IST687 - Final Project: Music Classification

Sebastian Castro, John Fields, Courtney Smith, Jeremy Wallner

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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

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

```
## 'data.frame':    9996 obs. of  36 variables:
##  $ artist.hotttnesss        : num  0.402 0.417 0.343 0.454 0.402 ...
##  $ artist.id                : Factor w/ 3885 levels "AR009211187B989185",..: 1269 2353 2168 715 3606
##  $ artist.name              : Factor w/ 4409 levels ":Blacks On :Blondes",..: 682 3796 3560 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 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/ 7830 levels " Lazy Afternoon En Anglais",..: 2191 1746 3535 
##  $ similar                  : Factor w/ 2837 levels "AR00K8N11C8A41687B",..: 2408 2225 1145 304 2331
##  $ song.hotttnesss          : num  0.602 NA NA NA 0.605 ...
##  $ song.id                  : Factor w/ 9996 levels " Polovtsian Dances / Rimsky-Korsakov: Russian Ea
##  $ 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/ 9705 levels ""," -start ID-",..: 3572 7526 481 7474 2531 828
##  $ year                     : int  0 1969 0 1982 2007 0 0 0 1984 0 ...
##  $ artist.hotttnesss.label  : Factor w/ 3 levels "Cold","Hot","Warm": 3 3 3 3 3 3 1 2 1 3 ...
```

```
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,)
```

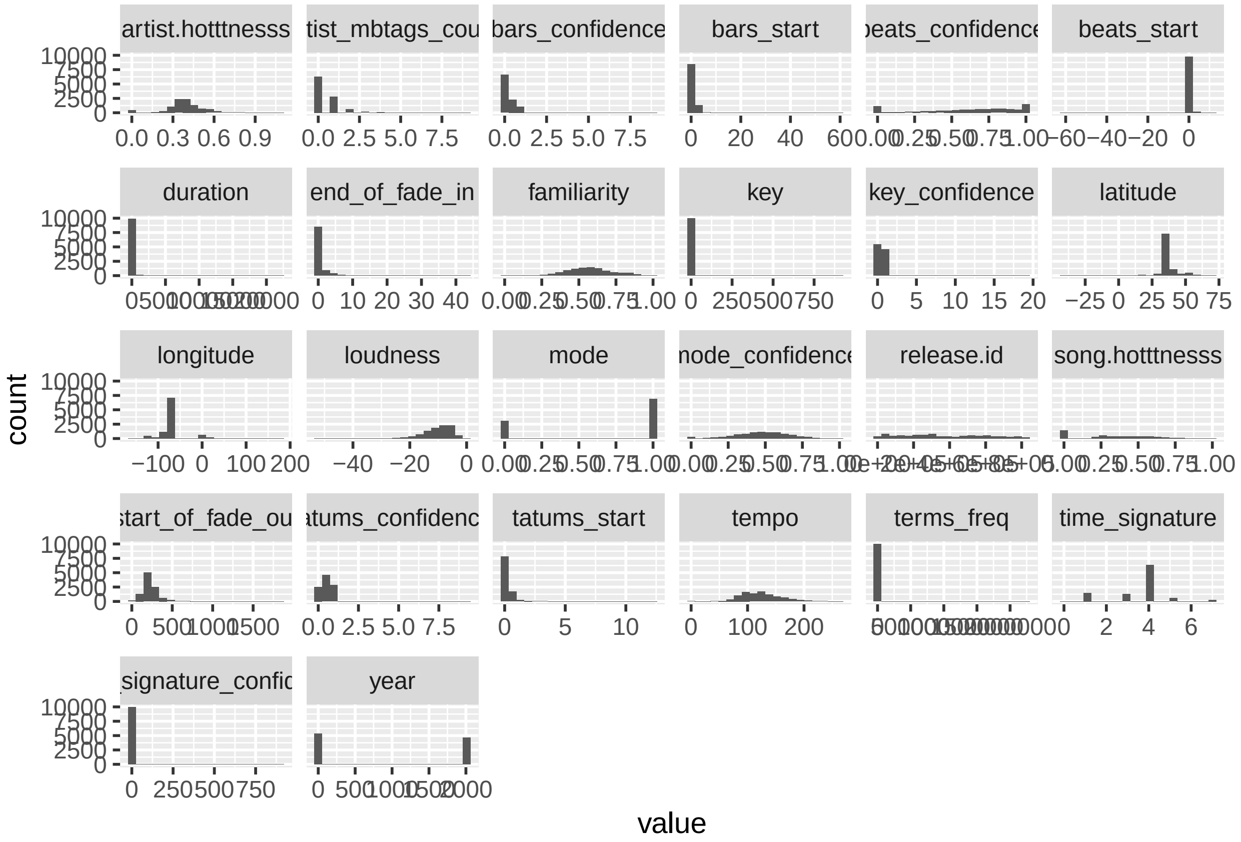
```
## Warning in describeBy(music, ): no grouping variable requested
```

```
##                           vars    n      mean        sd    median   trimmed       mad       min
## artist.hotttnesss            1 9996      0.39      0.14      0.38      0.39      0.09      0.00
## artist.id*                   2 9996   1905.96   1122.20   1881.50   1900.72   1429.23      1.00  3885
## artist.name*                 3 9996   2205.03   1269.94   2194.00   2206.58   1623.45      1.00  4409
## artist_mbtags*               4 9996     50.06     79.27      1.00     33.38      0.00      1.00   277
## artist_mbtags_count          5 9996      0.52      0.88      0.00      0.34      0.00      0.00     9
## bars_confidence              6 9996      0.24      0.29      0.12      0.19      0.15      0.00     8
## bars_start                   7 9996      1.07      1.72      0.79      0.84      0.57      0.00    59
## beats_confidence             8 9996      0.61      0.32      0.69      0.64      0.33      0.00
## beats_start                 9 9996      0.43      0.81      0.33      0.35      0.22  -60.00       12
## duration                   10 9996    240.63    246.13    223.06    226.88     73.82    1.04    22050
## end_of_fade_in             11 9996      0.76      1.86      0.20      0.33      0.30    0.00       43
## familiarity                12 9996      0.57      0.16      0.56      0.57      0.15    0.00        1
## key                        13 9996      5.37      9.67      5.00      5.25      4.45    0.00      904
## key_confidence             14 9996      0.45      0.33      0.47      0.45      0.31    0.00       19
## latitude                   15 9996     37.16      9.54     37.16     37.45      0.00  -41.28       69
## location*                  16 9996    596.91    238.96    705.00    616.26     65.23    1.00     1040
## longitude                  17 9996    -63.93     30.90    -63.93    -67.56      0.00 -162.44      174
## loudness                   18 9996    -10.49      5.40     -9.38     -9.84      4.75  -51.64        0
## mode                       19 9996      0.69      0.46      1.00      0.74      0.00    0.00        1
## mode_confidence            20 9996      0.48      0.19      0.49      0.48      0.18    0.00        1
## release.id                 21 9996 370953.83 236766.22 333100.50 364626.38 294894.33    0.00   823599
## release.name*              22 9996   3921.32   2257.12   3902.50   3923.69   2899.22    1.00     7830
## similar*                   23 9996   1416.79    822.48   1402.00   1418.57   1077.85    1.00     2837
## song.hotttnesss            24 5648      0.34      0.25      0.36      0.34      0.27    0.00        1
## song.id*                   25 9996   4998.50   2885.74   4998.50   4998.50   3705.02    1.00     9996
## start_of_fade_out          26 9996    229.89    112.04    213.88    218.25     71.55  -21.39     1813
## tatums_confidence          27 9996      0.51      0.33      0.50      0.51      0.40    0.00        9
## tatums_start               28 9996      0.30      0.51      0.19      0.21      0.13    0.00       12
## tempo                      29 9996    122.90     35.20    120.16    121.09     34.87    0.00      262
## terms*                     30 9996    215.27    129.18    214.00    212.02    169.02    1.00      459
## terms_freq                 31 9996    224.98  22396.64      1.00      0.98      0.00    0.00  2239217
## time_signature             32 9996      3.56      1.27      4.00      3.65      0.00    0.00        7
## time_signature_confidence  33 9996      0.60      8.99      0.55      0.51      0.53    0.00      898
## title*                     34 9996   4863.28   2799.10   4859.50   4864.67   3586.41    1.00     9705
## year                       35 9996    935.08    996.67      0.00    917.89      0.00    0.00     2010
## artist.hotttness.label*    36 9996      2.19      0.85      2.00      2.24      1.48    1.00        3
```

