Data Analysis Project 2: Mobile User Activity Predictor

Define the question

Objective

Build a function that predicts what activity a subject is performing based on the quantitative measurements from the Samsung phone.

Data

The UCI Machine Learning Repository is a collection of databases, domain theories, and data generators that are used by the machine learning community for the empirical analysis of machine learning algorithms. The Human Activity Recognition database was built from the recordings of 30 subjects performing activities of daily living (ADL) while carrying a waist-mounted smartphone with embedded inertial sensors.

The database is comprised of the results of experiments that have been carried out with a group of 30 volunteers within an age bracket of 19-48 years. Each person performed six activities (Walking,Walking-Upstairs, Walking-Downstairs, Sitting, Standing, and Laying) wearing a smartphone (Samsung Galaxy S II) on the waist. Using the devices' embedded accelerometer and gyroscope, the experiments captured 3-axial linear acceleration and 3-axial angular velocity at a constant rate of 50Hz. The experiments have been video-recorded to label the data manually. The obtained dataset has been randomly partitioned into two sets, where 70% of the volunteers was selected for generating the training data and 30% the test data.

The sensor signals (accelerometer and gyroscope) were pre-processed by applying noise filters and then sampled in fixed-width sliding windows of 2.56 sec and 50% overlap (128 readings/window). The sensor acceleration signal, which has gravitational and body motion components, was separated using a Butterworth low-pass filter into body acceleration and gravity. The gravitational force is assumed to have only low frequency components, therefore a filter with 0.3 Hz cutoff frequency was used. From each window, a vector of features was obtained by calculating variables from the time and frequency domain.

Since we are performing a predictive analysis exercise, we will need to segment our data for cross-validation. We will have three data sets that minimally include the following subjects:

- Training Subjects: 1,3,5 and 6
- Test Subjects: TBD
- Validation Subjects: 27, 28, 29, 30

We will ensure that there will be no overlap between subjects in the training and test sets that are also in the validation set.

Define the ideal data set

We only had observatiosn from 21 of the 30 subjects. Ideally, it would have been better to have observations for all 30 subjects. Optimally, observatiosn from a much broader set of subjects help to improve our results.

Determine what data you can access

We have been provided a preprocessed set of the Samsung ADL data that is compliant with R.

All of the columns of the data set (except the last two) represents one measurement from the Samsung phone. The variable “subject”“ indicates which subject was performing the tasks when the measurements were taken. The variable "activity” tells what activity they were performing.

Getting Started

Project Setup

We have established a root project folder, *dap2*, that contains the following sub-directories:

- code: organizing sandbox and finalize code for reproducibility
- data: storing sample sets and project workspaces (.rda)
- artifacts: dedicated for the text artifacts of this endeavor

Environment Setup

We will set the working directory and suppress warning messages in our RStudio environment.

```
setwd("~/Activity/Education/Coursera/dataanalaysis/dap2")
options(warn = -1)
```

Obtain the data

```
fileURL = "https://spark-
public.s3.amazonaws.com/dataanalysis/samsungData.rda"
localFile =
"~/Activity/Education/Coursera/dataanalaysis/dap2/data/samsungData.rda"

download.file(fileURL, localFile, method = "curl")
load(localFile)
```

Observation: Our corpus is comprised of 7352 observations each containing 563 variables. We can access the data using our samsungData dataframe.

Handle required files and libraries

```
library(stringr)
library(randomForest)
```

```
## randomForest 4.6-7
```

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

```
library(tree)
library(caret)
```

```
## Loading required package: cluster
```

```
## Loading required package: foreach
```

```
## Loading required package: lattice
```

```
## Loading required package: plyr
```

```
## Loading required package: reshape2
```

```
## Load Utility Functions
incFile <-
"~/Activity/Education/Coursera/dataanalaysis/dap2/code/raw/adlUtils.R"

fileHandle <- file(incFile, open = "r")
source(fileHandle)
close(fileHandle)
```

Tidy Data Check

Our sample set conforms to a number of the Tidy Data requirements:

- Variables in columns
- Observations in rows
- Tables holding elements of only one kind
- Row names are easy to use and informative
- Variable values are internally consistent
- No mistakes in the data

However, we do need to address a few ETL items:

- Column names are not easy to use and informative
- Appropriate transformed variables have yet to be added

Remove noise

```
dim(samsungData)
```

```
## [1] 7352  563
```

```
cleanData <- complete.cases(samsungData)
sum(!cleanData)
```

```
## [1] 0
```

```
which(!cleanData)
```

```
## integer(0)
```

```
## haradl == Human Activity Recognition for Activities of Daily
Life
haradl <- samsungData[cleanData, ]
dim(haradl)
```

```
## [1] 7352  563
```

Observation: We have a fully populated corpus of 7352 observations each having values for all 563 variables. There are no missing or incomplete observations.

Extract, Transform and Load (ETL)

Transform 1: Repair poorly named columns. Remove all "()" from column names.

```
cleanColumnHeader <- function(s) {
    gsub("\\(", "<", gsub("\\)", ">", s))
}
uniqueColumnHeader <- function(s) {

}
cNames.org <- names(haradl)
cNames.clean <- sapply(cNames.org[], FUN = cleanColumnHeader)
cNames.new <- NULL
for (uID in 1:length(cNames.clean)) {
    if (uID < length(cNames.clean)) {
        cNames.new <- c(cNames.new, paste(cNames.clean[uID], uID,
sep = "--"))
    } else {
        cNames.new <- c(cNames.new, cNames.clean[uID])
    }
}
colnames(haradl) <- cNames.new
```

Transform 2: activity(string) to activityID(numeric)

```
getActivityID <- function(x) {
    activities <- as.vector(names(table(haradl$activity)))
    match(x, activities)
}
activityVector <- data.frame(sapply(X = as.vector(haradl$activity),
FUN = getActivityID))
colnames(activityVector) <- c("activityID")
haradl <- cbind(haradl, activityVector)
```

Transform 3: Create a Factor of Activities

The *activity* variable is not of type char-vector. We need to use this in several statistical formulas like tree() and randomForeest() where a factor is required.

```
t2.df <- data.frame(as.factor(haradl$activity))
haradl.activityList <- as.factor(names(table(t2.df)))
colnames(t2.df) <- c("activityFactor")
haradl <- cbind(haradl, t2.df)
str(haradl[562:565])
```

```
## 'data.frame':    7352 obs. of  4 variables:
##  $ subject--562  : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ activity      : chr  "standing" "standing" "standing"
"standing" ...
##  $ activityID    : int  3 3 3 3 3 3 3 3 3 3 ...
##  $ activityFactor: Factor w/ 6 levels "laying","sitting",..: 3 3
3 3 3 3 3 3 3 3 ...
```

Transform 4: Prune and Rename

Lets isolate a few variables that may be interesting. Let's focus on some z-axis variables.

```
## Pick interested features
haradl.zDataOne <- haradl[, c(562, 564, 565, 3, 43, 268, 123)]
colnames(haradl.zDataOne) <- c("subject", "activityID", "activity",
"zMeanBodyAcc",
    "zMeanGravityAcc", "zMeanFftBodyAcc", "zMeanBodyGyro")
```

Transform 5: Prune and Rename

We need to prune the data set down to interested features and rename variable to useful names.

```
## Pick interested features
haradl.xyzMean <- haradl[, c(562, 564, 565, 1, 2, 3, 41, 42, 43)]
colnames(haradl.xyzMean) <- c("subject", "activityID", "activity",
"xMeanBodyAcc",
    "yMeanBodyAcc", "zMeanBodyAcc", "xMeanGravityAcc",
"yMeanGravityAcc", "zMeanGravityAcc")
```

Prepare and Load Test Accuracy Accumulation Matrix

Our prediction modeling process may eventually compare prediction accuracy results from several iterative training and test runs. We will keep track of our accuracy results in a global dataframe.

```
prediction.results.accuracy <- data.frame(runID = as.character(),
adl = as.character(),
    accuracy = as.numeric(), oobError = as.numeric())
prediction.results.accuracy <- rbind(c("a", "a", "a", "a"),
prediction.results.accuracy)
colnames(prediction.results.accuracy) <- c("runID", "adl",
"accuracy", "oobError")
prediction.results.accuracy <- prediction.results.accuracy[-1, ]
```

Exploratory Data Analysis

Question 1

What was the distribution of tests performed?

```
table(haradl$activity)
```

```
##
##   laying  sitting standing     walk walkdown   walkup
##     1407     1286     1374     1226      986     1073
```

Observation: We do not have an even distribution of activity tests. Min(walkdown)=986, Max(laying)=1407. We need to take this into consideration when creating our sample sets.

Question 2

What was the distribution of tests performed per subject

```
subjectdist <- table(haradl$subject)
print(subjectdist)
```

```
##
##   1   3   5   6   7   8  11  14  15  16  17  19  21  22  23  25
26  27
## 347 341 302 325 308 281 316 323 328 366 368 360 408 321 372 409
392 376
##  28  29  30
## 382 344 383
```

```
min(subjectdist)
```

```
## [1] 281
```

```
max(subjectdist)
```

```
## [1] 409
```

```
length(subjectdist)
```

```
## [1] 21
```

Observation: We do not have an even distribution of activity tests per subject. Min(subject#8)=281, Max(subject#25)=409. We need to take this into consideration when creating our sample sets. We also only had observatiosn from 21 of the 30 subjects.

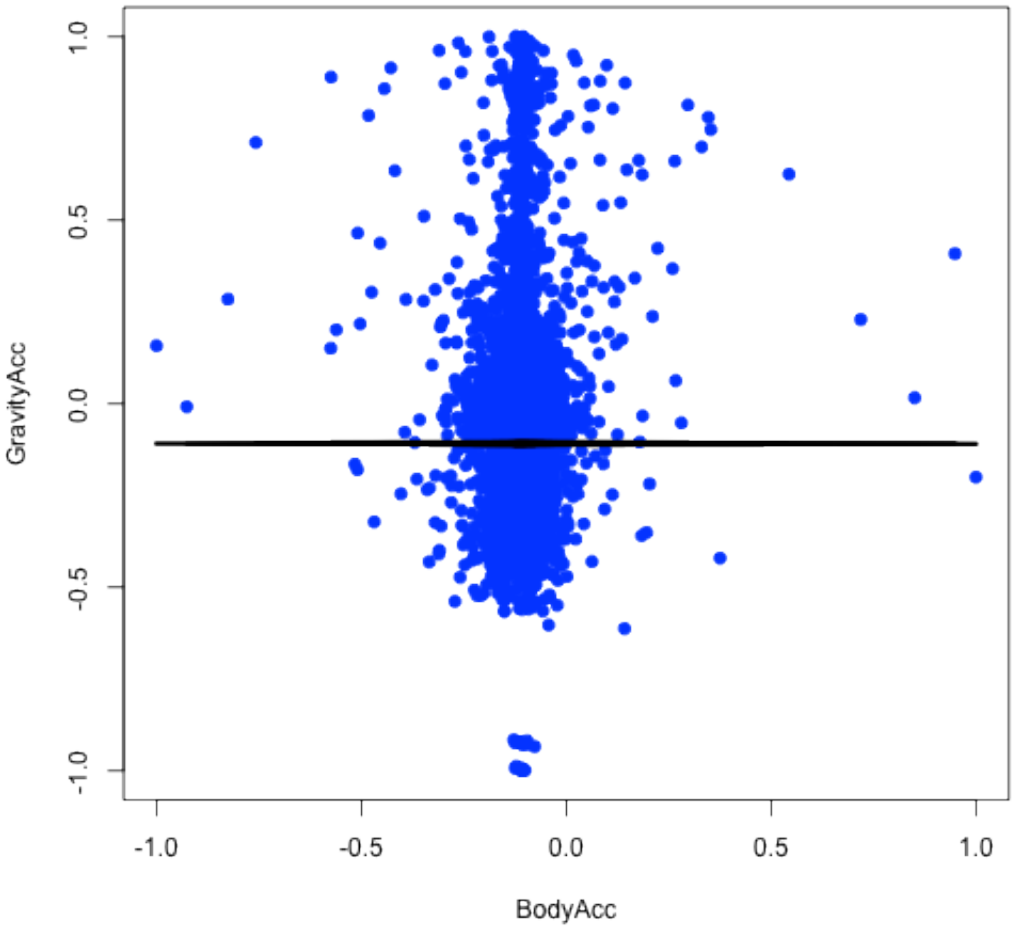
Question 3

We need to understand some of these variables. Lets look at tBodyAcc-XYZ. Is there a linear regression between Acceleration of the Body and Acceleration of Gravity?

```
## Plot linear Regression
q3.lm <- lm(zMeanBodyAcc ~ zMeanGravityAcc, data = haradl.zDataOne)
summary(q3.lm)
```

```
##
## Call:
## lm(formula = zMeanBodyAcc ~ zMeanGravityAcc, data =
haradl.zDataOne)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.8911 -0.0116 -0.0002  0.0115  1.1102
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)     -0.109488   0.000684 -160.06   <2e-16 ***
## zMeanGravityAcc  0.003690   0.001899    1.94    0.052 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0566 on 7350 degrees of freedom
## Multiple R-squared: 0.000513,    Adjusted R-squared: 0.000377
## F-statistic: 3.78 on 1 and 7350 DF,  p-value: 0.0521
```

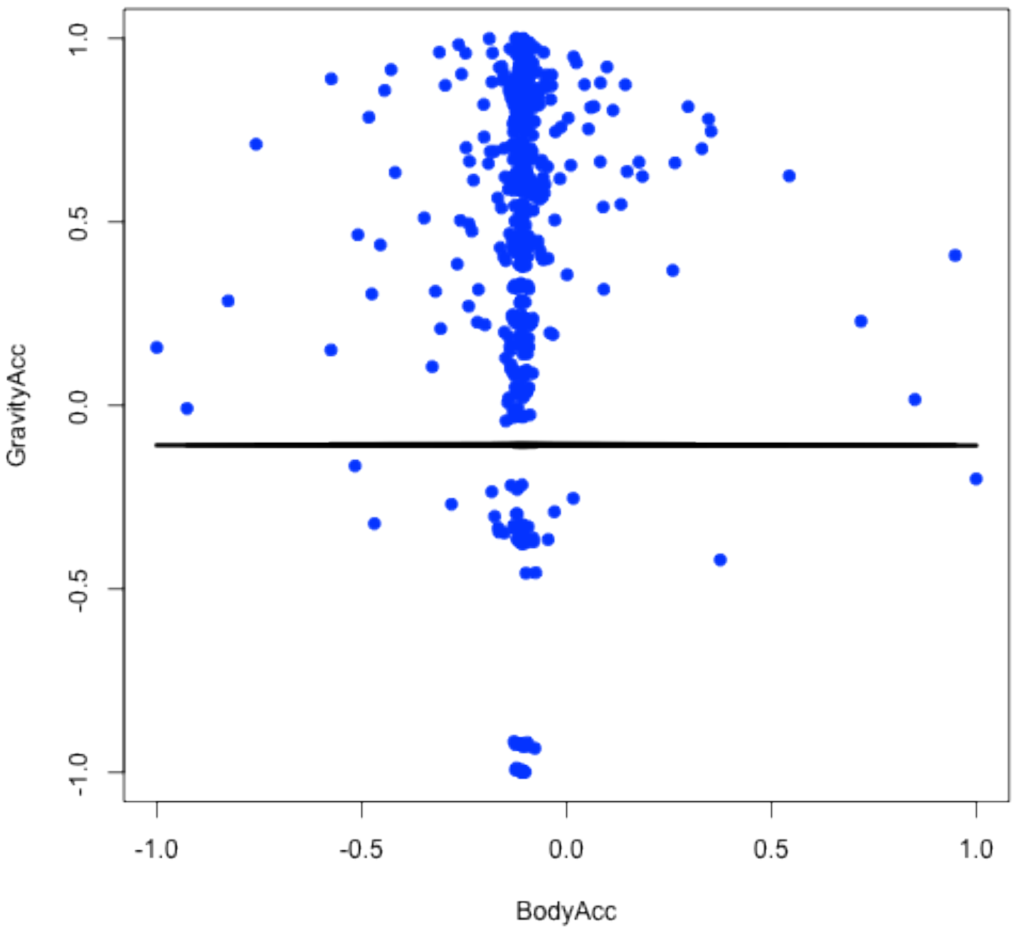
```
plot(haradl.zDataOne$zMeanBodyAcc, haradl.zDataOne$zMeanGravityAcc,
pch = 19,
    xlab = "BodyAcc", ylab = "GravityAcc", col = "blue")
lines(haradl.zDataOne$zMeanBodyAcc, q3.lm$fitted, lwd = 3)
```




```
## Lets just look at the laying activity
haradl.zDataOne.laying <- subset(haradl.zDataOne, activity ==
"laying")
## Plot linear Regression
haradl.zDataOne.laying.lm <- lm(zMeanBodyAcc ~ zMeanGravityAcc,
data = haradl.zDataOne.laying)
summary(haradl.zDataOne.laying.lm)
```

```
##
## Call:
## lm(formula = zMeanBodyAcc ~ zMeanGravityAcc, data =
haradl.zDataOne.laying)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.8916 -0.0047 -0.0011  0.0028  1.1095
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)     -0.10888    0.00422  -25.78   <2e-16 ***
## zMeanGravityAcc  0.00297    0.00605    0.49     0.62
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0898 on 1405 degrees of freedom
## Multiple R-squared: 0.000172,    Adjusted R-squared: -0.00054
## F-statistic: 0.241 on 1 and 1405 DF,  p-value: 0.623
```

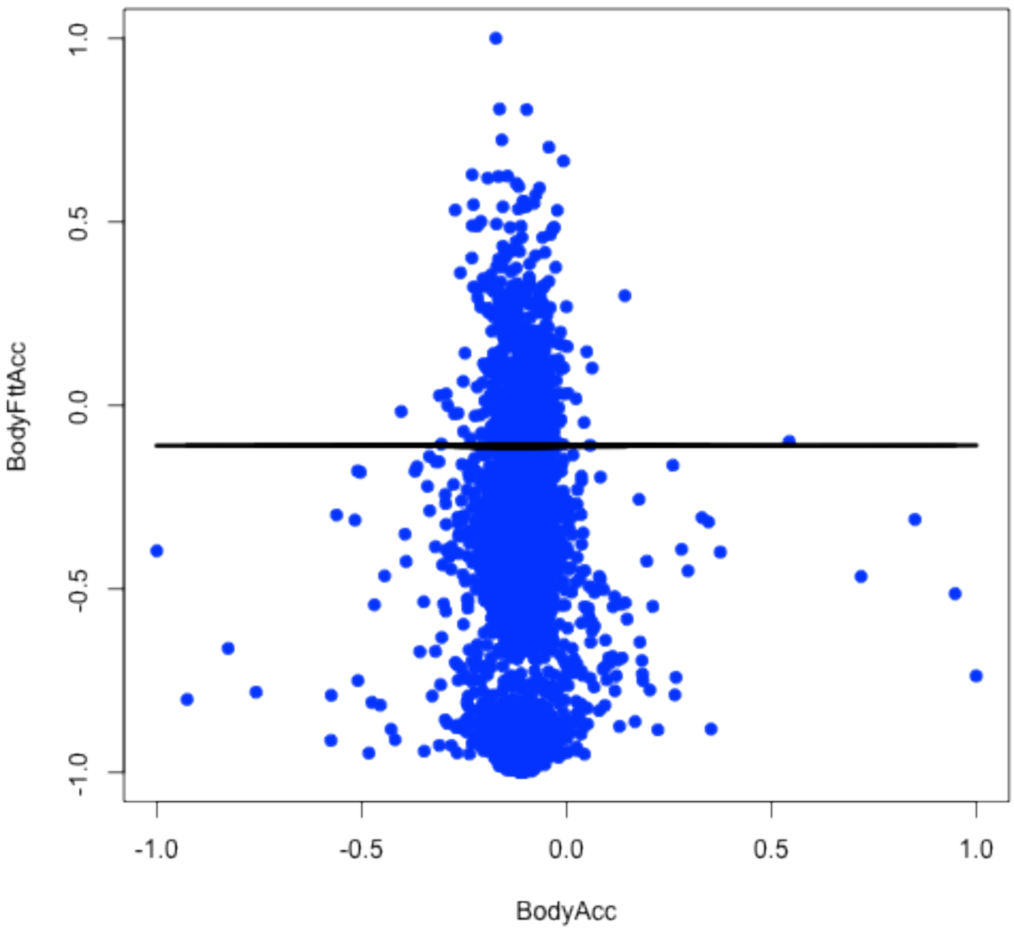
```
plot(haradl.zDataOne.laying$zMeanBodyAcc,
haradl.zDataOne.laying$zMeanGravityAcc,
    pch = 19, xlab = "BodyAcc", ylab = "GravityAcc", col = "blue")
lines(haradl.zDataOne.laying$zMeanBodyAcc,
haradl.zDataOne.laying.lm$fitted,
    lwd = 3)
```




```
## Plot linear Regression
q3.lm2 <- lm(zMeanBodyAcc ~ zMeanFftBodyAcc, data =
haradl.zDataOne)
summary(q3.lm2)
```

```
##
## Call:
## lm(formula = zMeanBodyAcc ~ zMeanFftBodyAcc, data =
haradl.zDataOne)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.8901 -0.0119 -0.0002  0.0111  1.1089
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)     -0.11096    0.00135  -82.12   <2e-16 ***
## zMeanFftBodyAcc -0.00275    0.00178   -1.54     0.12
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0566 on 7350 degrees of freedom
## Multiple R-squared: 0.000322,    Adjusted R-squared: 0.000186
## F-statistic: 2.37 on 1 and 7350 DF,  p-value: 0.124
```

```
plot(haradl.zDataOne$zMeanBodyAcc, haradl.zDataOne$zMeanFftBodyAcc,
pch = 19,
    xlab = "BodyAcc", ylab = "BodyFttAcc", col = "blue")
lines(haradl.zDataOne$zMeanBodyAcc, q3.lm2$fitted, lwd = 3)
```



Observation: Hard to interpret these plots.

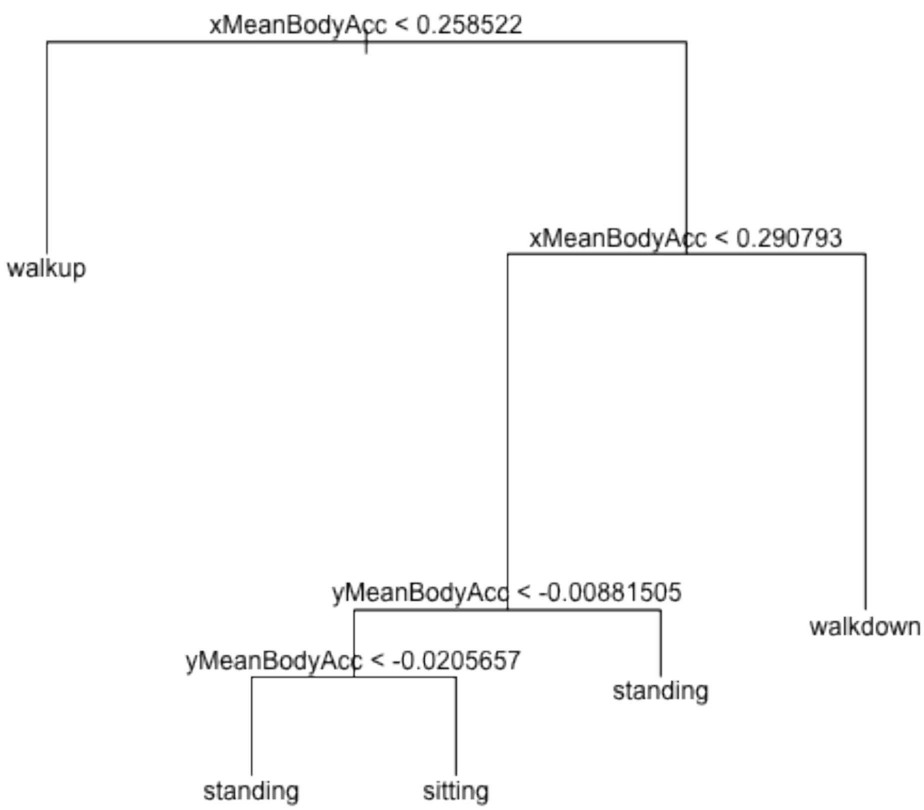
Question 4

Can we use predictive trees against the data?

```
haradl.xyzMean.tree <- tree(activity ~ xMeanBodyAcc + yMeanBodyAcc
+ zMeanBodyAcc,
    data = haradl.xyzMean)
summary(haradl.xyzMean.tree)
```

```
##
## Classification tree:
## tree(formula = activity ~ xMeanBodyAcc + yMeanBodyAcc +
zMeanBodyAcc,
##     data = haradl.xyzMean)
## Variables actually used in tree construction:
## [1] "xMeanBodyAcc" "yMeanBodyAcc"
## Number of terminal nodes:  5
## Residual mean deviance:  2.96 = 21800 / 7350
## Misclassification error rate: 0.679 = 4990 / 7352
```

```
plot(haradl.xyzMean.tree)
text(haradl.xyzMean.tree)
```



Observation: Yes but we need to isolate the relative features(variables). There are over 500 variables in this dataset, we should isolate our features of interest down to a few that are related to some educated guess/estimate about predictability.

