IST687 - Music Classification Project

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Executive Summary

The purpose of this project is to analyze the Million Song Database to predict "Hot" artists and songs based on the attributes such as familiarity, artist location, loudness, terms used, etc. The analysis was done using R software on a 10,000 track subset of the data and our model was able to predict "Hot" songs with ~80% accuracy.

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Introduction

Related Work

Thierry Bertin-Mahieux, Daniel P.W. Ellis, Brian Whitman, and Paul Lamere. The Million Song Dataset. In Proceedings of the 12th International Society for Music Information Retrieval Conference (ISMIR 2011), 2011.

Dataset

```
#New code from Courtney to change from 3 to 5 categories of artist hotness
#music <- read.csv("~/Intro data science/Music project/newmusic.csv")
music <- read.csv("/Users/johnfields/Library/Mobile Documents/com~apple~CloudDocs/Syracuse/IST687/Proje
str(music)
```

```
## 'data.frame':    10000 obs. of  35 variables:
##  $ artist.hotttnesss        : num  0.402 0.417 0.343 0.454 0.402 ...
##  $ artist.id                : Factor w/ 3888 levels "AR009211187B989185",..: 1269 2354 2168 715 3609
##  $ artist.name              : Factor w/ 4412 levels ":Blacks On :Blondes",..: 682 3798 3562 67 1569 
##  $ artist_mbtags            : Factor w/ 277 levels "","0.333","60s",..: 1 52 1 262 1 1 1 1 1 1 ...
##  $ artist_mbtags_count      : num  0 1 0 1 0 0 0 0 0 0 ...
##  $ bars_confidence          : num  0.643 0.007 0.98 0.017 0.175 0.121 0.709 0.142 0.806 0.047 ...
##  $ bars_start               : num  0.585 0.711 0.732 1.306 1.064 ...
##  $ beats_confidence         : num  0.834 1 0.98 0.809 0.883 0.438 0.709 0.234 0.44 1 ...
##  $ beats_start              : num  0.585 0.206 0.732 0.81 0.136 ...
##  $ duration                 : num  219 148 177 233 210 ...
##  $ end_of_fade_in           : num  0.247 0.148 0.282 0 0.066 ...
##  $ familiarity              : num  0.582 0.631 0.487 0.63 0.651 ...
##  $ key                      : num  1 6 8 0 2 5 1 4 4 7 ...
##  $ key_confidence           : num  0.736 0.169 0.643 0.751 0.092 0.635 0 0 0.717 0.053 ...
##  $ latitude                 : num  37.2 35.1 37.2 37.2 37.2 ...
##  $ location                 : Factor w/ 1046 levels " "," NC"," UbA!, Minas Gerais",..: 157 584 705 5
##  $ longitude                : num  -63.9 -90 -63.9 -63.9 -63.9 ...
```

```
##  $ loudness                 : num  -11.2 -9.84 -9.69 -9.01 -4.5 ...
##  $ mode                     : int  0 0 1 1 1 1 0 1 0 ...
##  $ mode_confidence          : num  0.636 0.43 0.565 0.749 0.371 0.557 0 0.16 0.652 0.473 ...
##  $ release.id               : int  300848 300822 514953 287650 611336 41838 25824 8876 358182 692313
##  $ release.name             : Factor w/ 7833 levels " Lazy Afternoon En Anglais",..: 2192 1746 3536 1
##  $ similar                  : Factor w/ 2839 levels "AR0OK8N11C8A41687B",..: 2410 2227 1145 304 2333
##  $ song.hotttnesss          : num  0.602 NA NA NA 0.605 ...
##  $ song.id                  : Factor w/ 10000 levels " Polovtsian Dances / Rimsky-Korsakov: Russian I
##  $ start_of_fade_out        : num  219 138 172 217 199 ...
##  $ tatums_confidence        : num  0.779 0.969 0.482 0.601 1 0.136 0.467 0.292 0.121 1 ...
##  $ tatums_start             : num  0.285 0.206 0.421 0.563 0.136 ...
##  $ tempo                    : num  92.2 121.3 100.1 119.3 129.7 ...
##  $ terms                    : Factor w/ 459 levels "","8-bit","acid jazz",..: 216 34 372 327 325 396
##  $ terms_freq               : num  1 1 1 0.989 0.887 ...
##  $ time_signature           : num  4 4 1 4 4 3 1 3 4 4 ...
##  $ time_signature_confidence: num  0.778 0.384 0 0 0.562 0.454 0 0.408 0.487 0.878 ...
##  $ title                    : Factor w/ 9709 levels "","," -start ID-",..: 3574 7529 482 7477 2532 8285
##  $ year                     : int  0 1969 0 1982 2007 0 0 0 1984 0 ...
```

```
colnames(music)[1] <- "artist.hotttnesss"

#Plot of the variables
library(ggplot2)
```

```
## Registered S3 methods overwritten by 'ggplot2':
##   method         from
##   [.quosures     rlang
##   c.quosures     rlang
##   print.quosures rlang
```

```
library(reshape2)

#understand the structure of the data
#install.packages("psych")
library(psych)
```

```
##
## Attaching package: 'psych'
```

```
## The following objects are masked from 'package:ggplot2':
##
##     %+%, alpha
```

```
describeBy(music,)
```

```
## Warning in describeBy(music, ): no grouping variable requested
```

```
##                           vars     n      mean        sd    median
## artist.hotttnesss            1 10000      0.39      0.14      0.38
## artist.id*                   2 10000   1907.24   1123.21   1882.00
## artist.name*                 3 10000   2206.28   1270.75   2195.00
## artist_mbtags*               4 10000     50.04     79.26      1.00
## artist_mbtags_count          5 10000      0.52      0.88      0.00
## bars_confidence              6 10000      0.24      0.29      0.12
## bars_start                   7 10000      1.07      1.72      0.79
## beats_confidence             8 10000      0.61      0.32      0.69
## beats_start                  9 10000      0.43      0.81      0.33
```