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

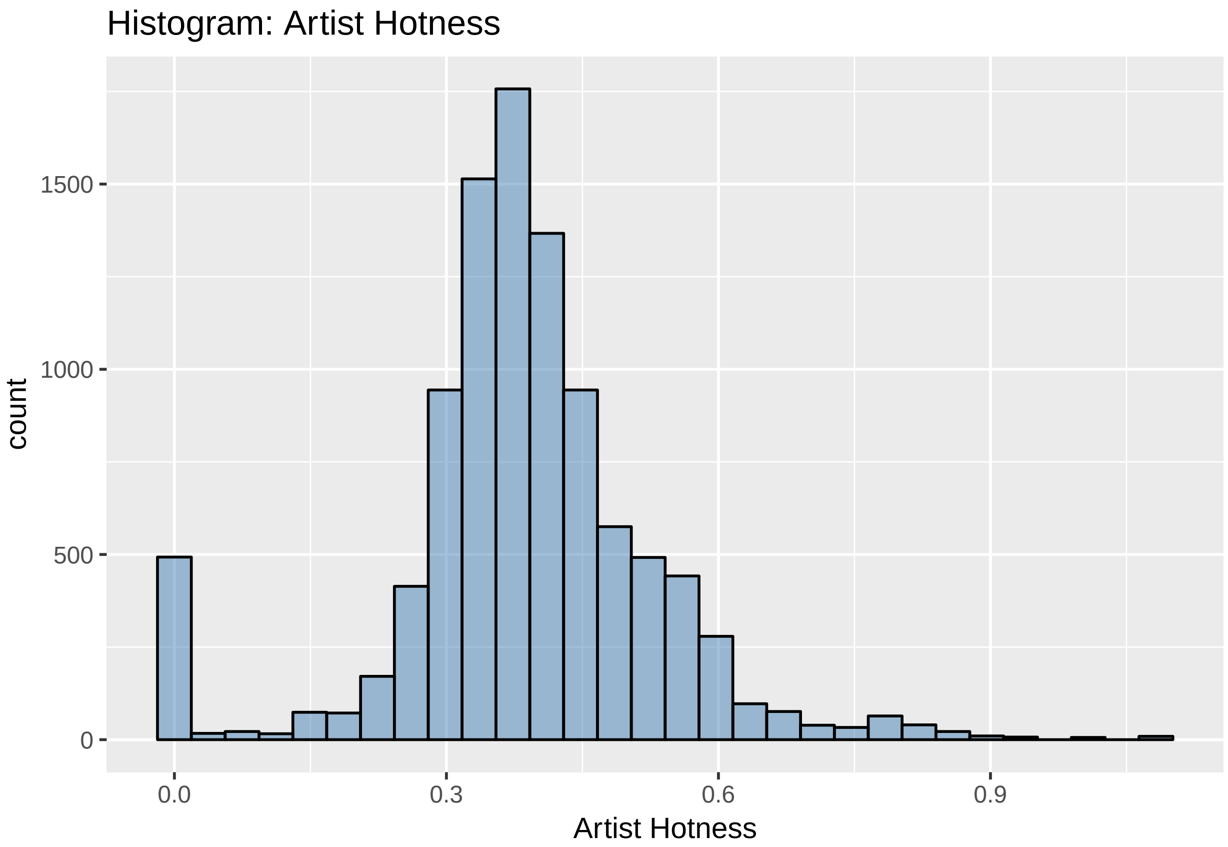
```
## Using artist.id, artist.name, artist_mbtags, location, release.name, similar, song.id, terms, title,
```

```
## Warning: Removed 4348 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/Gi
#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 Quantile.25% Quantile.50% Quantile.
##    0.3857065    0.3807564    0.0000000    1.0825026    0.1434688    0.3255062    0.3807564    0.4539
```

```
##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)
```