Action: Do some external research into the meaning, purpose and relationship of some of these variables.

Question 5

What was the distribution of tests performed per subject

```
lmtest1 <- lm(activityID ~ xMeanBodyAcc + xMeanBodyAcc +
yMeanBodyAcc + zMeanBodyAcc +
    xMeanGravityAcc + yMeanGravityAcc + zMeanGravityAcc, data =
haradl.xyzMean)
summary(lmtest1)
```

```
##
## Call:
## lm(formula = activityID ~ xMeanBodyAcc + xMeanBodyAcc +
yMeanBodyAcc +
##     zMeanBodyAcc + xMeanGravityAcc + yMeanGravityAcc +
zMeanGravityAcc,
##     data = haradl.xyzMean)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -4.282 -0.790  0.011  0.791  2.739
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)       3.2687     0.0618   52.91  < 2e-16 ***
## xMeanBodyAcc     -0.5631     0.1861   -3.03   0.0025 **
## yMeanBodyAcc     -2.4157     0.3107   -7.78  8.5e-15 ***
## zMeanBodyAcc     -1.4793     0.2291   -6.46  1.1e-10 ***
## xMeanGravityAcc   0.1858     0.0423    4.39  1.2e-05 ***
## yMeanGravityAcc  -2.5416     0.0586  -43.38  < 2e-16 ***
## zMeanGravityAcc  -1.0500     0.0504  -20.82  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.07 on 7345 degrees of freedom
## Multiple R-squared: 0.597,   Adjusted R-squared: 0.597
## F-statistic: 1.81e+03 on 6 and 7345 DF,  p-value: <2e-16
```

Observation: There is significant evidence of a relationship between the orientations of the Gravity and Body movement signals from an Acceleraometer, namely the mean XYZ coordinates. This is also documented in tests using the Kalman Filter to estimate body orientations using the three axis of an Accelerometer and a Gyroscope. See section 3.17.

Given prior knowledge of the relationship certain variable may have with the activity of a human, we have decided to isolate our study on a few XYZ measurements from an Accelerometer. Our premise is that we can achieve a fair degree of prediction accuracy just with these variables.

Action: Before we are able to measure and define or models error rate, we need to see if the variables we believe to be significant actually are.

