Machine Learning - Assignment 2 (Spotify)

Conor Heffron (23211267)

Load R libraries

```
library(tidyverse)
```

```
-- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
v dplyr     1.1.3     v readr     2.1.4
v forcats   1.0.0     v stringr   1.5.0
v ggplot2   3.4.4     v tibble    3.2.1
v lubridate 1.9.3     v tidyr     1.3.0
v purrr     1.0.2
-- Conflicts ------------------------------------------ tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to becor
```

```
library(dendextend)
```

```
---------------------
Welcome to dendextend version 1.17.1
Type citation('dendextend') for how to cite the package.

Type browseVignettes(package = 'dendextend') for the package vignette.
The github page is: https://github.com/talgalili/dendextend/

Suggestions and bug-reports can be submitted at: https://github.com/talgalili/dendextend/issu
You may ask questions at stackoverflow, use the r and dendextend tags:
     https://stackoverflow.com/questions/tagged/dendextend
```

```
    To suppress this message use:  suppressPackageStartupMessages(library(dendextend))
---------------------


Attaching package: 'dendextend'

The following object is masked from 'package:stats':

    cutree
```

```
library(formatR)
library(knitr)
opts_chunk$set(tidy.opts=list(width.cutoff=60),tidy=TRUE)
```

Load Spotify Data

```
path = "/Users/conorheffron/Library/CloudStorage/GoogleDrive-conor.heffron@ucdconnect.ie/M
spotify_23211267 <- read_csv(paste(path, "spotify_23211267.csv",
    sep = "/"), na = "NA")
```

```
Rows: 21812 Columns: 13
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (1): playlist_genre
dbl (12): danceability, energy, key, loudness, mode, speechiness, acousticne...

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
# View(spotify_23211267)
```

Show Data Dimensions, Structure, Summary

```
dim(spotify_23211267)
```

```
[1] 21812    13
```

```r
str(spotify_23211267)
```

```
spc_tbl_ [21,812 x 13] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
 $ danceability    : num [1:21812] 0.533 0.66 0.812 0.654 0.605 0.762 0.58 0.453 0.625 0.789
 $ energy          : num [1:21812] 0.703 0.947 0.666 0.887 0.903 0.562 0.953 0.906 0.758 0.88
 $ key             : num [1:21812] 2 0 1 1 7 0 5 9 5 11 ...
 $ loudness        : num [1:21812] -6.36 -7.58 -7.1 -2 -4.54 ...
 $ mode            : num [1:21812] 1 1 1 1 1 0 1 1 0 1 ...
 $ speechiness     : num [1:21812] 0.0423 0.0707 0.0485 0.115 0.0637 0.0363 0.0614 0.115 0.04
 $ acousticness    : num [1:21812] 0.184 0.0367 0.000341 0.0588 0.188 0.08 0.00261 0.361 0.51
 $ instrumentalness: num [1:21812] 0 0.0316 0.862 0.000103 0.00814 0 0 0.000569 0.00022 0 ..
 $ liveness        : num [1:21812] 0.101 0.419 0.12 0.0849 0.0989 0.0806 0.218 0.26 0.153 0.3
 $ valence         : num [1:21812] 0.612 0.783 0.178 0.691 0.55 0.683 0.673 0.473 0.695 0.647
 $ tempo           : num [1:21812] 129 123 125 135 120 ...
 $ duration_ms     : num [1:21812] 186093 201110 485760 270222 307653 ...
 $ playlist_genre  : chr [1:21812] "rock" "edm" "edm" "edm" ...
 - attr(*, "spec")=
  .. cols(
  ..   danceability = col_double(),
  ..   energy = col_double(),
  ..   key = col_double(),
  ..   loudness = col_double(),
  ..   mode = col_double(),
  ..   speechiness = col_double(),
  ..   acousticness = col_double(),
  ..   instrumentalness = col_double(),
  ..   liveness = col_double(),
  ..   valence = col_double(),
  ..   tempo = col_double(),
  ..   duration_ms = col_double(),
  ..   playlist_genre = col_character()
  .. )
 - attr(*, "problems")=<externalptr>
```

```r
summary(spotify_23211267)
```

```
 danceability        energy              key            loudness
Min.   :0.0000   Min.   :0.000175   Min.   : 0.000   Min.   :-46.448
1st Qu.:0.5590   1st Qu.:0.613000   1st Qu.: 2.000   1st Qu.: -7.836
Median :0.6670   Median :0.745000   Median : 6.000   Median : -5.895
```

```
 Mean   :0.6514   Mean   :0.720189   Mean   : 5.359   Mean   : -6.489
 3rd Qu.:0.7580   3rd Qu.:0.856000   3rd Qu.: 8.000   3rd Qu.: -4.473
 Max.   :0.9830   Max.   :1.000000   Max.   :11.000   Max.   :  1.275
      mode          speechiness      acousticness    instrumentalness
 Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.000000
 1st Qu.:0.0000   1st Qu.:0.0408   1st Qu.:0.0116   1st Qu.:0.000000
 Median :1.0000   Median :0.0614   Median :0.0670   Median :0.000022
 Mean   :0.5788   Mean   :0.1048   Mean   :0.1582   Mean   :0.096463
 3rd Qu.:1.0000   3rd Qu.:0.1270   3rd Qu.:0.2230   3rd Qu.:0.007622
 Max.   :1.0000   Max.   :0.8770   Max.   :0.9940   Max.   :0.994000
    liveness         valence          tempo         duration_ms
 Min.   :0.0000   Min.   :0.0000   Min.   :  0.0   Min.   :  4000
 1st Qu.:0.0931   1st Qu.:0.3240   1st Qu.:101.0   1st Qu.:186619
 Median :0.1300   Median :0.5060   Median :124.0   Median :213507
 Mean   :0.1943   Mean   :0.5055   Mean   :122.2   Mean   :223585
 3rd Qu.:0.2560   3rd Qu.:0.6890   3rd Qu.:134.5   3rd Qu.:249590
 Max.   :0.9960   Max.   :0.9910   Max.   :220.3   Max.   :517810
 playlist_genre
 Length:21812
 Class :character
 Mode  :character
```