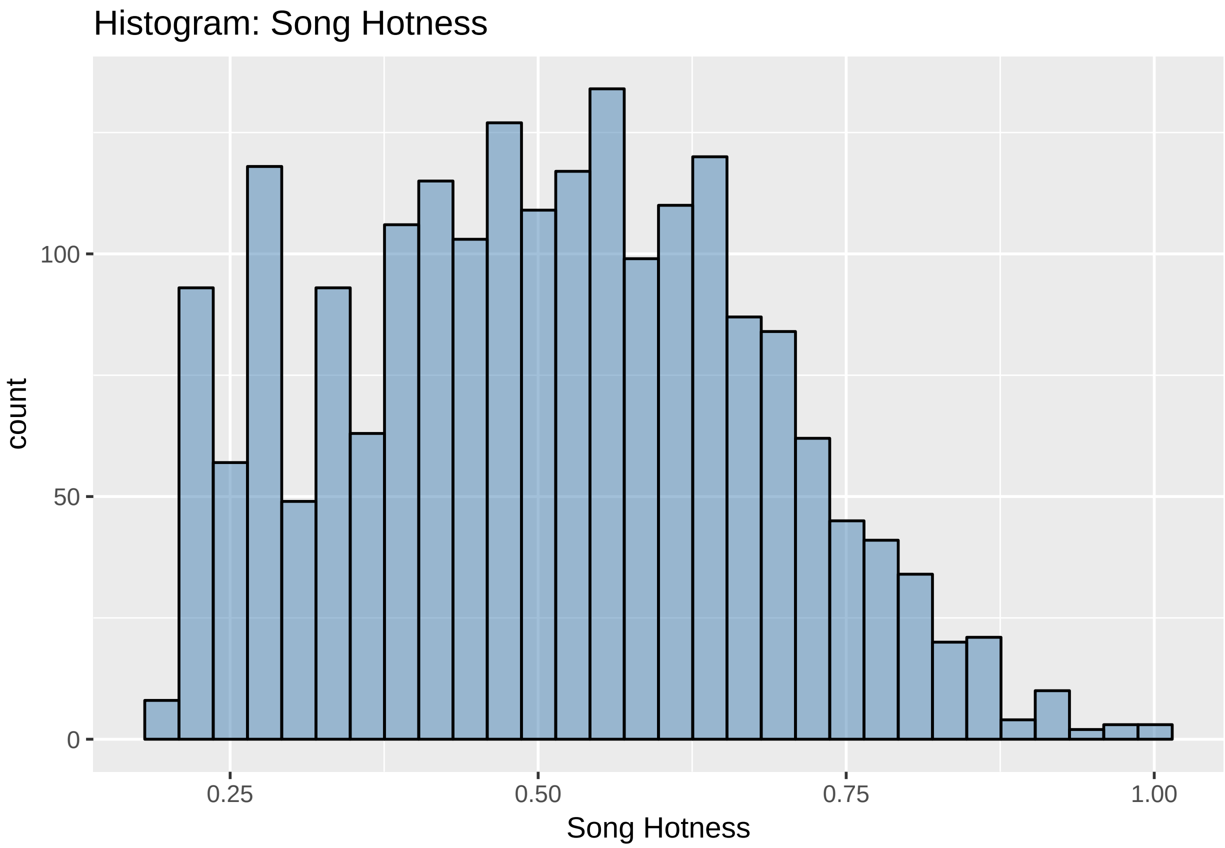
```
## 'data.frame':    5648 obs. of  23 variables:
##  $ artist.hotttnesss        : num  0.402 0.402 0.332 0.296 0.352 ...
##  $ bars_confidence          : num  0.643 0.175 0.806 0.873 0.018 0.013 1 0.507 0.125 0.03 ...
##  $ beats_confidence         : num  0.834 0.883 0.44 0.873 1 0.699 1 0 0.768 1 ...
##  $ 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.hotttnesss.label  : Factor w/ 3 levels "Cold","Hot","Warm": 3 3 1 1 3 3 1 3 1 2 ...
##  $ 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(cmbomu
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`.
```


Histogram: Song Hotness

```
##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 Quantile.25% Quantile.50% Quantile.7
##    0.5073226    0.5096410    0.1938578    1.0000000    0.1686679    0.3827233    0.5096410    0.6301
```

```
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 777947
##  $ 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 37 301 198 107
##  $ 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.hotttness.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 320
##  $ 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 777947
##  $ 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 37 301 198 107
##  $ 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.hotttness.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 320
##  $ 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

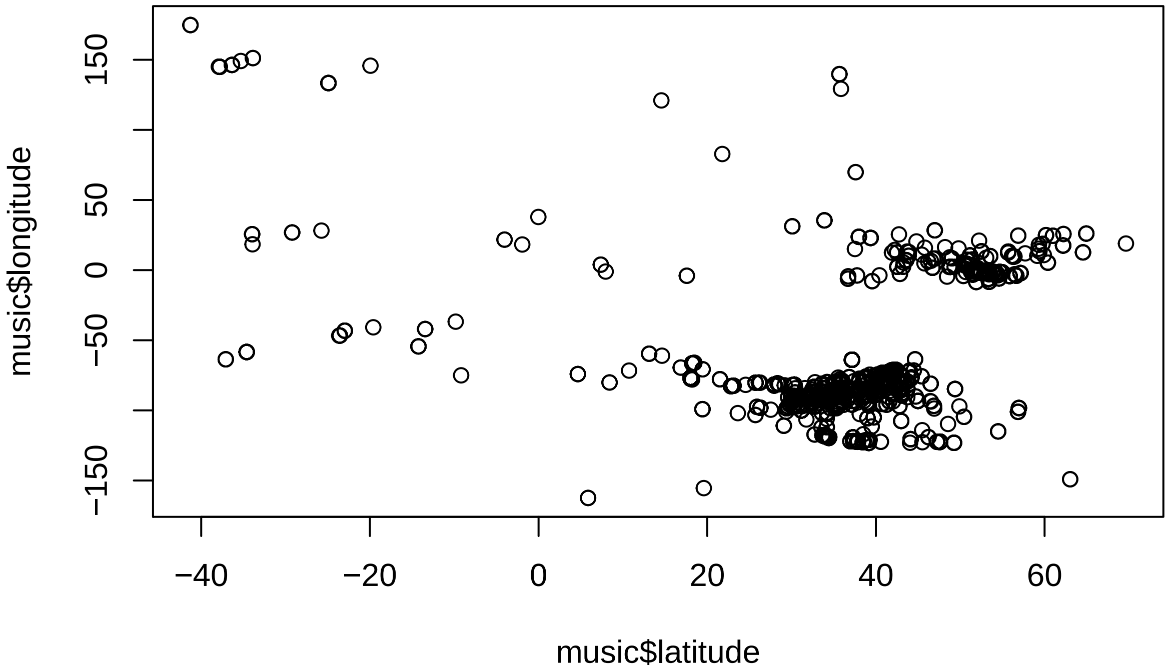
```
#View the number of Cold/Warm/Hot labels
table(music$artist.hotttnesss.label)
```

```
##
## Cold  Hot Warm
## 1180 1579 2889
```

```
#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 ...
```

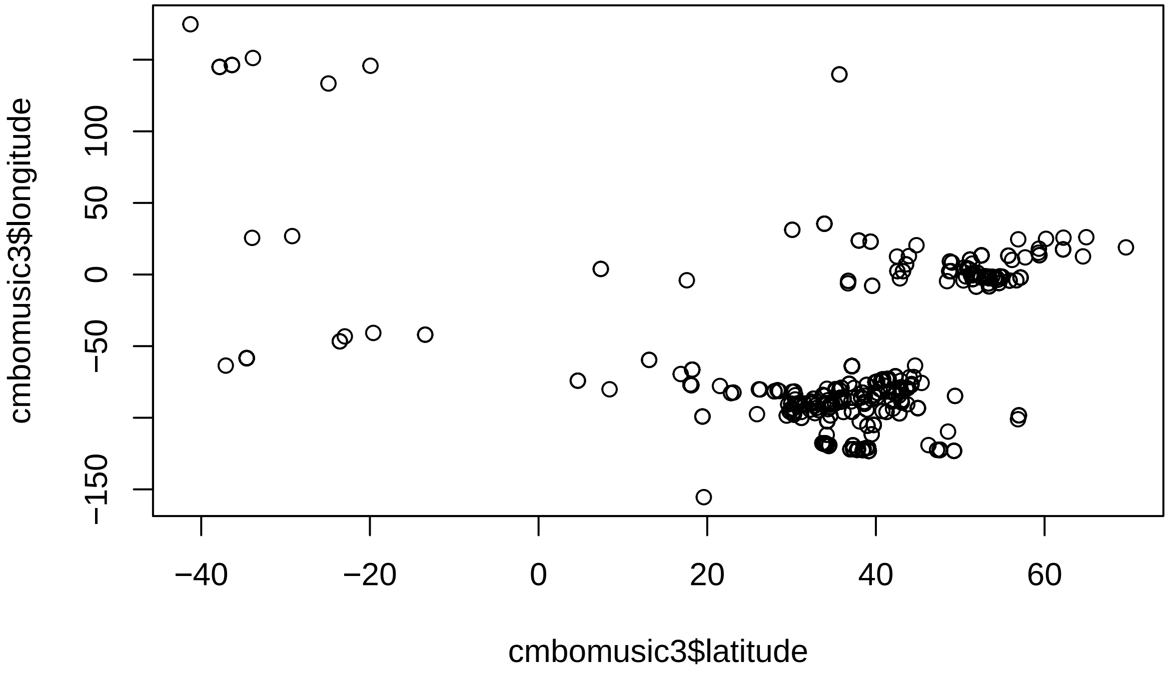
```
#View the number of Cold/Warm/Hot labels
table(cmbomusic3$song.hotness.label)
```