Question 6

Measure the significance of our choice variables with respect to the entire list.

```
lmtest2 <- lm(activityID ~ ., data = haradl)
```

```
## Warning: variable 'activity' converted to a factor
```

```
summary(lmtest2)
```

```
##
## Call:
## lm(formula = activityID ~ ., data = haradl)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -2.29e-12 -5.20e-15  0.00e+00  5.60e-15  2.04e-13
##
## Coefficients: (87 not defined because of singularities)
##                                                 Estimate Std. Error
t value
## (Intercept)                                      1.00e+00   1.14e-07
8.75e+06
## `tBodyAcc-mean<>-X--1`                          -1.45e-15   1.13e-14
-1.30e-01
## `tBodyAcc-mean<>-Y--2`                           4.38e-15   1.50e-14
2.90e-01
## `tBodyAcc-mean<>-Z--3`                          -1.90e-14   1.15e-14
-1.65e+00
## `tBodyAcc-std<>-X--4`                            1.45e-13   2.77e-13
5.20e-01
## `tBodyAcc-std<>-Y--5`                           -4.23e-14   2.26e-13
-1.90e-01
## `tBodyAcc-std<>-Z--6`                           -2.31e-13   1.79e-13
-1.29e+00
## `tBodyAcc-mad<>-X--7`                            1.47e-14   5.36e-14
2.70e-01
## `tBodyAcc-mad<>-Y--8`                           -5.00e-14   3.66e-14
-1.37e+00
## `tBodyAcc-mad<>-Z--9`                            7.16e-14   4.00e-14
1.79e+00
## `tBodyAcc-max<>-X--10`                          -1.30e-14   7.26e-15
```

```
-1.79e+00
## `tBodyAcc-max<>-Y--11`                  8.44e-17   6.95e-15
1.00e-02
## `tBodyAcc-max<>-Z--12`                  1.94e-14   7.10e-15
2.73e+00
## `tBodyAcc-min<>-X--13`                  2.64e-14   7.30e-15
3.62e+00
## `tBodyAcc-min<>-Y--14`                  6.18e-15   8.58e-15
7.20e-01
## `tBodyAcc-min<>-Z--15`                 -2.15e-14   8.85e-15
-2.43e+00
## `tBodyAcc-sma<>--16`                   -8.23e-14   4.95e-14
-1.66e+00
## `tBodyAcc-energy<>-X--17`               1.19e-13   1.35e-13
8.80e-01
## `tBodyAcc-energy<>-Y--18`               4.37e-15   2.38e-14
1.80e-01
## `tBodyAcc-energy<>-Z--19`              -2.56e-14   1.96e-14
-1.31e+00
## `tBodyAcc-iqr<>-X--20`                  9.25e-15   1.34e-14
6.90e-01
## `tBodyAcc-iqr<>-Y--21`                  2.85e-14   1.19e-14
2.39e+00
## `tBodyAcc-iqr<>-Z--22`                  2.73e-15   1.02e-14
2.70e-01
## `tBodyAcc-entropy<>-X--23`             -8.17e-15   3.14e-15
-2.60e+00
## `tBodyAcc-entropy<>-Y--24`             -1.95e-15   3.17e-15
-6.20e-01
## `tBodyAcc-entropy<>-Z--25`              1.97e-15   3.15e-15
6.30e-01
## `tBodyAcc-arCoeff<>-X,1--26`            4.68e-14   2.39e-14
1.96e+00
## `tBodyAcc-arCoeff<>-X,2--27`            1.76e-13   2.73e-14
6.46e+00
## `tBodyAcc-arCoeff<>-X,3--28`            1.12e-13   1.67e-14
6.72e+00
## `tBodyAcc-arCoeff<>-X,4--29`           -4.83e-15   1.35e-14
-3.60e-01
## `tBodyAcc-arCoeff<>-Y,1--30`           -6.00e-14   2.52e-14
-2.38e+00
## `tBodyAcc-arCoeff<>-Y,2--31`           -4.81e-14   3.19e-14
-1.51e+00
## `tBodyAcc-arCoeff<>-Y,3--32`           -1.26e-14   1.99e-14
-6.30e-01
## `tBodyAcc-arCoeff<>-Y,4--33`            1.64e-14   1.36e-14
1.21e+00
## `tBodyAcc-arCoeff<>-Z,1--34`            6.10e-14   2.37e-14
2.58e+00
## `tBodyAcc-arCoeff<>-Z,2--35`            3.06e-14   3.16e-14
9.70e-01
## `tBodyAcc-arCoeff<>-Z,3--36`           -8.74e-14   1.76e-14
-4.97e+00
```

```
## `tBodyAcc-arCoeff<>-Z,4--37`                  -4.95e-14   1.43e-14
-3.46e+00
## `tBodyAcc-correlation<>-X,Y--38`              -1.45e-15   1.77e-15
-8.20e-01
## `tBodyAcc-correlation<>-X,Z--39`              -4.12e-15   1.80e-15
-2.29e+00
## `tBodyAcc-correlation<>-Y,Z--40`              -2.93e-15   1.72e-15
-1.71e+00
## `tGravityAcc-mean<>-X--41`                     4.82e-15   4.85e-14
1.00e-01
## `tGravityAcc-mean<>-Y--42`                     5.67e-14   5.42e-14
1.05e+00
## `tGravityAcc-mean<>-Z--43`                    -8.52e-14   5.15e-14
-1.65e+00
## `tGravityAcc-std<>-X--44`                      3.11e-13   3.93e-13
7.90e-01
## `tGravityAcc-std<>-Y--45`                     -9.65e-14   3.29e-13
-2.90e-01
## `tGravityAcc-std<>-Z--46`                     -1.09e-13   2.35e-13
-4.60e-01
## `tGravityAcc-mad<>-X--47`                     -2.90e-13   3.67e-13
-7.90e-01
## `tGravityAcc-mad<>-Y--48`                      1.13e-13   3.21e-13
3.50e-01
## `tGravityAcc-mad<>-Z--49`                      4.01e-13   2.33e-13
1.72e+00
## `tGravityAcc-max<>-X--50`                     -4.79e-14   1.49e-13
-3.20e-01
## `tGravityAcc-max<>-Y--51`                     -4.85e-15   1.47e-13
-3.00e-02
## `tGravityAcc-max<>-Z--52`                     -2.14e-13   1.36e-13
-1.56e+00
## `tGravityAcc-min<>-X--53`                      6.15e-14   1.56e-13
3.90e-01
## `tGravityAcc-min<>-Y--54`                      5.09e-15   1.47e-13
3.00e-02
## `tGravityAcc-min<>-Z--55`                      2.85e-13   1.33e-13
2.14e+00
## `tGravityAcc-sma<>--56`                       -1.88e-16   4.31e-15
-4.00e-02
## `tGravityAcc-energy<>-X--57`                  -7.19e-16   1.75e-14
-4.00e-02
## `tGravityAcc-energy<>-Y--58`                  -1.32e-14   1.89e-14
-7.00e-01
## `tGravityAcc-energy<>-Z--59`                  -1.46e-14   1.87e-14
-7.80e-01
## `tGravityAcc-iqr<>-X--60`                      9.11e-15   7.72e-14
1.20e-01
## `tGravityAcc-iqr<>-Y--61`                     -1.72e-14   7.46e-14
-2.30e-01
## `tGravityAcc-iqr<>-Z--62`                     -1.72e-13   5.75e-14
-2.98e+00
## `tGravityAcc-entropy<>-X--63`                  3.69e-15   2.17e-15
```

```
1.70e+00
## `tGravityAcc-entropy<>-Y--64`                    9.57e-16   2.71e-15
3.50e-01
## `tGravityAcc-entropy<>-Z--65`                   -3.91e-15   1.76e-15
-2.22e+00
## `tGravityAcc-arCoeff<>-X,1--66`                  1.69e-11   3.06e-11
5.50e-01
## `tGravityAcc-arCoeff<>-X,2--67`                  4.98e-11   9.09e-11
5.50e-01
## `tGravityAcc-arCoeff<>-X,3--68`                  4.88e-11   9.00e-11
5.40e-01
## `tGravityAcc-arCoeff<>-X,4--69`                  1.60e-11   2.97e-11
5.40e-01
## `tGravityAcc-arCoeff<>-Y,1--70`                 -7.14e-12   1.21e-11
-5.90e-01
## `tGravityAcc-arCoeff<>-Y,2--71`                 -1.91e-11   3.28e-11
-5.80e-01
## `tGravityAcc-arCoeff<>-Y,3--72`                 -1.80e-11   3.17e-11
-5.70e-01
## `tGravityAcc-arCoeff<>-Y,4--73`                 -5.84e-12   1.05e-11
-5.60e-01
## `tGravityAcc-arCoeff<>-Z,1--74`                  9.13e-12   6.74e-12
1.35e+00
## `tGravityAcc-arCoeff<>-Z,2--75`                  2.69e-11   2.01e-11
1.34e+00
## `tGravityAcc-arCoeff<>-Z,3--76`                  2.65e-11   1.99e-11
1.33e+00
## `tGravityAcc-arCoeff<>-Z,4--77`                  8.73e-12   6.63e-12
1.32e+00
## `tGravityAcc-correlation<>-X,Y--78`             -7.29e-16   6.95e-16
-1.05e+00
## `tGravityAcc-correlation<>-X,Z--79`             -1.56e-16   7.09e-16
-2.20e-01
## `tGravityAcc-correlation<>-Y,Z--80`              3.89e-16   7.05e-16
5.50e-01
## `tBodyAccJerk-mean<>-X--81`                     -8.22e-16   3.36e-15
-2.40e-01
## `tBodyAccJerk-mean<>-Y--82`                     -8.90e-16   2.74e-15
-3.20e-01
## `tBodyAccJerk-mean<>-Z--83`                     -1.73e-15   2.87e-15
-6.00e-01
## `tBodyAccJerk-std<>-X--84`                      -1.10e-13   3.70e-13
-3.00e-01
## `tBodyAccJerk-std<>-Y--85`                      -4.06e-14   3.36e-13
-1.20e-01
## `tBodyAccJerk-std<>-Z--86`                      -3.87e-13   4.42e-13
-8.80e-01
## `tBodyAccJerk-mad<>-X--87`                      -1.65e-15   1.75e-13
-1.00e-02
## `tBodyAccJerk-mad<>-Y--88`                      -3.75e-14   1.21e-13
-3.10e-01
## `tBodyAccJerk-mad<>-Z--89`                      -2.86e-14   1.57e-13
-1.80e-01
```

```
## `tBodyAccJerk-max<>-X--90`                     1.69e-14   6.65e-15
2.54e+00
## `tBodyAccJerk-max<>-Y--91`                     2.98e-15   7.59e-15
3.90e-01
## `tBodyAccJerk-max<>-Z--92`                     1.26e-14   9.88e-15
1.28e+00
## `tBodyAccJerk-min<>-X--93`                    -5.01e-15   5.96e-15
-8.40e-01
## `tBodyAccJerk-min<>-Y--94`                    -7.72e-15   6.72e-15
-1.15e+00
## `tBodyAccJerk-min<>-Z--95`                     1.58e-17   7.36e-15
0.00e+00
## `tBodyAccJerk-sma<>--96`                       1.12e-13   4.11e-13
2.70e-01
## `tBodyAccJerk-energy<>-X--97`                 -3.08e-12   4.77e-12
-6.50e-01
## `tBodyAccJerk-energy<>-Y--98`                  2.54e-12   5.04e-12
5.00e-01
## `tBodyAccJerk-energy<>-Z--99`                 -1.03e-12   1.05e-11
-1.00e-01
## `tBodyAccJerk-iqr<>-X--100`                   -5.76e-15   1.15e-14
-5.00e-01
## `tBodyAccJerk-iqr<>-Y--101`                    6.65e-15   1.29e-14
5.20e-01
## `tBodyAccJerk-iqr<>-Z--102`                   -1.26e-14   1.64e-14
-7.70e-01
## `tBodyAccJerk-entropy<>-X--103`                4.94e-15   5.98e-15
8.30e-01
## `tBodyAccJerk-entropy<>-Y--104`                2.57e-15   5.94e-15
4.30e-01
## `tBodyAccJerk-entropy<>-Z--105`                1.18e-14   6.03e-15
1.95e+00
## `tBodyAccJerk-arCoeff<>-X,1--106`              7.53e-14   1.68e-14
4.47e+00
## `tBodyAccJerk-arCoeff<>-X,2--107`             -1.43e-14   1.83e-14
-7.80e-01
## `tBodyAccJerk-arCoeff<>-X,3--108`             -9.41e-14   1.20e-14
-7.83e+00
## `tBodyAccJerk-arCoeff<>-X,4--109`             -4.52e-14   6.89e-15
-6.56e+00
## `tBodyAccJerk-arCoeff<>-Y,1--110`              3.55e-14   1.61e-14
2.21e+00
## `tBodyAccJerk-arCoeff<>-Y,2--111`              1.21e-14   1.71e-14
7.00e-01
## `tBodyAccJerk-arCoeff<>-Y,3--112`              6.18e-15   1.09e-14
5.70e-01
## `tBodyAccJerk-arCoeff<>-Y,4--113`             -4.11e-15   6.09e-15
-6.80e-01
## `tBodyAccJerk-arCoeff<>-Z,1--114`             -3.24e-14   1.75e-14
-1.86e+00
## `tBodyAccJerk-arCoeff<>-Z,2--115`             -6.41e-14   1.95e-14
-3.28e+00
## `tBodyAccJerk-arCoeff<>-Z,3--116`              1.56e-14   1.29e-14
```

```
1.21e+00
## `tBodyAccJerk-arCoeff<>-Z,4--117`          2.73e-14   5.46e-15
5.00e+00
## `tBodyAccJerk-correlation<>-X,Y--118`      6.63e-15   2.15e-15
3.08e+00
## `tBodyAccJerk-correlation<>-X,Z--119`      5.05e-15   2.02e-15
2.50e+00
## `tBodyAccJerk-correlation<>-Y,Z--120`      5.64e-15   2.05e-15
2.75e+00
## `tBodyGyro-mean<>-X--121`                  1.28e-14   6.63e-15
1.92e+00
## `tBodyGyro-mean<>-Y--122`                  2.09e-15   6.28e-15
3.30e-01
## `tBodyGyro-mean<>-Z--123`                  1.35e-14   5.36e-15
2.51e+00
## `tBodyGyro-std<>-X--124`                   9.49e-14   2.51e-13
3.80e-01
## `tBodyGyro-std<>-Y--125`                   4.76e-14   1.82e-13
2.60e-01
## `tBodyGyro-std<>-Z--126`                   5.92e-14   1.91e-13
3.10e-01
## `tBodyGyro-mad<>-X--127`                   7.06e-15   5.11e-14
1.40e-01
## `tBodyGyro-mad<>-Y--128`                   7.32e-15   5.08e-14
1.40e-01
## `tBodyGyro-mad<>-Z--129`                  -7.30e-14   4.50e-14
-1.62e+00
## `tBodyGyro-max<>-X--130`                  -1.61e-14   8.38e-15
-1.93e+00
## `tBodyGyro-max<>-Y--131`                   6.57e-15   1.10e-14
6.00e-01
## `tBodyGyro-max<>-Z--132`                  -1.53e-14   7.79e-15
-1.97e+00
## `tBodyGyro-min<>-X--133`                   2.26e-15   9.92e-15
2.30e-01
## `tBodyGyro-min<>-Y--134`                   3.55e-15   1.09e-14
3.20e-01
## `tBodyGyro-min<>-Z--135`                  -1.59e-15   8.46e-15
-1.90e-01
## `tBodyGyro-sma<>--136`                    -4.77e-14   3.82e-14
-1.25e+00
## `tBodyGyro-energy<>-X--137`               -6.67e-14   2.99e-14
-2.23e+00
## `tBodyGyro-energy<>-Y--138`               -4.53e-14   7.13e-14
-6.40e-01
## `tBodyGyro-energy<>-Z--139`               -5.01e-15   2.51e-14
-2.00e-01
## `tBodyGyro-iqr<>-X--140`                  -7.87e-16   1.39e-14
-6.00e-02
## `tBodyGyro-iqr<>-Y--141`                   3.38e-16   1.38e-14
2.00e-02
## `tBodyGyro-iqr<>-Z--142`                   4.22e-15   1.39e-14
3.00e-01
```

```
## `tBodyGyro-entropy<>-X--143`                      -4.88e-15   1.97e-15
-2.48e+00
## `tBodyGyro-entropy<>-Y--144`                      -5.07e-15   2.16e-15
-2.35e+00
## `tBodyGyro-entropy<>-Z--145`                      -5.91e-15   2.12e-15
-2.79e+00
## `tBodyGyro-arCoeff<>-X,1--146`                    -1.24e-14   2.67e-14
-4.70e-01
## `tBodyGyro-arCoeff<>-X,2--147`                    -4.38e-14   3.10e-14
-1.41e+00
## `tBodyGyro-arCoeff<>-X,3--148`                    -4.57e-14   1.75e-14
-2.61e+00
## `tBodyGyro-arCoeff<>-X,4--149`                    -1.31e-14   1.34e-14
-9.70e-01
## `tBodyGyro-arCoeff<>-Y,1--150`                    -4.79e-15   2.85e-14
-1.70e-01
## `tBodyGyro-arCoeff<>-Y,2--151`                     1.13e-13   3.27e-14
3.46e+00
## `tBodyGyro-arCoeff<>-Y,3--152`                     8.86e-14   1.81e-14
4.89e+00
## `tBodyGyro-arCoeff<>-Y,4--153`                     1.11e-14   1.43e-14
7.80e-01
## `tBodyGyro-arCoeff<>-Z,1--154`                     2.31e-14   2.64e-14
8.80e-01
## `tBodyGyro-arCoeff<>-Z,2--155`                     6.29e-14   2.95e-14
2.13e+00
## `tBodyGyro-arCoeff<>-Z,3--156`                     6.35e-14   1.82e-14
3.50e+00
## `tBodyGyro-arCoeff<>-Z,4--157`                     9.48e-15   1.34e-14
7.10e-01
## `tBodyGyro-correlation<>-X,Y--158`                -3.11e-15   1.36e-15
-2.29e+00
## `tBodyGyro-correlation<>-X,Z--159`                -1.26e-15   1.23e-15
-1.02e+00
## `tBodyGyro-correlation<>-Y,Z--160`                -4.31e-16   1.37e-15
-3.20e-01
## `tBodyGyroJerk-mean<>-X--161`                      1.74e-15   4.12e-15
4.20e-01
## `tBodyGyroJerk-mean<>-Y--162`                      2.07e-15   3.59e-15
5.80e-01
## `tBodyGyroJerk-mean<>-Z--163`                      3.25e-15   3.22e-15
1.01e+00
## `tBodyGyroJerk-std<>-X--164`                       3.32e-14   6.11e-14
5.40e-01
## `tBodyGyroJerk-std<>-Y--165`                       5.20e-14   8.02e-14
6.50e-01
## `tBodyGyroJerk-std<>-Z--166`                      -3.44e-14   6.32e-14
-5.40e-01
## `tBodyGyroJerk-mad<>-X--167`                       3.89e-15   2.00e-13
2.00e-02
## `tBodyGyroJerk-mad<>-Y--168`                      -6.10e-15   3.59e-13
-2.00e-02
## `tBodyGyroJerk-mad<>-Z--169`                       8.04e-14   1.70e-13
```

```
4.70e-01
## `tBodyGyroJerk-max<>-X--170`                    -2.52e-15   7.58e-15
-3.30e-01
## `tBodyGyroJerk-max<>-Y--171`                    -1.56e-15   1.13e-14
-1.40e-01
## `tBodyGyroJerk-max<>-Z--172`                     4.45e-15   7.56e-15
5.90e-01
## `tBodyGyroJerk-min<>-X--173`                     5.33e-15   7.84e-15
6.80e-01
## `tBodyGyroJerk-min<>-Y--174`                     6.55e-15   1.18e-14
5.60e-01
## `tBodyGyroJerk-min<>-Z--175`                    -7.00e-15   9.61e-15
-7.30e-01
## `tBodyGyroJerk-sma<>--176`                      -5.38e-14   7.05e-13
-8.00e-02
## `tBodyGyroJerk-energy<>-X--177`                 -1.58e-14   4.25e-14
-3.70e-01
## `tBodyGyroJerk-energy<>-Y--178`                  8.45e-14   8.55e-14
9.90e-01
## `tBodyGyroJerk-energy<>-Z--179`                  2.03e-14   4.85e-14
4.20e-01
## `tBodyGyroJerk-iqr<>-X--180`                     6.29e-15   1.62e-14
3.90e-01
## `tBodyGyroJerk-iqr<>-Y--181`                     3.14e-15   2.33e-14
1.30e-01
## `tBodyGyroJerk-iqr<>-Z--182`                    -1.41e-14   1.85e-14
-7.60e-01
## `tBodyGyroJerk-entropy<>-X--183`                -7.30e-16   4.94e-15
-1.50e-01
## `tBodyGyroJerk-entropy<>-Y--184`                -4.41e-16   4.62e-15
-1.00e-01
## `tBodyGyroJerk-entropy<>-Z--185`                -8.05e-15   5.05e-15
-1.60e+00
## `tBodyGyroJerk-arCoeff<>-X,1--186`              -1.21e-14   1.68e-14
-7.20e-01
## `tBodyGyroJerk-arCoeff<>-X,2--187`              -1.42e-14   2.06e-14
-6.90e-01
## `tBodyGyroJerk-arCoeff<>-X,3--188`               1.28e-14   1.10e-14
1.17e+00
## `tBodyGyroJerk-arCoeff<>-X,4--189`               1.23e-14   5.15e-15
2.40e+00
## `tBodyGyroJerk-arCoeff<>-Y,1--190`               5.57e-14   1.71e-14
3.25e+00
## `tBodyGyroJerk-arCoeff<>-Y,2--191`               1.66e-15   2.21e-14
7.00e-02
## `tBodyGyroJerk-arCoeff<>-Y,3--192`              -5.69e-14   1.40e-14
-4.08e+00
## `tBodyGyroJerk-arCoeff<>-Y,4--193`              -2.10e-14   5.25e-15
-3.99e+00
## `tBodyGyroJerk-arCoeff<>-Z,1--194`               1.74e-14   1.57e-14
1.11e+00
## `tBodyGyroJerk-arCoeff<>-Z,2--195`               1.85e-14   1.94e-14
9.50e-01
```

```
## `tBodyGyroJerk-arCoeff<>-Z,3--196`          -3.17e-14   1.06e-14
-2.98e+00
## `tBodyGyroJerk-arCoeff<>-Z,4--197`          -2.29e-14   4.83e-15
-4.75e+00
## `tBodyGyroJerk-correlation<>-X,Y--198`       4.24e-15   1.95e-15
2.17e+00
## `tBodyGyroJerk-correlation<>-X,Z--199`       1.35e-15   1.92e-15
7.00e-01
## `tBodyGyroJerk-correlation<>-Y,Z--200`      -2.44e-15   2.07e-15
-1.18e+00
## `tBodyAccMag-mean<>--201`                    8.64e-14   4.89e-14
1.77e+00
## `tBodyAccMag-std<>--202`                    -1.17e-13   1.82e-13
-6.50e-01
## `tBodyAccMag-mad<>--203`                     2.24e-14   4.53e-14
4.90e-01
## `tBodyAccMag-max<>--204`                     1.65e-15   1.08e-14
1.50e-01
## `tBodyAccMag-min<>--205`                    -8.56e-17   4.84e-15
-2.00e-02
## `tBodyAccMag-sma<>--206`                           NA         NA
NA
## `tBodyAccMag-energy<>--207`                        NA         NA
NA
## `tBodyAccMag-iqr<>--208`                    -4.27e-16   1.31e-14
-3.00e-02
## `tBodyAccMag-entropy<>--209`                -2.25e-14   8.13e-15
-2.76e+00
## `tBodyAccMag-arCoeff<>1--210`                1.75e-13   7.10e-14
2.46e+00
## `tBodyAccMag-arCoeff<>2--211`                2.44e-13   1.05e-13
2.32e+00
## `tBodyAccMag-arCoeff<>3--212`                1.19e-13   5.46e-14
2.19e+00
## `tBodyAccMag-arCoeff<>4--213`                6.69e-14   3.22e-14
2.08e+00
## `tGravityAccMag-mean<>--214`                       NA         NA
NA
## `tGravityAccMag-std<>--215`                        NA         NA
NA
## `tGravityAccMag-mad<>--216`                        NA         NA
NA
## `tGravityAccMag-max<>--217`                        NA         NA
NA
## `tGravityAccMag-min<>--218`                        NA         NA
NA
## `tGravityAccMag-sma<>--219`                        NA         NA
NA
## `tGravityAccMag-energy<>--220`                     NA         NA
NA
## `tGravityAccMag-iqr<>--221`                        NA         NA
NA
## `tGravityAccMag-entropy<>--222`                    NA         NA
```

```
NA
## `tGravityAccMag-arCoeff<>1--223`                NA         NA
NA
## `tGravityAccMag-arCoeff<>2--224`                NA         NA
NA
## `tGravityAccMag-arCoeff<>3--225`                NA         NA
NA
## `tGravityAccMag-arCoeff<>4--226`                NA         NA
NA
## `tBodyAccJerkMag-mean<>--227`            -1.76e-14   9.31e-14
-1.90e-01
## `tBodyAccJerkMag-std<>--228`              1.22e-13   2.33e-13
5.20e-01
## `tBodyAccJerkMag-mad<>--229`              3.03e-15   4.80e-14
6.00e-02
## `tBodyAccJerkMag-max<>--230`             -3.59e-15   9.83e-15
-3.70e-01
## `tBodyAccJerkMag-min<>--231`              2.93e-17   3.18e-15
1.00e-02
## `tBodyAccJerkMag-sma<>--232`                    NA         NA
NA
## `tBodyAccJerkMag-energy<>--233`                 NA         NA
NA
## `tBodyAccJerkMag-iqr<>--234`             -5.62e-15   1.49e-14
-3.80e-01
## `tBodyAccJerkMag-entropy<>--235`          1.35e-14   1.10e-14
1.23e+00
## `tBodyAccJerkMag-arCoeff<>1--236`         1.46e-14   3.58e-14
4.10e-01
## `tBodyAccJerkMag-arCoeff<>2--237`         9.76e-15   3.53e-14
2.80e-01
## `tBodyAccJerkMag-arCoeff<>3--238`         7.02e-15   2.50e-14
2.80e-01
## `tBodyAccJerkMag-arCoeff<>4--239`         4.46e-15   2.20e-14
2.00e-01
## `tBodyGyroMag-mean<>--240`                9.94e-14   4.32e-14
2.30e+00
## `tBodyGyroMag-std<>--241`                 3.80e-14   1.41e-13
2.70e-01
## `tBodyGyroMag-mad<>--242`                -7.74e-15   4.01e-14
-1.90e-01
## `tBodyGyroMag-max<>--243`                -3.72e-15   1.43e-14
-2.60e-01
## `tBodyGyroMag-min<>--244`                 3.82e-16   2.79e-15
1.40e-01
## `tBodyGyroMag-sma<>--245`                       NA         NA
NA
## `tBodyGyroMag-energy<>--246`                    NA         NA
NA
## `tBodyGyroMag-iqr<>--247`                 2.44e-15   1.13e-14
2.20e-01
## `tBodyGyroMag-entropy<>--248`            -6.13e-16   4.46e-15
-1.40e-01
```

```
## `tBodyGyroMag-arCoeff<>1--249`                    3.15e-14   6.88e-14
4.60e-01
## `tBodyGyroMag-arCoeff<>2--250`                    4.90e-14   9.82e-14
5.00e-01
## `tBodyGyroMag-arCoeff<>3--251`                    2.49e-14   6.33e-14
3.90e-01
## `tBodyGyroMag-arCoeff<>4--252`                    5.74e-15   3.39e-14
1.70e-01
## `tBodyGyroJerkMag-mean<>--253`                   -1.30e-14   9.38e-14
-1.40e-01
## `tBodyGyroJerkMag-std<>--254`                    -1.43e-14   3.26e-13
-4.00e-02
## `tBodyGyroJerkMag-mad<>--255`                    -2.41e-14   6.63e-14
-3.60e-01
## `tBodyGyroJerkMag-max<>--256`                    -7.99e-15   1.54e-14
-5.20e-01
## `tBodyGyroJerkMag-min<>--257`                     4.96e-17   3.44e-15
1.00e-02
## `tBodyGyroJerkMag-sma<>--258`                           NA         NA
NA
## `tBodyGyroJerkMag-energy<>--259`                        NA         NA
NA
## `tBodyGyroJerkMag-iqr<>--260`                    -4.22e-15   1.98e-14
-2.10e-01
## `tBodyGyroJerkMag-entropy<>--261`                 2.33e-15   8.82e-15
2.60e-01
## `tBodyGyroJerkMag-arCoeff<>1--262`                2.61e-14   3.20e-14
8.20e-01
## `tBodyGyroJerkMag-arCoeff<>2--263`                3.42e-14   3.97e-14
8.60e-01
## `tBodyGyroJerkMag-arCoeff<>3--264`                3.37e-14   2.58e-14
1.30e+00
## `tBodyGyroJerkMag-arCoeff<>4--265`                2.91e-14   2.20e-14
1.32e+00
## `fBodyAcc-mean<>-X--266`                         -2.87e-14   7.80e-14
-3.70e-01
## `fBodyAcc-mean<>-Y--267`                          1.96e-14   7.94e-14
2.50e-01
## `fBodyAcc-mean<>-Z--268`                          5.64e-14   6.51e-14
8.70e-01
## `fBodyAcc-std<>-X--269`                          -1.54e-13   2.05e-13
-7.50e-01
## `fBodyAcc-std<>-Y--270`                           7.20e-14   1.67e-13
4.30e-01
## `fBodyAcc-std<>-Z--271`                           1.32e-13   1.35e-13
9.80e-01
## `fBodyAcc-mad<>-X--272`                          -1.07e-14   2.50e-14
-4.30e-01
## `fBodyAcc-mad<>-Y--273`                           1.13e-14   2.49e-14
4.60e-01
## `fBodyAcc-mad<>-Z--274`                          -3.73e-14   2.85e-14
-1.31e+00
## `fBodyAcc-max<>-X--275`                          -7.63e-15   1.37e-14
```

```
-5.60e-01
## `fBodyAcc-max<>-Y--276`                  -3.25e-15   1.07e-14
-3.00e-01
## `fBodyAcc-max<>-Z--277`                  -1.02e-14   1.07e-14
-9.60e-01
## `fBodyAcc-min<>-X--278`                   1.75e-15   3.22e-15
5.40e-01
## `fBodyAcc-min<>-Y--279`                   4.20e-15   4.05e-15
1.04e+00
## `fBodyAcc-min<>-Z--280`                   1.40e-15   5.42e-15
2.60e-01
## `fBodyAcc-sma<>--281`                           NA          NA
NA
## `fBodyAcc-energy<>-X--282`               -1.08e-07   9.99e-08
-1.08e+00
## `fBodyAcc-energy<>-Y--283`               -8.04e-08   9.68e-08
-8.30e-01
## `fBodyAcc-energy<>-Z--284`               -1.58e-07   9.66e-08
-1.63e+00
## `fBodyAcc-iqr<>-X--285`                  -6.61e-15   5.92e-15
-1.12e+00
## `fBodyAcc-iqr<>-Y--286`                  -3.28e-15   6.37e-15
-5.10e-01
## `fBodyAcc-iqr<>-Z--287`                   7.97e-15   8.56e-15
9.30e-01
## `fBodyAcc-entropy<>-X--288`               6.07e-15   7.18e-15
8.40e-01
## `fBodyAcc-entropy<>-Y--289`               1.56e-14   7.28e-15
2.14e+00
## `fBodyAcc-entropy<>-Z--290`              -3.71e-15   7.26e-15
-5.10e-01
## `fBodyAcc-maxInds-X--291`                -4.04e-15   2.15e-15
-1.88e+00
## `fBodyAcc-maxInds-Y--292`                 4.89e-16   2.26e-15
2.20e-01
## `fBodyAcc-maxInds-Z--293`                 7.57e-16   2.17e-15
3.50e-01
## `fBodyAcc-meanFreq<>-X--294`             -5.39e-15   4.44e-15
-1.22e+00
## `fBodyAcc-meanFreq<>-Y--295`              5.32e-15   4.13e-15
1.29e+00
## `fBodyAcc-meanFreq<>-Z--296`             -3.00e-15   3.85e-15
-7.80e-01
## `fBodyAcc-skewness<>-X--297`             -2.98e-15   1.09e-14
-2.70e-01
## `fBodyAcc-kurtosis<>-X--298`              2.46e-15   9.36e-15
2.60e-01
## `fBodyAcc-skewness<>-Y--299`             -8.98e-15   1.14e-14
-7.90e-01
## `fBodyAcc-kurtosis<>-Y--300`              1.15e-14   9.80e-15
1.17e+00
## `fBodyAcc-skewness<>-Z--301`              4.77e-15   1.05e-14
4.50e-01
```

```
## `fBodyAcc-kurtosis<>-Z--302`                 -6.78e-15  9.47e-15
-7.20e-01
## `fBodyAcc-bandsEnergy<>-1,8--303`             7.74e-08  7.16e-08
1.08e+00
## `fBodyAcc-bandsEnergy<>-9,16--304`            2.86e-08  2.64e-08
1.08e+00
## `fBodyAcc-bandsEnergy<>-17,24--305`           7.42e-09  6.86e-09
1.08e+00
## `fBodyAcc-bandsEnergy<>-25,32--306`           2.58e-09  2.39e-09
1.08e+00
## `fBodyAcc-bandsEnergy<>-33,40--307`           1.09e-09  1.01e-09
1.08e+00
## `fBodyAcc-bandsEnergy<>-41,48--308`           6.52e-10  6.03e-10
1.08e+00
## `fBodyAcc-bandsEnergy<>-49,56--309`           4.66e-10  4.31e-10
1.08e+00
## `fBodyAcc-bandsEnergy<>-57,64--310`           2.35e-10  2.17e-10
1.08e+00
## `fBodyAcc-bandsEnergy<>-1,16--311`                  NA        NA
NA
## `fBodyAcc-bandsEnergy<>-17,32--312`                 NA        NA
NA
## `fBodyAcc-bandsEnergy<>-33,48--313`                 NA        NA
NA
## `fBodyAcc-bandsEnergy<>-49,64--314`                 NA        NA
NA
## `fBodyAcc-bandsEnergy<>-1,24--315`                  NA        NA
NA
## `fBodyAcc-bandsEnergy<>-25,48--316`                 NA        NA
NA
## `fBodyAcc-bandsEnergy<>-1,8--317`             5.50e-08  6.62e-08
8.30e-01
## `fBodyAcc-bandsEnergy<>-9,16--318`            3.69e-08  4.44e-08
8.30e-01
## `fBodyAcc-bandsEnergy<>-17,24--319`           1.38e-08  1.67e-08
8.30e-01
## `fBodyAcc-bandsEnergy<>-25,32--320`           4.14e-09  4.99e-09
8.30e-01
## `fBodyAcc-bandsEnergy<>-33,40--321`           1.27e-09  1.53e-09
8.30e-01
## `fBodyAcc-bandsEnergy<>-41,48--322`           6.68e-10  8.05e-10
8.30e-01
## `fBodyAcc-bandsEnergy<>-49,56--323`           3.39e-10  4.09e-10
8.30e-01
## `fBodyAcc-bandsEnergy<>-57,64--324`           2.35e-10  2.82e-10
8.30e-01
## `fBodyAcc-bandsEnergy<>-1,16--325`                  NA        NA
NA
## `fBodyAcc-bandsEnergy<>-17,32--326`                 NA        NA
NA
## `fBodyAcc-bandsEnergy<>-33,48--327`                 NA        NA
NA