Hiearchial Cluster via Euclidean Distance of Spotify Data

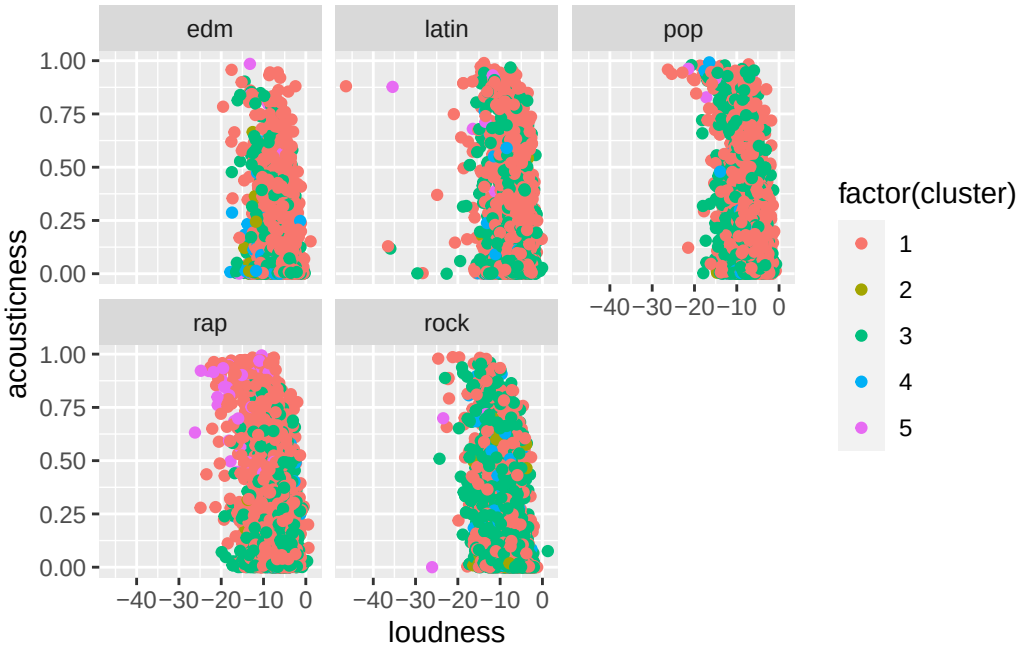
```
hc_spotify <- hclust(dist(spotify_23211267, method = "euclidean"),
    method = "complete")
```

```
Warning in dist(spotify_23211267, method = "euclidean"): NAs introduced by
coercion
```

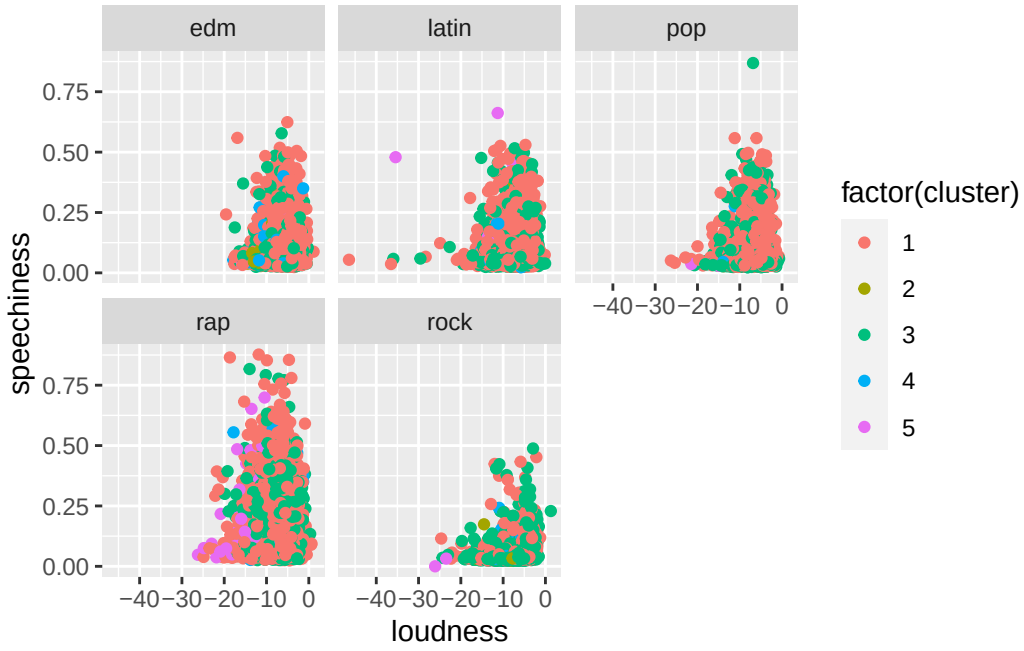
Segment Spotify Data into 5 clusters / groups

```
grp5 <- cutree(hc_spotify, k = 5)
segmented_spotify <- mutate(spotify_23211267, cluster = grp5)

# Plots
```

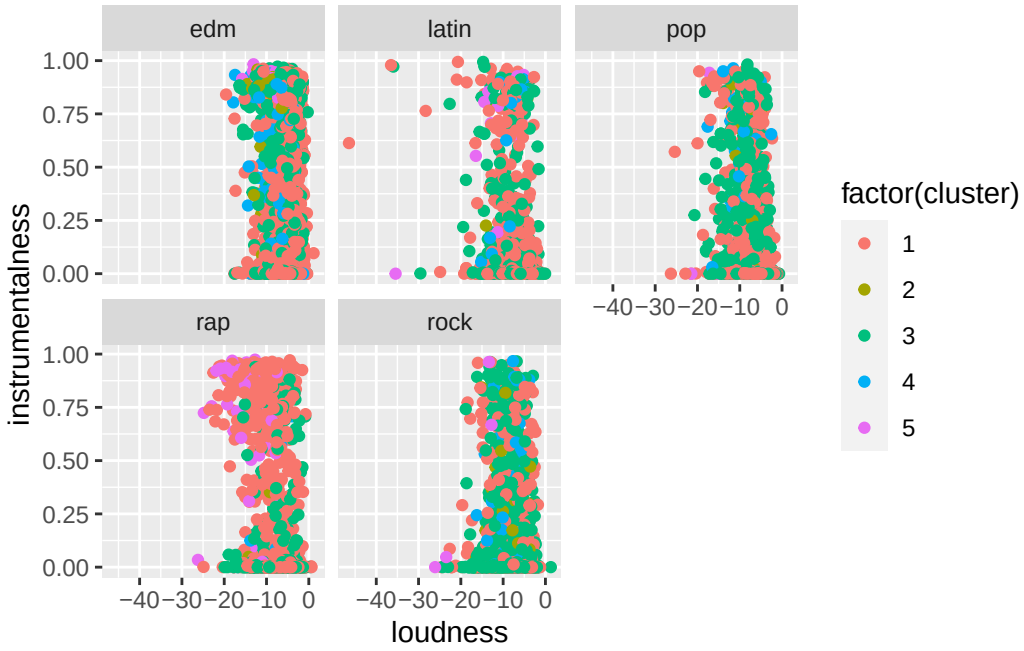
```
ggplot(segmented_spotify, aes(x = loudness, y = acousticness,
    color = factor(cluster))) + geom_point() + facet_wrap(~playlist_genre)
```