```
##
## 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)
```



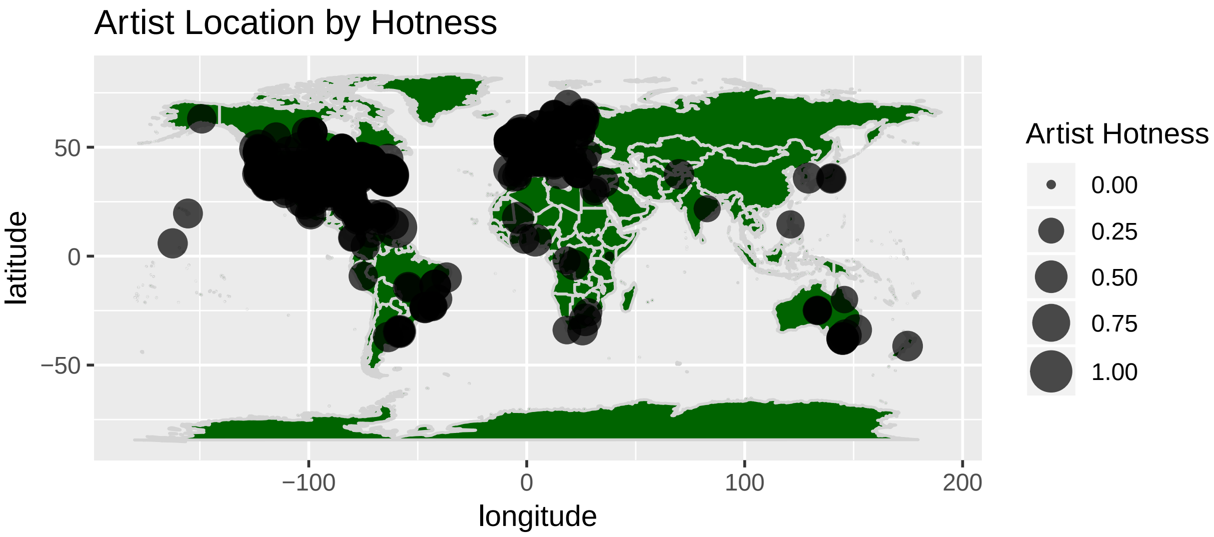
```
#Plot artist hotttnesss
#hist(music$artist.hotttnesss,breaks=20)
#hist(music$artist.hotness,breaks=20)
```

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

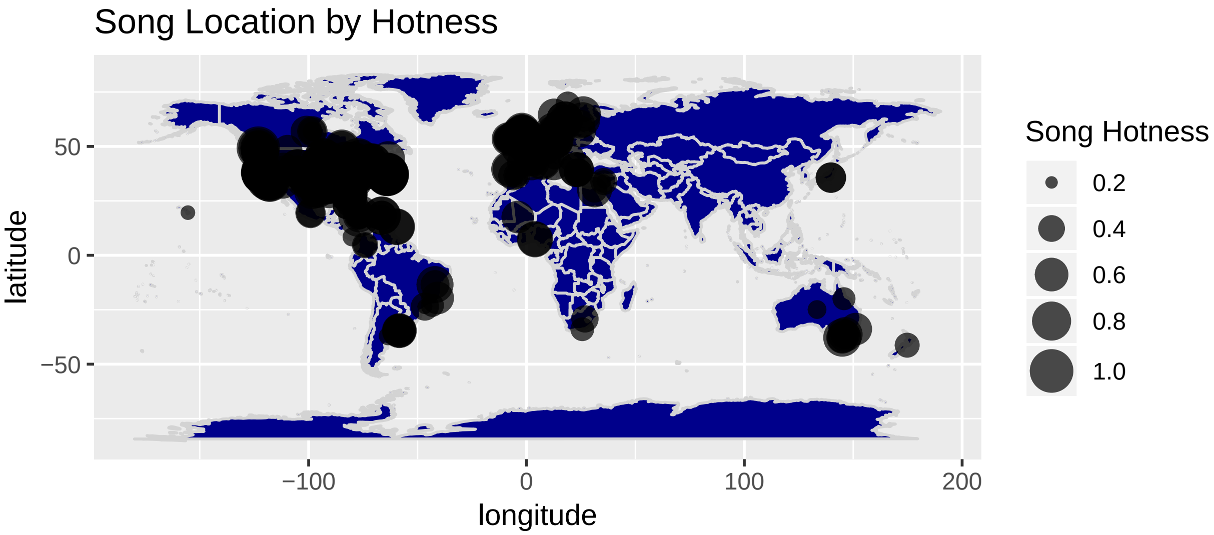
```
#New code from John for creating a map of the world showing latitude/longitude and artist hotness
#Code based on info from https://rpubs.com/spoonerf/global_map
library(dplyr)
```