## `fBodyAcc-bandsEnergy<>-49,64--328`                 NA        NA
```

```
NA
## `fBodyAcc-bandsEnergy<>-1,24--329`                    NA          NA
NA
## `fBodyAcc-bandsEnergy<>-25,48--330`                   NA          NA
NA
## `fBodyAcc-bandsEnergy<>-1,8--331`               1.19e-07    7.29e-08
1.63e+00
## `fBodyAcc-bandsEnergy<>-9,16--332`              4.80e-08    2.94e-08
1.63e+00
## `fBodyAcc-bandsEnergy<>-17,24--333`             3.21e-08    1.96e-08
1.63e+00
## `fBodyAcc-bandsEnergy<>-25,32--334`             1.82e-08    1.12e-08
1.63e+00
## `fBodyAcc-bandsEnergy<>-33,40--335`             5.90e-09    3.61e-09
1.63e+00
## `fBodyAcc-bandsEnergy<>-41,48--336`             1.89e-09    1.16e-09
1.63e+00
## `fBodyAcc-bandsEnergy<>-49,56--337`             7.68e-10    4.70e-10
1.63e+00
## `fBodyAcc-bandsEnergy<>-57,64--338`             3.25e-10    1.99e-10
1.63e+00
## `fBodyAcc-bandsEnergy<>-1,16--339`                    NA          NA
NA
## `fBodyAcc-bandsEnergy<>-17,32--340`                   NA          NA
NA
## `fBodyAcc-bandsEnergy<>-33,48--341`                   NA          NA
NA
## `fBodyAcc-bandsEnergy<>-49,64--342`                   NA          NA
NA
## `fBodyAcc-bandsEnergy<>-1,24--343`                    NA          NA
NA
## `fBodyAcc-bandsEnergy<>-25,48--344`                   NA          NA
NA
## `fBodyAccJerk-mean<>-X--345`                    7.31e-14    1.98e-13
3.70e-01
## `fBodyAccJerk-mean<>-Y--346`                    1.96e-14    1.83e-13
1.10e-01
## `fBodyAccJerk-mean<>-Z--347`                    1.76e-13    2.25e-13
7.80e-01
## `fBodyAccJerk-std<>-X--348`                     8.08e-14    1.93e-13
4.20e-01
## `fBodyAccJerk-std<>-Y--349`                     1.37e-14    1.67e-13
8.00e-02
## `fBodyAccJerk-std<>-Z--350`                     1.88e-13    2.34e-13
8.00e-01
## `fBodyAccJerk-mad<>-X--351`                    -3.52e-15    2.84e-14
-1.20e-01
## `fBodyAccJerk-mad<>-Y--352`                     4.64e-15    3.25e-14
1.40e-01
## `fBodyAccJerk-mad<>-Z--353`                    -5.54e-15    4.75e-14
-1.20e-01
## `fBodyAccJerk-max<>-X--354`                     3.77e-15    1.32e-14
2.90e-01
```

```
## `fBodyAccJerk-max<>-Y--355`                    -5.89e-15   1.14e-14
-5.20e-01
## `fBodyAccJerk-max<>-Z--356`                     5.39e-15   1.71e-14
3.20e-01
## `fBodyAccJerk-min<>-X--357`                    -2.22e-16   3.68e-15
-6.00e-02
## `fBodyAccJerk-min<>-Y--358`                     2.54e-15   3.23e-15
7.90e-01
## `fBodyAccJerk-min<>-Z--359`                     2.53e-15   3.63e-15
7.00e-01
## `fBodyAccJerk-sma<>--360`                             NA          NA
NA
## `fBodyAccJerk-energy<>-X--361`                 -1.65e-07   1.09e-07
-1.52e+00
## `fBodyAccJerk-energy<>-Y--362`                 -1.53e-07   1.07e-07
-1.43e+00
## `fBodyAccJerk-energy<>-Z--363`                 -9.25e-08   1.11e-07
-8.40e-01
## `fBodyAccJerk-iqr<>-X--364`                     5.24e-15   8.19e-15
6.40e-01
## `fBodyAccJerk-iqr<>-Y--365`                     2.95e-15   1.11e-14
2.70e-01
## `fBodyAccJerk-iqr<>-Z--366`                    -2.69e-16   1.35e-14
-2.00e-02
## `fBodyAccJerk-entropy<>-X--367`                -1.14e-14   8.98e-15
-1.27e+00
## `fBodyAccJerk-entropy<>-Y--368`                 3.23e-15   8.94e-15
3.60e-01
## `fBodyAccJerk-entropy<>-Z--369`                -3.81e-15   9.97e-15
-3.80e-01
## `fBodyAccJerk-maxInds-X--370`                  -7.57e-15   1.85e-15
-4.08e+00
## `fBodyAccJerk-maxInds-Y--371`                  -7.41e-16   1.91e-15
-3.90e-01
## `fBodyAccJerk-maxInds-Z--372`                   3.04e-15   1.74e-15
1.75e+00
## `fBodyAccJerk-meanFreq<>-X--373`                7.13e-15   6.53e-15
1.09e+00
## `fBodyAccJerk-meanFreq<>-Y--374`               -6.06e-15   6.14e-15
-9.90e-01
## `fBodyAccJerk-meanFreq<>-Z--375`               -9.13e-15   5.79e-15
-1.58e+00
## `fBodyAccJerk-skewness<>-X--376`                5.05e-16   7.86e-15
6.00e-02
## `fBodyAccJerk-kurtosis<>-X--377`               -3.37e-15   9.24e-15
-3.60e-01
## `fBodyAccJerk-skewness<>-Y--378`                5.41e-15   9.33e-15
5.80e-01
## `fBodyAccJerk-kurtosis<>-Y--379`                1.74e-15   1.18e-14
1.50e-01
## `fBodyAccJerk-skewness<>-Z--380`               -7.56e-15   8.53e-15
-8.90e-01
## `fBodyAccJerk-kurtosis<>-Z--381`                5.94e-15   1.06e-14
```

```
5.60e-01
## `fBodyAccJerk-bandsEnergy<>-1,8--382`      4.49e-08   2.95e-08
1.52e+00
## `fBodyAccJerk-bandsEnergy<>-9,16--383`     6.44e-08   4.24e-08
1.52e+00
## `fBodyAccJerk-bandsEnergy<>-17,24--384`    4.84e-08   3.18e-08
1.52e+00
## `fBodyAccJerk-bandsEnergy<>-25,32--385`    2.68e-08   1.76e-08
1.52e+00
## `fBodyAccJerk-bandsEnergy<>-33,40--386`    1.64e-08   1.08e-08
1.52e+00
## `fBodyAccJerk-bandsEnergy<>-41,48--387`    1.01e-08   6.61e-09
1.52e+00
## `fBodyAccJerk-bandsEnergy<>-49,56--388`    6.77e-09   4.45e-09
1.52e+00
## `fBodyAccJerk-bandsEnergy<>-57,64--389`    1.33e-09   8.76e-10
1.52e+00
## `fBodyAccJerk-bandsEnergy<>-1,16--390`           NA         NA
NA
## `fBodyAccJerk-bandsEnergy<>-17,32--391`          NA         NA
NA
## `fBodyAccJerk-bandsEnergy<>-33,48--392`          NA         NA
NA
## `fBodyAccJerk-bandsEnergy<>-49,64--393`          NA         NA
NA
## `fBodyAccJerk-bandsEnergy<>-1,24--394`           NA         NA
NA
## `fBodyAccJerk-bandsEnergy<>-25,48--395`          NA         NA
NA
## `fBodyAccJerk-bandsEnergy<>-1,8--396`      1.90e-08   1.33e-08
1.43e+00
## `fBodyAccJerk-bandsEnergy<>-9,16--397`     7.32e-08   5.13e-08
1.43e+00
## `fBodyAccJerk-bandsEnergy<>-17,24--398`    4.88e-08   3.42e-08
1.43e+00
## `fBodyAccJerk-bandsEnergy<>-25,32--399`    3.16e-08   2.21e-08
1.43e+00
## `fBodyAccJerk-bandsEnergy<>-33,40--400`    1.58e-08   1.11e-08
1.43e+00
## `fBodyAccJerk-bandsEnergy<>-41,48--401`    8.29e-09   5.81e-09
1.43e+00
## `fBodyAccJerk-bandsEnergy<>-49,56--402`    5.08e-09   3.56e-09
1.43e+00
## `fBodyAccJerk-bandsEnergy<>-57,64--403`    7.34e-10   5.14e-10
1.43e+00
## `fBodyAccJerk-bandsEnergy<>-1,16--404`           NA         NA
NA
## `fBodyAccJerk-bandsEnergy<>-17,32--405`          NA         NA
NA
## `fBodyAccJerk-bandsEnergy<>-33,48--406`          NA         NA
NA
## `fBodyAccJerk-bandsEnergy<>-49,64--407`          NA         NA
NA
```

```
## `fBodyAccJerk-bandsEnergy<>-1,24--408`          NA          NA
NA
## `fBodyAccJerk-bandsEnergy<>-25,48--409`         NA          NA
NA
## `fBodyAccJerk-bandsEnergy<>-1,8--410`     6.94e-09    8.29e-09
8.40e-01
## `fBodyAccJerk-bandsEnergy<>-9,16--411`    1.67e-08    2.00e-08
8.40e-01
## `fBodyAccJerk-bandsEnergy<>-17,24--412`   3.02e-08    3.61e-08
8.40e-01
## `fBodyAccJerk-bandsEnergy<>-25,32--413`   2.89e-08    3.45e-08
8.40e-01
## `fBodyAccJerk-bandsEnergy<>-33,40--414`   1.43e-08    1.71e-08
8.40e-01
## `fBodyAccJerk-bandsEnergy<>-41,48--415`   5.65e-09    6.75e-09
8.40e-01
## `fBodyAccJerk-bandsEnergy<>-49,56--416`   1.68e-09    2.01e-09
8.40e-01
## `fBodyAccJerk-bandsEnergy<>-57,64--417`   2.03e-10    2.42e-10
8.40e-01
## `fBodyAccJerk-bandsEnergy<>-1,16--418`          NA          NA
NA
## `fBodyAccJerk-bandsEnergy<>-17,32--419`         NA          NA
NA
## `fBodyAccJerk-bandsEnergy<>-33,48--420`         NA          NA
NA
## `fBodyAccJerk-bandsEnergy<>-49,64--421`         NA          NA
NA
## `fBodyAccJerk-bandsEnergy<>-1,24--422`          NA          NA
NA
## `fBodyAccJerk-bandsEnergy<>-25,48--423`         NA          NA
NA
## `fBodyGyro-mean<>-X--424`                -3.92e-14    5.86e-14
-6.70e-01
## `fBodyGyro-mean<>-Y--425`                 6.56e-15    6.61e-14
1.00e-01
## `fBodyGyro-mean<>-Z--426`                -4.90e-15    5.54e-14
-9.00e-02
## `fBodyGyro-std<>-X--427`                 -5.86e-14    2.08e-13
-2.80e-01
## `fBodyGyro-std<>-Y--428`                 -1.67e-14    1.29e-13
-1.30e-01
## `fBodyGyro-std<>-Z--429`                 -1.98e-14    1.63e-13
-1.20e-01
## `fBodyGyro-mad<>-X--430`                  1.12e-14    2.75e-14
4.10e-01
## `fBodyGyro-mad<>-Y--431`                 -3.46e-14    3.29e-14
-1.05e+00
## `fBodyGyro-mad<>-Z--432`                  1.32e-14    2.64e-14
5.00e-01
## `fBodyGyro-max<>-X--433`                  1.42e-14    1.37e-14
1.04e+00
## `fBodyGyro-max<>-Y--434`                 -9.81e-15    1.39e-14
```

```
-7.00e-01
## `fBodyGyro-max<>-Z--435`                    -1.08e-14   1.55e-14
-7.00e-01
## `fBodyGyro-min<>-X--436`                     4.55e-16   6.88e-15
7.00e-02
## `fBodyGyro-min<>-Y--437`                    -2.97e-15   4.27e-15
-7.00e-01
## `fBodyGyro-min<>-Z--438`                     4.73e-15   5.29e-15
8.90e-01
## `fBodyGyro-sma<>--439`                             NA          NA
NA
## `fBodyGyro-energy<>-X--440`                  2.73e-08   9.15e-08
3.00e-01
## `fBodyGyro-energy<>-Y--441`                  9.01e-09   9.28e-08
1.00e-01
## `fBodyGyro-energy<>-Z--442`                  5.13e-08   8.77e-08
5.90e-01
## `fBodyGyro-iqr<>-X--443`                    -1.65e-17   6.07e-15
0.00e+00
## `fBodyGyro-iqr<>-Y--444`                     2.96e-15   9.03e-15
3.30e-01
## `fBodyGyro-iqr<>-Z--445`                    -6.61e-15   6.33e-15
-1.04e+00
## `fBodyGyro-entropy<>-X--446`                 3.52e-15   6.03e-15
5.80e-01
## `fBodyGyro-entropy<>-Y--447`                -1.27e-14   6.71e-15
-1.89e+00
## `fBodyGyro-entropy<>-Z--448`                 1.05e-14   5.95e-15
1.77e+00
## `fBodyGyro-maxInds-X--449`                   6.40e-16   2.57e-15
2.50e-01
## `fBodyGyro-maxInds-Y--450`                  -1.74e-15   2.07e-15
-8.40e-01
## `fBodyGyro-maxInds-Z--451`                   2.48e-15   2.53e-15
9.80e-01
## `fBodyGyro-meanFreq<>-X--452`                3.04e-15   3.46e-15
8.80e-01
## `fBodyGyro-meanFreq<>-Y--453`                3.02e-15   3.38e-15
8.90e-01
## `fBodyGyro-meanFreq<>-Z--454`               -8.94e-15   3.43e-15
-2.60e+00
## `fBodyGyro-skewness<>-X--455`                7.85e-15   1.01e-14
7.80e-01
## `fBodyGyro-kurtosis<>-X--456`               -1.34e-14   8.91e-15
-1.51e+00
## `fBodyGyro-skewness<>-Y--457`                3.48e-15   9.83e-15
3.50e-01
## `fBodyGyro-kurtosis<>-Y--458`               -1.45e-15   8.26e-15
-1.80e-01
## `fBodyGyro-skewness<>-Z--459`                1.55e-14   1.03e-14
1.50e+00
## `fBodyGyro-kurtosis<>-Z--460`               -8.00e-15   9.13e-15
-8.80e-01
```

```
## `fBodyGyro-bandsEnergy<>-1,8--461`        -2.51e-08   8.42e-08
-3.00e-01
## `fBodyGyro-bandsEnergy<>-9,16--462`       -3.89e-09   1.31e-08
-3.00e-01
## `fBodyGyro-bandsEnergy<>-17,24--463`      -1.48e-09   4.97e-09
-3.00e-01
## `fBodyGyro-bandsEnergy<>-25,32--464`      -7.51e-10   2.52e-09
-3.00e-01
## `fBodyGyro-bandsEnergy<>-33,40--465`      -2.08e-10   6.98e-10
-3.00e-01
## `fBodyGyro-bandsEnergy<>-41,48--466`      -1.22e-10   4.10e-10
-3.00e-01
## `fBodyGyro-bandsEnergy<>-49,56--467`      -7.83e-11   2.63e-10
-3.00e-01
## `fBodyGyro-bandsEnergy<>-57,64--468`      -6.21e-11   2.09e-10
-3.00e-01
## `fBodyGyro-bandsEnergy<>-1,16--469`              NA          NA
NA
## `fBodyGyro-bandsEnergy<>-17,32--470`             NA          NA
NA
## `fBodyGyro-bandsEnergy<>-33,48--471`             NA          NA
NA
## `fBodyGyro-bandsEnergy<>-49,64--472`             NA          NA
NA
## `fBodyGyro-bandsEnergy<>-1,24--473`              NA          NA
NA
## `fBodyGyro-bandsEnergy<>-25,48--474`             NA          NA
NA
## `fBodyGyro-bandsEnergy<>-1,8--475`        -5.04e-09   5.19e-08
-1.00e-01
## `fBodyGyro-bandsEnergy<>-9,16--476`       -4.86e-09   5.01e-08
-1.00e-01
## `fBodyGyro-bandsEnergy<>-17,24--477`      -3.87e-09   3.99e-08
-1.00e-01
## `fBodyGyro-bandsEnergy<>-25,32--478`      -1.25e-09   1.29e-08
-1.00e-01
## `fBodyGyro-bandsEnergy<>-33,40--479`      -4.14e-10   4.26e-09
-1.00e-01
## `fBodyGyro-bandsEnergy<>-41,48--480`      -1.06e-10   1.09e-09
-1.00e-01
## `fBodyGyro-bandsEnergy<>-49,56--481`      -3.71e-11   3.82e-10
-1.00e-01
## `fBodyGyro-bandsEnergy<>-57,64--482`      -2.29e-11   2.36e-10
-1.00e-01
## `fBodyGyro-bandsEnergy<>-1,16--483`              NA          NA
NA
## `fBodyGyro-bandsEnergy<>-17,32--484`             NA          NA
NA
## `fBodyGyro-bandsEnergy<>-33,48--485`             NA          NA
NA
## `fBodyGyro-bandsEnergy<>-49,64--486`             NA          NA
NA
## `fBodyGyro-bandsEnergy<>-1,24--487`              NA          NA
```

```
NA
## `fBodyGyro-bandsEnergy<>-25,48--488`                  NA         NA
NA
## `fBodyGyro-bandsEnergy<>-1,8--489`              -4.86e-08   8.29e-08
-5.90e-01
## `fBodyGyro-bandsEnergy<>-9,16--490`             -1.71e-08   2.92e-08
-5.90e-01
## `fBodyGyro-bandsEnergy<>-17,24--491`            -6.89e-09   1.18e-08
-5.90e-01
## `fBodyGyro-bandsEnergy<>-25,32--492`            -3.50e-09   5.97e-09
-5.90e-01
## `fBodyGyro-bandsEnergy<>-33,40--493`            -1.16e-09   1.97e-09
-5.90e-01
## `fBodyGyro-bandsEnergy<>-41,48--494`            -4.24e-10   7.24e-10
-5.90e-01
## `fBodyGyro-bandsEnergy<>-49,56--495`            -1.54e-10   2.63e-10
-5.90e-01
## `fBodyGyro-bandsEnergy<>-57,64--496`            -1.19e-10   2.03e-10
-5.90e-01
## `fBodyGyro-bandsEnergy<>-1,16--497`                    NA         NA
NA
## `fBodyGyro-bandsEnergy<>-17,32--498`                   NA         NA
NA
## `fBodyGyro-bandsEnergy<>-33,48--499`                   NA         NA
NA
## `fBodyGyro-bandsEnergy<>-49,64--500`                   NA         NA
NA
## `fBodyGyro-bandsEnergy<>-1,24--501`                    NA         NA
NA
## `fBodyGyro-bandsEnergy<>-25,48--502`                   NA         NA
NA
## `fBodyAccMag-mean<>--503`                        5.53e-14   7.76e-14
7.10e-01
## `fBodyAccMag-std<>--504`                         6.83e-14   1.39e-13
4.90e-01
## `fBodyAccMag-mad<>--505`                         1.01e-14   2.31e-14
4.40e-01
## `fBodyAccMag-max<>--506`                        -9.19e-15   1.42e-14
-6.50e-01
## `fBodyAccMag-min<>--507`                        -2.73e-15   4.18e-15
-6.50e-01
## `fBodyAccMag-sma<>--508`                               NA         NA
NA
## `fBodyAccMag-energy<>--509`                     -1.47e-15   2.81e-14
-5.00e-02
## `fBodyAccMag-iqr<>--510`                        -7.52e-15   7.63e-15
-9.90e-01
## `fBodyAccMag-entropy<>--511`                    -6.20e-15   8.23e-15
-7.50e-01
## `fBodyAccMag-maxInds--512`                      -5.22e-16   1.98e-15
-2.60e-01
## `fBodyAccMag-meanFreq<>--513`                   -1.29e-14   5.11e-15
-2.53e+00
```

```
## `fBodyAccMag-skewness<>--514`                  -7.22e-15   9.63e-15
-7.50e-01
## `fBodyAccMag-kurtosis<>--515`                   1.28e-14   8.60e-15
1.49e+00
## `fBodyBodyAccJerkMag-mean<>--516`              -1.02e-13   1.34e-13
-7.60e-01
## `fBodyBodyAccJerkMag-std<>--517`               -5.11e-14   1.05e-13
-4.80e-01
## `fBodyBodyAccJerkMag-mad<>--518`               -1.24e-15   2.42e-14
-5.00e-02
## `fBodyBodyAccJerkMag-max<>--519`                6.62e-15   1.55e-14
4.30e-01
## `fBodyBodyAccJerkMag-min<>--520`                4.71e-16   2.50e-15
1.90e-01
## `fBodyBodyAccJerkMag-sma<>--521`                      NA          NA
NA
## `fBodyBodyAccJerkMag-energy<>--522`             4.18e-14   4.89e-14
8.60e-01
## `fBodyBodyAccJerkMag-iqr<>--523`               -1.07e-15   8.57e-15
-1.30e-01
## `fBodyBodyAccJerkMag-entropy<>--524`           -4.13e-16   9.98e-15
-4.00e-02
## `fBodyBodyAccJerkMag-maxInds--525`              1.98e-15   2.09e-15
9.50e-01
## `fBodyBodyAccJerkMag-meanFreq<>--526`          -4.33e-15   4.63e-15
-9.30e-01
## `fBodyBodyAccJerkMag-skewness<>--527`          -1.70e-15   7.32e-15
-2.30e-01
## `fBodyBodyAccJerkMag-kurtosis<>--528`          -1.02e-15   7.58e-15
-1.40e-01
## `fBodyBodyGyroMag-mean<>--529`                 -2.49e-14   6.54e-14
-3.80e-01
## `fBodyBodyGyroMag-std<>--530`                  -4.66e-14   1.02e-13
-4.60e-01
## `fBodyBodyGyroMag-mad<>--531`                   7.17e-15   2.63e-14
2.70e-01
## `fBodyBodyGyroMag-max<>--532`                   6.00e-15   1.21e-14
5.00e-01
## `fBodyBodyGyroMag-min<>--533`                  -9.43e-16   3.83e-15
-2.50e-01
## `fBodyBodyGyroMag-sma<>--534`                         NA          NA
NA
## `fBodyBodyGyroMag-energy<>--535`                4.67e-14   2.80e-14
1.67e+00
## `fBodyBodyGyroMag-iqr<>--536`                  -1.35e-15   7.44e-15
-1.80e-01
## `fBodyBodyGyroMag-entropy<>--537`               6.66e-15   7.66e-15
8.70e-01
## `fBodyBodyGyroMag-maxInds--538`                 4.30e-15   3.14e-15
1.37e+00
## `fBodyBodyGyroMag-meanFreq<>--539`              4.48e-15   4.57e-15
9.80e-01
## `fBodyBodyGyroMag-skewness<>--540`              1.81e-14   9.10e-15
```

```
1.99e+00
## `fBodyBodyGyroMag-kurtosis<>--541`         -1.91e-14   8.10e-15
-2.35e+00
## `fBodyBodyGyroJerkMag-mean<>--542`          1.44e-14   1.87e-13
8.00e-02
## `fBodyBodyGyroJerkMag-std<>--543`           2.39e-14   1.52e-13
1.60e-01
## `fBodyBodyGyroJerkMag-mad<>--544`           1.98e-14   3.70e-14
5.30e-01
## `fBodyBodyGyroJerkMag-max<>--545`          -1.76e-14   1.94e-14
-9.10e-01
## `fBodyBodyGyroJerkMag-min<>--546`          -9.08e-16   3.52e-15
-2.60e-01
## `fBodyBodyGyroJerkMag-sma<>--547`                 NA          NA
NA
## `fBodyBodyGyroJerkMag-energy<>--548`       -3.94e-14   6.36e-14
-6.20e-01
## `fBodyBodyGyroJerkMag-iqr<>--549`          -4.99e-15   1.08e-14
-4.60e-01
## `fBodyBodyGyroJerkMag-entropy<>--550`      -2.63e-15   8.99e-15
-2.90e-01
## `fBodyBodyGyroJerkMag-maxInds--551`        -1.80e-15   2.83e-15
-6.40e-01
## `fBodyBodyGyroJerkMag-meanFreq<>--552`      9.13e-15   4.63e-15
1.97e+00
## `fBodyBodyGyroJerkMag-skewness<>--553`     -9.25e-15   7.18e-15
-1.29e+00
## `fBodyBodyGyroJerkMag-kurtosis<>--554`      1.02e-14   7.15e-15
1.43e+00
## `angle<tBodyAccMean,gravity>--555`          1.99e-15   1.59e-15
1.25e+00
## `angle<tBodyAccJerkMean>,gravityMean>--556` -7.07e-16   1.28e-15
-5.50e-01
## `angle<tBodyGyroMean,gravityMean>--557`    -2.28e-16   9.45e-16
-2.40e-01
## `angle<tBodyGyroJerkMean,gravityMean>--558`  5.45e-16   1.03e-15
5.30e-01
## `angle<X,gravityMean>--559`                 2.74e-14   2.20e-14
1.25e+00
## `angle<Y,gravityMean>--560`                 6.04e-14   4.03e-14
1.50e+00
## `angle<Z,gravityMean>--561`                -1.43e-14   2.20e-14
-6.50e-01
## `subject--562`                              2.07e-16   5.64e-17
3.66e+00
## activitysitting                             1.00e+00   6.76e-15
1.48e+14
## activitystanding                            2.00e+00   6.94e-15
2.88e+14
## activitywalk                                3.00e+00   1.13e-14
2.66e+14
## activitywalkdown                            4.00e+00   1.18e-14
3.38e+14
```

```
## activitywalkup                                     5.00e+00   1.12e-14
4.45e+14
## activityFactorsitting                                   NA         NA
NA
## activityFactorstanding                                  NA         NA
NA
## activityFactorwalk                                      NA         NA
NA
## activityFactorwalkdown                                  NA         NA
NA
## activityFactorwalkup                                    NA         NA
NA
##                                                   Pr(>|t|)
## (Intercept)                                       < 2e-16 ***
## `tBodyAcc-mean<>-X--1`                            0.89796
## `tBodyAcc-mean<>-Y--2`                            0.77038
## `tBodyAcc-mean<>-Z--3`                            0.09929 .
## `tBodyAcc-std<>-X--4`                             0.60121
## `tBodyAcc-std<>-Y--5`                             0.85130
## `tBodyAcc-std<>-Z--6`                             0.19602
## `tBodyAcc-mad<>-X--7`                             0.78397
## `tBodyAcc-mad<>-Y--8`                             0.17111
## `tBodyAcc-mad<>-Z--9`                             0.07350 .
## `tBodyAcc-max<>-X--10`                            0.07270 .
## `tBodyAcc-max<>-Y--11`                            0.99031
## `tBodyAcc-max<>-Z--12`                            0.00644 **
## `tBodyAcc-min<>-X--13`                            0.00030 ***
## `tBodyAcc-min<>-Y--14`                            0.47130
## `tBodyAcc-min<>-Z--15`                            0.01507 *
## `tBodyAcc-sma<>--16`                              0.09691 .
## `tBodyAcc-energy<>-X--17`                         0.37798
## `tBodyAcc-energy<>-Y--18`                         0.85453
## `tBodyAcc-energy<>-Z--19`                         0.18986
## `tBodyAcc-iqr<>-X--20`                            0.48976
## `tBodyAcc-iqr<>-Y--21`                            0.01673 *
## `tBodyAcc-iqr<>-Z--22`                            0.78931
## `tBodyAcc-entropy<>-X--23`                        0.00926 **
## `tBodyAcc-entropy<>-Y--24`                        0.53733
## `tBodyAcc-entropy<>-Z--25`                        0.53128
## `tBodyAcc-arCoeff<>-X,1--26`                      0.04978 *
## `tBodyAcc-arCoeff<>-X,2--27`                      1.2e-10 ***
## `tBodyAcc-arCoeff<>-X,3--28`                      1.9e-11 ***
## `tBodyAcc-arCoeff<>-X,4--29`                      0.72002
## `tBodyAcc-arCoeff<>-Y,1--30`                      0.01734 *
## `tBodyAcc-arCoeff<>-Y,2--31`                      0.13116
## `tBodyAcc-arCoeff<>-Y,3--32`                      0.52691
## `tBodyAcc-arCoeff<>-Y,4--33`                      0.22732
## `tBodyAcc-arCoeff<>-Z,1--34`                      0.00995 **
## `tBodyAcc-arCoeff<>-Z,2--35`                      0.33303
## `tBodyAcc-arCoeff<>-Z,3--36`                      7.0e-07 ***
## `tBodyAcc-arCoeff<>-Z,4--37`                      0.00054 ***
## `tBodyAcc-correlation<>-X,Y--38`                  0.41399
## `tBodyAcc-correlation<>-X,Z--39`                  0.02205 *
```

```
## `tBodyAcc-correlation<>-Y,Z--40`             0.08767 .
## `tGravityAcc-mean<>-X--41`                    0.92089
## `tGravityAcc-mean<>-Y--42`                    0.29562
## `tGravityAcc-mean<>-Z--43`                    0.09842 .
## `tGravityAcc-std<>-X--44`                     0.42866
## `tGravityAcc-std<>-Y--45`                     0.76935
## `tGravityAcc-std<>-Z--46`                     0.64421
## `tGravityAcc-mad<>-X--47`                     0.43051
## `tGravityAcc-mad<>-Y--48`                     0.72446
## `tGravityAcc-mad<>-Z--49`                     0.08543 .
## `tGravityAcc-max<>-X--50`                     0.74704
## `tGravityAcc-max<>-Y--51`                     0.97367
## `tGravityAcc-max<>-Z--52`                     0.11763
## `tGravityAcc-min<>-X--53`                     0.69403
## `tGravityAcc-min<>-Y--54`                     0.97243
## `tGravityAcc-min<>-Z--55`                     0.03278 *
## `tGravityAcc-sma<>--56`                       0.96515
## `tGravityAcc-energy<>-X--57`                  0.96720
## `tGravityAcc-energy<>-Y--58`                  0.48477
## `tGravityAcc-energy<>-Z--59`                  0.43575
## `tGravityAcc-iqr<>-X--60`                     0.90607
## `tGravityAcc-iqr<>-Y--61`                     0.81793
## `tGravityAcc-iqr<>-Z--62`                     0.00285 **
## `tGravityAcc-entropy<>-X--63`                 0.08860 .
## `tGravityAcc-entropy<>-Y--64`                 0.72385
## `tGravityAcc-entropy<>-Z--65`                 0.02627 *
## `tGravityAcc-arCoeff<>-X,1--66`               0.58041
## `tGravityAcc-arCoeff<>-X,2--67`               0.58384
## `tGravityAcc-arCoeff<>-X,3--68`               0.58754
## `tGravityAcc-arCoeff<>-X,4--69`               0.59126
## `tGravityAcc-arCoeff<>-Y,1--70`               0.55343
## `tGravityAcc-arCoeff<>-Y,2--71`               0.56147
## `tGravityAcc-arCoeff<>-Y,3--72`               0.56971
## `tGravityAcc-arCoeff<>-Y,4--73`               0.57794
## `tGravityAcc-arCoeff<>-Z,1--74`               0.17565
## `tGravityAcc-arCoeff<>-Z,2--75`               0.18018
## `tGravityAcc-arCoeff<>-Z,3--76`               0.18428
## `tGravityAcc-arCoeff<>-Z,4--77`               0.18788
## `tGravityAcc-correlation<>-X,Y--78`           0.29486
## `tGravityAcc-correlation<>-X,Z--79`           0.82569
## `tGravityAcc-correlation<>-Y,Z--80`           0.58045
## `tBodyAccJerk-mean<>-X--81`                   0.80653
## `tBodyAccJerk-mean<>-Y--82`                   0.74550
## `tBodyAccJerk-mean<>-Z--83`                   0.54586
## `tBodyAccJerk-std<>-X--84`                    0.76583
## `tBodyAccJerk-std<>-Y--85`                    0.90383
## `tBodyAccJerk-std<>-Z--86`                    0.38110
## `tBodyAccJerk-mad<>-X--87`                    0.99246
## `tBodyAccJerk-mad<>-Y--88`                    0.75602
## `tBodyAccJerk-mad<>-Z--89`                    0.85524
## `tBodyAccJerk-max<>-X--90`                    0.01124 *
## `tBodyAccJerk-max<>-Y--91`                    0.69446
## `tBodyAccJerk-max<>-Z--92`                    0.20231
```

```
## `tBodyAccJerk-min<>-X--93`                     0.40127
## `tBodyAccJerk-min<>-Y--94`                     0.25097
## `tBodyAccJerk-min<>-Z--95`                     0.99829
## `tBodyAccJerk-sma<>--96`                       0.78549
## `tBodyAccJerk-energy<>-X--97`                  0.51853
## `tBodyAccJerk-energy<>-Y--98`                  0.61398
## `tBodyAccJerk-energy<>-Z--99`                  0.92177
## `tBodyAccJerk-iqr<>-X--100`                    0.61545
## `tBodyAccJerk-iqr<>-Y--101`                    0.60641
## `tBodyAccJerk-iqr<>-Z--102`                    0.44166
## `tBodyAccJerk-entropy<>-X--103`                0.40874
## `tBodyAccJerk-entropy<>-Y--104`                0.66501
## `tBodyAccJerk-entropy<>-Z--105`                0.05077 .
## `tBodyAccJerk-arCoeff<>-X,1--106`              7.9e-06 ***
## `tBodyAccJerk-arCoeff<>-X,2--107`              0.43428
## `tBodyAccJerk-arCoeff<>-X,3--108`              5.7e-15 ***
## `tBodyAccJerk-arCoeff<>-X,4--109`              5.9e-11 ***
## `tBodyAccJerk-arCoeff<>-Y,1--110`              0.02724 *
## `tBodyAccJerk-arCoeff<>-Y,2--111`              0.48104
## `tBodyAccJerk-arCoeff<>-Y,3--112`              0.57061
## `tBodyAccJerk-arCoeff<>-Y,4--113`              0.49949
## `tBodyAccJerk-arCoeff<>-Z,1--114`              0.06339 .
## `tBodyAccJerk-arCoeff<>-Z,2--115`              0.00104 **
## `tBodyAccJerk-arCoeff<>-Z,3--116`              0.22509
## `tBodyAccJerk-arCoeff<>-Z,4--117`              5.9e-07 ***
## `tBodyAccJerk-correlation<>-X,Y--118`          0.00204 **
## `tBodyAccJerk-correlation<>-X,Z--119`          0.01232 *
## `tBodyAccJerk-correlation<>-Y,Z--120`          0.00600 **
## `tBodyGyro-mean<>-X--121`                      0.05436 .
## `tBodyGyro-mean<>-Y--122`                      0.73902
## `tBodyGyro-mean<>-Z--123`                      0.01198 *
## `tBodyGyro-std<>-X--124`                       0.70559
## `tBodyGyro-std<>-Y--125`                       0.79331
## `tBodyGyro-std<>-Z--126`                       0.75677
## `tBodyGyro-mad<>-X--127`                       0.89004
## `tBodyGyro-mad<>-Y--128`                       0.88550
## `tBodyGyro-mad<>-Z--129`                       0.10526
## `tBodyGyro-max<>-X--130`                       0.05421 .
## `tBodyGyro-max<>-Y--131`                       0.54913
## `tBodyGyro-max<>-Z--132`                       0.04942 *
## `tBodyGyro-min<>-X--133`                       0.82003
## `tBodyGyro-min<>-Y--134`                       0.74587
## `tBodyGyro-min<>-Z--135`                       0.85070
## `tBodyGyro-sma<>--136`                         0.21189
## `tBodyGyro-energy<>-X--137`                    0.02554 *
## `tBodyGyro-energy<>-Y--138`                    0.52504
## `tBodyGyro-energy<>-Z--139`                    0.84175
## `tBodyGyro-iqr<>-X--140`                       0.95479
## `tBodyGyro-iqr<>-Y--141`                       0.98048
## `tBodyGyro-iqr<>-Z--142`                       0.76182
## `tBodyGyro-entropy<>-X--143`                   0.01320 *
## `tBodyGyro-entropy<>-Y--144`                   0.01872 *
## `tBodyGyro-entropy<>-Z--145`                   0.00536 **
```