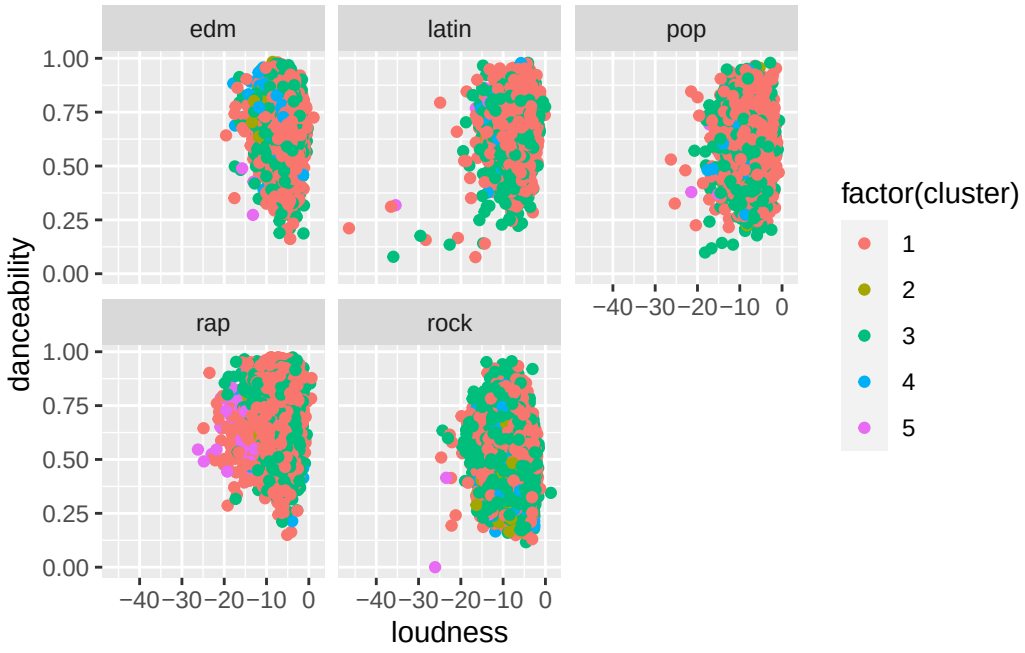

```
ggplot(segmented_spotify, aes(x = loudness, y = speechiness,
    color = factor(cluster))) + geom_point() + facet_wrap(~playlist_genre)
```



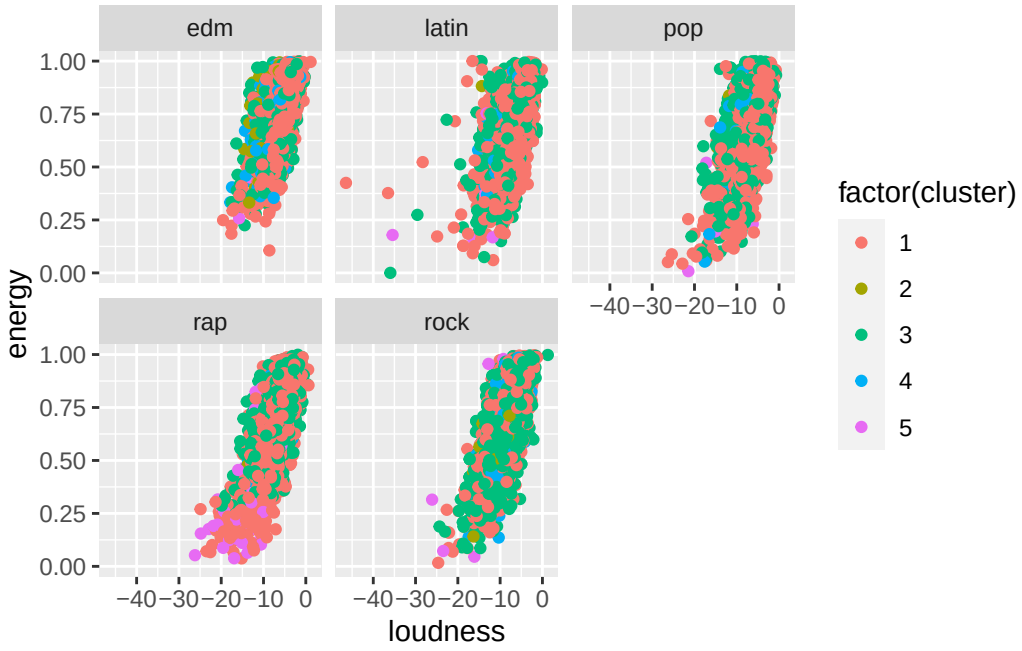

```
ggplot(segmented_spotify, aes(x = loudness, y = instrumentalness,
    color = factor(cluster))) + geom_point() + facet_wrap(~playlist_genre)
```



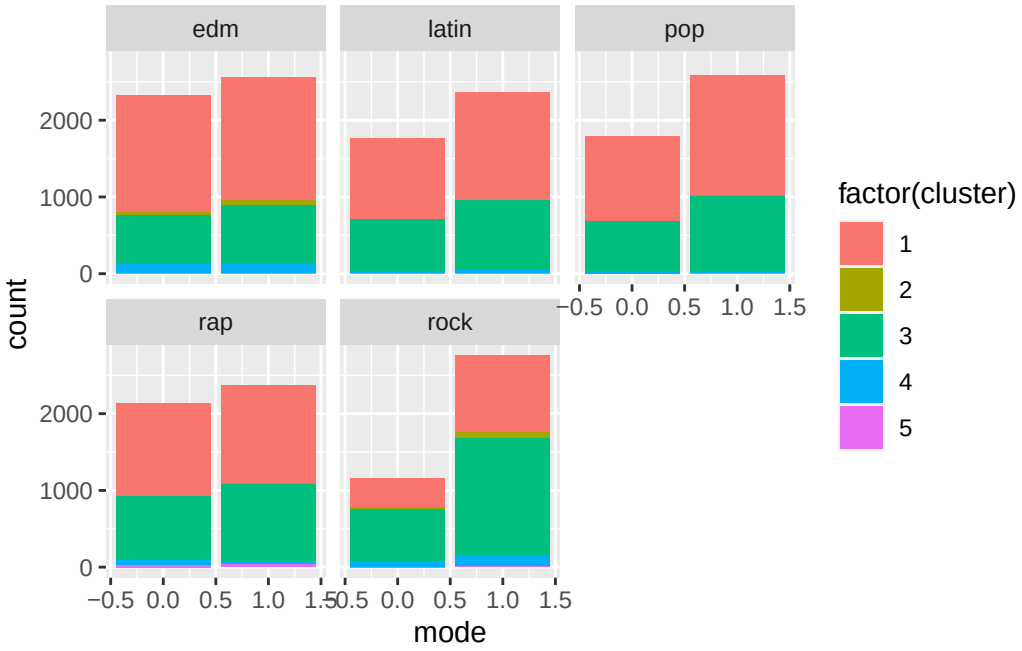
```
ggplot(segmented_spotify, aes(x = loudness, y = danceability,
    color = factor(cluster))) + geom_point() + facet_wrap(~playlist_genre)
```