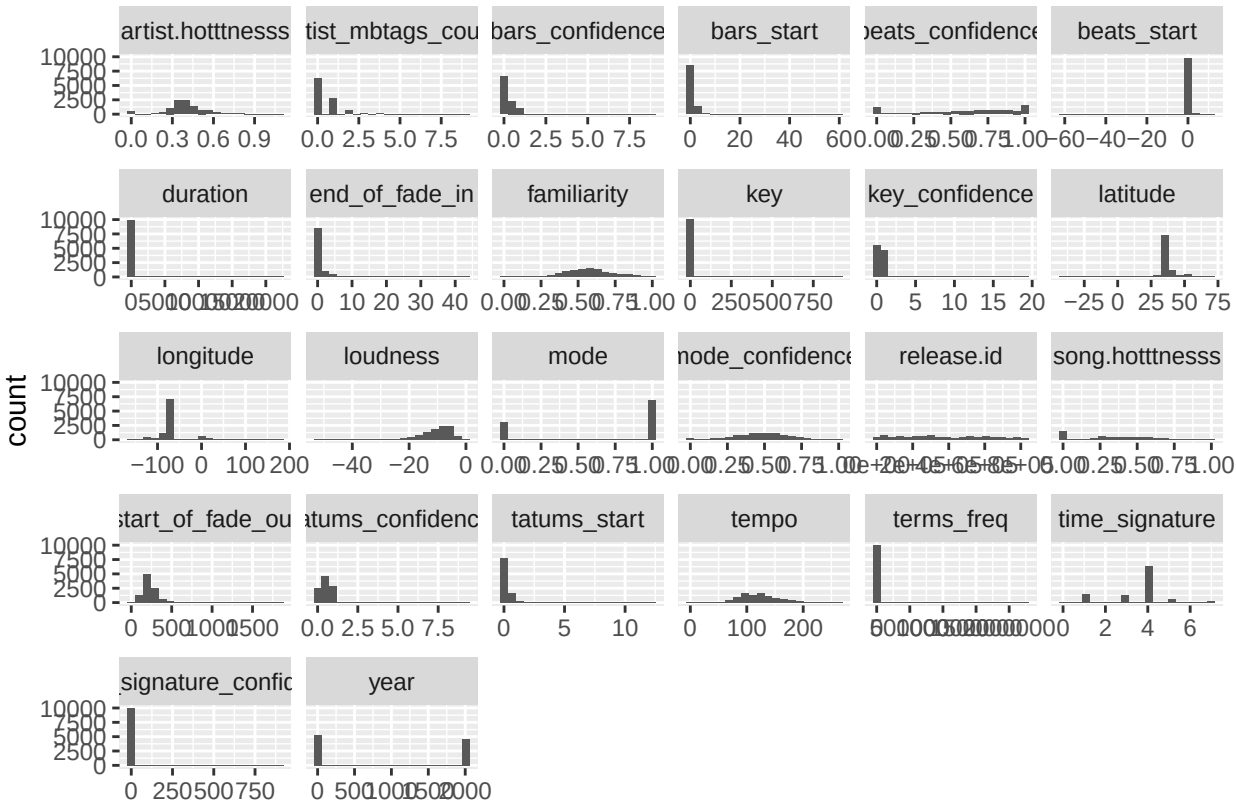
```
## duration                    10 10000    240.62    246.08    223.06
## end_of_fade_in              11 10000      0.76      1.86      0.20
## familiarity                 12  9996      0.57      0.16      0.56
## key                         13 10000      5.37      9.67      5.00
## key_confidence              14 10000      0.45      0.33      0.47
## latitude                    15 10000     37.16      9.54     37.16
## location*                   16 10000    596.95    238.92    705.00
## longitude                   17 10000    -63.93     30.89    -63.93
## loudness                    18 10000    -10.48      5.40     -9.38
## mode                        19 10000      0.69      0.46      1.00
## mode_confidence             20 10000      0.48      0.19      0.49
## release.id                  21 10000 371024.06 236777.83 333103.00
## release.name*               22 10000   3923.10   2258.13   3904.00
## similar*                    23 10000   1417.80    823.19   1402.00
## song.hotttnesss             24  5649      0.34      0.25      0.36
## song.id*                    25 10000   5000.50   2886.90   5000.50
## start_of_fade_out           26 10000    229.88    112.02    213.86
## tatums_confidence           27 10000      0.51      0.33      0.50
## tatums_start                28 10000      0.30      0.51      0.19
## tempo                       29 10000    122.90     35.20    120.16
## terms*                      30 10000    215.30    129.17    214.00
## terms_freq                  31 10000    224.89  22392.16      1.00
## time_signature              32 10000      3.56      1.27      4.00
## time_signature_confidence   33 10000      0.60      8.99      0.55
## title*                      34 10000   4865.28   2800.26   4861.50
## year                        35 10000    934.70    996.65      0.00
##                            trimmed       mad     min        max
## artist.hotttnesss             0.39      0.09    0.00       1.08
## artist.id*                 1901.94   1430.71    1.00    3888.00
## artist.name*               2207.83   1624.93    1.00    4412.00
## artist_mbtags*               33.35      0.00    1.00     277.00
## artist_mbtags_count           0.34      0.00    0.00       9.00
## bars_confidence               0.19      0.15    0.00       8.86
## bars_start                    0.84      0.57    0.00      59.74
## beats_confidence              0.64      0.33    0.00       1.00
## beats_start                   0.35      0.22  -60.00      12.25
## duration                    226.86     73.78    1.04   22050.00
## end_of_fade_in                0.33      0.30    0.00      43.12
## familiarity                   0.57      0.15    0.00       1.00
## key                           5.25      4.45    0.00     904.80
## key_confidence                0.45      0.31    0.00      19.08
## latitude                     37.45      0.00  -41.28      69.65
## location*                   616.33     65.23    1.00    1046.00
## longitude                   -67.56      0.00 -162.44     174.77
## loudness                     -9.84      4.75  -51.64       0.57
## mode                          0.74      0.00    0.00       1.00
## mode_confidence               0.48      0.18    0.00       1.00
## release.id               364712.83 294890.62    0.00  823599.00
## release.name*              3925.50   2900.71    1.00    7833.00
## similar*                   1419.58   1077.85    1.00    2839.00
## song.hotttnesss               0.34      0.27    0.00       1.00
## song.id*                   5000.50   3706.50    1.00   10000.00
## start_of_fade_out           218.24     71.46  -21.39    1813.43
## tatums_confidence             0.51      0.40    0.00       9.23
```

```
## tatums_start                   0.21      0.13    0.00      12.25
## tempo                        121.10     34.88    0.00     262.83
## terms*                       212.06    169.02    1.00     459.00
## terms_freq                     0.98      0.00    0.00 2239217.00
## time_signature                 3.65      0.00    0.00       7.00
## time_signature_confidence      0.51      0.53    0.00     898.89
## title*                      4866.67   3587.89    1.00    9709.00
## year                         917.41      0.00    0.00    2010.00
##                                range   skew kurtosis       se
## artist.hotttnesss               1.08  -0.15     2.51    0.00
## artist.id*                   3887.00   0.03    -1.20   11.23
## artist.name*                 4411.00  -0.01    -1.19   12.71
## artist_mbtags*                276.00   1.43     0.65    0.79
## artist_mbtags_count             9.00   2.78    11.94    0.01
## bars_confidence                 8.86   3.83    79.88    0.00
## bars_start                     59.74  13.28   280.06    0.02
## beats_confidence                1.00  -0.64    -0.74    0.00
## beats_start                    72.25 -39.88  3173.40    0.01
## duration                    22048.96  69.94  6167.73    2.46
## end_of_fade_in                 43.12   7.30    97.49    0.02
## familiarity                     1.00  -0.26     0.64    0.00
## key                           904.80  80.42  7476.22    0.10
## key_confidence                 19.08  17.61   987.67    0.00
## latitude                      110.93  -4.16    29.65    0.10
## location*                    1045.00  -0.84    -0.06    2.39
## longitude                     337.20   2.38    11.89    0.31
## loudness                       52.21  -1.36     2.86    0.05
## mode                            1.00  -0.83    -1.32    0.00
## mode_confidence                 1.00  -0.27     0.09    0.00
## release.id                 823599.00   0.18    -1.15 2367.78
## release.name*                7832.00   0.00    -1.20   22.58
## similar*                     2838.00   0.00    -1.20    8.23
## song.hotttnesss                 1.00  -0.03    -1.04    0.00
## song.id*                     9999.00   0.00    -1.20   28.87
## start_of_fade_out            1834.82   3.47    28.75    1.12
## tatums_confidence               9.23   1.84    45.95    0.00
## tatums_start                   12.25   8.76   122.97    0.01
## tempo                         262.83   0.41     0.48    0.35
## terms*                        458.00   0.15    -1.20    1.29
## terms_freq                2239217.00  99.97  9993.00  223.92
## time_signature                  7.00  -0.59     1.17    0.01
## time_signature_confidence     898.89  99.71  9958.55    0.09
## title*                       9708.00   0.00    -1.20   28.00
## year                         2010.00   0.13    -1.98    9.97
```

```
ggplot(data = melt(music), mapping = aes(x = value)) + geom_histogram(bins = 20) + facet_wrap(~variable
```

```
## Using artist.id, artist.name, artist_mbtags, location, release.name, similar, song.id, terms, title a
```

```
## Warning: Removed 4355 rows containing non-finite values (stat_bin).
```



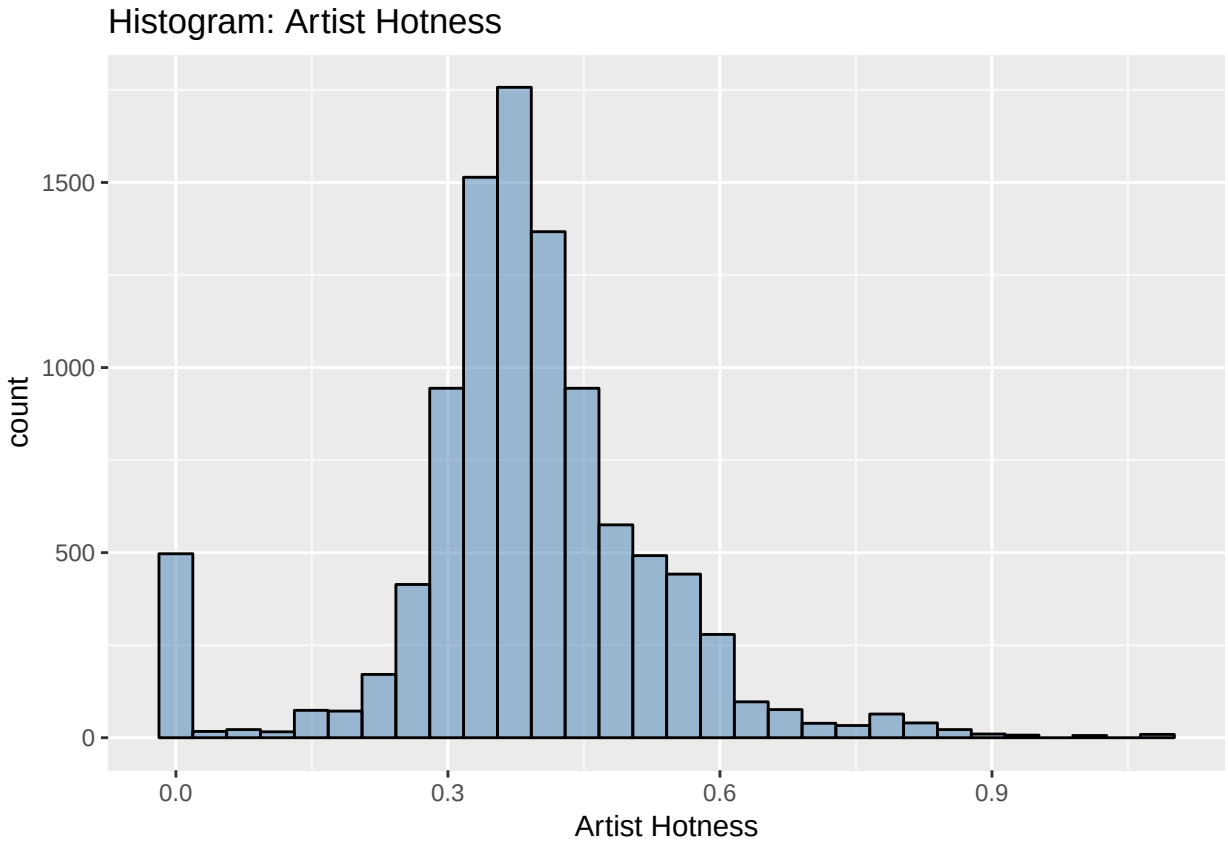

```
#New code from Jeremy importing of song list
#newmusic <- read.csv("~/Intro data science/Music project/newmusic3.csv")
newmusic <- read.csv("/Users/johnfields/Library/Mobile Documents/com~apple~CloudDocs/Syracuse/IST687/Pr

#head(newmusic)
newmusic2 <- newmusic
newmusic3 <- newmusic2[-c(1:2,4:9,11,13:14,19:20,23,36)]

newmusic3 <- na.omit(newmusic3)
cmbomusic <- newmusic3


##Artist Hotness Histogram
library(ggplot2)
ggplot(music, aes(x=artist.hotttnesss))  + geom_histogram(color="black", fill="steelblue", alpha=0.5) +

## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
##Function to create descriptive statistics for artist hotness
descriptive_stats <- function(vector) { library(moments)
  result <- c(Mean=mean(vector),
              Median=median(vector),
              Min = min(vector),
              Max = max(vector),
              SD = sd(vector),
              Quantile = quantile(vector, probs = c(0.25,.50,0.75, 0.95)),
              Skewness = skewness(vector) )
  print(result)
}
descriptive_stats(music$artist.hotttnesss)
```

```
##          Mean       Median          Min          Max           SD
##    0.3855522    0.3807423    0.0000000    1.0825026    0.1436473
## Quantile.25% Quantile.50% Quantile.75% Quantile.95%     Skewness
##    0.3252656    0.3807423    0.4538581    0.6011861   -0.1522617
```

```
##Methodology for assigning artist hotness levels - uses quantiles from descriptitive_statistics functi
#95% Quantile: 0.6011861 - Hot
#75% Quantile: 0.453858  - Warm
#50% Quantile: 0.3807423 - Tepid
#25% Quantile: 0.3252656 - Cool
##Code for assigning labels based on above quantiles
music$artist.hotness.label <- ifelse(music$artist.hotttnesss >=0.6011861, "Hot",
                                     ifelse(music$artist.hotttnesss >=0.453858 & music$artist.hotttness
                                            ifelse(music$artist.hotttnesss >=0.3807423 & music$artist.h
                                                   ifelse(music$artist.hotttnesss >=0.3252656 & music$a
```

```
                                                    ifelse(music$artist.hotttnesss < 0.3252656, "
unique(music$artist.hotness.label)
```

```
## [1] "Tepid"  "Cool"   "Warm"   "Frigid" "Hot"
```

```
#End of new code from Courtney
#Prior to importing, a new column artist.hotttnesss.label was adding with
#Hot(>.4590), Warm(<.4590 and >.3357), Cold(<.3357).  Four rows with blanks in
#famiiarity were also deleted.
```

```
music <- na.omit(music)
#Copy original data to a new dataframe music1 and exclude unneeded data
music <- music[-c(2:5,7,16,19,21:25,30,34)]
music$artist.hotness.label <- as.factor(music$artist.hotness.label)
str(music)
```