```
## `tBodyGyro-arCoeff<>-X,1--146`              0.64171
## `tBodyGyro-arCoeff<>-X,2--147`              0.15743
## `tBodyGyro-arCoeff<>-X,3--148`              0.00907 **
## `tBodyGyro-arCoeff<>-X,4--149`              0.33058
## `tBodyGyro-arCoeff<>-Y,1--150`              0.86660
## `tBodyGyro-arCoeff<>-Y,2--151`              0.00053 ***
## `tBodyGyro-arCoeff<>-Y,3--152`              1.1e-06 ***
## `tBodyGyro-arCoeff<>-Y,4--153`              0.43693
## `tBodyGyro-arCoeff<>-Z,1--154`              0.38157
## `tBodyGyro-arCoeff<>-Z,2--155`              0.03327 *
## `tBodyGyro-arCoeff<>-Z,3--156`              0.00048 ***
## `tBodyGyro-arCoeff<>-Z,4--157`              0.47808
## `tBodyGyro-correlation<>-X,Y--158`          0.02189 *
## `tBodyGyro-correlation<>-X,Z--159`          0.30682
## `tBodyGyro-correlation<>-Y,Z--160`          0.75234
## `tBodyGyroJerk-mean<>-X--161`               0.67200
## `tBodyGyroJerk-mean<>-Y--162`               0.56458
## `tBodyGyroJerk-mean<>-Z--163`               0.31268
## `tBodyGyroJerk-std<>-X--164`                0.58663
## `tBodyGyroJerk-std<>-Y--165`                0.51663
## `tBodyGyroJerk-std<>-Z--166`                0.58645
## `tBodyGyroJerk-mad<>-X--167`                0.98447
## `tBodyGyroJerk-mad<>-Y--168`                0.98644
## `tBodyGyroJerk-mad<>-Z--169`                0.63717
## `tBodyGyroJerk-max<>-X--170`                0.73968
## `tBodyGyroJerk-max<>-Y--171`                0.89017
## `tBodyGyroJerk-max<>-Z--172`                0.55599
## `tBodyGyroJerk-min<>-X--173`                0.49617
## `tBodyGyroJerk-min<>-Y--174`                0.57872
## `tBodyGyroJerk-min<>-Z--175`                0.46644
## `tBodyGyroJerk-sma<>--176`                  0.93916
## `tBodyGyroJerk-energy<>-X--177`             0.70941
## `tBodyGyroJerk-energy<>-Y--178`             0.32327
## `tBodyGyroJerk-energy<>-Z--179`             0.67623
## `tBodyGyroJerk-iqr<>-X--180`                0.69724
## `tBodyGyroJerk-iqr<>-Y--181`                0.89274
## `tBodyGyroJerk-iqr<>-Z--182`                0.44639
## `tBodyGyroJerk-entropy<>-X--183`            0.88250
## `tBodyGyroJerk-entropy<>-Y--184`            0.92395
## `tBodyGyroJerk-entropy<>-Z--185`            0.11070
## `tBodyGyroJerk-arCoeff<>-X,1--186`          0.47221
## `tBodyGyroJerk-arCoeff<>-X,2--187`          0.48851
## `tBodyGyroJerk-arCoeff<>-X,3--188`          0.24179
## `tBodyGyroJerk-arCoeff<>-X,4--189`          0.01648 *
## `tBodyGyroJerk-arCoeff<>-Y,1--190`          0.00115 **
## `tBodyGyroJerk-arCoeff<>-Y,2--191`          0.94026
## `tBodyGyroJerk-arCoeff<>-Y,3--192`          4.6e-05 ***
## `tBodyGyroJerk-arCoeff<>-Y,4--193`          6.6e-05 ***
## `tBodyGyroJerk-arCoeff<>-Z,1--194`          0.26825
## `tBodyGyroJerk-arCoeff<>-Z,2--195`          0.34031
## `tBodyGyroJerk-arCoeff<>-Z,3--196`          0.00291 **
## `tBodyGyroJerk-arCoeff<>-Z,4--197`          2.1e-06 ***
## `tBodyGyroJerk-correlation<>-X,Y--198`      0.03026 *
```

```
## `tBodyGyroJerk-correlation<>-X,Z--199`        0.48437
## `tBodyGyroJerk-correlation<>-Y,Z--200`        0.23913
## `tBodyAccMag-mean<>--201`                     0.07716 .
## `tBodyAccMag-std<>--202`                      0.51829
## `tBodyAccMag-mad<>--203`                      0.62209
## `tBodyAccMag-max<>--204`                      0.87778
## `tBodyAccMag-min<>--205`                      0.98588
## `tBodyAccMag-sma<>--206`                           NA
## `tBodyAccMag-energy<>--207`                        NA
## `tBodyAccMag-iqr<>--208`                      0.97402
## `tBodyAccMag-entropy<>--209`                  0.00578 **
## `tBodyAccMag-arCoeff<>1--210`                 0.01393 *
## `tBodyAccMag-arCoeff<>2--211`                 0.02063 *
## `tBodyAccMag-arCoeff<>3--212`                 0.02889 *
## `tBodyAccMag-arCoeff<>4--213`                 0.03772 *
## `tGravityAccMag-mean<>--214`                       NA
## `tGravityAccMag-std<>--215`                        NA
## `tGravityAccMag-mad<>--216`                        NA
## `tGravityAccMag-max<>--217`                        NA
## `tGravityAccMag-min<>--218`                        NA
## `tGravityAccMag-sma<>--219`                        NA
## `tGravityAccMag-energy<>--220`                     NA
## `tGravityAccMag-iqr<>--221`                        NA
## `tGravityAccMag-entropy<>--222`                    NA
## `tGravityAccMag-arCoeff<>1--223`                   NA
## `tGravityAccMag-arCoeff<>2--224`                   NA
## `tGravityAccMag-arCoeff<>3--225`                   NA
## `tGravityAccMag-arCoeff<>4--226`                   NA
## `tBodyAccJerkMag-mean<>--227`                 0.85007
## `tBodyAccJerkMag-std<>--228`                  0.60173
## `tBodyAccJerkMag-mad<>--229`                  0.94961
## `tBodyAccJerkMag-max<>--230`                  0.71488
## `tBodyAccJerkMag-min<>--231`                  0.99265
## `tBodyAccJerkMag-sma<>--232`                       NA
## `tBodyAccJerkMag-energy<>--233`                    NA
## `tBodyAccJerkMag-iqr<>--234`                  0.70537
## `tBodyAccJerkMag-entropy<>--235`              0.22038
## `tBodyAccJerkMag-arCoeff<>1--236`             0.68313
## `tBodyAccJerkMag-arCoeff<>2--237`             0.78224
## `tBodyAccJerkMag-arCoeff<>3--238`             0.77849
## `tBodyAccJerkMag-arCoeff<>4--239`             0.83922
## `tBodyGyroMag-mean<>--240`                    0.02148 *
## `tBodyGyroMag-std<>--241`                     0.78738
## `tBodyGyroMag-mad<>--242`                     0.84706
## `tBodyGyroMag-max<>--243`                     0.79498
## `tBodyGyroMag-min<>--244`                     0.89107
## `tBodyGyroMag-sma<>--245`                          NA
## `tBodyGyroMag-energy<>--246`                       NA
## `tBodyGyroMag-iqr<>--247`                     0.82919
## `tBodyGyroMag-entropy<>--248`                 0.89063
## `tBodyGyroMag-arCoeff<>1--249`                0.64697
## `tBodyGyroMag-arCoeff<>2--250`                0.61777
## `tBodyGyroMag-arCoeff<>3--251`                0.69390
```

```
## `tBodyGyroMag-arCoeff<>4--252`              0.86545
## `tBodyGyroJerkMag-mean<>--253`              0.88983
## `tBodyGyroJerkMag-std<>--254`               0.96507
## `tBodyGyroJerkMag-mad<>--255`               0.71616
## `tBodyGyroJerkMag-max<>--256`               0.60350
## `tBodyGyroJerkMag-min<>--257`               0.98849
## `tBodyGyroJerkMag-sma<>--258`                    NA
## `tBodyGyroJerkMag-energy<>--259`                 NA
## `tBodyGyroJerkMag-iqr<>--260`               0.83124
## `tBodyGyroJerkMag-entropy<>--261`           0.79157
## `tBodyGyroJerkMag-arCoeff<>1--262`          0.41480
## `tBodyGyroJerkMag-arCoeff<>2--263`          0.38857
## `tBodyGyroJerkMag-arCoeff<>3--264`          0.19208
## `tBodyGyroJerkMag-arCoeff<>4--265`          0.18646
## `fBodyAcc-mean<>-X--266`                    0.71251
## `fBodyAcc-mean<>-Y--267`                    0.80531
## `fBodyAcc-mean<>-Z--268`                    0.38639
## `fBodyAcc-std<>-X--269`                     0.45184
## `fBodyAcc-std<>-Y--270`                     0.66591
## `fBodyAcc-std<>-Z--271`                     0.32909
## `fBodyAcc-mad<>-X--272`                     0.66839
## `fBodyAcc-mad<>-Y--273`                     0.64873
## `fBodyAcc-mad<>-Z--274`                     0.19132
## `fBodyAcc-max<>-X--275`                     0.57717
## `fBodyAcc-max<>-Y--276`                     0.76239
## `fBodyAcc-max<>-Z--277`                     0.33893
## `fBodyAcc-min<>-X--278`                     0.58721
## `fBodyAcc-min<>-Y--279`                     0.29903
## `fBodyAcc-min<>-Z--280`                     0.79611
## `fBodyAcc-sma<>--281`                            NA
## `fBodyAcc-energy<>-X--282`                  0.27941
## `fBodyAcc-energy<>-Y--283`                  0.40628
## `fBodyAcc-energy<>-Z--284`                  0.10219
## `fBodyAcc-iqr<>-X--285`                     0.26478
## `fBodyAcc-iqr<>-Y--286`                     0.60680
## `fBodyAcc-iqr<>-Z--287`                     0.35178
## `fBodyAcc-entropy<>-X--288`                 0.39828
## `fBodyAcc-entropy<>-Y--289`                 0.03216 *
## `fBodyAcc-entropy<>-Z--290`                 0.60910
## `fBodyAcc-maxInds-X--291`                   0.06010 .
## `fBodyAcc-maxInds-Y--292`                   0.82827
## `fBodyAcc-maxInds-Z--293`                   0.72701
## `fBodyAcc-meanFreq<>-X--294`                0.22426
## `fBodyAcc-meanFreq<>-Y--295`                0.19762
## `fBodyAcc-meanFreq<>-Z--296`                0.43709
## `fBodyAcc-skewness<>-X--297`                0.78510
## `fBodyAcc-kurtosis<>-X--298`                0.79247
## `fBodyAcc-skewness<>-Y--299`                0.43200
## `fBodyAcc-kurtosis<>-Y--300`                0.24104
## `fBodyAcc-skewness<>-Z--301`                0.65043
## `fBodyAcc-kurtosis<>-Z--302`                0.47406
## `fBodyAcc-bandsEnergy<>-1,8--303`           0.27941
## `fBodyAcc-bandsEnergy<>-9,16--304`          0.27941
```

```
## `fBodyAcc-bandsEnergy<>-17,24--305`              0.27941
## `fBodyAcc-bandsEnergy<>-25,32--306`              0.27941
## `fBodyAcc-bandsEnergy<>-33,40--307`              0.27941
## `fBodyAcc-bandsEnergy<>-41,48--308`              0.27941
## `fBodyAcc-bandsEnergy<>-49,56--309`              0.27941
## `fBodyAcc-bandsEnergy<>-57,64--310`              0.27940
## `fBodyAcc-bandsEnergy<>-1,16--311`                    NA
## `fBodyAcc-bandsEnergy<>-17,32--312`                   NA
## `fBodyAcc-bandsEnergy<>-33,48--313`                   NA
## `fBodyAcc-bandsEnergy<>-49,64--314`                   NA
## `fBodyAcc-bandsEnergy<>-1,24--315`                    NA
## `fBodyAcc-bandsEnergy<>-25,48--316`                   NA
## `fBodyAcc-bandsEnergy<>-1,8--317`                0.40628
## `fBodyAcc-bandsEnergy<>-9,16--318`               0.40628
## `fBodyAcc-bandsEnergy<>-17,24--319`              0.40628
## `fBodyAcc-bandsEnergy<>-25,32--320`              0.40629
## `fBodyAcc-bandsEnergy<>-33,40--321`              0.40628
## `fBodyAcc-bandsEnergy<>-41,48--322`              0.40629
## `fBodyAcc-bandsEnergy<>-49,56--323`              0.40629
## `fBodyAcc-bandsEnergy<>-57,64--324`              0.40628
## `fBodyAcc-bandsEnergy<>-1,16--325`                    NA
## `fBodyAcc-bandsEnergy<>-17,32--326`                   NA
## `fBodyAcc-bandsEnergy<>-33,48--327`                   NA
## `fBodyAcc-bandsEnergy<>-49,64--328`                   NA
## `fBodyAcc-bandsEnergy<>-1,24--329`                    NA
## `fBodyAcc-bandsEnergy<>-25,48--330`                   NA
## `fBodyAcc-bandsEnergy<>-1,8--331`                0.10219
## `fBodyAcc-bandsEnergy<>-9,16--332`               0.10219
## `fBodyAcc-bandsEnergy<>-17,24--333`              0.10219
## `fBodyAcc-bandsEnergy<>-25,32--334`              0.10219
## `fBodyAcc-bandsEnergy<>-33,40--335`              0.10219
## `fBodyAcc-bandsEnergy<>-41,48--336`              0.10219
## `fBodyAcc-bandsEnergy<>-49,56--337`              0.10219
## `fBodyAcc-bandsEnergy<>-57,64--338`              0.10219
## `fBodyAcc-bandsEnergy<>-1,16--339`                    NA
## `fBodyAcc-bandsEnergy<>-17,32--340`                   NA
## `fBodyAcc-bandsEnergy<>-33,48--341`                   NA
## `fBodyAcc-bandsEnergy<>-49,64--342`                   NA
## `fBodyAcc-bandsEnergy<>-1,24--343`                    NA
## `fBodyAcc-bandsEnergy<>-25,48--344`                   NA
## `fBodyAccJerk-mean<>-X--345`                     0.71191
## `fBodyAccJerk-mean<>-Y--346`                     0.91467
## `fBodyAccJerk-mean<>-Z--347`                     0.43348
## `fBodyAccJerk-std<>-X--348`                      0.67490
## `fBodyAccJerk-std<>-Y--349`                      0.93479
## `fBodyAccJerk-std<>-Z--350`                      0.42139
## `fBodyAccJerk-mad<>-X--351`                      0.90146
## `fBodyAccJerk-mad<>-Y--352`                      0.88635
## `fBodyAccJerk-mad<>-Z--353`                      0.90714
## `fBodyAccJerk-max<>-X--354`                      0.77490
## `fBodyAccJerk-max<>-Y--355`                      0.60429
## `fBodyAccJerk-max<>-Z--356`                      0.75276
## `fBodyAccJerk-min<>-X--357`                      0.95181
```

```
## `fBodyAccJerk-min<>-Y--358`                   0.43178
## `fBodyAccJerk-min<>-Z--359`                   0.48650
## `fBodyAccJerk-sma<>--360`                          NA
## `fBodyAccJerk-energy<>-X--361`                0.12832
## `fBodyAccJerk-energy<>-Y--362`                0.15365
## `fBodyAccJerk-energy<>-Z--363`                0.40267
## `fBodyAccJerk-iqr<>-X--364`                   0.52197
## `fBodyAccJerk-iqr<>-Y--365`                   0.79002
## `fBodyAccJerk-iqr<>-Z--366`                   0.98412
## `fBodyAccJerk-entropy<>-X--367`               0.20313
## `fBodyAccJerk-entropy<>-Y--368`               0.71736
## `fBodyAccJerk-entropy<>-Z--369`               0.70198
## `fBodyAccJerk-maxInds-X--370`                 4.5e-05 ***
## `fBodyAccJerk-maxInds-Y--371`                 0.69866
## `fBodyAccJerk-maxInds-Z--372`                 0.08084 .
## `fBodyAccJerk-meanFreq<>-X--373`              0.27515
## `fBodyAccJerk-meanFreq<>-Y--374`              0.32314
## `fBodyAccJerk-meanFreq<>-Z--375`              0.11492
## `fBodyAccJerk-skewness<>-X--376`              0.94875
## `fBodyAccJerk-kurtosis<>-X--377`              0.71549
## `fBodyAccJerk-skewness<>-Y--378`              0.56216
## `fBodyAccJerk-kurtosis<>-Y--379`              0.88309
## `fBodyAccJerk-skewness<>-Z--380`              0.37546
## `fBodyAccJerk-kurtosis<>-Z--381`              0.57324
## `fBodyAccJerk-bandsEnergy<>-1,8--382`         0.12831
## `fBodyAccJerk-bandsEnergy<>-9,16--383`        0.12831
## `fBodyAccJerk-bandsEnergy<>-17,24--384`       0.12831
## `fBodyAccJerk-bandsEnergy<>-25,32--385`       0.12831
## `fBodyAccJerk-bandsEnergy<>-33,40--386`       0.12831
## `fBodyAccJerk-bandsEnergy<>-41,48--387`       0.12831
## `fBodyAccJerk-bandsEnergy<>-49,56--388`       0.12831
## `fBodyAccJerk-bandsEnergy<>-57,64--389`       0.12832
## `fBodyAccJerk-bandsEnergy<>-1,16--390`             NA
## `fBodyAccJerk-bandsEnergy<>-17,32--391`            NA
## `fBodyAccJerk-bandsEnergy<>-33,48--392`            NA
## `fBodyAccJerk-bandsEnergy<>-49,64--393`            NA
## `fBodyAccJerk-bandsEnergy<>-1,24--394`             NA
## `fBodyAccJerk-bandsEnergy<>-25,48--395`            NA
## `fBodyAccJerk-bandsEnergy<>-1,8--396`         0.15366
## `fBodyAccJerk-bandsEnergy<>-9,16--397`        0.15366
## `fBodyAccJerk-bandsEnergy<>-17,24--398`       0.15366
## `fBodyAccJerk-bandsEnergy<>-25,32--399`       0.15366
## `fBodyAccJerk-bandsEnergy<>-33,40--400`       0.15366
## `fBodyAccJerk-bandsEnergy<>-41,48--401`       0.15366
## `fBodyAccJerk-bandsEnergy<>-49,56--402`       0.15366
## `fBodyAccJerk-bandsEnergy<>-57,64--403`       0.15366
## `fBodyAccJerk-bandsEnergy<>-1,16--404`             NA
## `fBodyAccJerk-bandsEnergy<>-17,32--405`            NA
## `fBodyAccJerk-bandsEnergy<>-33,48--406`            NA
## `fBodyAccJerk-bandsEnergy<>-49,64--407`            NA
## `fBodyAccJerk-bandsEnergy<>-1,24--408`             NA
## `fBodyAccJerk-bandsEnergy<>-25,48--409`            NA
## `fBodyAccJerk-bandsEnergy<>-1,8--410`         0.40267
```

```
## `fBodyAccJerk-bandsEnergy<>-9,16--411`       0.40267
## `fBodyAccJerk-bandsEnergy<>-17,24--412`      0.40267
## `fBodyAccJerk-bandsEnergy<>-25,32--413`      0.40267
## `fBodyAccJerk-bandsEnergy<>-33,40--414`      0.40267
## `fBodyAccJerk-bandsEnergy<>-41,48--415`      0.40267
## `fBodyAccJerk-bandsEnergy<>-49,56--416`      0.40266
## `fBodyAccJerk-bandsEnergy<>-57,64--417`      0.40267
## `fBodyAccJerk-bandsEnergy<>-1,16--418`            NA
## `fBodyAccJerk-bandsEnergy<>-17,32--419`           NA
## `fBodyAccJerk-bandsEnergy<>-33,48--420`           NA
## `fBodyAccJerk-bandsEnergy<>-49,64--421`           NA
## `fBodyAccJerk-bandsEnergy<>-1,24--422`            NA
## `fBodyAccJerk-bandsEnergy<>-25,48--423`           NA
## `fBodyGyro-mean<>-X--424`                    0.50388
## `fBodyGyro-mean<>-Y--425`                    0.92089
## `fBodyGyro-mean<>-Z--426`                    0.92957
## `fBodyGyro-std<>-X--427`                     0.77807
## `fBodyGyro-std<>-Y--428`                     0.89684
## `fBodyGyro-std<>-Z--429`                     0.90335
## `fBodyGyro-mad<>-X--430`                     0.68410
## `fBodyGyro-mad<>-Y--431`                     0.29313
## `fBodyGyro-mad<>-Z--432`                     0.61658
## `fBodyGyro-max<>-X--433`                     0.29902
## `fBodyGyro-max<>-Y--434`                     0.48088
## `fBodyGyro-max<>-Z--435`                     0.48349
## `fBodyGyro-min<>-X--436`                     0.94724
## `fBodyGyro-min<>-Y--437`                     0.48670
## `fBodyGyro-min<>-Z--438`                     0.37133
## `fBodyGyro-sma<>--439`                            NA
## `fBodyGyro-energy<>-X--440`                  0.76574
## `fBodyGyro-energy<>-Y--441`                  0.92266
## `fBodyGyro-energy<>-Z--442`                  0.55817
## `fBodyGyro-iqr<>-X--443`                     0.99783
## `fBodyGyro-iqr<>-Y--444`                     0.74287
## `fBodyGyro-iqr<>-Z--445`                     0.29627
## `fBodyGyro-entropy<>-X--446`                 0.55900
## `fBodyGyro-entropy<>-Y--447`                 0.05891 .
## `fBodyGyro-entropy<>-Z--448`                 0.07667 .
## `fBodyGyro-maxInds-X--449`                   0.80336
## `fBodyGyro-maxInds-Y--450`                   0.40121
## `fBodyGyro-maxInds-Z--451`                   0.32662
## `fBodyGyro-meanFreq<>-X--452`                0.37983
## `fBodyGyro-meanFreq<>-Y--453`                0.37187
## `fBodyGyro-meanFreq<>-Z--454`                0.00929 **
## `fBodyGyro-skewness<>-X--455`                0.43791
## `fBodyGyro-kurtosis<>-X--456`                0.13221
## `fBodyGyro-skewness<>-Y--457`                0.72310
## `fBodyGyro-kurtosis<>-Y--458`                0.86092
## `fBodyGyro-skewness<>-Z--459`                0.13280
## `fBodyGyro-kurtosis<>-Z--460`                0.38074
## `fBodyGyro-bandsEnergy<>-1,8--461`           0.76574
## `fBodyGyro-bandsEnergy<>-9,16--462`          0.76574
## `fBodyGyro-bandsEnergy<>-17,24--463`         0.76574
```

```
## `fBodyGyro-bandsEnergy<>-25,32--464`          0.76575
## `fBodyGyro-bandsEnergy<>-33,40--465`          0.76574
## `fBodyGyro-bandsEnergy<>-41,48--466`          0.76573
## `fBodyGyro-bandsEnergy<>-49,56--467`          0.76577
## `fBodyGyro-bandsEnergy<>-57,64--468`          0.76572
## `fBodyGyro-bandsEnergy<>-1,16--469`                NA
## `fBodyGyro-bandsEnergy<>-17,32--470`               NA
## `fBodyGyro-bandsEnergy<>-33,48--471`               NA
## `fBodyGyro-bandsEnergy<>-49,64--472`               NA
## `fBodyGyro-bandsEnergy<>-1,24--473`                NA
## `fBodyGyro-bandsEnergy<>-25,48--474`               NA
## `fBodyGyro-bandsEnergy<>-1,8--475`           0.92266
## `fBodyGyro-bandsEnergy<>-9,16--476`          0.92266
## `fBodyGyro-bandsEnergy<>-17,24--477`         0.92266
## `fBodyGyro-bandsEnergy<>-25,32--478`         0.92266
## `fBodyGyro-bandsEnergy<>-33,40--479`         0.92266
## `fBodyGyro-bandsEnergy<>-41,48--480`         0.92266
## `fBodyGyro-bandsEnergy<>-49,56--481`         0.92267
## `fBodyGyro-bandsEnergy<>-57,64--482`         0.92264
## `fBodyGyro-bandsEnergy<>-1,16--483`                NA
## `fBodyGyro-bandsEnergy<>-17,32--484`               NA
## `fBodyGyro-bandsEnergy<>-33,48--485`               NA
## `fBodyGyro-bandsEnergy<>-49,64--486`               NA
## `fBodyGyro-bandsEnergy<>-1,24--487`                NA
## `fBodyGyro-bandsEnergy<>-25,48--488`               NA
## `fBodyGyro-bandsEnergy<>-1,8--489`           0.55817
## `fBodyGyro-bandsEnergy<>-9,16--490`          0.55817
## `fBodyGyro-bandsEnergy<>-17,24--491`         0.55817
## `fBodyGyro-bandsEnergy<>-25,32--492`         0.55817
## `fBodyGyro-bandsEnergy<>-33,40--493`         0.55817
## `fBodyGyro-bandsEnergy<>-41,48--494`         0.55817
## `fBodyGyro-bandsEnergy<>-49,56--495`         0.55819
## `fBodyGyro-bandsEnergy<>-57,64--496`         0.55817
## `fBodyGyro-bandsEnergy<>-1,16--497`                NA
## `fBodyGyro-bandsEnergy<>-17,32--498`               NA
## `fBodyGyro-bandsEnergy<>-33,48--499`               NA
## `fBodyGyro-bandsEnergy<>-49,64--500`               NA
## `fBodyGyro-bandsEnergy<>-1,24--501`                NA
## `fBodyGyro-bandsEnergy<>-25,48--502`               NA
## `fBodyAccMag-mean<>--503`                    0.47594
## `fBodyAccMag-std<>--504`                     0.62373
## `fBodyAccMag-mad<>--505`                     0.66289
## `fBodyAccMag-max<>--506`                     0.51788
## `fBodyAccMag-min<>--507`                     0.51395
## `fBodyAccMag-sma<>--508`                           NA
## `fBodyAccMag-energy<>--509`                  0.95817
## `fBodyAccMag-iqr<>--510`                     0.32462
## `fBodyAccMag-entropy<>--511`                 0.45108
## `fBodyAccMag-maxInds--512`                   0.79206
## `fBodyAccMag-meanFreq<>--513`                0.01148 *
## `fBodyAccMag-skewness<>--514`                0.45373
## `fBodyAccMag-kurtosis<>--515`                0.13586
## `fBodyBodyAccJerkMag-mean<>--516`            0.44703
```

```
## `fBodyBodyAccJerkMag-std<>--517`               0.62789
## `fBodyBodyAccJerkMag-mad<>--518`               0.95919
## `fBodyBodyAccJerkMag-max<>--519`               0.66845
## `fBodyBodyAccJerkMag-min<>--520`               0.85071
## `fBodyBodyAccJerkMag-sma<>--521`                    NA
## `fBodyBodyAccJerkMag-energy<>--522`            0.39256
## `fBodyBodyAccJerkMag-iqr<>--523`               0.90049
## `fBodyBodyAccJerkMag-entropy<>--524`           0.96699
## `fBodyBodyAccJerkMag-maxInds--525`             0.34326
## `fBodyBodyAccJerkMag-meanFreq<>--526`          0.35032
## `fBodyBodyAccJerkMag-skewness<>--527`          0.81675
## `fBodyBodyAccJerkMag-kurtosis<>--528`          0.89252
## `fBodyBodyGyroMag-mean<>--529`                 0.70345
## `fBodyBodyGyroMag-std<>--530`                  0.64775
## `fBodyBodyGyroMag-mad<>--531`                  0.78540
## `fBodyBodyGyroMag-max<>--532`                  0.62024
## `fBodyBodyGyroMag-min<>--533`                  0.80556
## `fBodyBodyGyroMag-sma<>--534`                       NA
## `fBodyBodyGyroMag-energy<>--535`               0.09498 .
## `fBodyBodyGyroMag-iqr<>--536`                  0.85566
## `fBodyBodyGyroMag-entropy<>--537`              0.38406
## `fBodyBodyGyroMag-maxInds--538`                0.17091
## `fBodyBodyGyroMag-meanFreq<>--539`             0.32669
## `fBodyBodyGyroMag-skewness<>--540`             0.04712 *
## `fBodyBodyGyroMag-kurtosis<>--541`             0.01874 *
## `fBodyBodyGyroJerkMag-mean<>--542`             0.93872
## `fBodyBodyGyroJerkMag-std<>--543`              0.87472
## `fBodyBodyGyroJerkMag-mad<>--544`              0.59276
## `fBodyBodyGyroJerkMag-max<>--545`              0.36415
## `fBodyBodyGyroJerkMag-min<>--546`              0.79641
## `fBodyBodyGyroJerkMag-sma<>--547`                   NA
## `fBodyBodyGyroJerkMag-energy<>--548`           0.53577
## `fBodyBodyGyroJerkMag-iqr<>--549`              0.64508
## `fBodyBodyGyroJerkMag-entropy<>--550`          0.76991
## `fBodyBodyGyroJerkMag-maxInds--551`            0.52366
## `fBodyBodyGyroJerkMag-meanFreq<>--552`         0.04859 *
## `fBodyBodyGyroJerkMag-skewness<>--553`         0.19808
## `fBodyBodyGyroJerkMag-kurtosis<>--554`         0.15357
## `angle<tBodyAccMean,gravity>--555`             0.21184
## `angle<tBodyAccJerkMean>,gravityMean>--556`    0.58035
## `angle<tBodyGyroMean,gravityMean>--557`        0.80911
## `angle<tBodyGyroJerkMean,gravityMean>--558`    0.59681
## `angle<X,gravityMean>--559`                    0.21173
## `angle<Y,gravityMean>--560`                    0.13365
## `angle<Z,gravityMean>--561`                    0.51410
## `subject--562`                                 0.00025 ***
## activitysitting                                < 2e-16 ***
## activitystanding                               < 2e-16 ***
## activitywalk                                   < 2e-16 ***
## activitywalkdown                               < 2e-16 ***
## activitywalkup                                 < 2e-16 ***
## activityFactorsitting                               NA
## activityFactorstanding                              NA
```

```
## activityFactorwalk                                      NA
## activityFactorwalkdown                                  NA
## activityFactorwalkup                                    NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3e-14 on 6866 degrees of freedom
## Multiple R-squared:    1,    Adjusted R-squared:    1
## F-statistic: 4.83e+28 on 485 and 6866 DF,  p-value: <2e-16
```