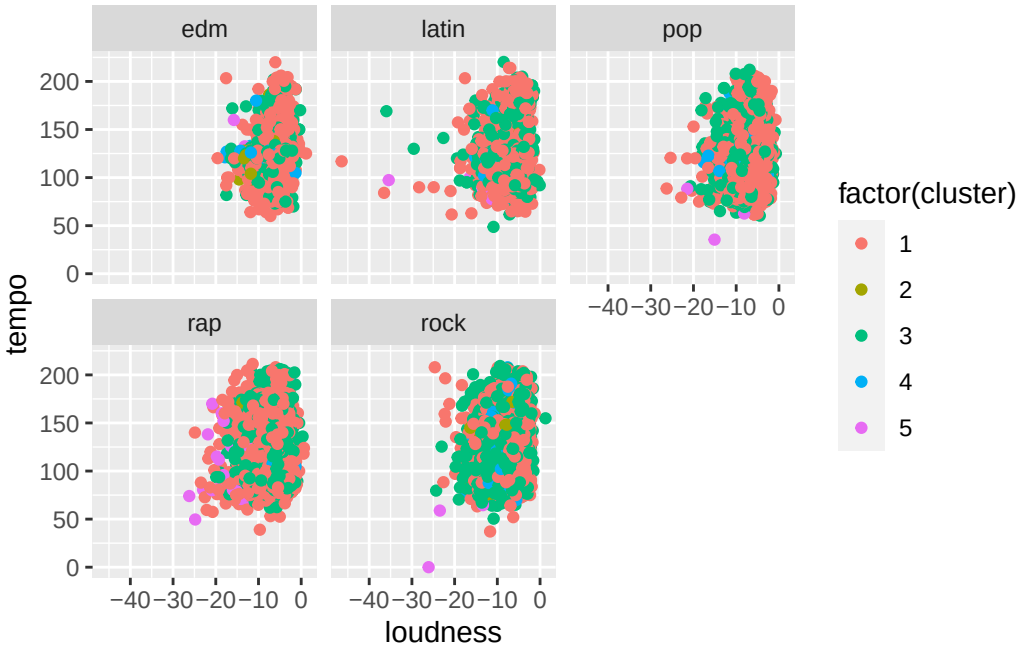

```
ggplot(segmented_spotify, aes(x = loudness, y = energy, color = factor(cluster))) +
    geom_point() + facet_wrap(~playlist_genre)
```




```
ggplot(segmented_spotify, aes(mode, fill = factor(cluster))) +
    geom_bar() + facet_wrap(~playlist_genre)
```



```
ggplot(segmented_spotify, aes(x = loudness, y = tempo, color = factor(cluster))) +
    geom_point() + facet_wrap(~playlist_genre)
```




```
avg_dend_obj <- as.dendrogram(hc_spotify)
avg_col_dend <- color_branches(avg_dend_obj, h = 16000)

# Create PDF for plotting
pdf("plots/plots_avg_col_dendrogram.pdf", width = 40, height = 15)

# Plotting
plot(avg_col_dend)
plot(cut(avg_col_dend, h = 16000)$upper, main = "Upper tree of cut at h=16000")
plot(cut(avg_col_dend, h = 16000)$lower[[2]], main = "Second branch of lower tree with cut

# Close the PDF file's associated graphics device
dev.off()
```

```
pdf
  2
```

```
path_weka <- "/Users/conorheffron/Library/CloudStorage/GoogleDrive-conor.heffron@ucdconnec
weka_acc <- read_csv(paste(path_weka, "weka_acc.csv", sep = "/"))
```

```
Rows: 76 Columns: 5
-- Column specification --------------------------------------------------------
Delimiter: ","
chr (2): Accuracy, Type
dbl (3): n, %, Bag

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

Get Data Dimensions & Summary, Print Data Frame

```
dim(weka_acc)
```

```
[1] 76  5
```

```
summary(weka_acc)
```

```
   Accuracy                n                %             Type          
 Length:76          Min.   : 8815   Min.   :40.41   Length:76         
 Class :character   1st Qu.: 9730   1st Qu.:44.61   Class :character  
 Mode  :character   Median :10906   Median :50.00   Mode  :character  
                    Mean   :10906   Mean   :50.00                     
                    3rd Qu.:12082   3rd Qu.:55.39                     
                    Max.   :12997   Max.   :59.59                     
      Bag        
 Min.   : 0.000  
 1st Qu.: 2.000  
 Median : 8.000  
 Mean   : 8.684  
 3rd Qu.:14.000  
 Max.   :20.000  
```

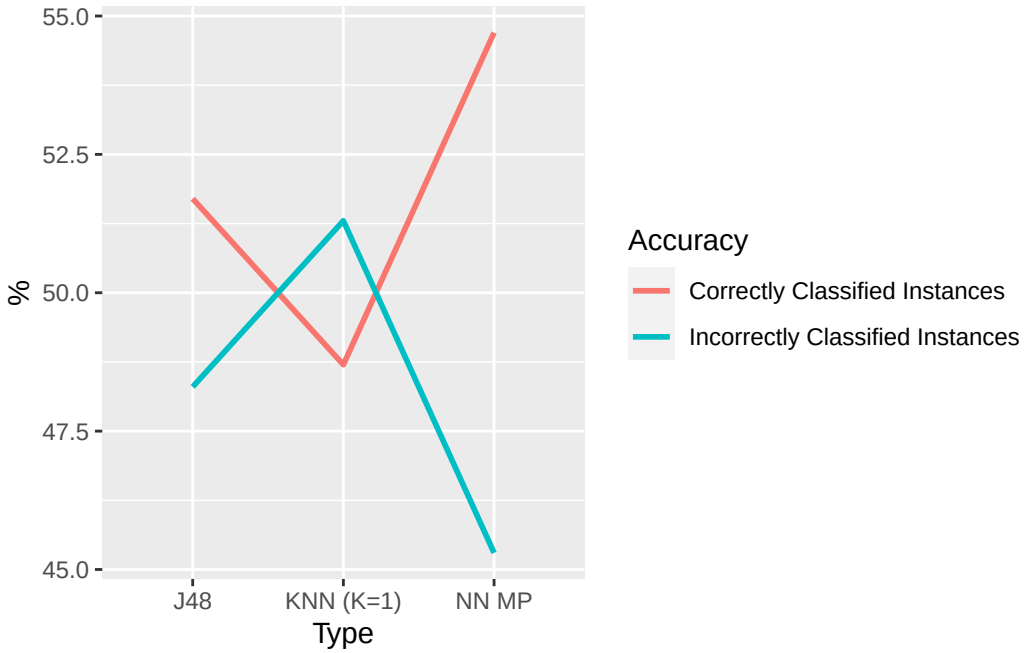
```
weka_acc
```