```
##
## 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="dark green",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="dark blue",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

```
library("PerformanceAnalytics")
```

```
## Loading required package: xts

## Loading required package: zoo

##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric

## Registered S3 method overwritten by 'xts':
##   method     from
##   as.zoo.xts zoo

##
## Attaching package: 'xts'

## The following objects are masked from 'package:dplyr':
##
##     first, last

##
## Attaching package: 'PerformanceAnalytics'

## The following objects are masked from 'package:moments':
```

```
##
##     kurtosis, skewness
```

```
## The following object is masked from 'package:graphics':
##
##     legend
```

```
#code from Juan
#Artist prediction
lm1 <- lm(formula = music$artist.hotttnesss ~ music$year + music$bars_confidence +music$tempo + music$du
music$tempo + music$longitude + music$beats_start + music$beats_confidence +  music$end_of_fade_in)
#removed music$bars_start which was causing an error

#Songs with labels
lm2 <- lm(cmbomusic3$song.hotttnesss ~ cmbomusic3$year + cmbomusic3$loudness + cmbomusic3$tatums_confide

#Songs no labels
lm3 <- lm(cmbomusic3$song.hotttnesss ~ cmbomusic3$year + cmbomusic3$loudness + cmbomusic3$tatums_confide


summary(lm1)
```

```
##
## 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)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.41865 -0.03239 -0.00136  0.03219  0.50014
##
## Coefficients:
##                           Estimate Std. Error t value Pr(>|t|)
## (Intercept)              1.500e-02  8.045e-03   1.865   0.0622 .
## music$year               6.911e-06  1.081e-06   6.392 1.77e-10 ***
## music$bars_confidence   -4.242e-04  3.754e-03  -0.113   0.9100
## music$tempo             -3.122e-05  3.082e-05  -1.013   0.3111
## music$duration           1.842e-05  1.881e-05   0.979   0.3276
## music$start_of_fade_out -2.842e-05  2.121e-05  -1.340   0.1803
## music$tatums_start      -5.004e-03  7.041e-03  -0.711   0.4773
## music$familiarity        6.625e-01  7.156e-03  92.582  < 2e-16 ***
## music$latitude          -1.039e-04  1.006e-04  -1.033   0.3015
## music$longitude         -5.606e-05  3.190e-05  -1.758   0.0789 .
## music$beats_start        5.494e-03  6.748e-03   0.814   0.4155
## music$beats_confidence  -2.277e-03  3.227e-03  -0.706   0.4804
## music$end_of_fade_in     9.355e-05  6.367e-04   0.147   0.8832
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.07602 on 5635 degrees of freedom
## Multiple R-squared:  0.6443, Adjusted R-squared:  0.6436
## F-statistic: 850.6 on 12 and 5635 DF,  p-value: < 2.2e-16
```

```r
summary(lm2)
```

```
##
## Call:
## lm(formula = cmbomusic3$song.hotttnesss ~ cmbomusic3$year + cmbomusic3$loudness +
##     cmbomusic3$tatums_confidence + cmbomusic3$tatums_start +
##     cmbomusic3$tempo + cmbomusic3$terms_freq + cmbomusic3$time_signature_confidence +
##     cmbomusic3$year + factor(cmbomusic3$song.hotttnesss.label) +
##     factor(cmbomusic3$song.hotness.label))
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.091973 -0.025431 -0.000346  0.019615  0.262749
##
## Coefficients:
##                                                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)                                      7.378e-01  2.254e-01   3.273  0.00108 **
## cmbomusic3$year                                 -1.955e-04  1.119e-04  -1.747  0.08071 .
## cmbomusic3$loudness                              4.688e-04  2.289e-04   2.048  0.04070 *
## cmbomusic3$tatums_confidence                     5.998e-04  3.520e-03   0.170  0.86473
## cmbomusic3$tatums_start                         -3.365e-04  1.940e-03  -0.174  0.86226
## cmbomusic3$tempo                                 3.435e-05  3.042e-05   1.129  0.25891
## cmbomusic3$terms_freq                            2.783e-03  2.177e-02   0.128  0.89827
## cmbomusic3$time_signature_confidence             4.067e-03  3.476e-03   1.170  0.24217
## factor(cmbomusic3$song.hotttnesss.label)Frigid -9.418e-02  4.209e-03 -22.373  < 2e-16 ***
## factor(cmbomusic3$song.hotttnesss.label)Hot     2.351e-01  7.613e-03  30.877  < 2e-16 ***
## factor(cmbomusic3$song.hotttnesss.label)Tepid   5.401e-02  4.676e-03  11.550  < 2e-16 ***
## factor(cmbomusic3$song.hotttnesss.label)Warm    1.374e-01  7.112e-03  19.321  < 2e-16 ***
## factor(cmbomusic3$song.hotness.label)Hot        1.504e-01  7.127e-03  21.103  < 2e-16 ***
## factor(cmbomusic3$song.hotness.label)Warm       3.659e-02  5.961e-03   6.139 9.96e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.04478 on 2023 degrees of freedom
## Multiple R-squared:   0.93,  Adjusted R-squared:  0.9295
## F-statistic:  2067 on 13 and 2023 DF,  p-value: < 2.2e-16
```

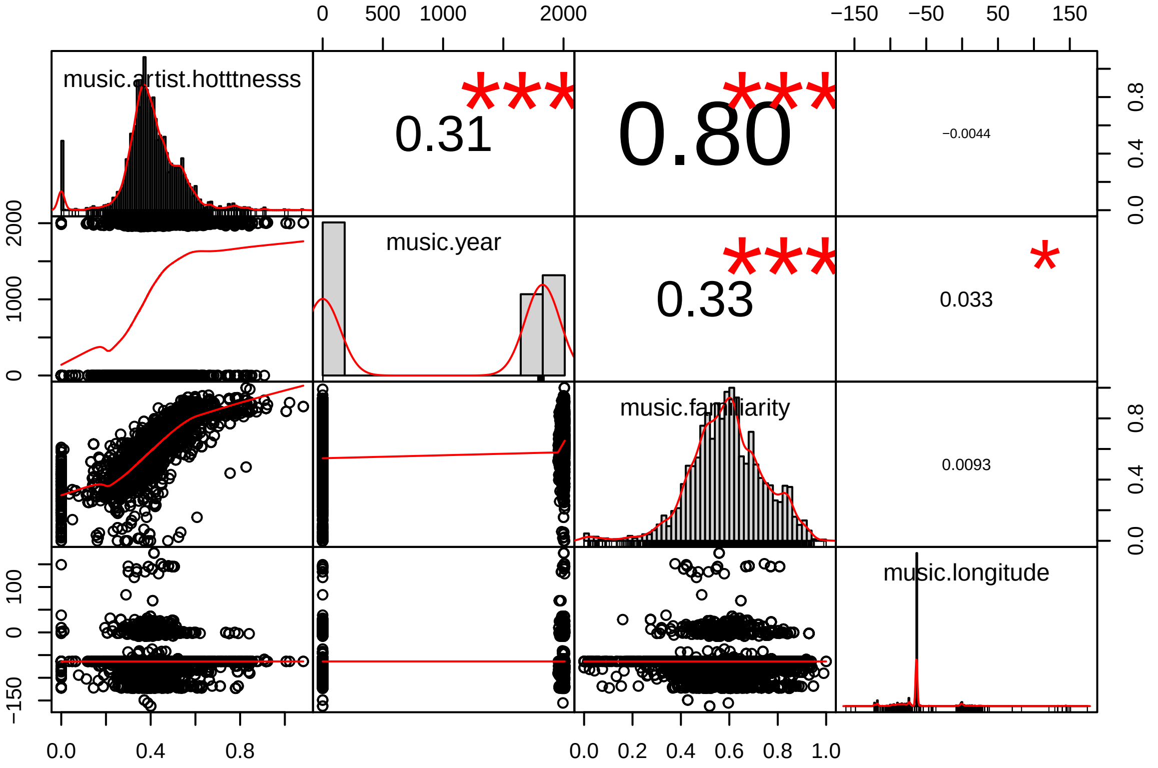
```r
summary(lm3)
```

```
##
## Call:
## lm(formula = cmbomusic3$song.hotttnesss ~ cmbomusic3$year + cmbomusic3$loudness +
##     cmbomusic3$tatums_confidence + cmbomusic3$tatums_start +
##     cmbomusic3$tempo + cmbomusic3$terms_freq + cmbomusic3$time_signature_confidence +
##     cmbomusic3$year)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.34868 -0.12344 -0.00192  0.11879  0.50615
##
## Coefficients:
##                                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)                          -0.0030165  0.8243585  -0.004    0.997
## cmbomusic3$year                       0.0002593  0.0004092   0.634    0.526
## cmbomusic3$loudness                     0.0082323  0.0008177  10.068   <2e-16 ***
## cmbomusic3$tatums_confidence           -0.0057153  0.0128559  -0.445    0.657
## cmbomusic3$tatums_start                -0.0010096  0.0070970  -0.142    0.887
## cmbomusic3$tempo                        0.0001436  0.0001112   1.291    0.197
## cmbomusic3$terms_freq                   0.0515568  0.0794760   0.649    0.517
## cmbomusic3$time_signature_confidence    0.0021321  0.0127176   0.168    0.867
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1639 on 2029 degrees of freedom
## Multiple R-squared:  0.05922,    Adjusted R-squared:  0.05597
## F-statistic: 18.24 on 7 and 2029 DF,  p-value: < 2.2e-16
```

```
#Artist hotness correlation
cor1 <- data.frame(music$artist.hotttnesss, music$year, music$familiarity, music$longitude)
cor(cor1)
```

```
##                            music.artist.hotttnesss music.year music.familiarity music.longitude
## music.artist.hotttnesss                1.000000000 0.31443416       0.800773449    -0.004446176
## music.year                             0.314434159 1.00000000       0.333867762     0.032639949
## music.familiarity                      0.800773449 0.33386776       1.000000000     0.009304099
## music.longitude                       -0.004446176 0.03263995       0.009304099     1.000000000
```