Observation: Our variables of interest seem to be insignificant coefficients when grouped in a more complex model where there are too many variables. Yet when we isolate a linear regression model on them we observe high significance on all 6 variables.

Predictive Analysis

Find the right data

There are 563 variables in the corpus and we do not have any domain knowledge. A good prediction for us would be where we can establish consistent classification accuracy while minimizing the optimism associated with our model's error rate. The Kalman Filter was designed to use the three signals (x, y and z coordinates) derived from an accelerometer for both Body and Gravity to estimate the human movement. Based on research regarding the Kalman Filter, we will narrow our focus of interest to 6 variables, namely the XYZ Coordinates of from MeanBodyAcc and MeanGravityAcc.

```
## Pick interested features
head(haradl.xyzMean)
```

```
##   subject activityID activity xMeanBodyAcc yMeanBodyAcc
zMeanBodyAcc
## 1       1          3 standing       0.2886     -0.02029
-0.1329
## 2       1          3 standing       0.2784     -0.01641
-0.1235
## 3       1          3 standing       0.2797     -0.01947
-0.1135
## 4       1          3 standing       0.2792     -0.02620
-0.1233
## 5       1          3 standing       0.2766     -0.01657
-0.1154
## 6       1          3 standing       0.2772     -0.01010
-0.1051
##   xMeanGravityAcc yMeanGravityAcc zMeanGravityAcc
## 1          0.9634         -0.1408         0.11537
## 2          0.9666         -0.1416         0.10938
## 3          0.9669         -0.1420         0.10188
## 4          0.9676         -0.1440         0.09985
## 5          0.9682         -0.1488         0.09449
## 6          0.9679         -0.1482         0.09191
```

Define your error rate

- Optimism = True Prediction Error - Training Error
- Optimism Acceptability Scale: ** Perfection: Optimism = 0 ** Optimistic: 0 < 1.5 ** Highly Optimistic: >1.5
- We seek an Optimistic Model.

Prepare your prediction environment

Our goal is to use a baseline training set of observations from a select set of subjects. We will split this training set into a sub-training and sub-test(validation) sets to validate our predictability against a baseline validation set of observations. Additionally, we will compare how our approach performs as we expand the two baselines. We will segment our training data such that observations from four subjects are used for testing and refinement. We have ensured that there are no overlaps between the baseline, expanded and testing groups.

```
## Baseline Training Subjects: 1,3,5 and 6.
subject.training.baseline <- c(1, 3, 5, 6)
data.training.baseline <- subset(haradl.xyzMean, subject %in%
subject.training.baseline)
dim(data.training.baseline)
```

```
## [1] 1315    9
```

```
subject.training.expanded <- c(1, 3, 5, 6, 14, 15, 16, 17, 19, 22,
23)
data.training.expanded <- subset(haradl.xyzMean, subject %in%
subject.training.expanded)
dim(data.training.expanded)
```

```
## [1] 3753    9
```

```
## Test Subjects
subject.training.test <- c(7, 8, 11, 25)
data.training.test <- subset(haradl.xyzMean, subject %in%
subject.training.test)
dim(data.training.test)
```

```
## [1] 1314    9
```

```
## Validation Subjects: 27, 28, 29, 30
subject.validation.baseline <- c(27, 28, 29, 30)
data.validation.baseline <- subset(haradl.xyzMean, subject %in%
subject.validation.baseline)
dim(data.validation.baseline)
```

```
## [1] 1485    9
```

```
subject.validation.expanded <- c(21, 27, 28, 29, 30)
data.validation.expanded <- subset(haradl.xyzMean, subject %in%
subject.validation.expanded)
dim(data.validation.expanded)
```

```
## [1] 1893    9
```

Identify the benchmark

Our probability benchmark for our data is based on an approximation equal to $(0.5)^{\text{size-of-sample-set.}}$ We have 0% probability for a perfect classification!

```
sampleSize <- dim(data.validation.baseline)[1]
as.double(0.5^sampleSize)
```

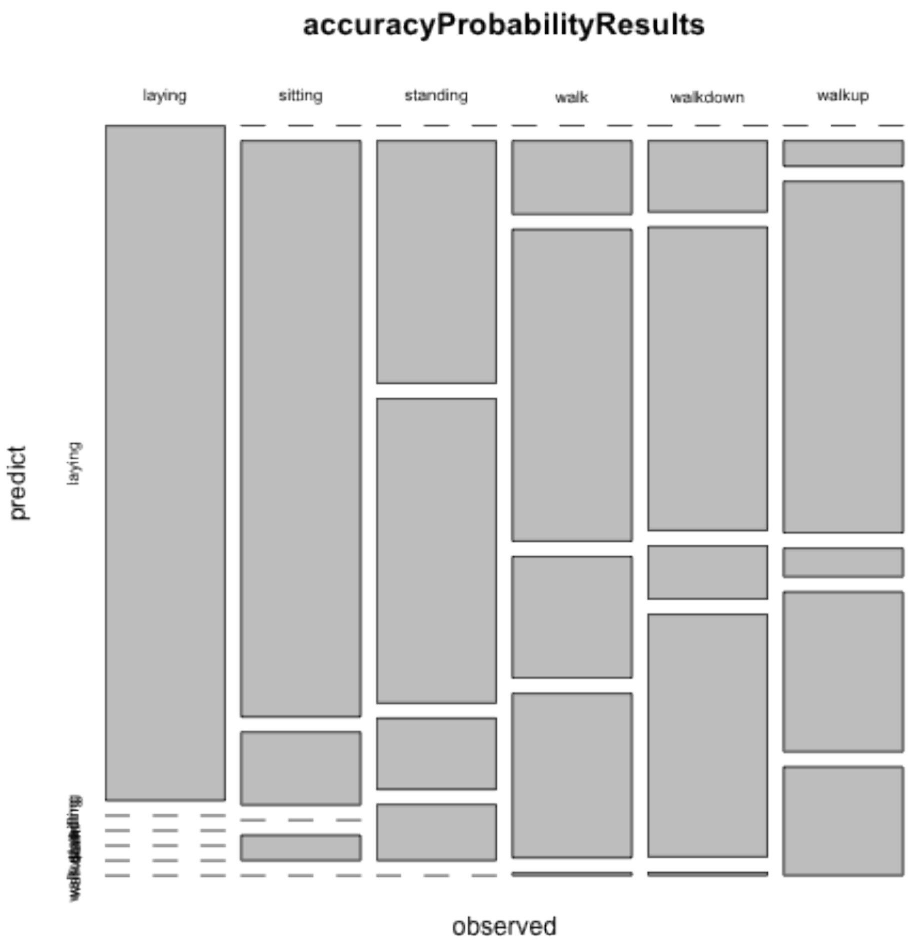
```
## [1] 0
```

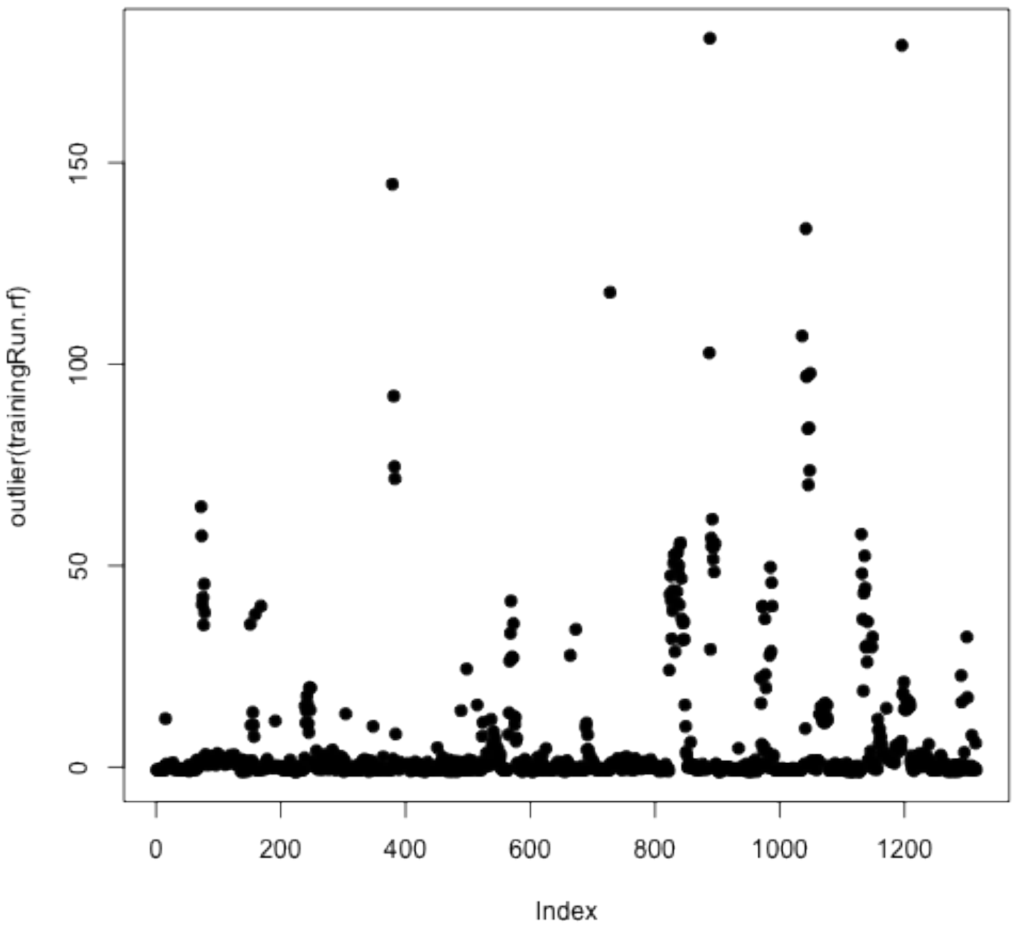
Using Training Set

Baseline Training with 3 splits for 500 and 1000 trees

```
## Define the prediction formula
model.formula <- activity ~ xMeanBodyAcc + yMeanBodyAcc +
zMeanBodyAcc + xMeanGravityAcc +
    yMeanGravityAcc + zMeanGravityAcc
prediction.results.accuracy <-
performPredictionTraining(model.formula, data.training.baseline,
    data.training.test, "Baseline3Splits500trees",
prediction.results.accuracy)
```

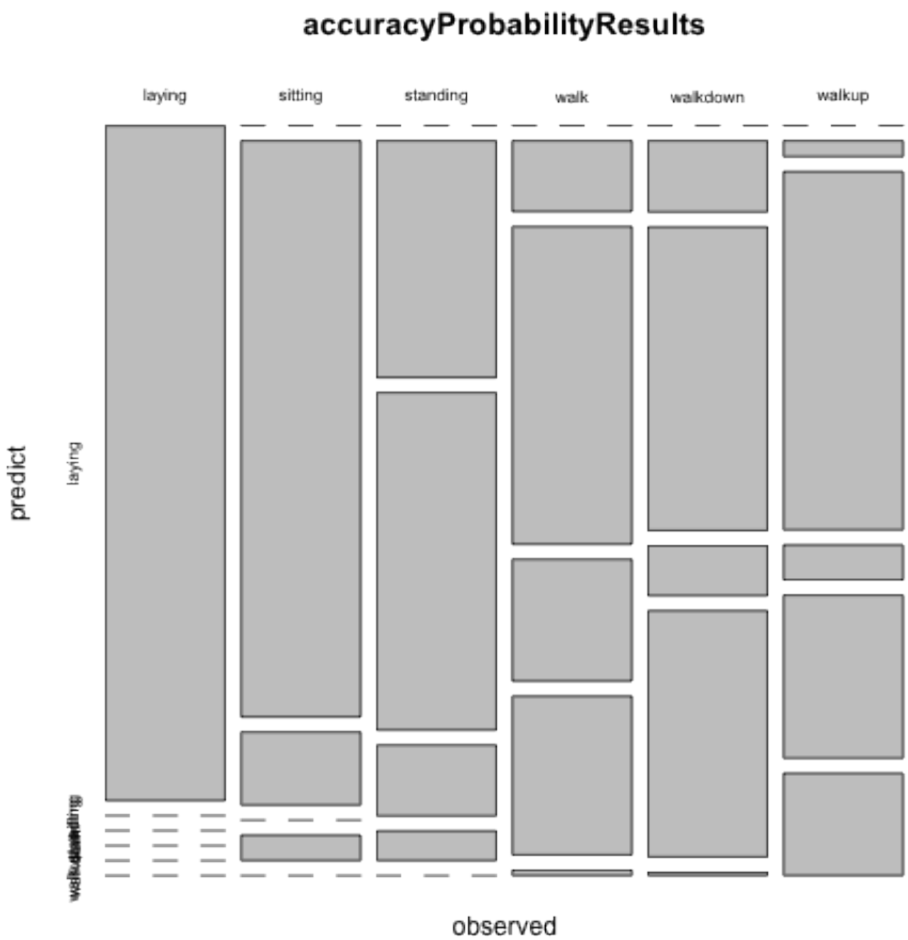
```
## ntree      OOB      1      2      3      4      5      6
##   100:   7.68%  0.00%  3.54%  8.37%  9.40% 15.03% 10.00%
##   200:   7.76%  0.00%  3.54%  7.93%  9.77% 16.06%  9.52%
##   300:   7.60%  0.00%  4.04%  7.93%  8.27% 16.06% 10.00%
##   400:   7.83%  0.00%  4.04%  7.93%  8.65% 16.06% 10.95%
##   500:   8.06%  0.00%  4.04%  7.93%  9.02% 16.58% 11.43%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 3
##
##         OOB estimate of  error rate: 8.06%
## Confusion matrix:
##          laying sitting standing walk walkdown walkup
class.error
## laying      221       0        0    0        0      0
0.00000
## sitting       0     190        6    1        1      0
0.04040
## standing      0       4      209    7        2      5
0.07930
## walk          0       0        3  242       14      7
0.09023
## walkdown      0       1        0   27      161      4
0.16580
## walkup        0       0        3   10       11    186
0.11429
##           predict
## observed     laying  sitting standing     walk walkdown   walkup
##   laying   1.000000 0.000000 0.000000 0.000000 0.000000 0.000000
##   sitting  0.000000 0.853774 0.108491 0.000000 0.037736 0.000000
##   standing 0.000000 0.359649 0.451754 0.105263 0.083333 0.000000
##   walk     0.000000 0.109244 0.462185 0.180672 0.243697 0.004202
##   walkdown 0.000000 0.105820 0.449735 0.079365 0.359788 0.005291
##   walkup   0.000000 0.037915 0.521327 0.042654 0.236967 0.161137
```