```
# A tibble: 76 x 5
   Accuracy                              n   `%` Type              Bag
   <chr>                             <dbl> <dbl> <chr>           <dbl>
 1 Correctly Classified Instances    12102  55.5 Vote(AVG)           0
 2 Incorrectly Classified Instances   9710  44.5 Vote(AVG)           0
 3 Correctly Classified Instances    12248  56.2 Vote(Majority)      0
 4 Incorrectly Classified Instances   9564  43.8 Vote(Majority)      0
 5 Correctly Classified Instances    10700  49.1 Vote(MAX)           0
 6 Incorrectly Classified Instances 11112  50.9 Vote(MAX)           0
 7 Correctly Classified Instances    10509  48.2 Vote(MIN)           0
 8 Incorrectly Classified Instances 11303  51.8 Vote(MIN)           0
 9 Correctly Classified Instances    10938  50.2 Vote(PRODUCT)       0
10 Incorrectly Classified Instances 10874  49.8 Vote(PRODUCT)       0
# i 66 more rows
```

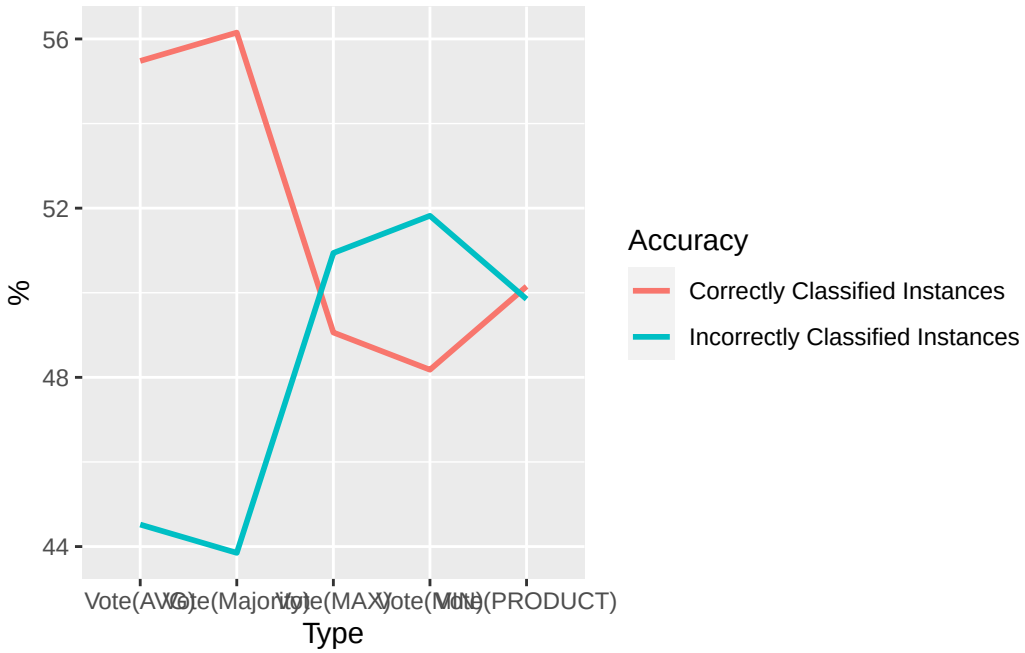
Plot for voting with 3x Combination Rules(KNN K=1, Multilayer Perceptron Neural Network (MP NN), JV8 (Decision Tree))

```
ggplot(weka_acc %>%
    filter(substr(Type, 1, 4) != "Vote" & Bag == 0), aes(x = Type,
    y = `%`, color = Accuracy, group = Accuracy)) + geom_line(size = 1)
```

```
Warning: Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
i Please use `linewidth` instead.
```

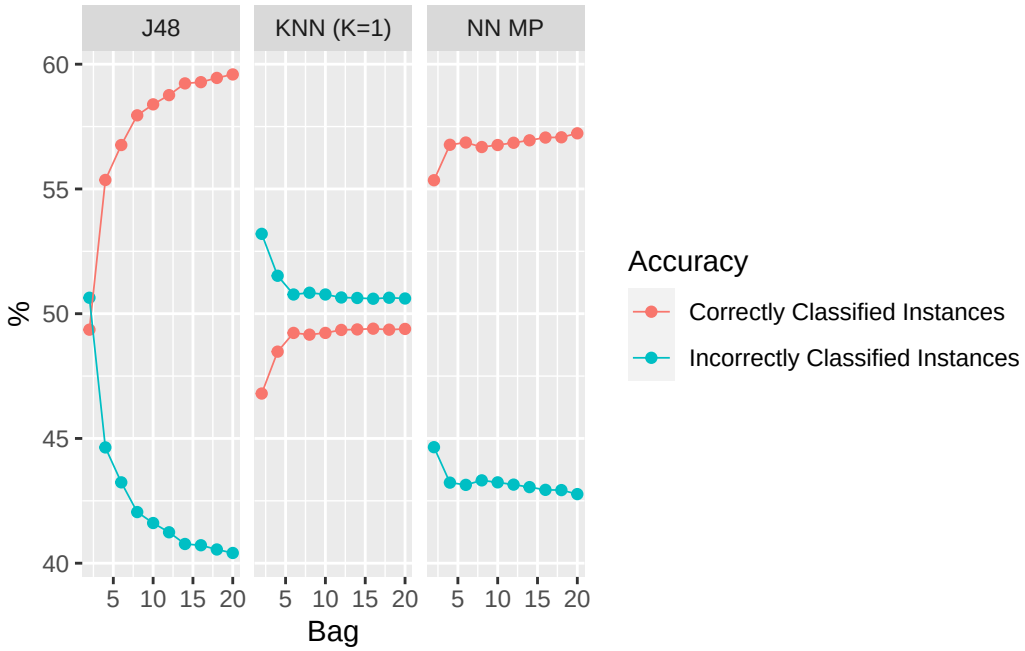



```
ggplot(weka_acc %>%
    filter(substr(Type, 1, 4) == "Vote" & Bag == 0), aes(x = Type,
    y = `%`, color = Accuracy, group = Accuracy)) + geom_line(size = 1)
```



Plot Ensembles by Bagging (Bag == 2->20 in increments of 2)

