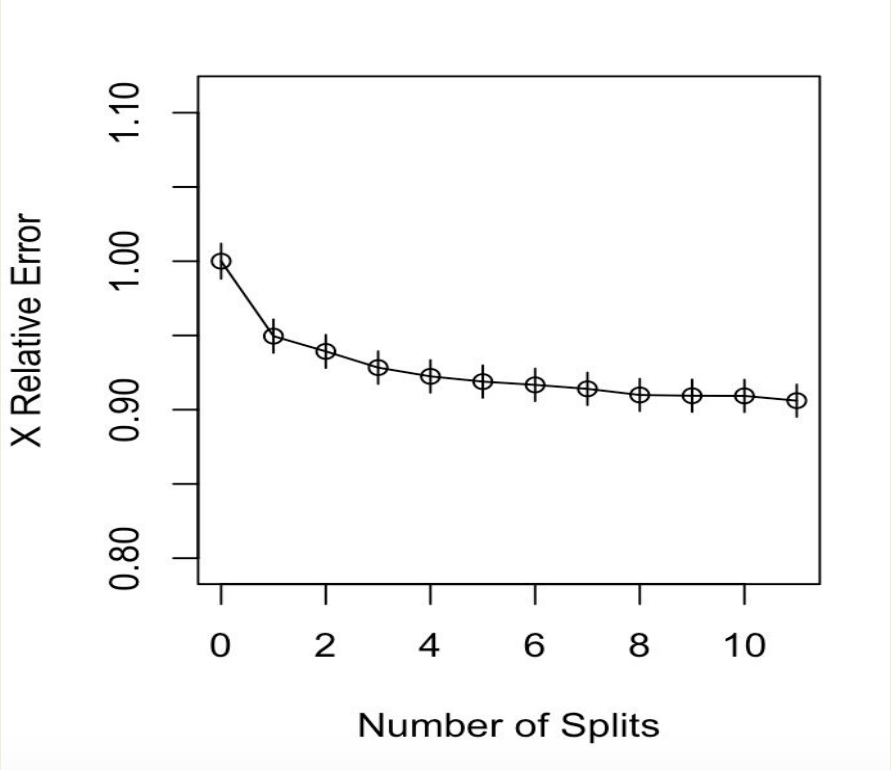
1. cp is the amount by which splitting that node improved the relative error.

2. The relative error is (1 − R2) , similar to linear regression.

3. The xerror is related to the PRESS statistic.

Regression Tree- rpart





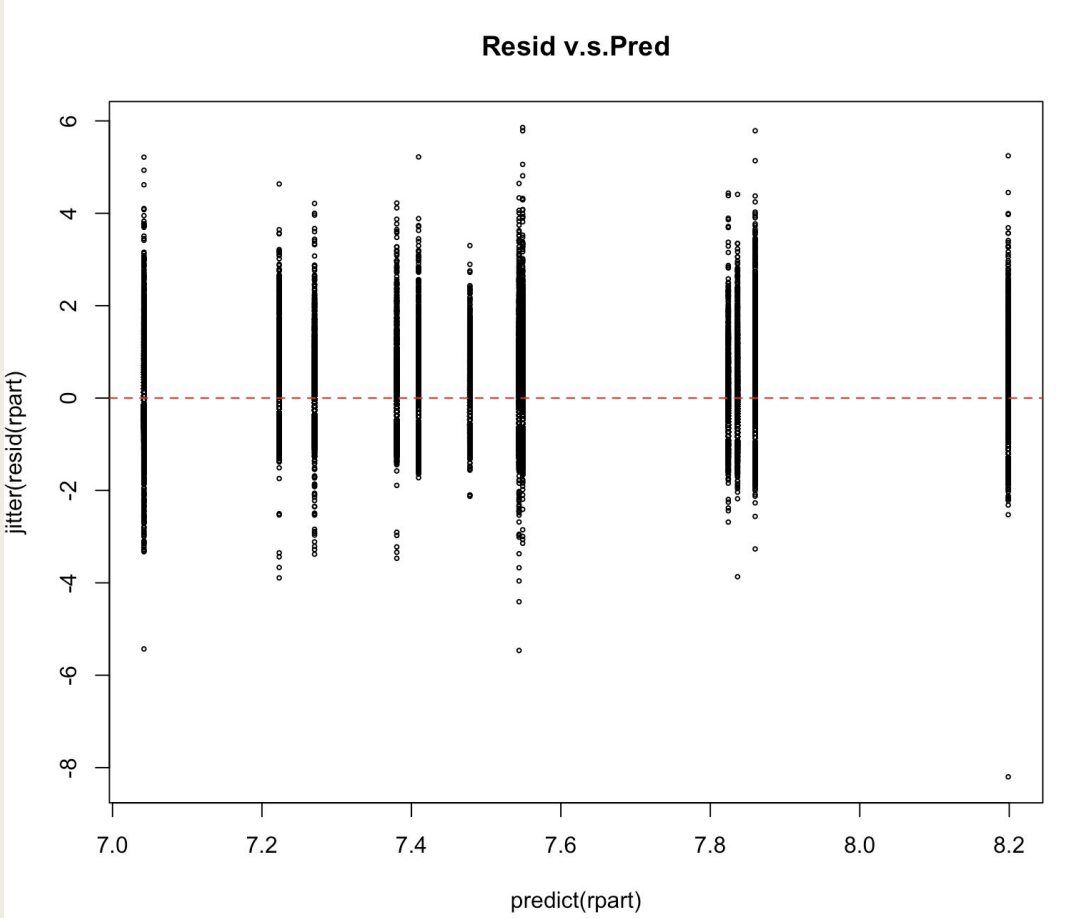
1. The first split and second appears to improve the fit the most.