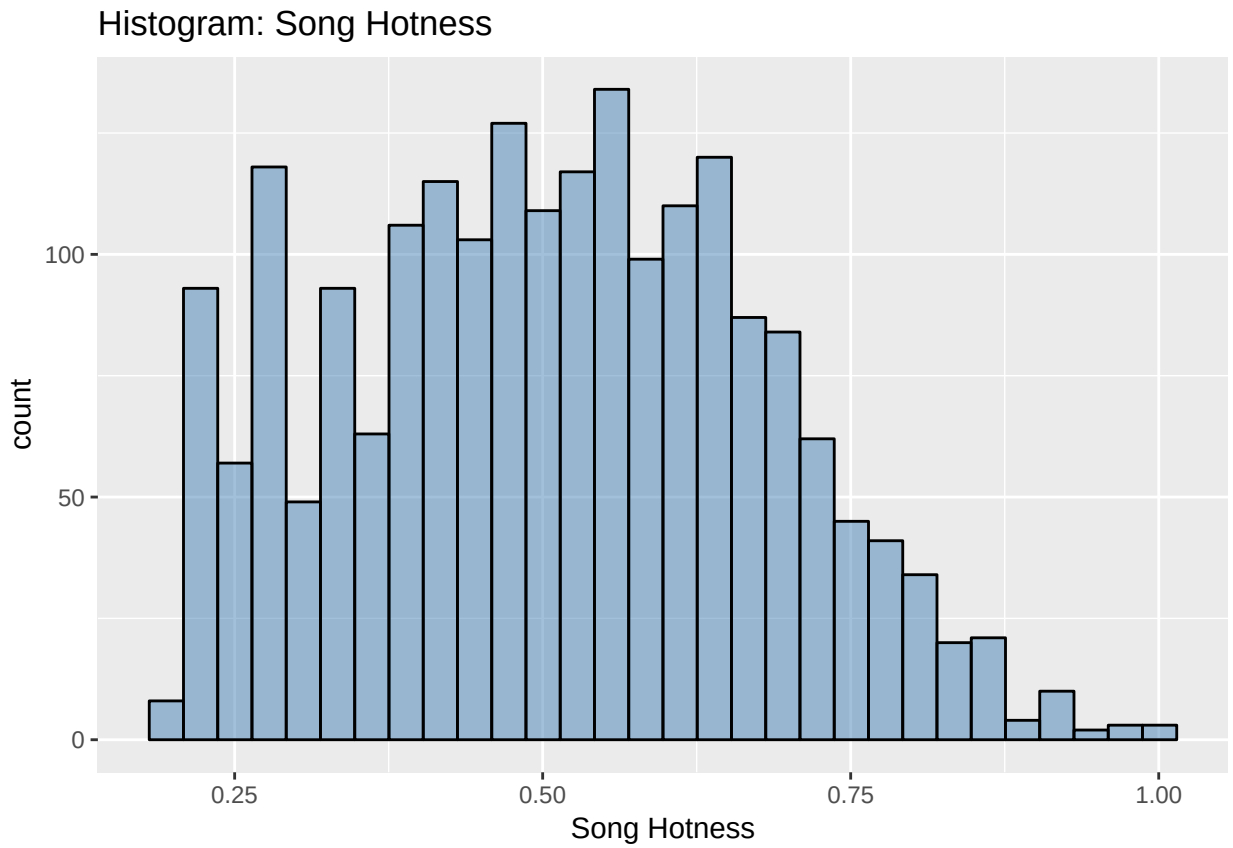
```
## 'data.frame':    5648 obs. of  22 variables:
##  $ artist.hotttnesss        : num  0.402 0.402 0.332 0.296 0.352 ...
##  $ bars_confidence          : num  0.643 0.175 0.806 0.873 0.018 0.013 1 0.507 0.125 0.03 ...
##  $ beats_confidence         : num  0.834 0.883 0.44 0.873 1 0.699 1 0 0.768 1 ...
##  $ beats_start              : num  0.585 0.136 1.226 0.112 0.429 ...
##  $ duration                 : num  219 210 270 219 245 ...
##  $ end_of_fade_in           : num  0.247 0.066 5.3 2.125 0.357 ...
##  $ familiarity              : num  0.582 0.651 0.427 0.36 0.545 ...
##  $ key                      : num  1 2 4 5 7 9 10 7 8 7 ...
##  $ key_confidence           : num  0.736 0.092 0.717 0.354 0.07 0.205 0 1 0.041 0.725 ...
##  $ latitude                 : num  37.2 37.2 37.2 35.2 37.2 ...
##  $ longitude                : num  -63.9 -63.9 -63.9 -80 -63.9 ...
##  $ loudness                 : num  -11.2 -4.5 -13.5 -10.02 -7.54 ...
##  $ mode_confidence          : num  0.636 0.371 0.652 0.485 0.686 0.305 0.198 0.829 0.516 0.756 ...
##  $ start_of_fade_out        : num  219 199 259 207 227 ...
##  $ tatums_confidence        : num  0.779 1 0.121 0.229 0.728 1 0.774 0.377 0.767 0.238 ...
##  $ tatums_start             : num  0.285 0.136 1.226 0.112 0.173 ...
##  $ tempo                    : num  92.2 129.7 86.6 146.8 118 ...
##  $ terms_freq               : num  1 0.887 0.96 0.956 1 ...
##  $ time_signature           : num  4 4 4 1 4 4 1 4 5 4 ...
##  $ time_signature_confidence: num  0.778 0.562 0.487 0 0.835 0 0.319 0.756 0.579 0.931 ...
##  $ year                     : int  0 2007 1984 0 0 0 0 1987 0 2004 ...
##  $ artist.hotness.label     : Factor w/ 5 levels "Cool","Frigid",..: 4 4 1 2 1 1 2 4 1 5 ...
```

```
##SONG HOTNESS HISTOGRAM From Jeremy
cmbomusic[cmbomusic==0]<- NA
#cmbomusic2 <- cmbomusic[-c(5,6)]
cmbomusic3 <- na.omit(cmbomusic)
cmbomusic3$song.hotttnesss.label <- ifelse( cmbomusic3$song.hotttnesss >=0.6011861, "Hot",ifelse(cmbomus
unique(cmbomusic3$song.hotttnesss.label)
```

```
## [1] "Hot"    "Tepid"  "Cool"   "Warm"   "Frigid"
```

```
cmbomusic3 <- cmbomusic3[-c(2:3,12)]
ggplot(cmbomusic3, aes(x=song.hotttnesss))  + geom_histogram(color="black", fill="steelblue", alpha=0.5)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
##Function to create descriptive statistics for song  hotness
descriptive_stats2 <- function(vector) { library(moments)
  result <- c(Mean=mean(vector),
              Median=median(vector),
              Min = min(vector),
              Max = max(vector),
              SD = sd(vector),
              Quantile = quantile(vector, probs = c(0.25,.50,0.75, 0.95)),
              Skewness = skewness(vector) )
  print(result)
}
descriptive_stats2(cmbomusic3$song.hotttnesss)
```

```
##          Mean       Median          Min          Max           SD
##    0.5073226    0.5096410    0.1938578    1.0000000    0.1686679
## Quantile.25% Quantile.50% Quantile.75% Quantile.95%     Skewness
##    0.3827233    0.5096410    0.6301876    0.7900643    0.1304601
```

```
cmbomusic3$song.hotness.label <- ifelse( cmbomusic3$song.hotttnesss >=0.64787976, "Hot",ifelse(cmbomusi
unique(cmbomusic3$song.hotness.label)
```

```
## [1] "Hot"  "Cold" "Warm"
```

```
cmbomusic3$song.hotttnesss.label <- as.factor(cmbomusic3$song.hotttnesss.label)
str(cmbomusic3)
```

```
## 'data.frame':    2037 obs. of  20 variables:
##  $ artist.name             : Factor w/ 4408 levels ":Blacks On :Blondes",..: 3571 3380 1641 2281 32
##  $ latitude                : num  47.6 37.2 53.5 37.2 37.2 ...
```

```
##  $ location                 : Factor w/ 1043 levels "","," UbA!, Minas Gerais",..: 856 703 557 283 703
##  $ longitude                : num  -122.33 -63.93 -2.25 -63.93 -63.93 ...
##  $ loudness                 : num  -9.31 -6.08 -9.62 -10.54 -14.01 ...
##  $ release.id               : int  15964 114401 186364 171807 512792 583091 192588 92902 15316 77794
##  $ release.name             : Factor w/ 7829 levels ". . . Till Then",..: 715 5751 1083 3597 921 909
##  $ song.hotttnesss          : num  0.654 0.43 0.346 1 0.694 ...
##  $ song.id                  : Factor w/ 9995 levels "SOAAAQN12AB01856D3",..: 3 6 7 11 15 16 19 24 29
##  $ tatums_confidence        : num  0.898 1 0.445 0.388 0.484 0.873 0.408 0.284 0.992 1 ...
##  $ tatums_start             : num  0.1569 0.0346 0.089 0.1008 0.2263 ...
##  $ tempo                    : num  131 114 102 151 123 ...
##  $ terms                    : Factor w/ 458 levels "","8-bit","acid jazz",..: 10 216 8 37 301 198 10
##  $ terms_freq               : num  1 1 1 0.998 0.82 ...
##  $ time_signature           : int  4 5 4 3 4 4 4 4 4 3 ...
##  $ time_signature_confidence: num  0.59 0.583 0.097 1 0.369 1 1 0.866 0.919 0.741 ...
##  $ title                    : Factor w/ 9704 levels "","-start ID-",..: 7342 6931 9501 3916 539 4665
##  $ year                     : int  1991 2005 1988 1970 1977 2009 2008 2007 1998 2010 ...
##  $ song.hotttnesss.label    : Factor w/ 5 levels "Cool","Frigid",..: 3 4 1 3 3 3 3 1 3 3 ...
##  $ song.hotness.label       : chr  "Hot" "Cold" "Cold" "Hot" ...
```

```
cmbomusic3$song.hotttnesss.label <- ifelse( cmbomusic3$song.hotttnesss >=0.6011861, "Hot",ifelse(cmbomus
unique(cmbomusic3$song.hotttnesss.label)
```

```
## [1] "Hot"    "Tepid"  "Cool"   "Warm"   "Frigid"
```

```
cmbomusic3$song.hotttnesss.label <- as.factor(cmbomusic3$song.hotttnesss.label)
str(cmbomusic3)
```

```