```
ggplot(weka_acc %>%
    filter(Bag != 0), aes(y = `%`, x = Bag, color = Accuracy,
    group = Accuracy)) + geom_point() + geom_line(size = 0.31) +
    facet_wrap(~Type)
```



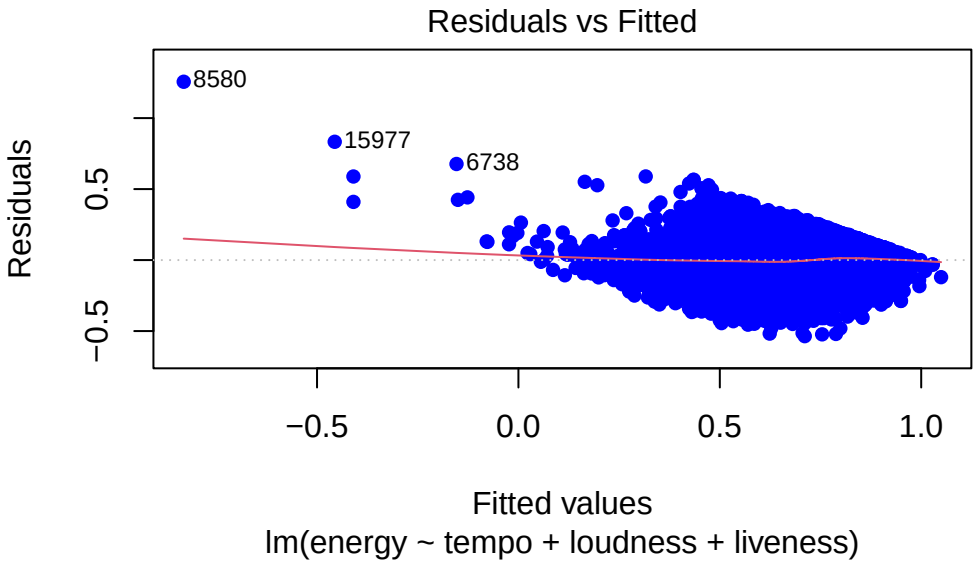
Build Linear Regression Model (predict energy based on tempo, loudness, liveness)

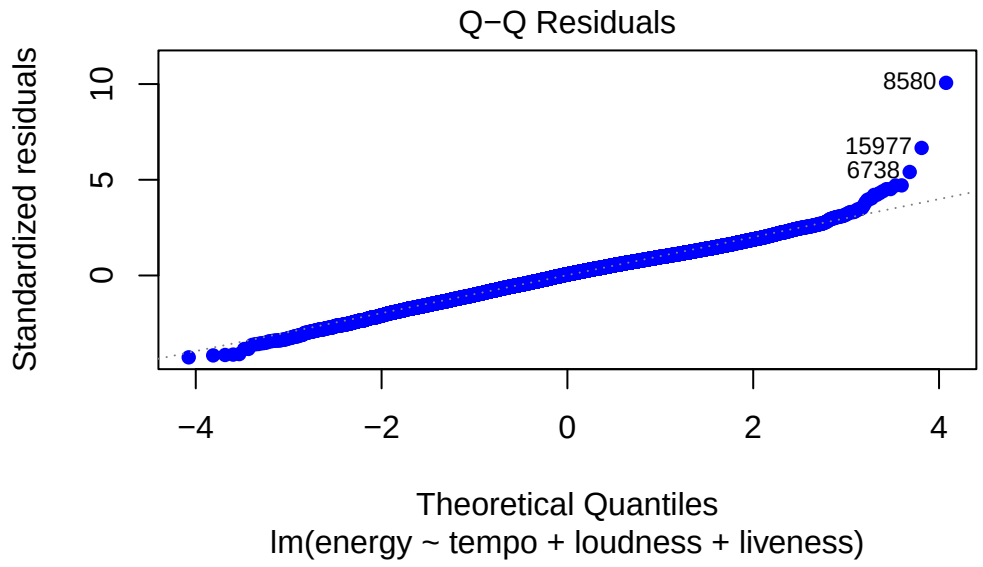
```
# library()
lm_energy1 <- lm(formula = energy ~ tempo + loudness + liveness,
    data = spotify_23211267)
summary(lm_energy1)
```

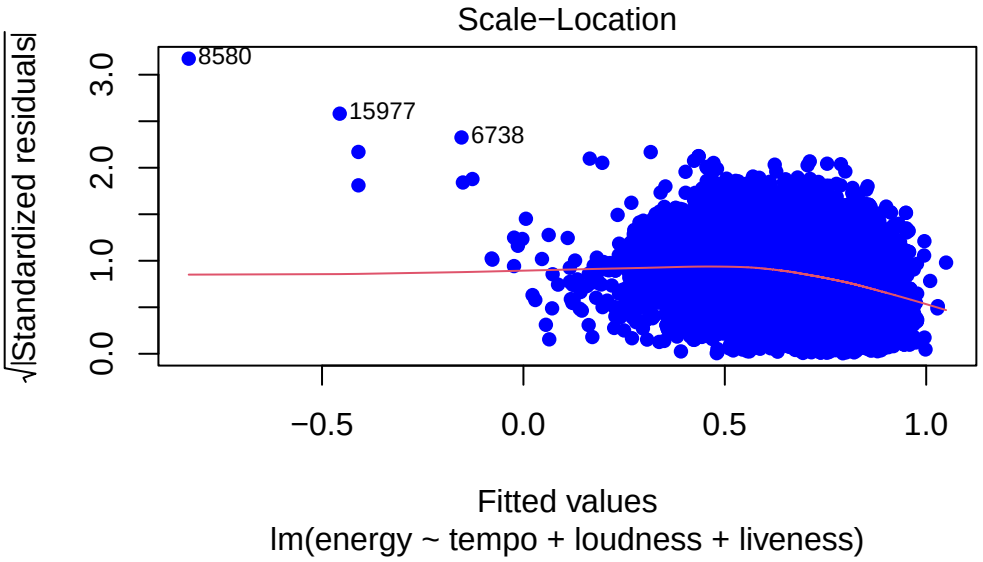
```
Call:
lm(formula = energy ~ tempo + loudness + liveness, data = spotify_23211267)

Residuals:
     Min       1Q   Median       3Q      Max
-0.53589 -0.08146  0.00745  0.08633  1.25599