2. The figure on the right shows the tree should be pruned to include only 1 or 2 splits

rpart- important variables

```
Variable importance
                  kw_avg_avg                   kw_max_avg                   kw_min_avg
                          22                           14                            8
   self_reference_avg_sharess self_reference_max_shares                      LDA_03
                           8                            7                            7
                  kw_avg_max                   kw_min_max self_reference_min_shares
                           6                            6                            5
                   timedelta                   kw_max_max                   kw_min_min
                           2                            2                            2
data_channel_is_entertainment       data_channel_is_tech                      LDA_04
                           1                            1                            1
                    num_imgs                num_self_hrefs               n_unique_tokens
                           1                            1                            1
        average_token_length     n_non_stop_unique_tokens
                           1                            1
```

rpart- prediction accuracy



MSE = 0.8108

This plot shows the residuals of predicted shares v.s. the predicted shares based on the nodes/leaves. There appears to be more variability in node 11 than in some of the other leaves.

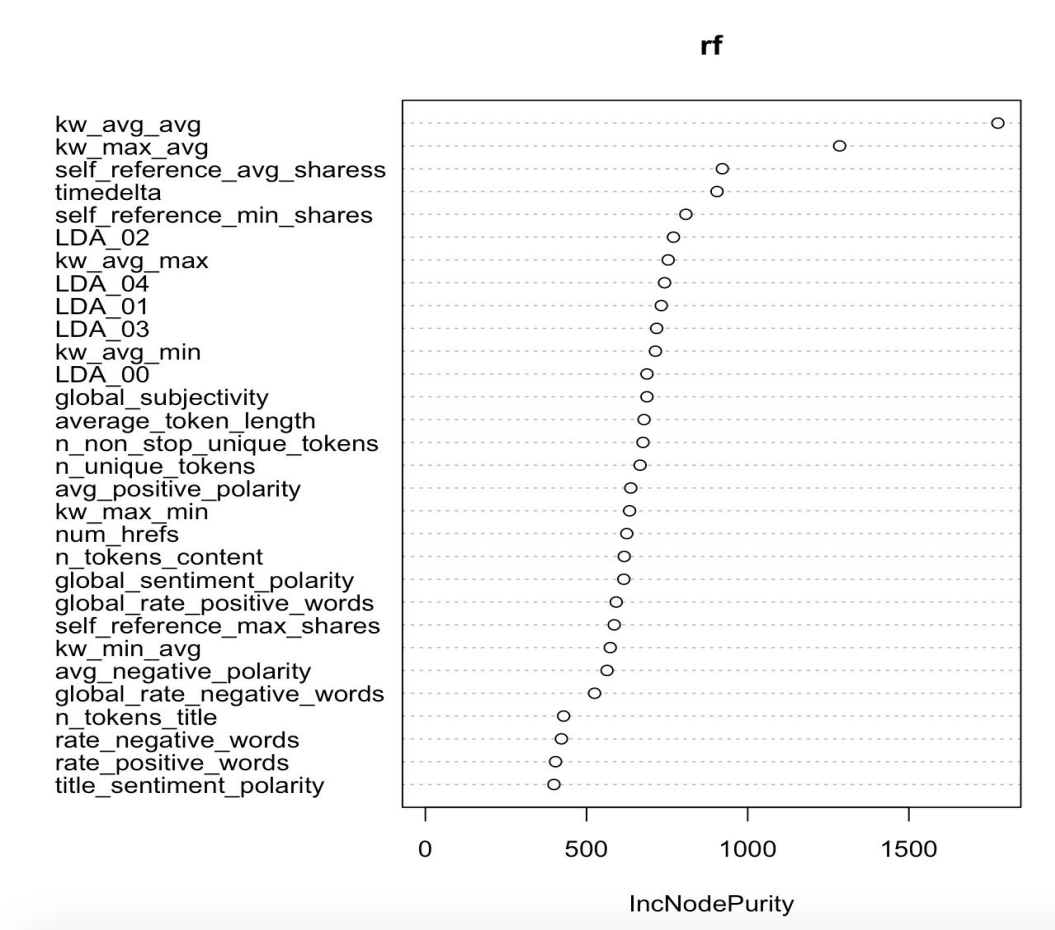
Why we need a random Forest?