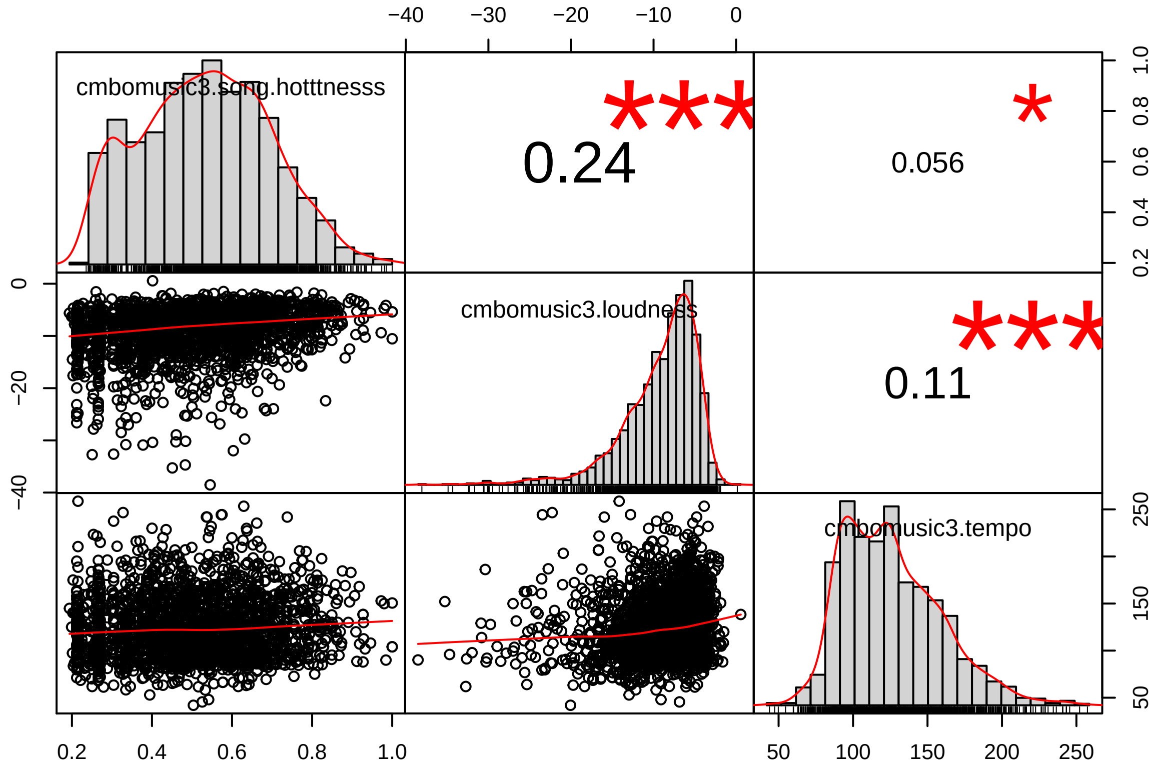
```
#install.packages("PerformanceAnalytics")
library(PerformanceAnalytics)
chart.Correlation(cor1, histogram=TRUE, pch=10, cex.labels=2.9)
```



```
#Song hotness correlation
cor2 <- data.frame(cmbomusic3$song.hotttnesss, cmbomusic3$loudness, cmbomusic3$tempo)
cor(cor2)
```

```
##                               cmbomusic3.song.hotttnesss cmbomusic3.loudness cmbomusic3.tempo
## cmbomusic3.song.hotttnesss                 1.00000000           0.2406421       0.05570821
## cmbomusic3.loudness                        0.24064215           1.0000000       0.11259809
## cmbomusic3.tempo                           0.05570821           0.1125981       1.00000000
```

```
chart.Correlation(cor2, histogram=TRUE, pch=10, cex.labels=2.9)
```



```
#svm
library(kernlab)
```

```
##
## Attaching package: 'kernlab'

## The following object is masked from 'package:psych':
##
##     alpha

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

```
library(e1071)
```

```
##
## Attaching package: 'e1071'

## The following objects are masked from 'package:PerformanceAnalytics':
##
##     kurtosis, skewness

## The following objects are masked from 'package:moments':
##
##     kurtosis, moment, skewness
```

```
rndm <- sample(1:dim(music)[1])
summary(rndm)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##       1    1413    2824    2824    4236    5648
```

```
length(rndm)
```

```
## [1] 5648
```

```
cut <- floor(2 * dim(music)[1]/3)
cut
```

```
## [1] 3765
```

```
train <- music[rndm[1:cut],]
test <- music[rndm[(cut + 1):dim(music)[1]],]
svm0 <- ksvm(artist.hotttnesss.label ~ ., data=train, kernel= "rbfdot", kpar="automatic", C=5, cross=3,
svm0
```

```
## Support Vector Machine object of class "ksvm"
##
## SV type: C-svc  (classification)
##  parameter : cost C = 5
##
## Gaussian Radial Basis kernel function.
##  Hyperparameter : sigma =  0.045254225887197
##
## Number of Support Vectors : 874
##
## Objective Function Value : -49.6253 -1108.442 -581.8383
## Training error : 0.03081
## Cross validation error : 0.060027
## Probability model included.
```

```
svmP <- predict(svm0, test, type= "votes")
comp <- data.frame(test[,22],(svmP[1,]))
table(comp)
```