## 'data.frame':    2037 obs. of  20 variables:
##  $ artist.name              : Factor w/ 4408 levels ":Blacks On :Blondes",..: 3571 3380 1641 2281 32
##  $ latitude                 : num  47.6 37.2 53.5 37.2 37.2 ...
##  $ location                 : Factor w/ 1043 levels "","," UbA!, Minas Gerais",..: 856 703 557 283 703
##  $ longitude                : num  -122.33 -63.93 -2.25 -63.93 -63.93 ...
##  $ loudness                 : num  -9.31 -6.08 -9.62 -10.54 -14.01 ...
##  $ release.id               : int  15964 114401 186364 171807 512792 583091 192588 92902 15316 77794
##  $ release.name             : Factor w/ 7829 levels ". . . Till Then",..: 715 5751 1083 3597 921 909
##  $ song.hotttnesss          : num  0.654 0.43 0.346 1 0.694 ...
##  $ song.id                  : Factor w/ 9995 levels "SOAAAQN12AB01856D3",..: 3 6 7 11 15 16 19 24 29
##  $ tatums_confidence        : num  0.898 1 0.445 0.388 0.484 0.873 0.408 0.284 0.992 1 ...
##  $ tatums_start             : num  0.1569 0.0346 0.089 0.1008 0.2263 ...
##  $ tempo                    : num  131 114 102 151 123 ...
##  $ terms                    : Factor w/ 458 levels "","8-bit","acid jazz",..: 10 216 8 37 301 198 10
##  $ terms_freq               : num  1 1 1 0.998 0.82 ...
##  $ time_signature           : int  4 5 4 3 4 4 4 4 4 3 ...
##  $ time_signature_confidence: num  0.59 0.583 0.097 1 0.369 1 1 0.866 0.919 0.741 ...
##  $ title                    : Factor w/ 9704 levels "","-start ID-",..: 7342 6931 9501 3916 539 4665
##  $ year                     : int  1991 2005 1988 1970 1977 2009 2008 2007 1998 2010 ...
##  $ song.hotttnesss.label    : Factor w/ 5 levels "Cool","Frigid",..: 3 4 1 3 3 3 3 1 3 3 ...
##  $ song.hotness.label       : chr  "Hot" "Cold" "Cold" "Hot" ...
```

```
cmbomusic3$song.hotttnesss.label <- ifelse( cmbomusic3$song.hotttnesss >=0.6011861, "Hot",ifelse(cmbomus
unique(cmbomusic3$song.hotttnesss.label)
```

```
## [1] "Hot"    "Tepid"  "Cool"   "Warm"   "Frigid"
```

```
str(cmbomusic3)
```

```
## 'data.frame':    2037 obs. of  20 variables:
```

```
##  $ artist.name              : Factor w/ 4408 levels ":Blacks On :Blondes",..: 3571 3380 1641 2281 32
##  $ latitude                 : num  47.6 37.2 53.5 37.2 37.2 ...
##  $ location                 : Factor w/ 1043 levels "","," UbA!, Minas Gerais",..: 856 703 557 283 703
##  $ longitude                : num  -122.33 -63.93 -2.25 -63.93 -63.93 ...
##  $ loudness                 : num  -9.31 -6.08 -9.62 -10.54 -14.01 ...
##  $ release.id               : int  15964 114401 186364 171807 512792 583091 192588 92902 15316 77794
##  $ release.name             : Factor w/ 7829 levels ". . . Till Then",..: 715 5751 1083 3597 921 909
##  $ song.hotttnesss          : num  0.654 0.43 0.346 1 0.694 ...
##  $ song.id                  : Factor w/ 9995 levels "SOAAAQN12AB01856D3",..: 3 6 7 11 15 16 19 24 29
##  $ tatums_confidence        : num  0.898 1 0.445 0.388 0.484 0.873 0.408 0.284 0.992 1 ...
##  $ tatums_start             : num  0.1569 0.0346 0.089 0.1008 0.2263 ...
##  $ tempo                    : num  131 114 102 151 123 ...
##  $ terms                    : Factor w/ 458 levels "","8-bit","acid jazz",..: 10 216 8 37 301 198 10
##  $ terms_freq               : num  1 1 1 0.998 0.82 ...
##  $ time_signature           : int  4 5 4 3 4 4 4 4 4 3 ...
##  $ time_signature_confidence: num  0.59 0.583 0.097 1 0.369 1 1 0.866 0.919 0.741 ...
##  $ title                    : Factor w/ 9704 levels "","-start ID-",..: 7342 6931 9501 3916 539 4665
##  $ year                     : int  1991 2005 1988 1970 1977 2009 2008 2007 1998 2010 ...
##  $ song.hotttnesss.label    : chr  "Hot" "Tepid" "Cool" "Hot" ...
##  $ song.hotness.label       : chr  "Hot" "Cold" "Cold" "Hot" ...
```

```
cmbomusic3$song.hotttnesss.label <- as.factor(cmbomusic3$song.hotttnesss.label)
cmbomusic3$song.hotttnesss.label <- as.factor(cmbomusic3$song.hotttnesss.label)
str(cmbomusic3)
```

```
## 'data.frame':    2037 obs. of  20 variables:
##  $ artist.name              : Factor w/ 4408 levels ":Blacks On :Blondes",..: 3571 3380 1641 2281 32
##  $ latitude                 : num  47.6 37.2 53.5 37.2 37.2 ...
##  $ location                 : Factor w/ 1043 levels "","," UbA!, Minas Gerais",..: 856 703 557 283 703
##  $ longitude                : num  -122.33 -63.93 -2.25 -63.93 -63.93 ...
##  $ loudness                 : num  -9.31 -6.08 -9.62 -10.54 -14.01 ...
##  $ release.id               : int  15964 114401 186364 171807 512792 583091 192588 92902 15316 77794
##  $ release.name             : Factor w/ 7829 levels ". . . Till Then",..: 715 5751 1083 3597 921 909
##  $ song.hotttnesss          : num  0.654 0.43 0.346 1 0.694 ...
##  $ song.id                  : Factor w/ 9995 levels "SOAAAQN12AB01856D3",..: 3 6 7 11 15 16 19 24 29
##  $ tatums_confidence        : num  0.898 1 0.445 0.388 0.484 0.873 0.408 0.284 0.992 1 ...
##  $ tatums_start             : num  0.1569 0.0346 0.089 0.1008 0.2263 ...
##  $ tempo                    : num  131 114 102 151 123 ...
##  $ terms                    : Factor w/ 458 levels "","8-bit","acid jazz",..: 10 216 8 37 301 198 10
##  $ terms_freq               : num  1 1 1 0.998 0.82 ...
##  $ time_signature           : int  4 5 4 3 4 4 4 4 4 3 ...
##  $ time_signature_confidence: num  0.59 0.583 0.097 1 0.369 1 1 0.866 0.919 0.741 ...
##  $ title                    : Factor w/ 9704 levels "","-start ID-",..: 7342 6931 9501 3916 539 4665
##  $ year                     : int  1991 2005 1988 1970 1977 2009 2008 2007 1998 2010 ...
##  $ song.hotttnesss.label    : Factor w/ 5 levels "Cool","Frigid",..: 3 4 1 3 3 3 3 1 3 3 ...
##  $ song.hotness.label       : chr  "Hot" "Cold" "Cold" "Hot" ...
```

```
 #View the number of Cold/Warm/Hot labels
 table(cmbomusic3$song.hotttnesss.label)
```

```
##
##   Cool Frigid    Hot  Tepid   Warm
##    171    337    629    278    622
```

```
 cmbomusic3$song.hotness.label <- ifelse( cmbomusic3$song.hotttnesss >=0.64787976, "Hot",ifelse(cmbomusi
unique(cmbomusic3$song.hotness.label)
```

```
## [1] "Hot"  "Cold" "Warm"
```