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 8.834e-01  4.736e-03  186.54   <2e-16 ***
tempo       5.312e-04  3.237e-05   16.41   <2e-16 ***
loudness    3.872e-02  2.877e-04  134.57   <2e-16 ***
```

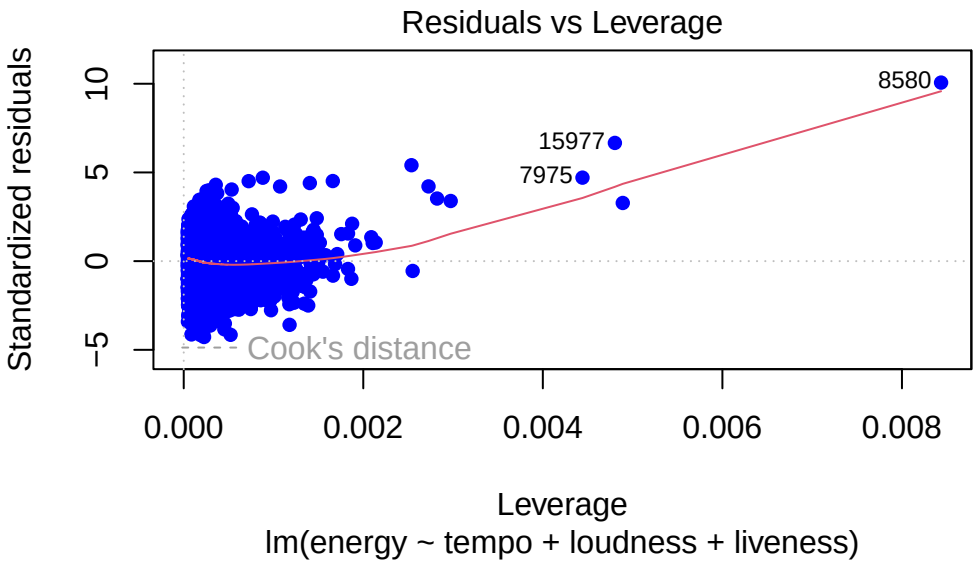
```
liveness    1.189e-01  5.382e-03   22.09   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1253 on 21808 degrees of freedom
Multiple R-squared:  0.4783,    Adjusted R-squared:  0.4782
F-statistic:  6665 on 3 and 21808 DF,  p-value: < 2.2e-16
```

```r
plot(lm_energy1, pch = 16, col = "blue")  #Plot the results
```




Q−Q Residuals
Standardized residuals
8580
15977
6738
0
5
10
−4
−2
0
2
4
Theoretical Quantiles
lm(energy ~ tempo + loudness + liveness)


Scale−Location
√|Standardized residuals|
8580
15977
6738
0.0
1.0
2.0
3.0
−0.5
0.0
0.5
1.0
Fitted values
lm(energy ~ tempo + loudness + liveness)




```
# abline(lm_energy1) #Add a regression line
confint(lm_energy1)
```

```
                  2.5 %       97.5 %
(Intercept) 0.8740980328 0.8926619375
tempo       0.0004677832 0.0005946626
loudness    0.0381533842 0.0392812685
liveness    0.1083588727 0.1294589853
```