"Given its performance, random forest and variable selection using random forest should probably become part of the standard tool-box of methods for the analysis of microarray data."

------ Ramón Díaz-Uriarte

(2010)

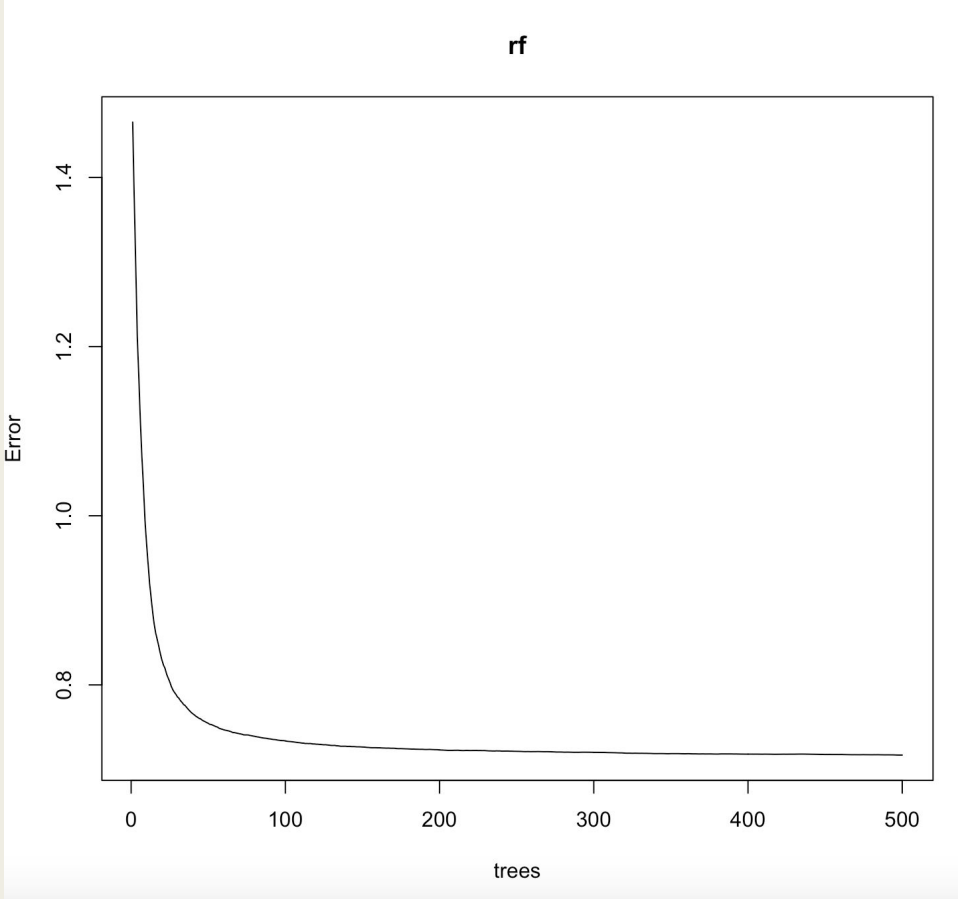
Random Forest -Variable Selection



RF calculated variable importance based on > RSS(residual sum of squares) for regression tree, and

Gini-Index for classification tree.

RandomForest



Improve on rpart with respect to:

- Accuracy: Random Forests test error = 0.7569 smaller than rpart, which is 0.8108
- Stability : If we change the data a little, random forest is relatively stable because it is a combination of many trees.

Gradient Boosting

- Machine learning technique for regression and classification problems
- In the form an ensemble of weak prediction models, typically decision trees
- Optimization of an arbitrary differentiable loss function

n. trees	**interaction.depth**	**shrinkage**	**n.minobsinnode**
150	3	0.1	10

Comparison

Algorithms	**MSE**	**Training Time (Without Cross Validation)**
Linear Regression	0.7841	<1min
Support Vector Machine (Linear)	0.8200	10min
Support Vector Machine (Gaussian)	07856	4min
Random Forest	0.7569	3min
Regression Tree	0.8108	<1min
Gradient Boosting	0.7582	3min