```
##           X.svmP.1....
## test...22.   0   1   2
##       Cold   0  58 331
##       Hot  526   0   0
##       Warm 268 695   5
```

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,]
```

```r
#Run randomForest on 3 levels
#library(randomForest)
#John commented out rf because it is running against the same file (music) as rf2
#set.seed(222)
#rf <- randomForest(music[,c(-1,-21,-22)],music[,21])
#print(rf)
#attributes(rf)
#rf$confusion
#Run randomForest on 5 levels
#John added -1 to remove the hotness variable from the rf
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
```

```r
set.seed(222)
rf2 <- randomForest(music[,c(-1,-22,-23)],music[,22])
print(rf2)
```

```
## 
## Call:
##  randomForest(x = music[, c(-1, -22, -23)], 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: 20.18%
## Confusion matrix:
##      Cold  Hot Warm class.error
## Cold  728    4  448   0.3830508
## Hot     6 1289  284   0.1836605
## Warm  200  198 2491   0.1377639
```

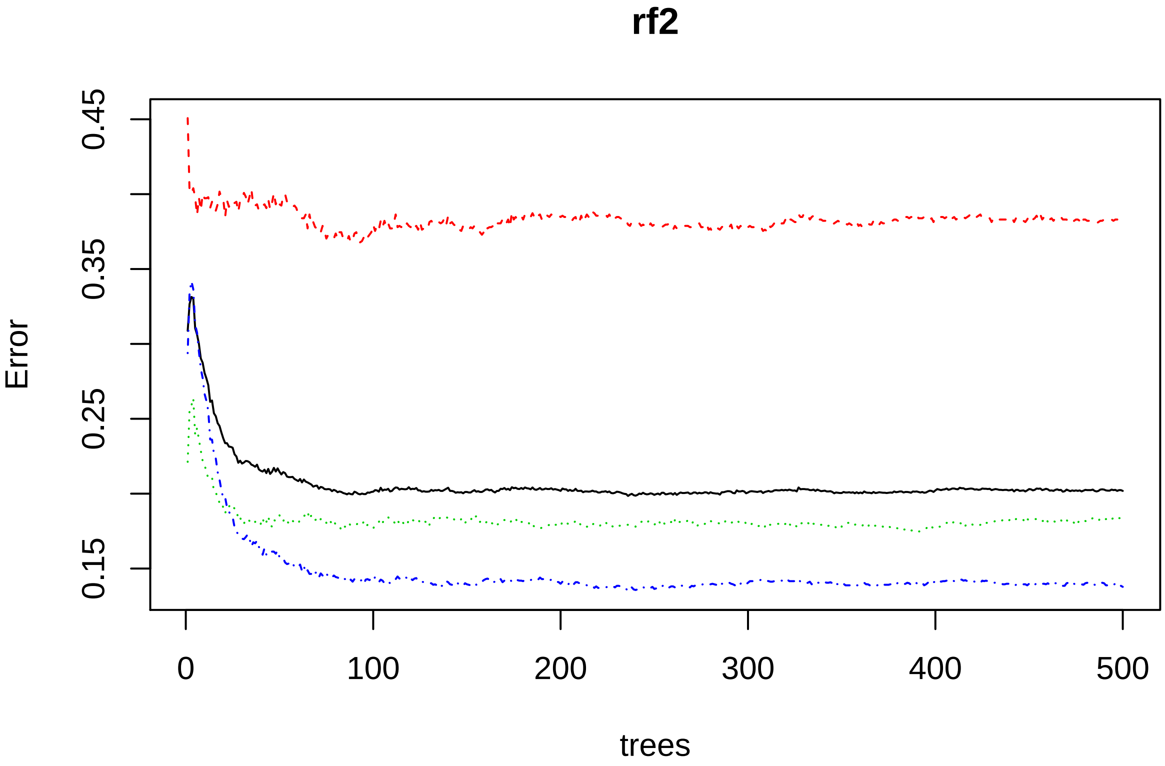
```r
attributes(rf2)
```

```
## $names
##  [1] "call"            "type"            "predicted"       "err.rate"        "confusion"       "vote
## 
## $class
## [1] "randomForest"
```

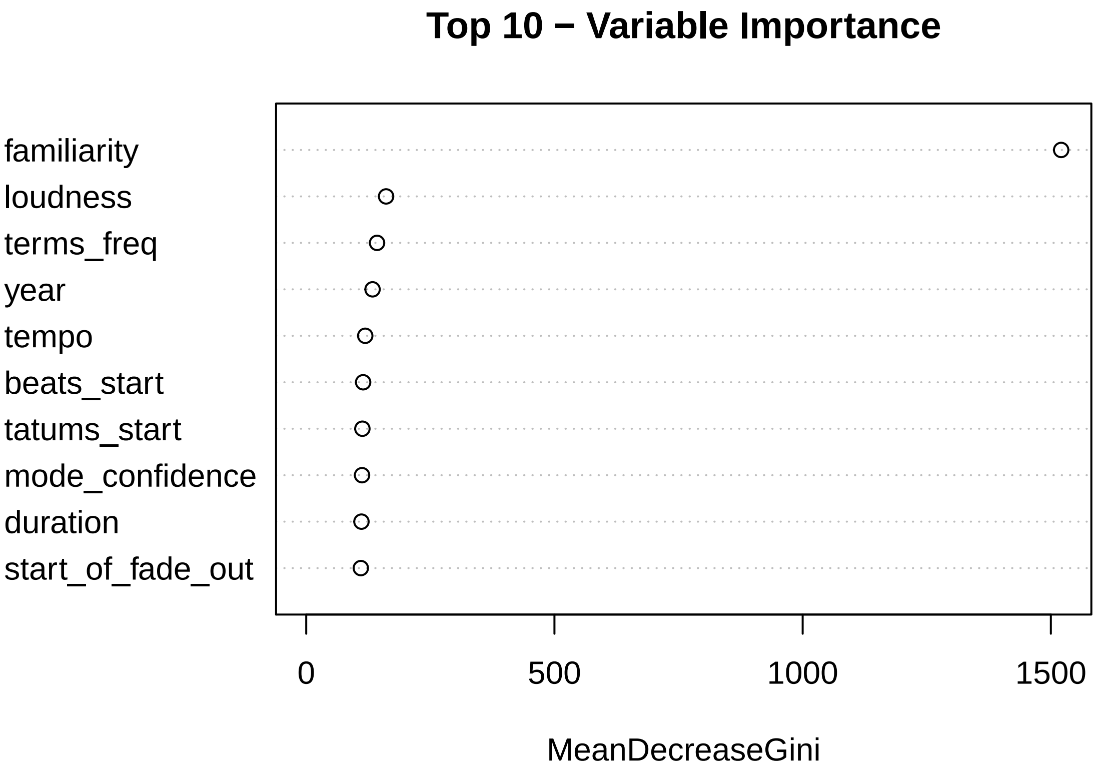
```
rf2$confusion
```

```
##       Cold  Hot Warm class.error
## Cold   728    4  448   0.3830508
## Hot      6 1289  284   0.1836605
## Warm   200  198 2491   0.1377639
```