Features

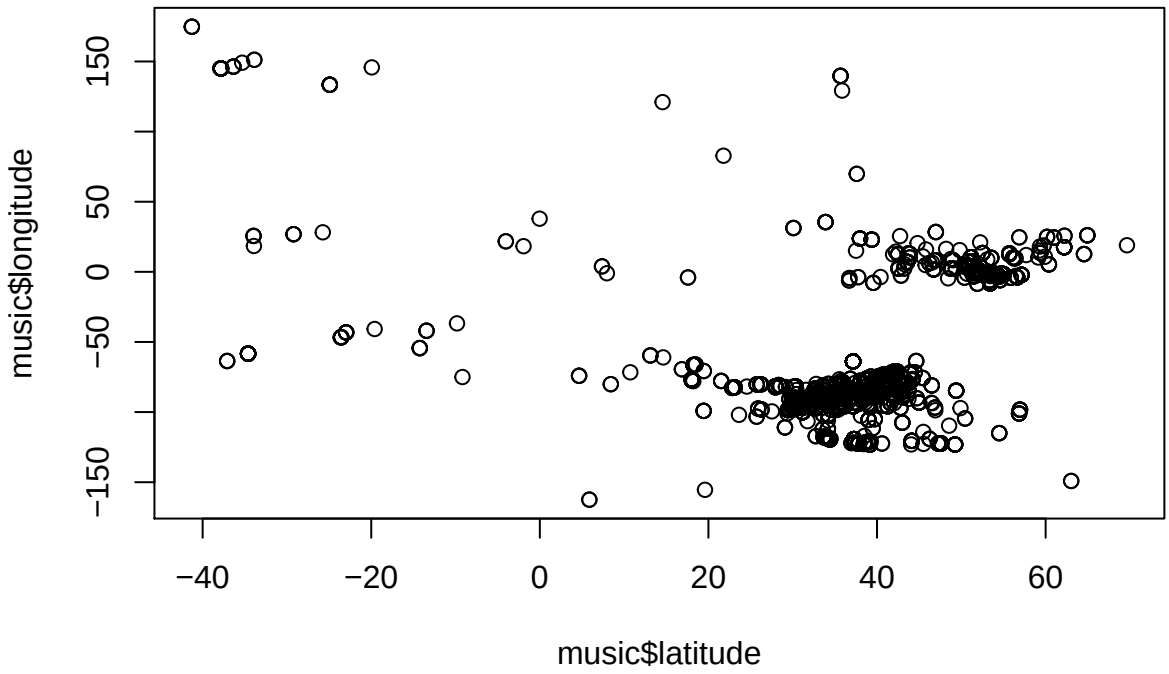
```
#View the number of Cold/Warm/Hot labels
table(music$artist.hotttnesss.label)
```

```
## < table of extent 0 >
```

```
#View the number of Frigid/Cool/Tepid/Warm/Hot labels
table(music$artist.hotness.label)
```

```
##
##   Cool Frigid    Hot  Tepid   Warm
##   1444    973    278   1566   1387
```

```
#Plot artists latitude and longitude
plot(music$latitude,music$longitude)
```




```
cmbomusic3$song.hotness.label <- as.factor(cmbomusic3$song.hotness.label)
cmbomusic3$song.hotness.label <- as.factor(cmbomusic3$song.hotness.label)
str(cmbomusic3)
```

```
## 'data.frame':    2037 obs. of  20 variables:
##  $ artist.name             : Factor w/ 4408 levels ":Blacks On :Blondes",..: 3571 3380 1641 2281 32
##  $ latitude                : num  47.6 37.2 53.5 37.2 37.2 ...
##  $ location                : Factor w/ 1043 levels "","," UbA!, Minas Gerais",..: 856 703 557 283 703
##  $ longitude               : num  -122.33 -63.93 -2.25 -63.93 -63.93 ...
##  $ loudness                : num  -9.31 -6.08 -9.62 -10.54 -14.01 ...
##  $ release.id              : int  15964 114401 186364 171807 512792 583091 192588 92902 15316 77794
##  $ release.name            : Factor w/ 7829 levels ". . . Till Then",..: 715 5751 1083 3597 921 909
##  $ song.hotttnesss         : num  0.654 0.43 0.346 1 0.694 ...
##  $ song.id                 : Factor w/ 9995 levels "SOAAAQN12AB01856D3",..: 3 6 7 11 15 16 19 24 29
##  $ tatums_confidence       : num  0.898 1 0.445 0.388 0.484 0.873 0.408 0.284 0.992 1 ...
```

```
##  $ tatums_start             : num  0.1569 0.0346 0.089 0.1008 0.2263 ...
##  $ tempo                    : num  131 114 102 151 123 ...
##  $ terms                    : Factor w/ 458 levels "","8-bit","acid jazz",..: 10 216 8 37 301 198 10
##  $ terms_freq               : num  1 1 1 0.998 0.82 ...
##  $ time_signature           : int  4 5 4 3 4 4 4 4 4 3 ...
##  $ time_signature_confidence: num  0.59 0.583 0.097 1 0.369 1 1 0.866 0.919 0.741 ...
##  $ title                    : Factor w/ 9704 levels "","-start ID-",..: 7342 6931 9501 3916 539 4665
##  $ year                     : int  1991 2005 1988 1970 1977 2009 2008 2007 1998 2010 ...
##  $ song.hotttnesss.label    : Factor w/ 5 levels "Cool","Frigid",..: 3 4 1 3 3 3 3 1 3 3 ...
##  $ song.hotness.label       : Factor w/ 3 levels "Cold","Hot","Warm": 2 1 1 2 2 2 2 1 3 2 ...
```

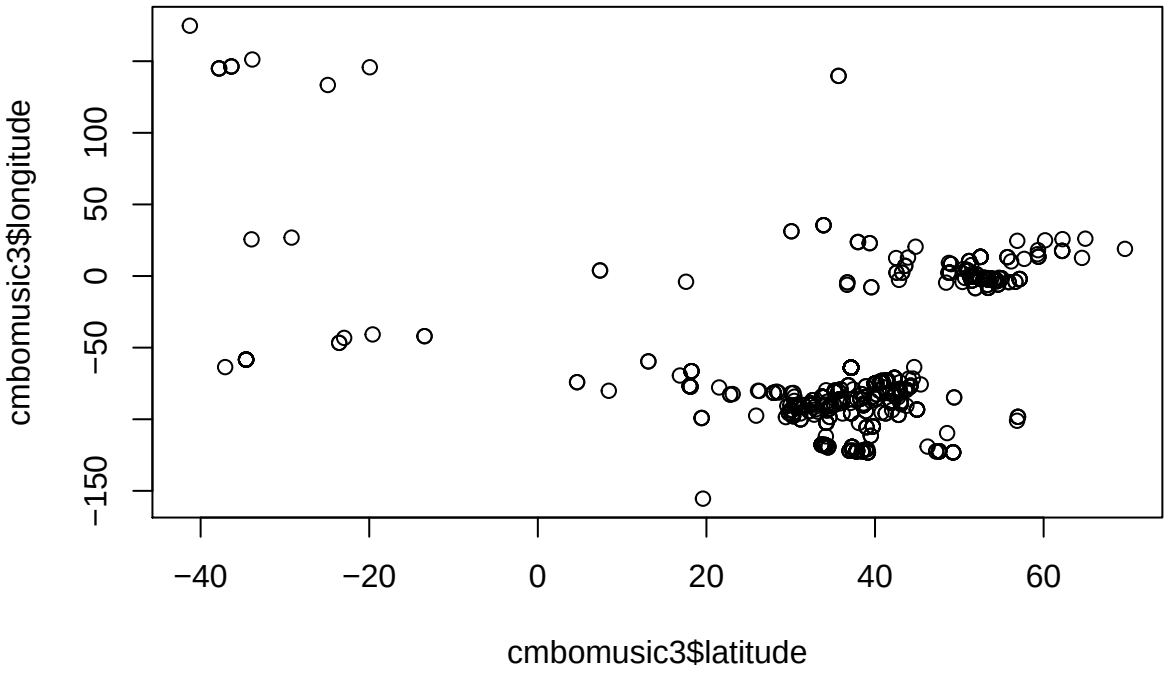
```
#View the number of Cold/Warm/Hot labels
table(cmbomusic3$song.hotness.label)
```

```
##
## Cold  Hot Warm
##  707  440  890
```

```
#View the number of Frigid/Cool/Tepid/Warm/Hot labels
 table(cmbomusic3$song.hotttnesss.label)
```

```
##
##   Cool Frigid    Hot  Tepid   Warm
##    171    337    629    278    622
```

```
 #Plot artists latitude and longitude
 plot(cmbomusic3$latitude,cmbomusic3$longitude)
```




```
#Plot artist hotttnesss
#hist(music$artist.hotttnesss,breaks=20)
#hist(music$artist.hotness,breaks=20)
```

#Create a map of the world mapWorld <- borders(“world”, colour=“gray50”, fill=“white”)