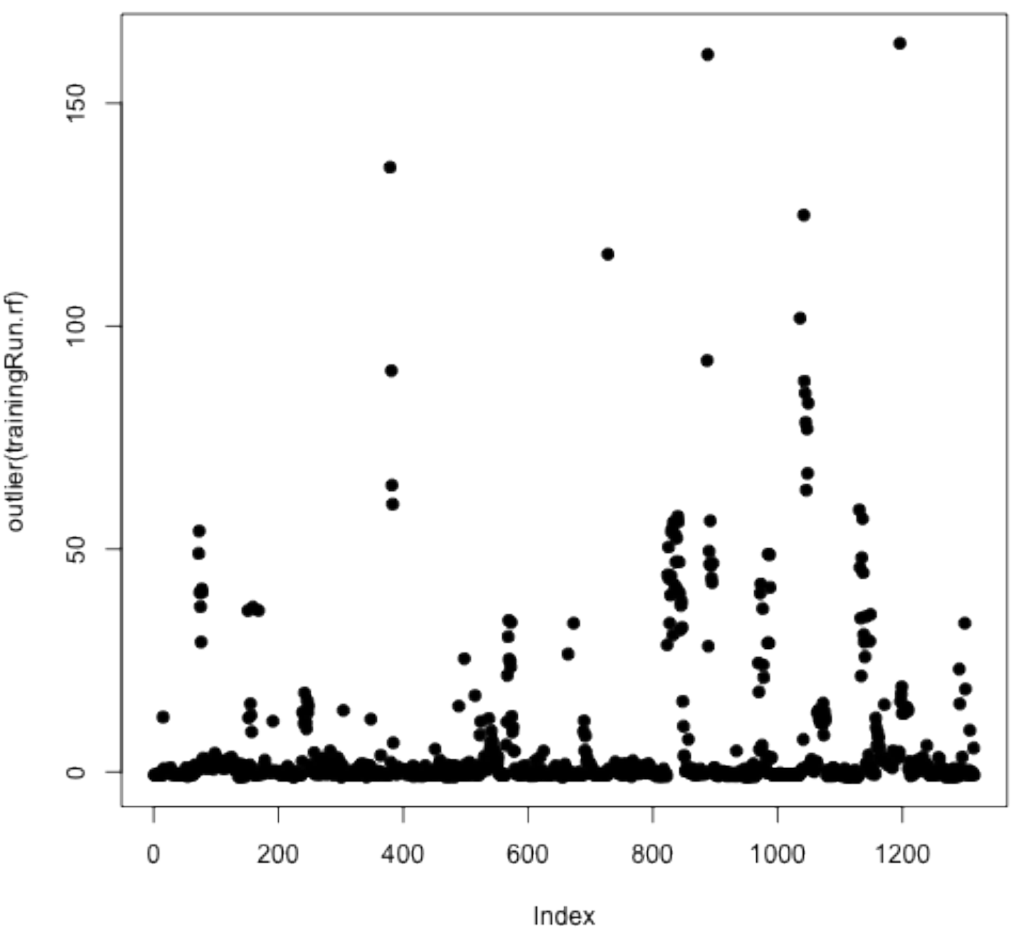

accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
observed




```
prediction.results.accuracy <-
performPredictionTraining(model.formula, data.training.baseline,
    data.training.test, "Baseline3Splits1000trees",
prediction.results.accuracy,
    trees = 1000)
```

```
## ntree      OOB      1      2      3      4      5      6
##   100:   7.68%  0.00%  3.54%  8.37%  9.40% 15.03% 10.00%
##   200:   7.76%  0.00%  3.54%  7.93%  9.77% 16.06%  9.52%
##   300:   7.60%  0.00%  4.04%  7.93%  8.27% 16.06% 10.00%
##   400:   7.83%  0.00%  4.04%  7.93%  8.65% 16.06% 10.95%
##   500:   8.06%  0.00%  4.04%  7.93%  9.02% 16.58% 11.43%
##   600:   7.98%  0.00%  4.04%  7.49%  9.02% 17.10% 10.95%
##   700:   7.76%  0.00%  4.04%  7.49%  9.02% 16.58% 10.00%
##   800:   7.83%  0.00%  4.04%  7.49%  9.02% 17.10% 10.00%
##   900:   7.76%  0.00%  4.04%  7.49%  8.27% 16.58% 10.95%
##  1000:   7.91%  0.00%  4.04%  7.49%  8.65% 17.10% 10.95%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 1000
## No. of variables tried at each split: 3
##
##         OOB estimate of  error rate: 7.91%
## Confusion matrix:
##          laying sitting standing walk walkdown walkup
class.error
## laying      221       0        0    0        0      0
0.00000
## sitting       0     190        6    1        1      0
0.04040
## standing      0       4      210    6        2      5
0.07489
## walk          0       0        3  243       13      7
0.08647
## walkdown      0       1        0   28      160      4
0.17098
## walkup        0       0        2   10       11    187
0.10952
##           predict
## observed     laying  sitting standing     walk walkdown   walkup
##   laying   1.000000 0.000000 0.000000 0.000000 0.000000 0.000000
##   sitting  0.000000 0.853774 0.108491 0.000000 0.037736 0.000000
##   standing 0.000000 0.350877 0.500000 0.105263 0.043860 0.000000
##   walk     0.000000 0.105042 0.470588 0.180672 0.235294 0.008403
##   walkdown 0.000000 0.105820 0.449735 0.074074 0.365079 0.005291
##   walkup   0.000000 0.023697 0.530806 0.052133 0.241706 0.151659
```


accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
observed



Observation:

- Split / Tree / Error Rate: 3 / 500 / 8.06%
- Split / Tree / Error Rate: 3 / 1000 / 7.91%
- Outliers ~= 4 in both cases
- While we were able to predict laying perfectly, our performance on the other 5 variables was as low as 15% prediction accuracy.

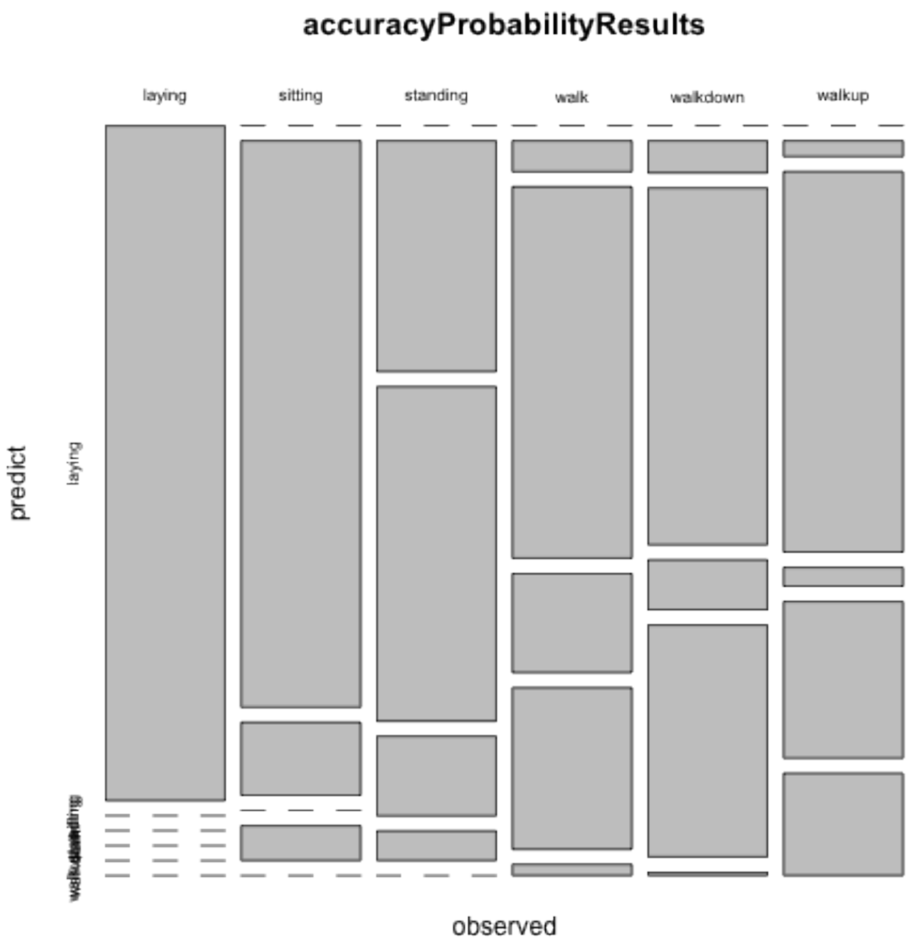
Action:

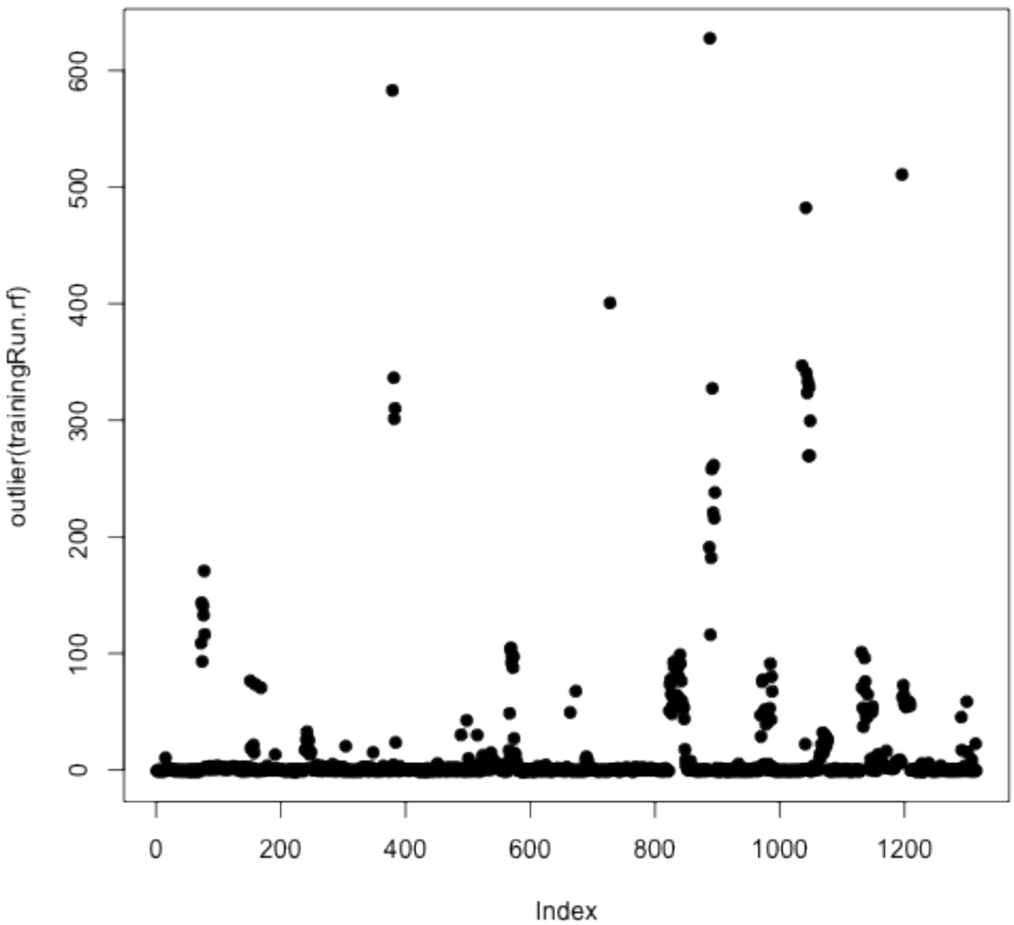
- We need to balance our results, which may increase the error rate but result In a better overall performance.
- We need to explore how we can weigh the classes
- We need to see if increasing variables at each split helps

Baseline Training with 4 splits for 500 and 1000 trees

```
## Define the prediction formula
model.formula <- activity ~ xMeanBodyAcc + yMeanBodyAcc +
zMeanBodyAcc + xMeanGravityAcc +
    yMeanGravityAcc + zMeanGravityAcc
prediction.results.accuracy <-
performPredictionTraining(model.formula, data.training.baseline,
    data.training.test, splits = 4, "Baseline4Splits500trees",
prediction.results.accuracy,
    trees = 500)
```

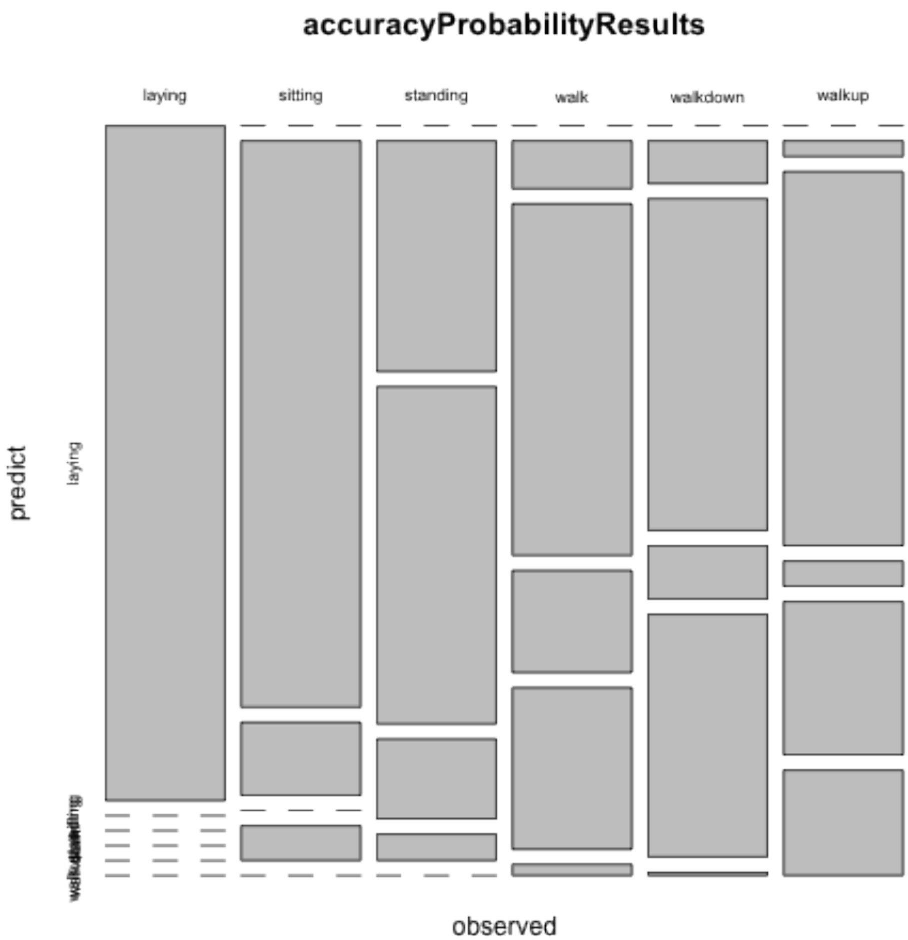
```
## ntree      OOB      1      2      3      4      5      6
##   100:   8.37%  0.00%  4.55%  7.49%  8.65% 17.10% 13.33%
##   200:   7.98%  0.00%  4.55%  7.05%  8.65% 17.10% 11.43%
##   300:   7.91%  0.00%  5.05%  7.49%  8.65% 17.10% 10.00%
##   400:   7.76%  0.00%  4.55%  7.05%  8.65% 17.10% 10.00%
##   500:   7.83%  0.00%  4.55%  7.05%  8.27% 17.62% 10.48%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 4
##
##         OOB estimate of  error rate: 7.83%
## Confusion matrix:
##          laying sitting standing walk walkdown walkup
class.error
## laying      221       0        0    0        0      0
0.00000
## sitting       0     189        6    2        1      0
0.04545
## standing      0       4      211    5        2      5
0.07048
## walk          0       1        2  244       13      6
0.08271
## walkdown      0       2        0   28      159      4
0.17617
## walkup        0       0        4    8       10    188
0.10476
##           predict
## observed     laying  sitting standing     walk walkdown   walkup
##   laying   1.000000 0.000000 0.000000 0.000000 0.000000 0.000000
##   sitting  0.000000 0.839623 0.108491 0.000000 0.051887 0.000000
##   standing 0.000000 0.342105 0.495614 0.118421 0.043860 0.000000
##   walk     0.000000 0.046218 0.550420 0.147059 0.239496 0.016807
##   walkdown 0.000000 0.047619 0.529101 0.074074 0.343915 0.005291
##   walkup   0.000000 0.023697 0.563981 0.028436 0.232227 0.151659
```

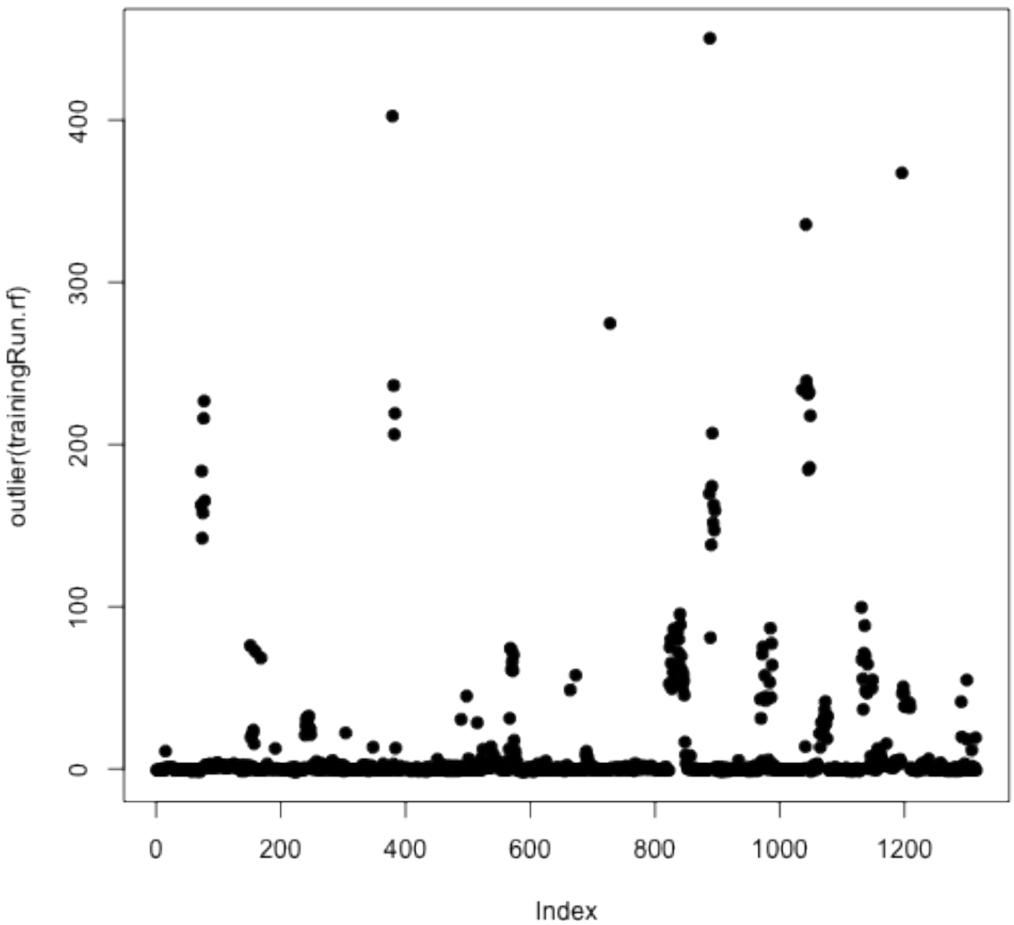

accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
observed




```
prediction.results.accuracy <-
performPredictionTraining(model.formula, data.training.baseline,
    data.training.test, splits = 4, "Baseline4Splits1000trees",
prediction.results.accuracy,
    trees = 1000)
```

```
## ntree      OOB      1      2      3      4      5      6
##   100:   8.37%  0.00%  4.55%  7.49%  8.65% 17.10% 13.33%
##   200:   7.98%  0.00%  4.55%  7.05%  8.65% 17.10% 11.43%
##   300:   7.91%  0.00%  5.05%  7.49%  8.65% 17.10% 10.00%
##   400:   7.76%  0.00%  4.55%  7.05%  8.65% 17.10% 10.00%
##   500:   7.83%  0.00%  4.55%  7.05%  8.27% 17.62% 10.48%
##   600:   7.76%  0.00%  4.55%  7.05%  8.27% 17.62% 10.00%
##   700:   7.76%  0.00%  4.55%  7.05%  8.27% 17.10% 10.48%
##   800:   7.60%  0.00%  4.55%  6.61%  8.27% 17.10% 10.00%
##   900:   7.68%  0.00%  4.55%  7.05%  8.27% 16.58% 10.48%
##  1000:   7.68%  0.00%  4.55%  7.05%  8.27% 16.58% 10.48%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 1000
## No. of variables tried at each split: 4
##
##         OOB estimate of  error rate: 7.68%
## Confusion matrix:
##          laying sitting standing walk walkdown walkup
class.error
## laying      221       0        0    0        0      0
0.00000
## sitting       0     189        6    2        1      0
0.04545
## standing      0       4      211    5        2      5
0.07048
## walk          0       1        2  244       12      7
0.08271
## walkdown      0       2        0   26      161      4
0.16580
## walkup        0       0        4    8       10    188
0.10476
##          predict
## observed     laying  sitting standing     walk walkdown   walkup
##   laying   1.000000 0.000000 0.000000 0.000000 0.000000 0.000000
##   sitting  0.000000 0.839623 0.108491 0.000000 0.051887 0.000000
##   standing 0.000000 0.342105 0.500000 0.118421 0.039474 0.000000
##   walk     0.000000 0.071429 0.521008 0.151261 0.239496 0.016807
##   walkdown 0.000000 0.063492 0.492063 0.079365 0.359788 0.005291
##   walkup   0.000000 0.023697 0.554502 0.037915 0.227488 0.156398
```


accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
observed



Observation:

- Split / Tree / Error Rate: 4 / 500 / 7.83%
- Split / Tree / Error Rate: 4 / 1000 / 7.68%
- Increasing splits had a positive improvement.