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



```r
importance(rf2)
```

```
##                          MeanDecreaseGini
## bars_confidence                 107.58378
## beats_confidence                 94.47263
## beats_start                     114.60290
## duration                        111.20674
## end_of_fade_in                   88.18414
## familiarity                    1520.73102
## key                              70.97697
## key_confidence                  107.84287
## latitude                         80.31500
## longitude                        80.00661
## loudness                        160.85558
## mode_confidence                 112.40895
## start_of_fade_out               109.94686
## tatums_confidence               100.29904
## tatums_start                    113.12138
## tempo                           118.86929
## terms_freq                      142.67373
## time_signature                   31.82993
## time_signature_confidence        81.87304
## year                            133.56141
```

```r
varUsed(rf2)
```

```
##  [1] 22981 20248 24173 23234 18362 42545 16709 23076 13678 13543 26260 23733 23098 21580 23800 24889
```

```r
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: 51.74%
## Confusion matrix:
##      Cold Hot Warm class.error
## Cold  297  29  381   0.5799151
## Hot    76 118  246   0.7318182
## Warm  244  78  568   0.3617978
```

```
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: 51.74%
## Confusion matrix:
##      Cold Hot Warm class.error
## Cold  297  29  381   0.5799151
## Hot    76 118  246   0.7318182
## Warm  244  78  568   0.3617978
```

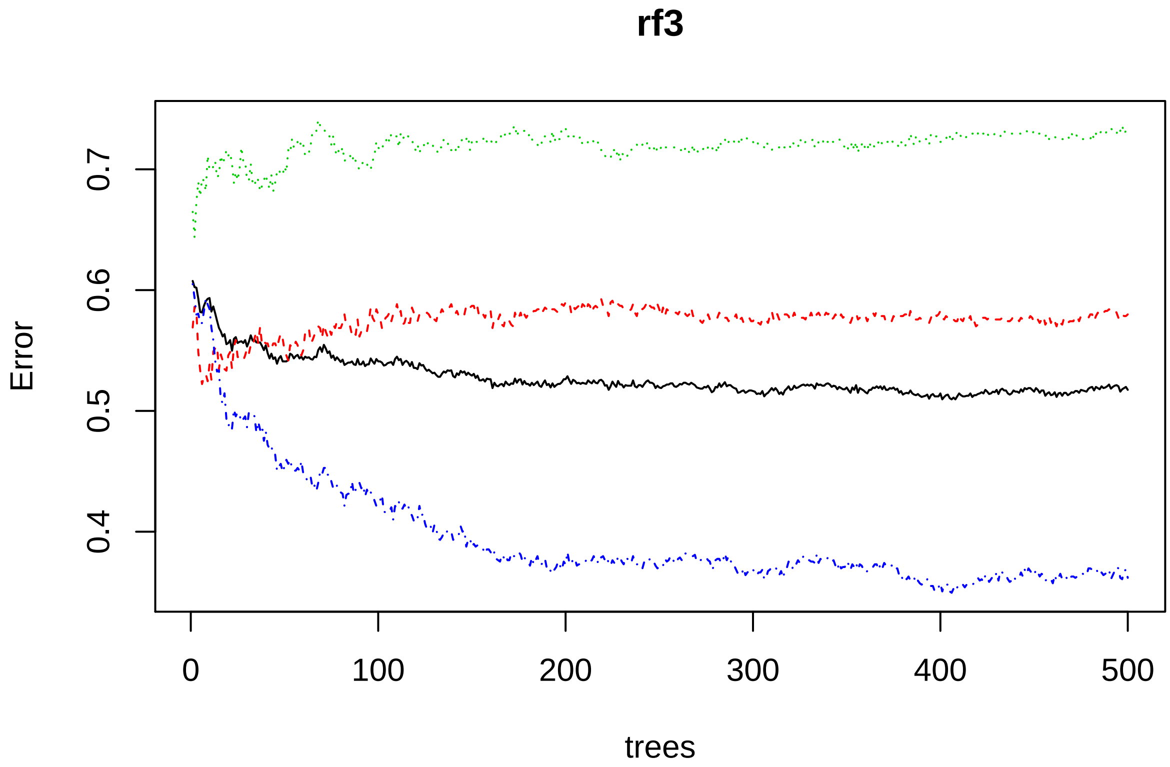
```
attributes(rf3)
```

```
## $names
##  [1] "call"            "type"            "predicted"       "err.rate"        "confusion"       "vote
##
## $class
## [1] "randomForest"
```

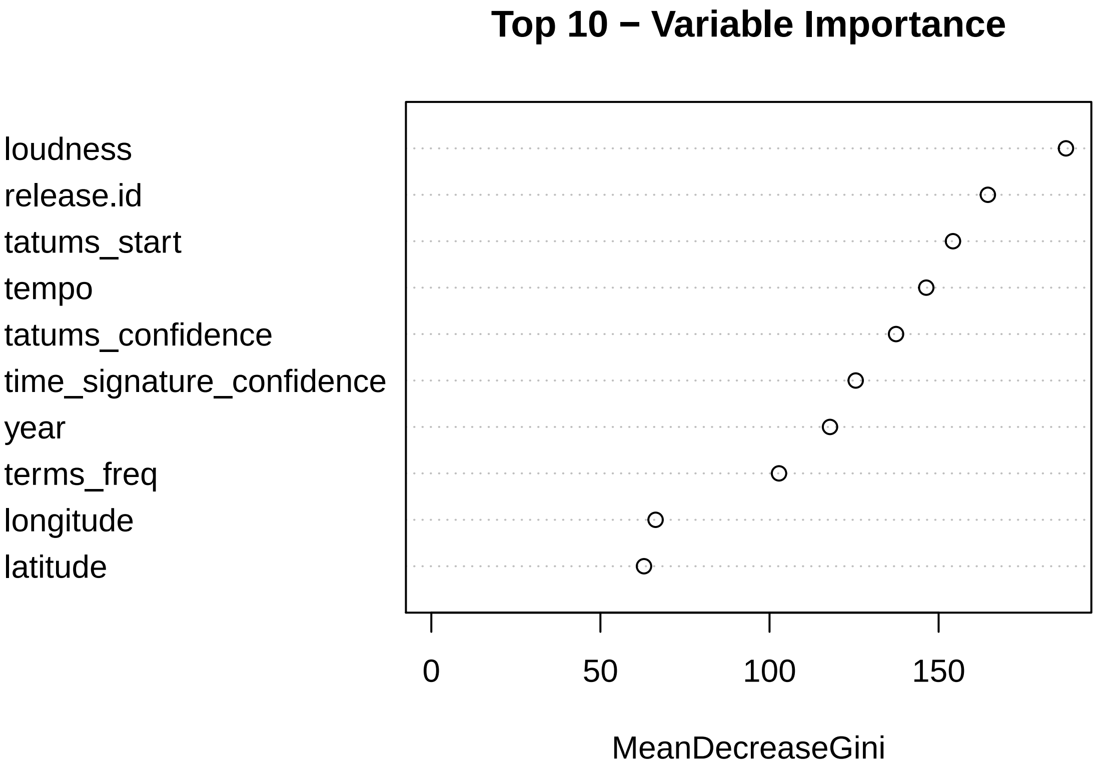
```
rf3$confusion
```

```
##      Cold Hot Warm class.error
## Cold  297  29  381   0.5799151
## Hot    76 118  246   0.7318182
## Warm  244  78  568   0.3617978
```

```
plot(rf3)
```



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



## Results

Conclusion

Appendices