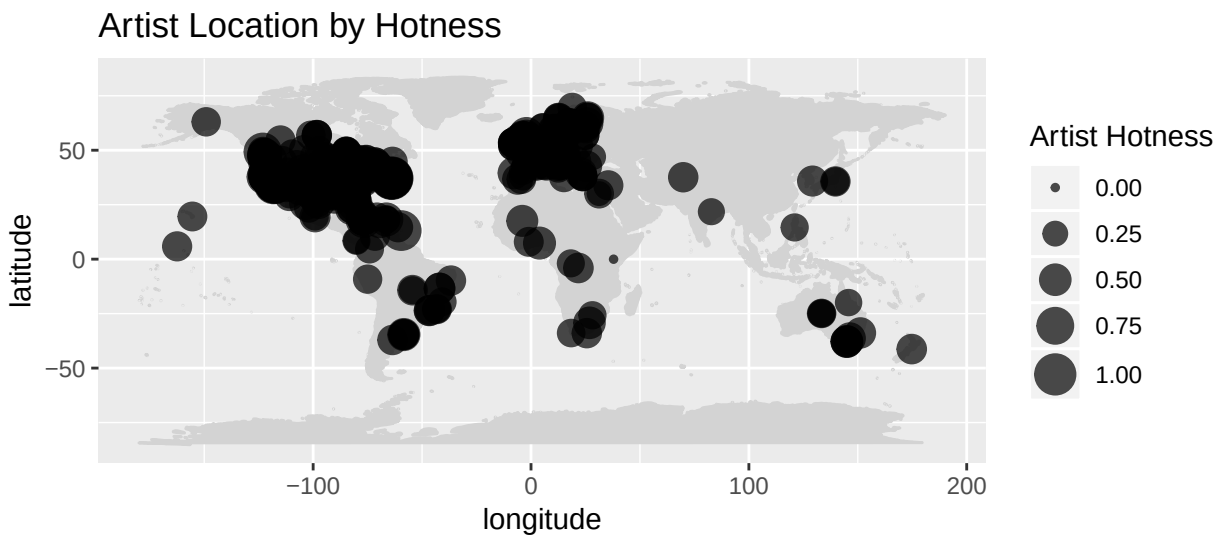
```
#New code from John for creating a map of the world showing latitude/longitude and artist hotness
#Code based on info from https://rpubs.com/spoonerf/global_map
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

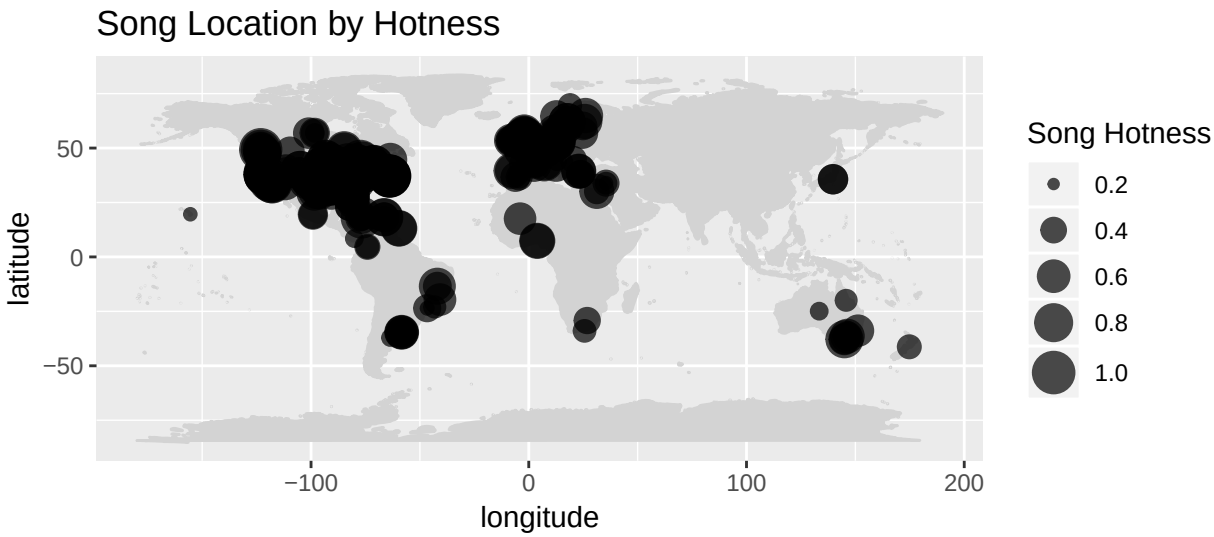
```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
loc<-data.frame(music$longitude,music$latitude,music$artist.hotttnesss)
loc<-unique(loc)
colnames(loc)<-c("longitude", "latitude","artist hotness")
loc_df<-data.frame(loc)
library(maps)
library(mapdata)
library(ggplot2)
ahworld <- ggplot(data=loc_df, aes(longitude, latitude, group=NULL,fill=NULL,size=artist.hotness))+#, f
  borders(fill="light grey",colour="light grey")+
  geom_point(color="black",alpha=I(7/10))+
  scale_size(range=c(1,7), guide = "legend",labs(size="Artist Hotness"))+
  coord_equal()+  ggtitle("Artist Location by Hotness")
ahworld
```




```
#New code from John for creating a map of the world showing latitude/longitude and artist hotness
#Code based on info from https://rpubs.com/spoonerf/global_map
library(dplyr)
songlc<-data.frame(cmbomusic3$longitude,cmbomusic3$latitude,cmbomusic3$song.hotttnesss)
songlc<-unique(songlc)
colnames(songlc)<-c("longitude", "latitude","song hotness")
songlc_df<-data.frame(songlc)
library(maps)
library(mapdata)
```

```
library(ggplot2)
songlc_dfwrld <- ggplot(data=songlc_df, aes(longitude, latitude, group=NULL,fill=NULL,size=song.hotness
  borders(fill="light grey",colour="light grey")+
  geom_point(color="black",alpha=I(7/10))+
  scale_size(range=c(1,7), guide = "legend",labs(size="Song Hotness"))+
  coord_equal()+  ggtitle("Song Location by Hotness")
songlc_dfwrld
```



Methods - Linear Regression

```
# code from Juan
lm(formula = music$artist.hotttnesss ~ music$year + music$bars_confidence +
    + music$tempo + music$duration + music$start_of_fade_out +
   music$tatums_start + music$familiarity + music$latitude +
   music$tempo + music$longitude + music$beats_start + music$beats_confidence +
   music$end_of_fade_in)
```

```
##
## Call:
## lm(formula = music$artist.hotttnesss ~ music$year + music$bars_confidence +
##     +music$tempo + music$duration + music$start_of_fade_out +
##     music$tatums_start + music$familiarity + music$latitude +
##     music$tempo + music$longitude + music$beats_start + music$beats_confidence +
##     music$end_of_fade_in)
##
## Coefficients:
##             (Intercept)              music$year    music$bars_confidence
##               1.500e-02               6.911e-06              -4.242e-04
##             music$tempo          music$duration  music$start_of_fade_out
##              -3.122e-05               1.842e-05              -2.842e-05
##      music$tatums_start       music$familiarity           music$latitude
##              -5.004e-03               6.625e-01              -1.039e-04
##         music$longitude       music$beats_start   music$beats_confidence
##              -5.606e-05               5.494e-03              -2.277e-03
##    music$end_of_fade_in
```

```
##               9.355e-05
```

```
#removed music$bars_start which was causing an error
```

Methods - Random Forest

```
#Do analysis to determine hot/warm/cold artists based on hotttnesss
#The ramdom forest analysis is from a training video by Bharatendra Rai
#at https://www.youtube.com/watch?v=dJclNIN-TPo
#Data Partition - ind = independent samples
#The code below runs in console but not R Markdown
set.seed(123)
ind<- sample(2,nrow(music), replace=TRUE,prob=c(0.7,0.3))
train <- music[ind==1,]
test <- music[ind==2,]
#Run randomForest on 3 levels
library(randomForest)
```

```
## randomForest 4.6-14
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```
##
## Attaching package: 'randomForest'
```

```
## The following object is masked from 'package:dplyr':
##
##     combine
```

```
## The following object is masked from 'package:psych':
##
##     outlier
```

```
## The following object is masked from 'package:ggplot2':
##
##     margin
```

```
set.seed(222)
rf <- randomForest(music[,-21:-22],music[,21])
print(rf)
```

```
##
## Call:
##  randomForest(x = music[, -21:-22], y = music[, 21])
##                Type of random forest: regression
##                      Number of trees: 500
## No. of variables tried at each split: 6
##
##           Mean of squared residuals: 826953
##                     % Var explained: 16.59
```

```
attributes(rf)
```

```
## $names
##  [1] "call"            "type"            "predicted"
##  [4] "mse"             "rsq"             "oob.times"
##  [7] "importance"      "importanceSD"    "localImportance"
```

```
## [10] "proximity"       "ntree"           "mtry"
## [13] "forest"          "coefs"           "y"
## [16] "test"            "inbag"
##
## $class
## [1] "randomForest"
```

```
rf$confusion
```

```
## NULL
```

```
#Run randomForest on 5 levels
library(randomForest)
set.seed(222)
rf2 <- randomForest(music[,-21:-22],music[,22])
print(rf2)
```

```
##
## Call:
##  randomForest(x = music[, -21:-22], y = music[, 22])
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 4
##
##         OOB estimate of  error rate: 0.18%
## Confusion matrix:
##        Cool Frigid Hot Tepid Warm class.error
## Cool   1444      0   0     0    0 0.000000000
## Frigid    0    973   0     0    0 0.000000000
## Hot       0      0 270     0    8 0.028776978
## Tepid     0      0   0  1566    0 0.000000000
## Warm      0      0   0     2 1385 0.001441961
```

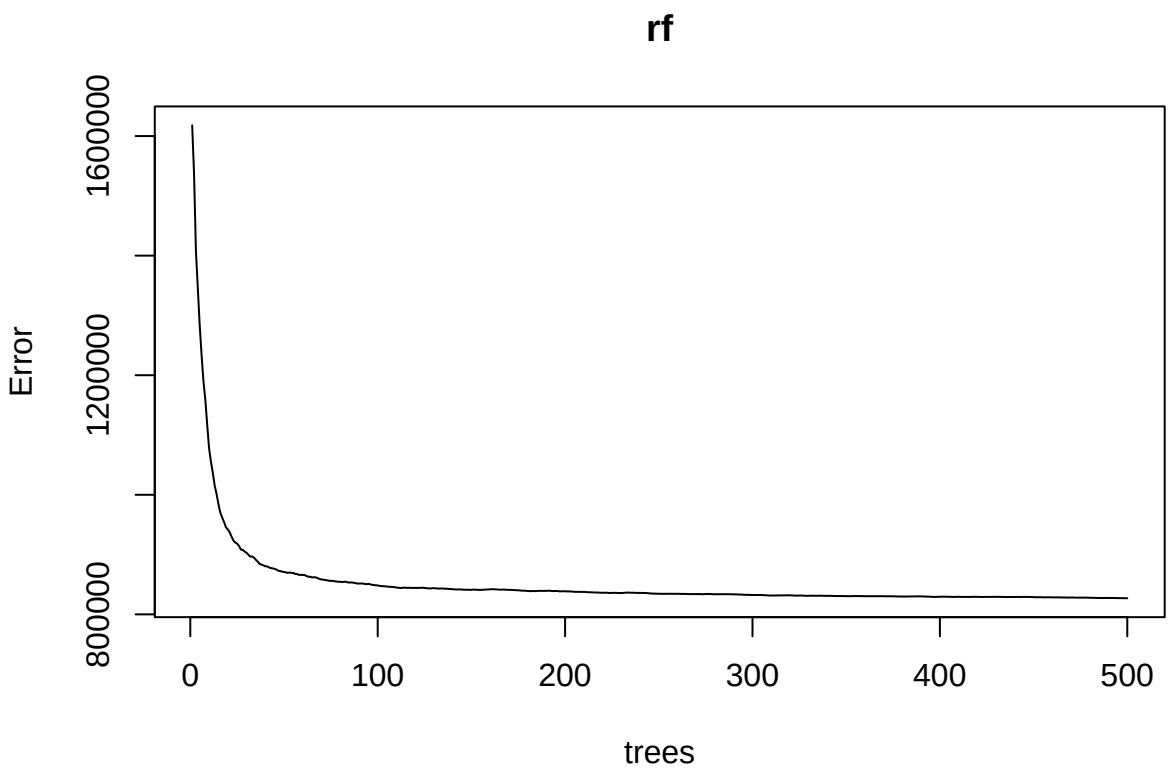
```
attributes(rf2)
```