```
sigma(lm_energy1)/mean(spotify_23211267$energy)
```

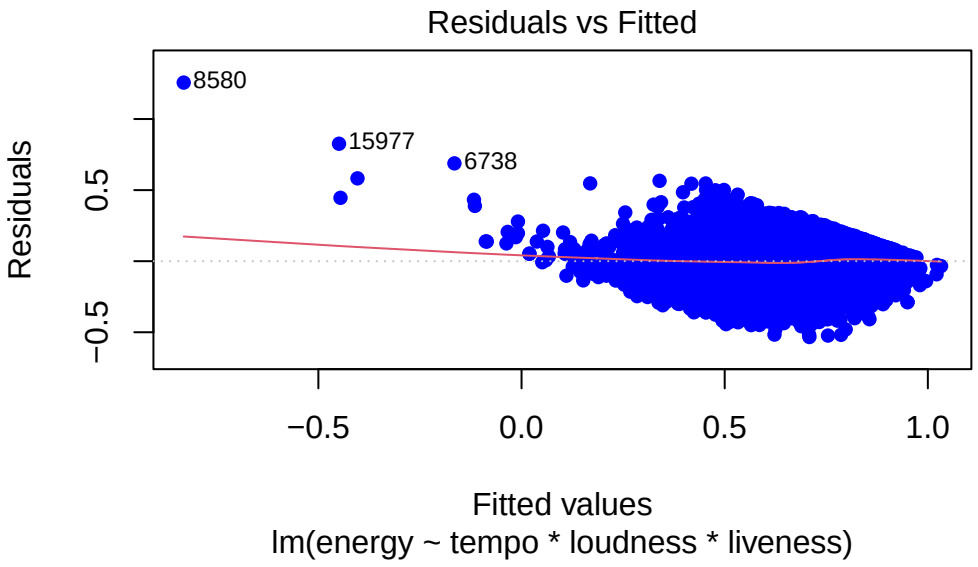
```
[1] 0.1740097
```

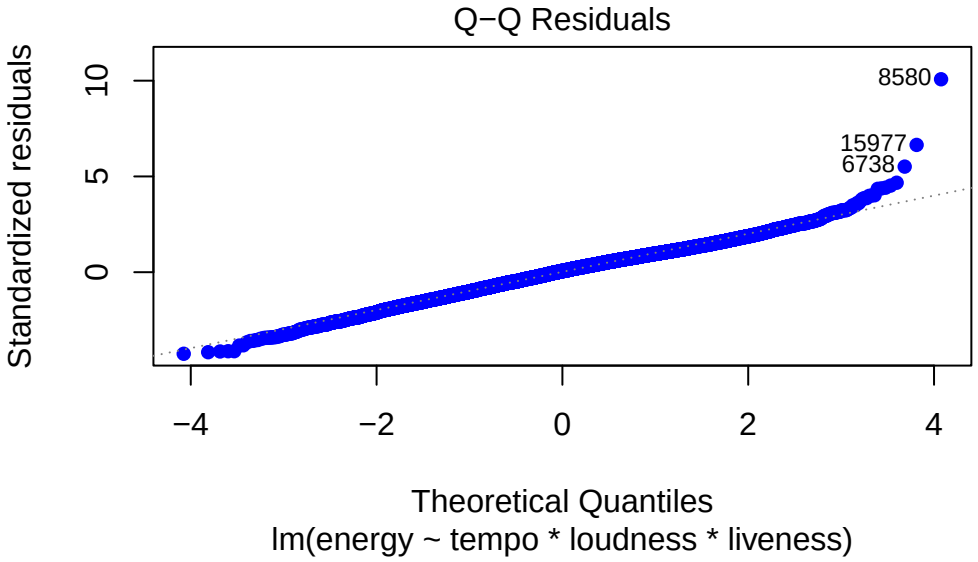
```
lm_energy2 <- lm(formula = energy ~ tempo * loudness * liveness,
    data = spotify_23211267)
summary(lm_energy2)
```

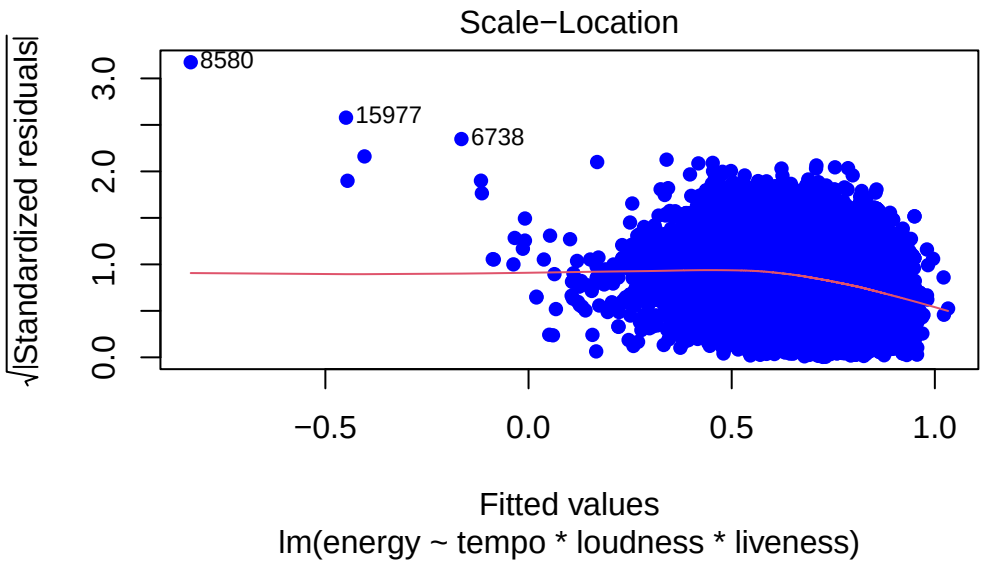
```
Call:
```

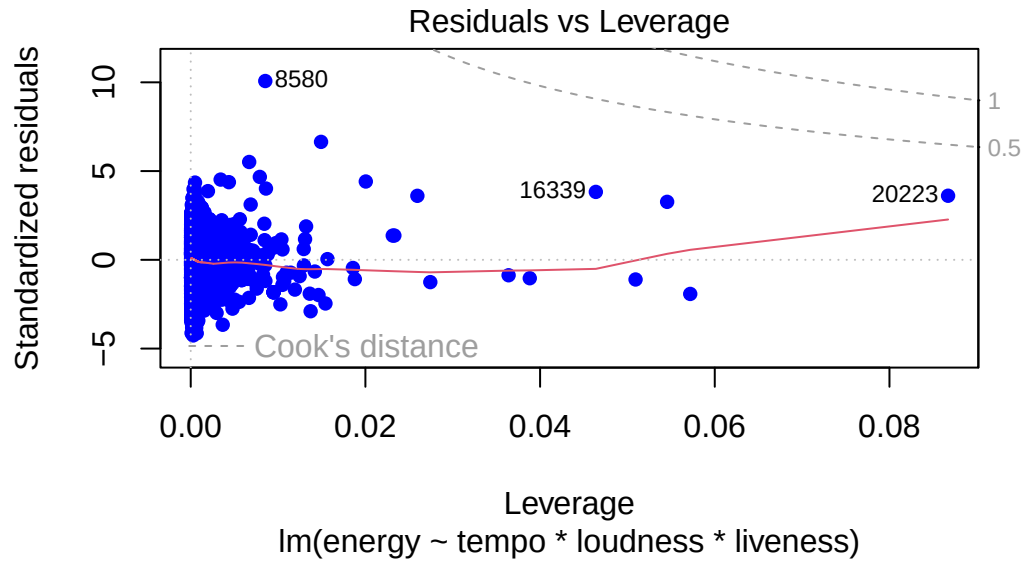
```
lm(formula = energy ~ tempo * loudness * liveness, data = spotify_23211267)

Residuals:
     Min       1Q   Median       3Q      Max
-0.53345 -0.08189  0.00758  0.08630  1.25639

Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)              8.951e-01  1.471e-02  60.860  < 2e-16 ***
tempo                    5.155e-04  1.172e-04   4.398  1.1e-05 ***
loudness                 3.880e-02  1.900e-03  20.417  < 2e-16 ***
liveness                 6.637e-02  6.134e-02   1.082    0.279
tempo:loudness           1.174e-05  1.536e-05   0.764    0.445
tempo:liveness           7.524e-06  4.833e-04   0.016    0.988
loudness:liveness        9.176e-04  8.187e-03   0.112    0.911
tempo:loudness:liveness -7.468e-05  6.525e-05  -1.145    0.252
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1253 on 21804 degrees of freedom
Multiple R-squared:  0.4789,    Adjusted R-squared:  0.4788
F-statistic:  2863 on 7 and 21804 DF,  p-value: < 2.2e-16
```

```r
plot(lm_energy2, pch = 16, col = "blue")  #Plot the results
```


Residuals vs Fitted
8580
15977
6738
Residuals
0.5
−0.5
−0.5
0.0
0.5
1.0
Fitted values
lm(energy ~ tempo * loudness * liveness)


Q−Q Residuals
8580
15977
6738
Standardized residuals
10
5
0
−4
−2
0
2
4
Theoretical Quantiles
lm(energy ~ tempo * loudness * liveness)


Scale−Location
√|Standardized residuals|
8580
15977
6738
0.0
1.0
2.0
3.0
−0.5
0.0
0.5
1.0
Fitted values
lm(energy ~ tempo * loudness * liveness)


Residuals vs Leverage
Standardized residuals
8580
16339
20223
1
0.5
Cook's distance
−5
0
5
10
0.00
0.02
0.04
0.06
0.08
Leverage
lm(energy ~ tempo * loudness * liveness)

```r
# abline(lm_energy2) #Add a regression line
confint(lm_energy2)
```

```
                                2.5 %       97.5 %
(Intercept)              8.662634e-01 9.239187e-01
tempo                    2.857892e-04 7.452546e-04
loudness                 3.507485e-02 4.252441e-02
liveness                -5.385881e-02 1.865952e-01
tempo:loudness          -1.836545e-05 4.183462e-05
tempo:liveness          -9.398294e-04 9.548769e-04
loudness:liveness       -1.513028e-02 1.696558e-02
tempo:loudness:liveness -2.025769e-04 5.321100e-05
```

```r
# Lower value here so is the more accurate model
sigma(lm_energy2)/mean(spotify_23211267$energy)
```

```
[1] 0.1739241
```