```
## $names
##  [1] "call"            "type"            "predicted"
##  [4] "err.rate"        "confusion"       "votes"
##  [7] "oob.times"       "classes"         "importance"
## [10] "importanceSD"    "localImportance" "proximity"
## [13] "ntree"           "mtry"            "forest"
## [16] "y"               "test"            "inbag"
##
## $class
## [1] "randomForest"
```

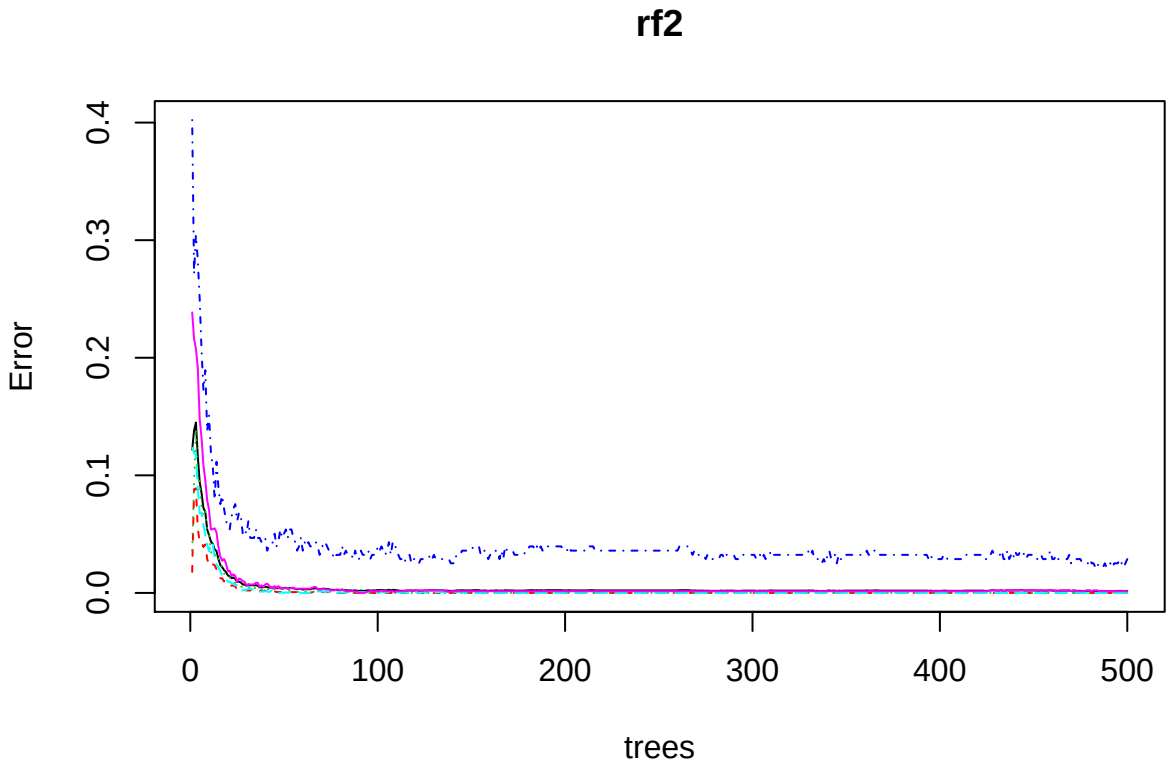
```
rf2$confusion
```

```
##        Cool Frigid Hot Tepid Warm class.error
## Cool   1444      0   0     0    0 0.000000000
## Frigid    0    973   0     0    0 0.000000000
## Hot       0      0 270     0    8 0.028776978
## Tepid     0      0   0  1566    0 0.000000000
## Warm      0      0   0     2 1385 0.001441961
```

```
#Error rate of Random Forest
plot(rf)
```



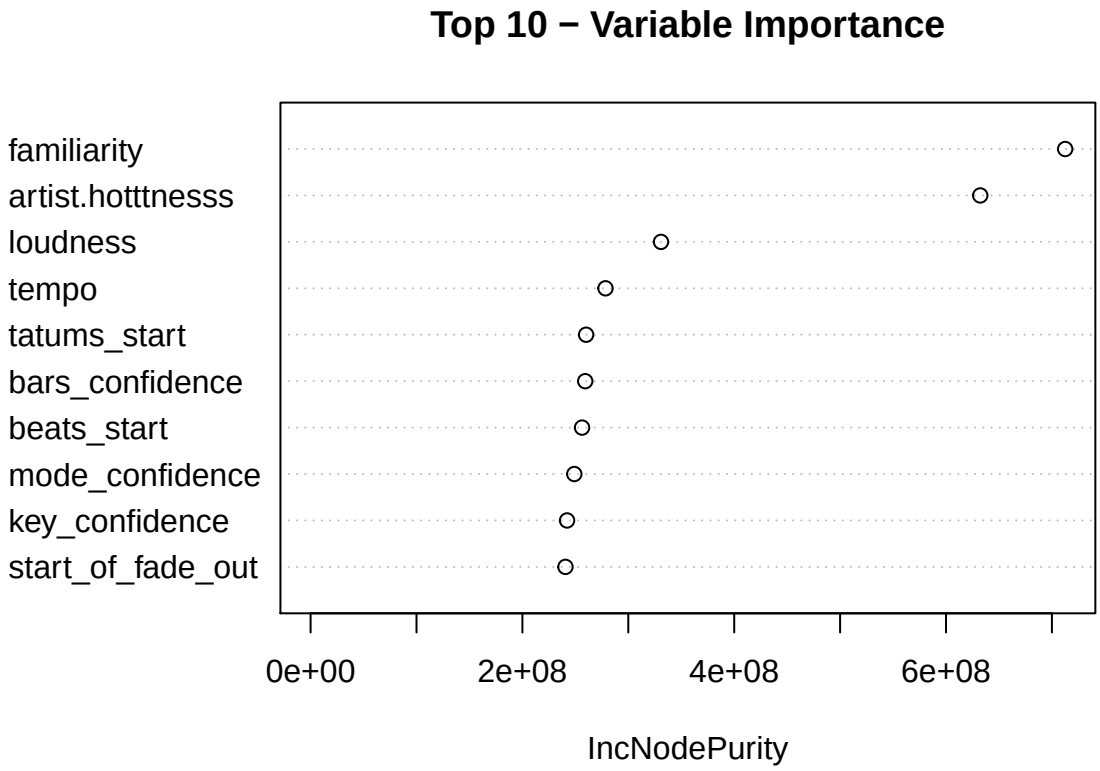

```
plot(rf2)
```




```
#The error rate is not improving after ~100 trees

# Variable Importance
# Familiarity is much more important than the other variables.
```

```
varImpPlot(rf,
           sort=T,
           n.var=10,
           main="Top 10 - Variable Importance")
```



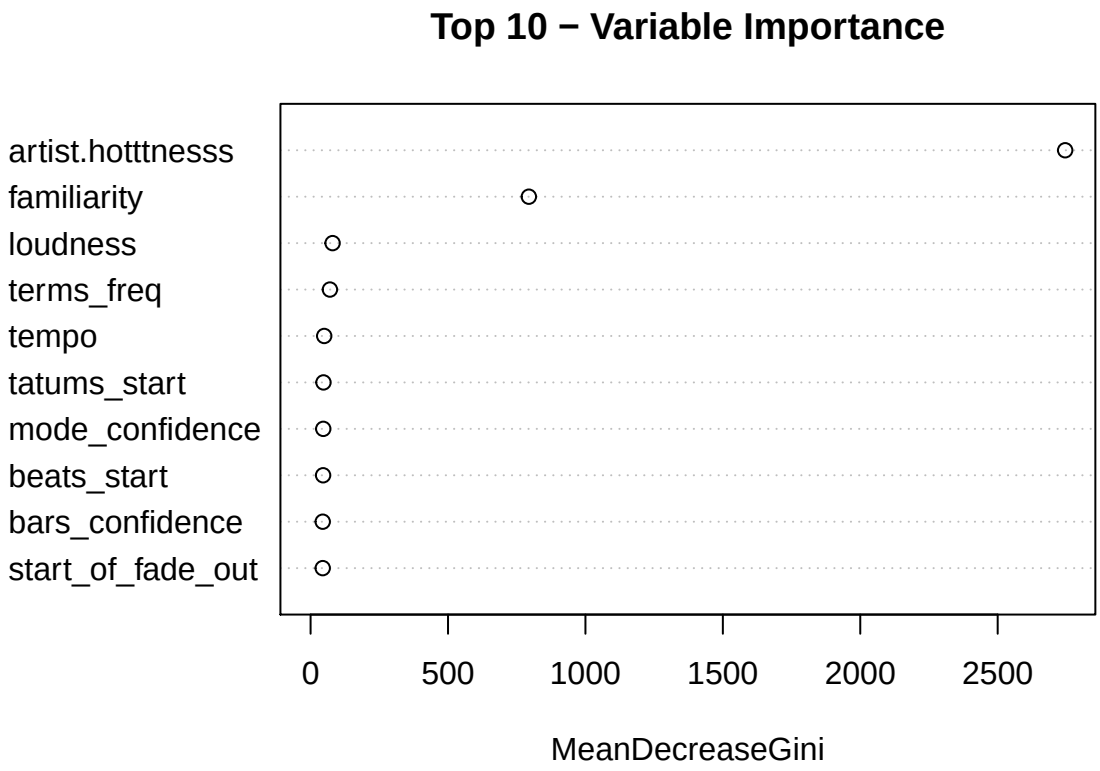

```
importance(rf)
```

```
##                           IncNodePurity
## artist.hotttnesss             632328644
## bars_confidence               259319249
## beats_confidence              206820915
## beats_start                   256324242
## duration                      240237155
## end_of_fade_in                192120434
## familiarity                   712524089
## key                           143890690
## key_confidence                242165770
## latitude                      153094783
## longitude                     149771653
## loudness                      330880900
## mode_confidence               248999376
## start_of_fade_out             240653115
## tatums_confidence             231190858
## tatums_start                  260177689
## tempo                         278464617
## terms_freq                    214067856
## time_signature                 64162932
## time_signature_confidence     180372321
```

```
varUsed(rf)
```

```
##  [1] 53861 51368 44324 50446 48698 41054 55164 37123 48813 29847 28240
## [12] 55430 49848 47951 47006 50713 52172 34675 20506 40779
```

```
varImpPlot(rf2,
           sort=T,
           n.var=10,
           main="Top 10 - Variable Importance")
```




```
importance(rf2)
```

```
##                         MeanDecreaseGini
## artist.hotttnesss            2745.57471
## bars_confidence                44.14672
## beats_confidence               40.36867
## beats_start                    45.50021
## duration                       43.16086
## end_of_fade_in                 39.30387
## familiarity                   794.13225
## key                            27.13917
## key_confidence                 41.77856
## latitude                       38.36968
## longitude                      39.90725
## loudness                       80.02057
## mode_confidence                46.08476
## start_of_fade_out              44.13825
## tatums_confidence              39.80128
## tatums_start                   46.82259
## tempo                          49.53280
## terms_freq                     70.28740
```

```
## time_signature                    12.79758
## time_signature_confidence         33.38332
```

```
varUsed(rf2)
```

```
##  [1] 29551  8173  7342  8318  8064  6548 16205  5780  7942  5273  5429
## [12]  9726  8386  8120  7533  8555  8940  7161  2773  6443
```

```
cmbomusic4 <- na.omit(cmbomusic3)
cmbomusic5 <- cmbomusic4[-c(1,3,7:9,13,17,20)]
str(cmbomusic5)
```

```
## 'data.frame':    2037 obs. of  12 variables:
##  $ latitude                 : num  47.6 37.2 53.5 37.2 37.2 ...
##  $ longitude                : num  -122.33 -63.93 -2.25 -63.93 -63.93 ...
##  $ loudness                 : num  -9.31 -6.08 -9.62 -10.54 -14.01 ...
##  $ release.id               : int  15964 114401 186364 171807 512792 583091 192588 92902 15316 77794
##  $ tatums_confidence        : num  0.898 1 0.445 0.388 0.484 0.873 0.408 0.284 0.992 1 ...
##  $ tatums_start             : num  0.1569 0.0346 0.089 0.1008 0.2263 ...
##  $ tempo                    : num  131 114 102 151 123 ...
##  $ terms_freq               : num  1 1 1 0.998 0.82 ...
##  $ time_signature           : int  4 5 4 3 4 4 4 4 4 3 ...
##  $ time_signature_confidence: num  0.59 0.583 0.097 1 0.369 1 1 0.866 0.919 0.741 ...
##  $ year                     : int  1991 2005 1988 1970 1977 2009 2008 2007 1998 2010 ...
##  $ song.hotttnesss.label    : Factor w/ 5 levels "Cool","Frigid",..: 3 4 1 3 3 3 3 1 3 3 ...
```

```
cmbomusic5$song.hotness.label <- as.factor(cmbomusic4$song.hotness.label)
rf3 <- randomForest(cmbomusic5[,-12:-13],cmbomusic5[,13])
rf3
```

```
##
## Call:
##  randomForest(x = cmbomusic5[, -12:-13], y = cmbomusic5[, 13])
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 3
##
##         OOB estimate of  error rate: 51.1%
## Confusion matrix:
##      Cold Hot Warm class.error
## Cold  303  35  369   0.5714286
## Hot    63 119  258   0.7295455
## Warm  243  73  574   0.3550562
```

```
print(rf3)
```

```
##
## Call:
##  randomForest(x = cmbomusic5[, -12:-13], y = cmbomusic5[, 13])
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 3
##
##         OOB estimate of  error rate: 51.1%
## Confusion matrix:
##      Cold Hot Warm class.error
## Cold  303  35  369   0.5714286
```

```
## Hot    63 119  258   0.7295455
## Warm  243  73  574   0.3550562
```

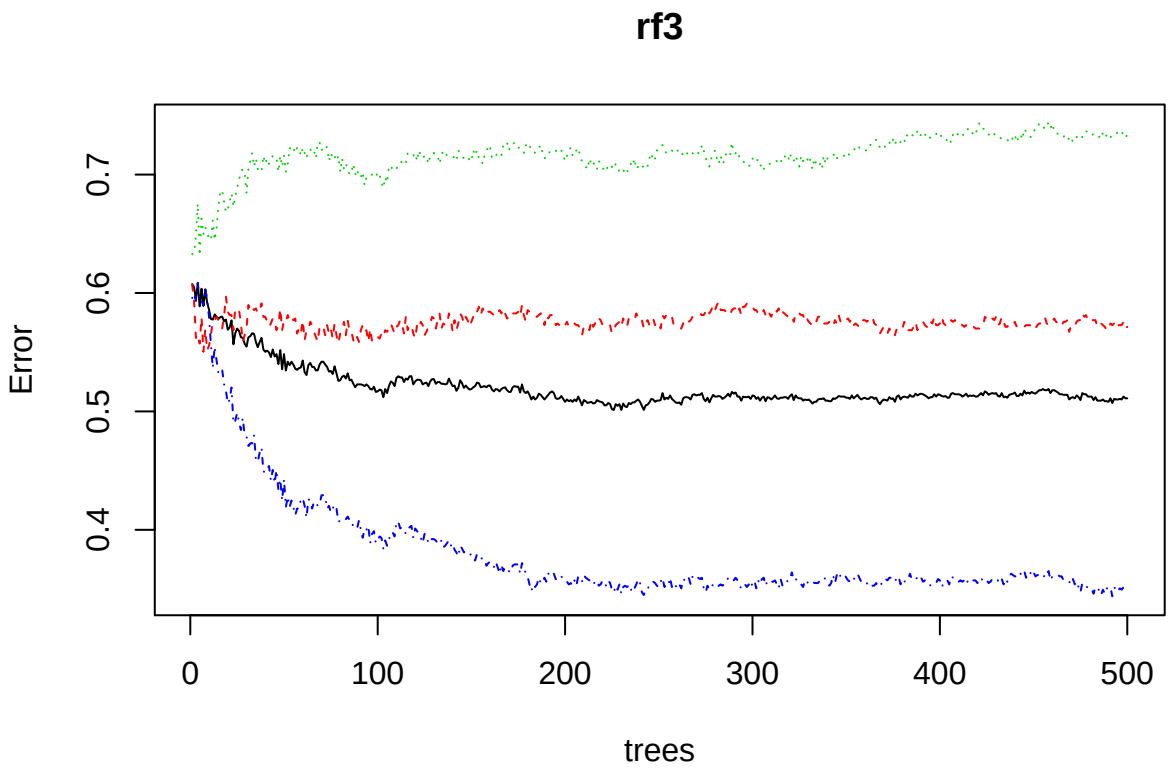
```
attributes(rf3)
```

```
## $names
##  [1] "call"            "type"            "predicted"
##  [4] "err.rate"        "confusion"       "votes"
##  [7] "oob.times"       "classes"         "importance"
## [10] "importanceSD"    "localImportance" "proximity"
## [13] "ntree"           "mtry"            "forest"
## [16] "y"               "test"            "inbag"
##
## $class
## [1] "randomForest"
```

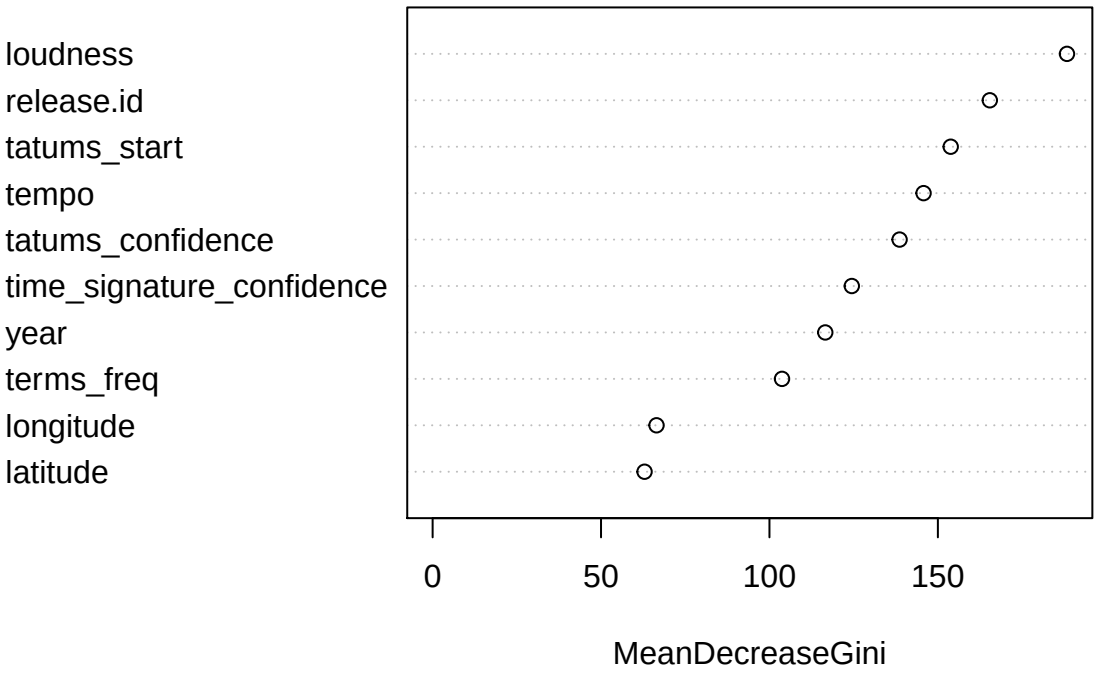
```
rf3$confusion
```

```
##      Cold Hot Warm class.error
## Cold  303  35  369   0.5714286
## Hot    63 119  258   0.7295455
## Warm  243  73  574   0.3550562
```

```
plot(rf3)
```




```
varImpPlot(rf3,
           sort=T,
           n.var=10,
           main="Top 10 - Variable Importance")
```



Conclusion

Appendices