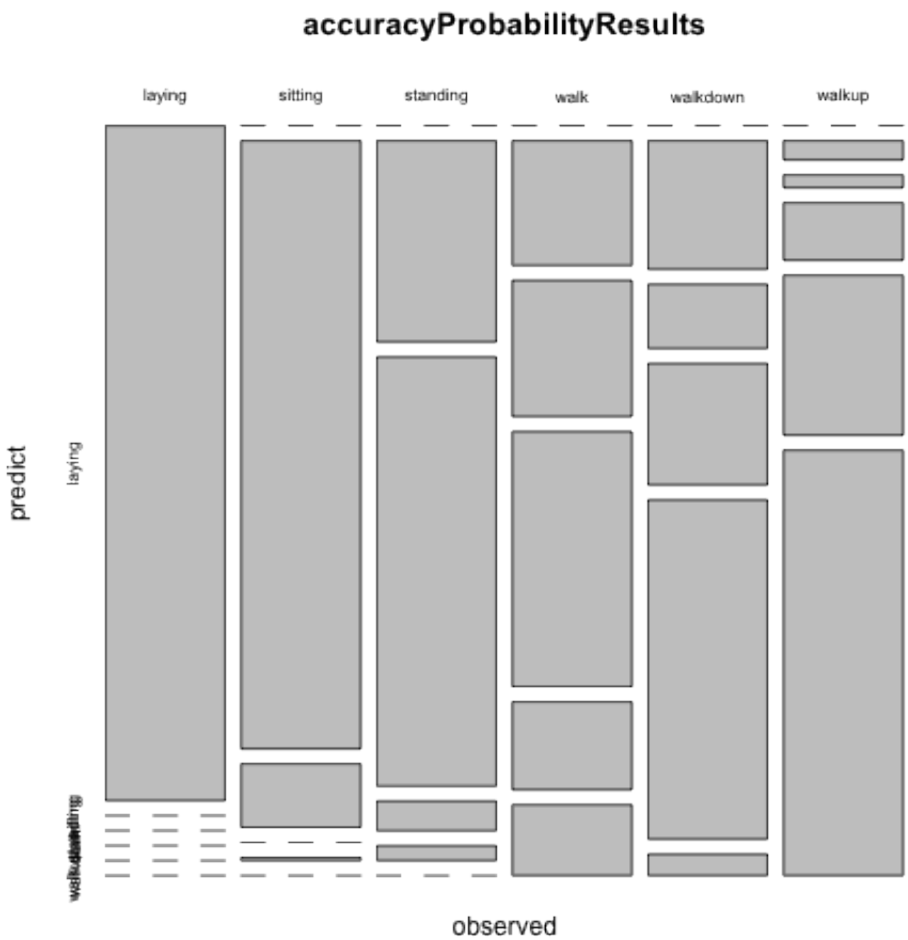
Action:

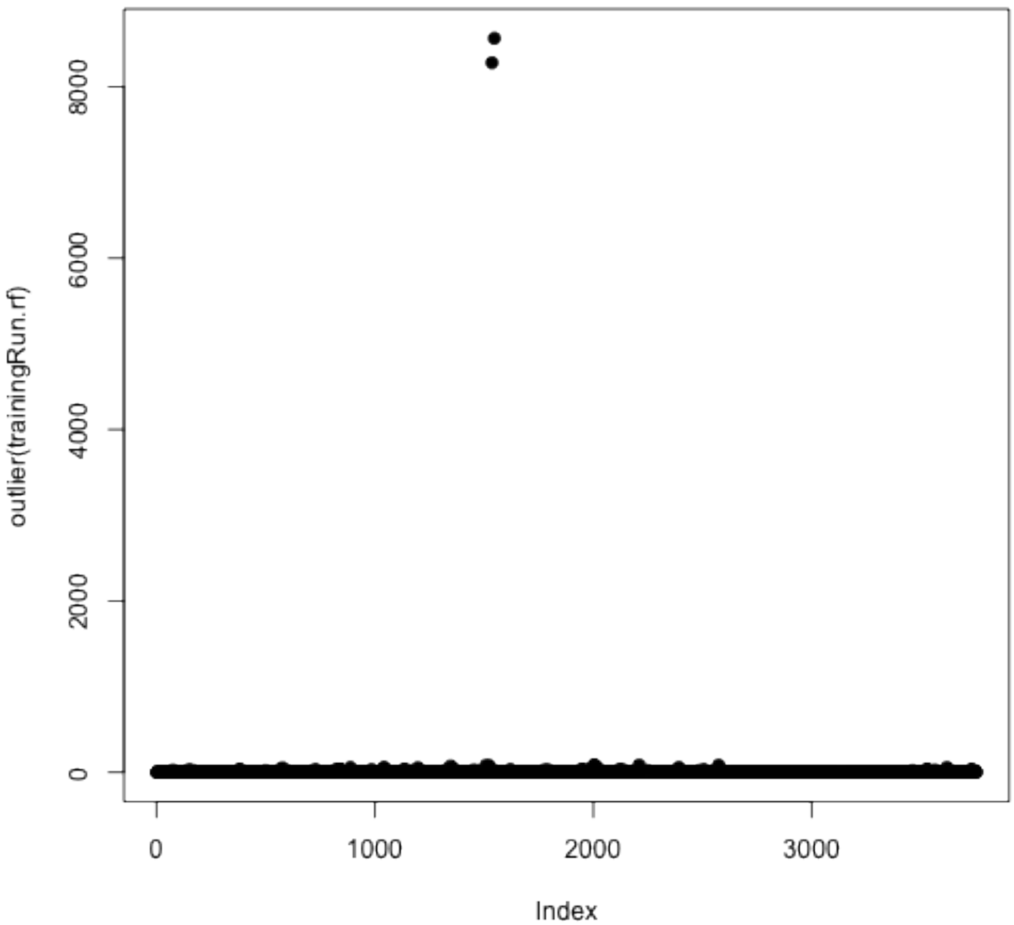
- We will setting from now on 4 variables per split
- We need to explore how we can weigh the classes
- Need to adjust formula
- Need to see if larger training set helps

Expanded Training with 4 splits for 500 and 1000 trees

```
## Define the prediction formula
model.formula <- activity ~ xMeanBodyAcc + yMeanBodyAcc +
zMeanBodyAcc + xMeanGravityAcc +
    yMeanGravityAcc + zMeanGravityAcc
prediction.results.accuracy <-
performPredictionTraining(model.formula, data.training.expanded,
    data.training.test, splits = 4, "Expanded4Splits500trees",
prediction.results.accuracy,
    trees = 500)
```

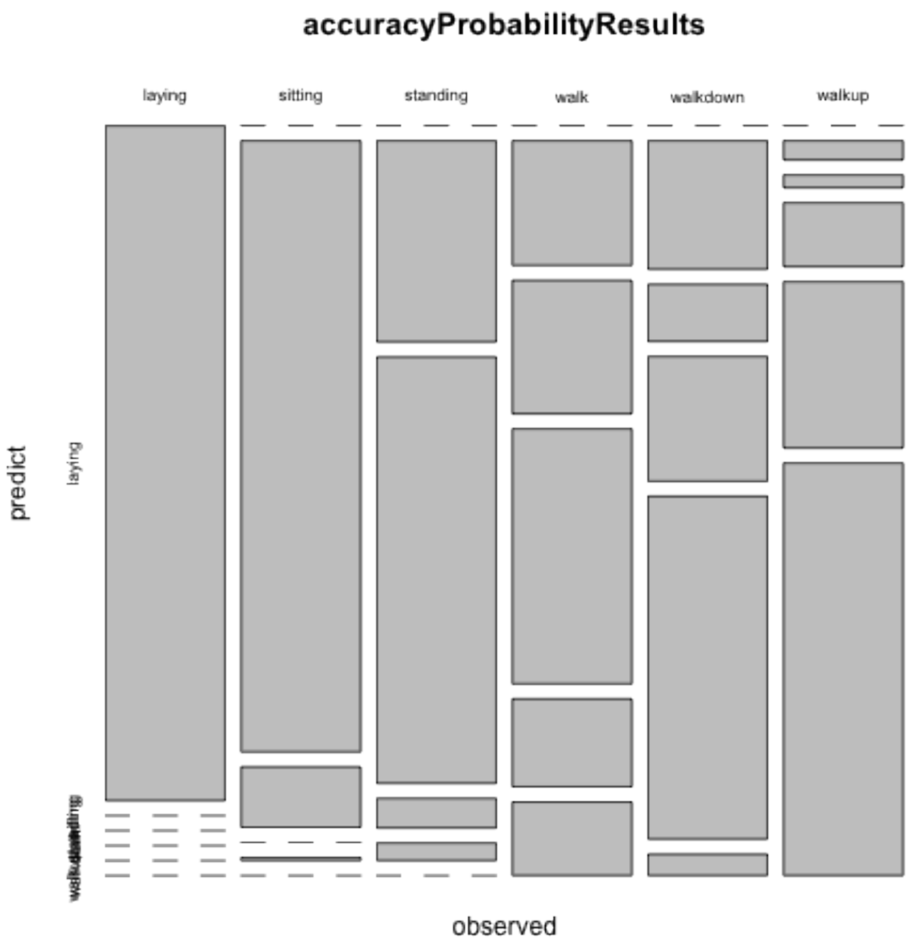
```
## ntree      OOB      1      2      3      4      5      6
##   100:   9.35%  0.28%  4.33% 11.00% 13.27% 21.12%  9.56%
##   200:   9.22%  0.28%  4.02% 11.14% 13.27% 20.52%  9.38%
##   300:   9.57%  0.28%  4.33% 11.14% 13.73% 22.31%  9.19%
##   400:   9.43%  0.28%  4.17% 11.14% 13.27% 22.11%  9.19%
##   500:   9.43%  0.28%  4.17% 10.71% 13.58% 22.11%  9.38%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 4
##
##         OOB estimate of  error rate: 9.43%
## Confusion matrix:
##          laying sitting standing walk walkdown walkup
class.error
## laying      710       2        0    0        0      0
0.002809
## sitting       0     620       17    3        5      2
0.041731
## standing      0      14      625   39       11     11
0.107143
## walk          0       3       27  560       48     10
0.135802
## walkdown      0       4       18   82      391      7
0.221116
## walkup        0       0       10   24       17    493
0.093750
##           predict
## observed     laying  sitting standing     walk walkdown   walkup
##   laying   1.000000 0.000000 0.000000 0.000000 0.000000 0.000000
##   sitting  0.000000 0.900943 0.094340 0.000000 0.004717 0.000000
##   standing 0.000000 0.298246 0.635965 0.043860 0.021930 0.000000
##   walk     0.000000 0.184874 0.201681 0.378151 0.130252 0.105042
##   walkdown 0.000000 0.190476 0.095238 0.179894 0.502646 0.031746
##   walkup   0.000000 0.028436 0.018957 0.085308 0.236967 0.630332
```

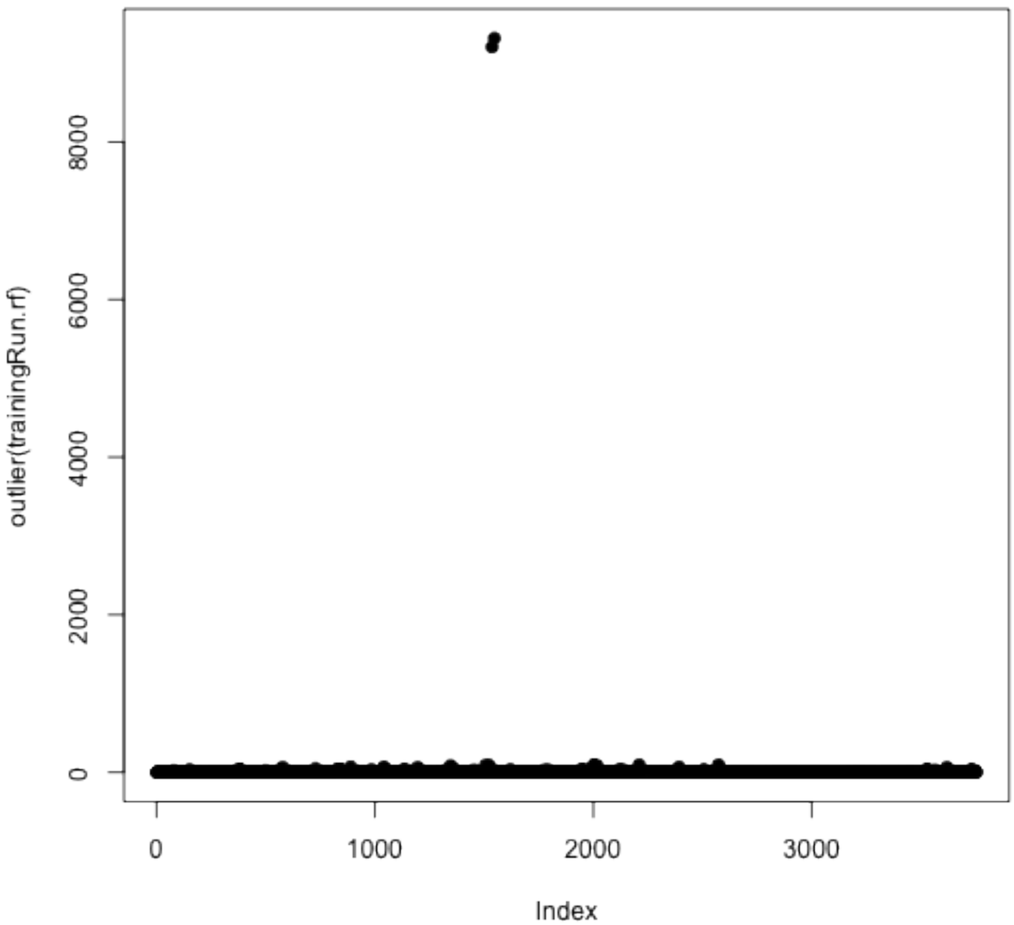

accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
observed




```
prediction.results.accuracy <-
performPredictionTraining(model.formula, data.training.expanded,
    data.training.test, splits = 4, "Expanded4Splits500trees",
prediction.results.accuracy,
    trees = 1000)
```

```
## ntree      OOB      1      2      3      4      5      6
##   100:   9.35%  0.28%  4.33% 11.00% 13.27% 21.12%  9.56%
##   200:   9.22%  0.28%  4.02% 11.14% 13.27% 20.52%  9.38%
##   300:   9.57%  0.28%  4.33% 11.14% 13.73% 22.31%  9.19%
##   400:   9.43%  0.28%  4.17% 11.14% 13.27% 22.11%  9.19%
##   500:   9.43%  0.28%  4.17% 10.71% 13.58% 22.11%  9.38%
##   600:   9.49%  0.28%  4.17% 11.14% 13.73% 22.11%  9.01%
##   700:   9.43%  0.28%  4.17% 11.00% 13.58% 21.91%  9.19%
##   800:   9.51%  0.28%  4.17% 11.14% 13.43% 22.11%  9.56%
##   900:   9.46%  0.28%  4.17% 11.29% 12.96% 22.31%  9.38%
##  1000:   9.46%  0.28%  4.17% 11.43% 12.96% 22.51%  9.01%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 1000
## No. of variables tried at each split: 4
##
##         OOB estimate of  error rate: 9.46%
## Confusion matrix:
##          laying sitting standing walk walkdown walkup
class.error
## laying      710       2        0    0        0      0
0.002809
## sitting       0     620       16    4        5      2
0.041731
## standing      0      15      620   39       13     13
0.114286
## walk          0       3       26  564       46      9
0.129630
## walkdown      0       4       19   82      389      8
0.225100
## walkup        0       0       10   22       17    495
0.090074
##           predict
## observed     laying  sitting standing     walk walkdown   walkup
##   laying   1.000000 0.000000 0.000000 0.000000 0.000000 0.000000
##   sitting  0.000000 0.905660 0.089623 0.000000 0.004717 0.000000
##   standing 0.000000 0.298246 0.631579 0.043860 0.026316 0.000000
##   walk     0.000000 0.184874 0.197479 0.378151 0.130252 0.109244
##   walkdown 0.000000 0.190476 0.084656 0.185185 0.507937 0.031746
##   walkup   0.000000 0.028436 0.018957 0.094787 0.246445 0.611374
```


accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
observed



Observation:

- Split / Tree / Error Rate: 4 / 500 / 9.43%
- Split / Tree / Error Rate: 4 / 1000 / 9.46%
- Increasing training set had negative results, but we may still need to balance training data
- Better performance seems to come from 4 splits per 1000 trees.

Action:

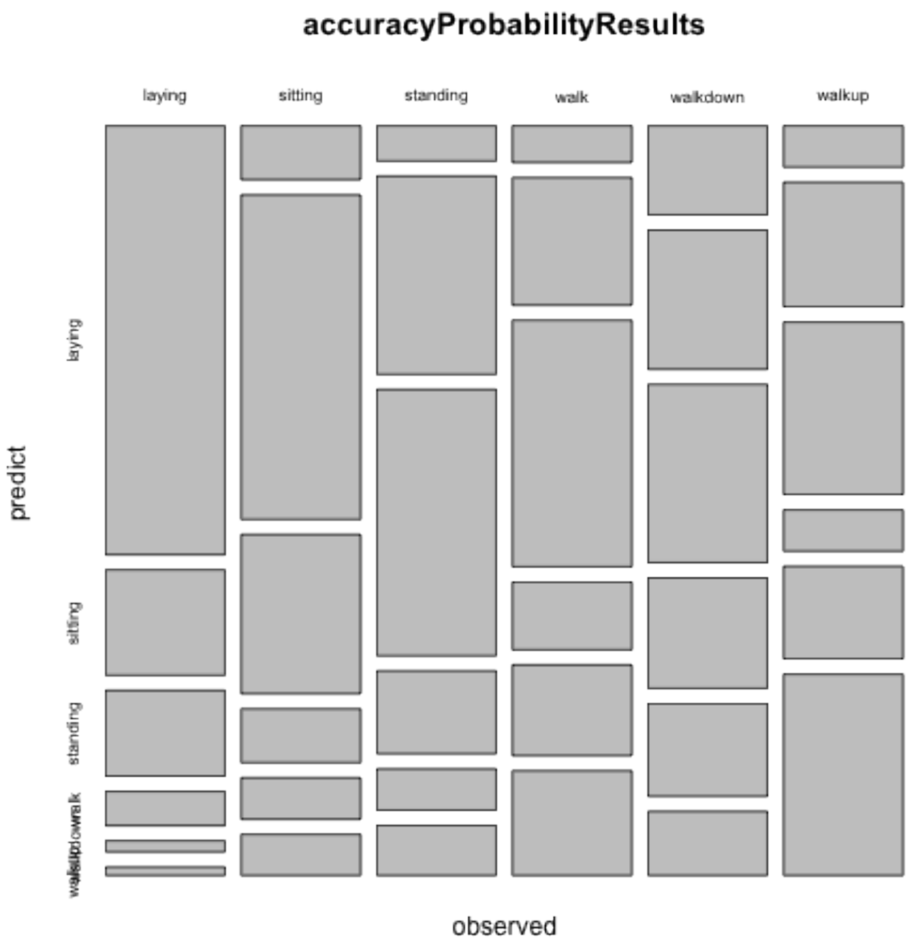
- We need to balance our results, which may increase the error rate but result In a better overall performance. We need to balance expanded training data.
- We need to explore how we can weigh the classes
- Need to adjust formula

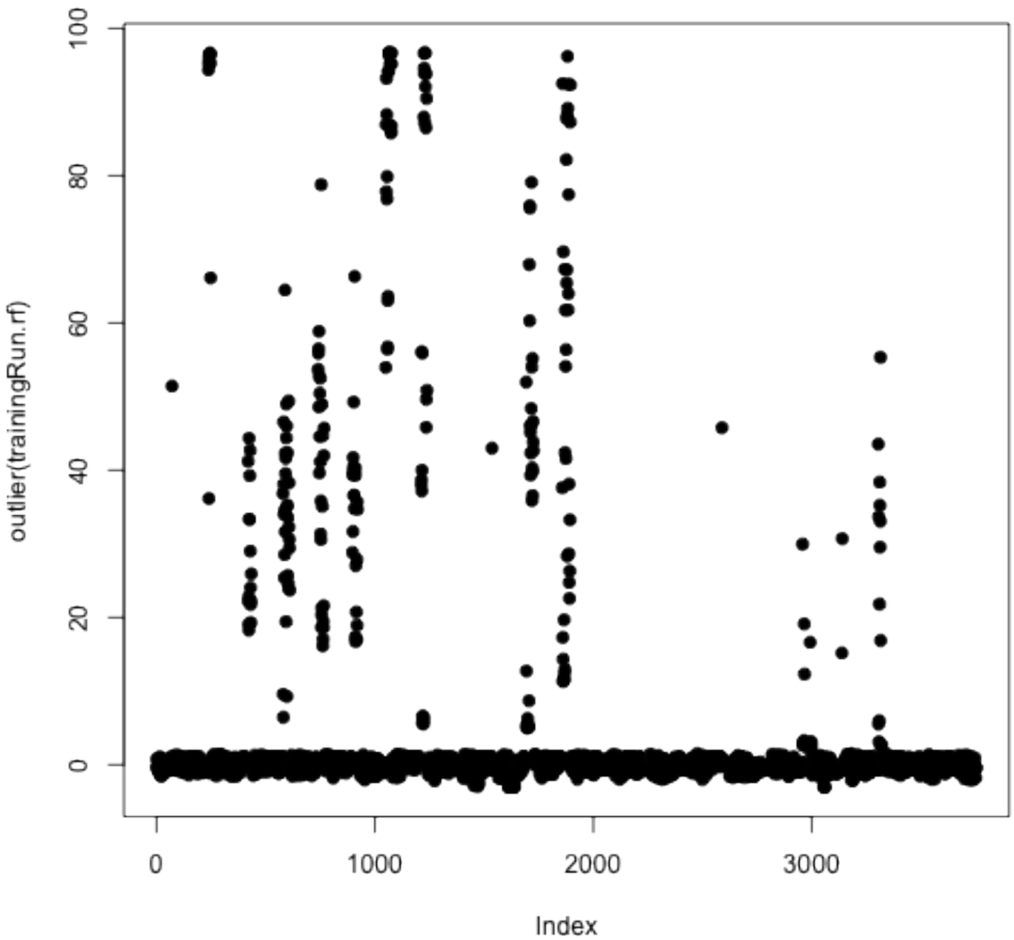
Expanded Training with 4 splits per 1000 trees zAxis-Only

```
## Define the prediction formula
model.formula <- activity ~ zMeanBodyAcc + zMeanGravityAcc
prediction.results.accuracy <-
performPredictionTraining(model.formula, data.training.expanded,
    data.training.test, splits = 4, "Expanded4Splits1000trees-Z",
prediction.results.accuracy,
    trees = 1000)
```

```
## Warning: invalid mtry: reset to within valid range
```

```
## ntree      OOB      1      2      3      4      5      6
##   100:  48.52% 19.52% 47.91% 47.57% 55.40% 69.52% 60.85%
##   200:  49.13% 20.22% 48.69% 47.71% 56.94% 69.92% 60.85%
##   300:  48.89% 19.80% 48.53% 48.14% 54.78% 70.32% 61.58%
##   400:  48.81% 20.22% 48.07% 48.14% 54.63% 70.12% 61.40%
##   500:  49.29% 20.37% 48.53% 48.43% 54.78% 71.51% 62.13%
##   600:  49.00% 20.08% 48.22% 49.00% 54.48% 70.32% 61.58%
##   700:  48.89% 20.22% 48.07% 49.14% 54.17% 70.12% 61.21%
##   800:  48.79% 20.22% 47.76% 48.43% 54.32% 70.32% 61.40%
##   900:  49.08% 20.37% 48.38% 48.43% 54.94% 70.72% 61.40%
##  1000:  49.05% 20.37% 48.53% 48.57% 54.48% 70.52% 61.58%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 1000
## No. of variables tried at each split: 2
##
##         OOB estimate of  error rate: 49.05%
## Confusion matrix:
##           laying sitting standing walk walkdown walkup
class.error
## laying      567      88       29    4        7     17
0.2037
## sitting      76     333       89   59       47     43
0.4853
## standing     16      75      360  103       73     73
0.4857
## walk          1      45      100  295      113     94
0.5448
## walkdown      4      40       81  139      148     90
0.7052
## walkup       11      29       88  115       92    209
0.6158
##           predict
## observed    laying sitting standing    walk walkdown  walkup
##   laying   0.63559 0.15678  0.12712 0.05085  0.01695 0.01271
##   sitting  0.08019 0.48113  0.23585 0.08019  0.06132 0.06132
##   standing 0.05263 0.29386  0.39474 0.12281  0.06140 0.07456
##   walk     0.05462 0.18908  0.36555 0.10084  0.13445 0.15546
##   walkdown 0.13228 0.20635  0.26455 0.16402  0.13757 0.09524
##   walkup   0.06161 0.18483  0.25592 0.06161  0.13744 0.29858
```


accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
sitting
standing
observed



Observation:

- Number of trees: 1000
- No. of variables tried at each split: 2
- OOB estimate of error rate: 49.057%
- Removing the x and y axis details totally regressed our results.
- We need to balance our results, which may increase the error rate but result In a better overall performance.

Action:

- We need to explore how we can weigh the classes

How out of balance are we in our expanded training set?

```
data.training.expanded.classDist <- table(data.training.expanded[,
"activity"])
print(data.training.expanded.classDist)
```

```
##
##   laying  sitting standing     walk walkdown   walkup
##      712      647      700      648      502      544
```

```
mean(data.training.expanded.classDist)
```

```
## [1] 625.5
```

Observation:

- We need to either down or up sample our training data to achieve a better balance.

Action:

- We need to obtain a better understanding of the impact resampling has on the prediction model v. class weights.

Resample and Test

```
data.training.expanded.downSampled <-
downSample(data.training.expanded, data.training.expanded$activity)
dim(data.training.expanded.downSampled)
```

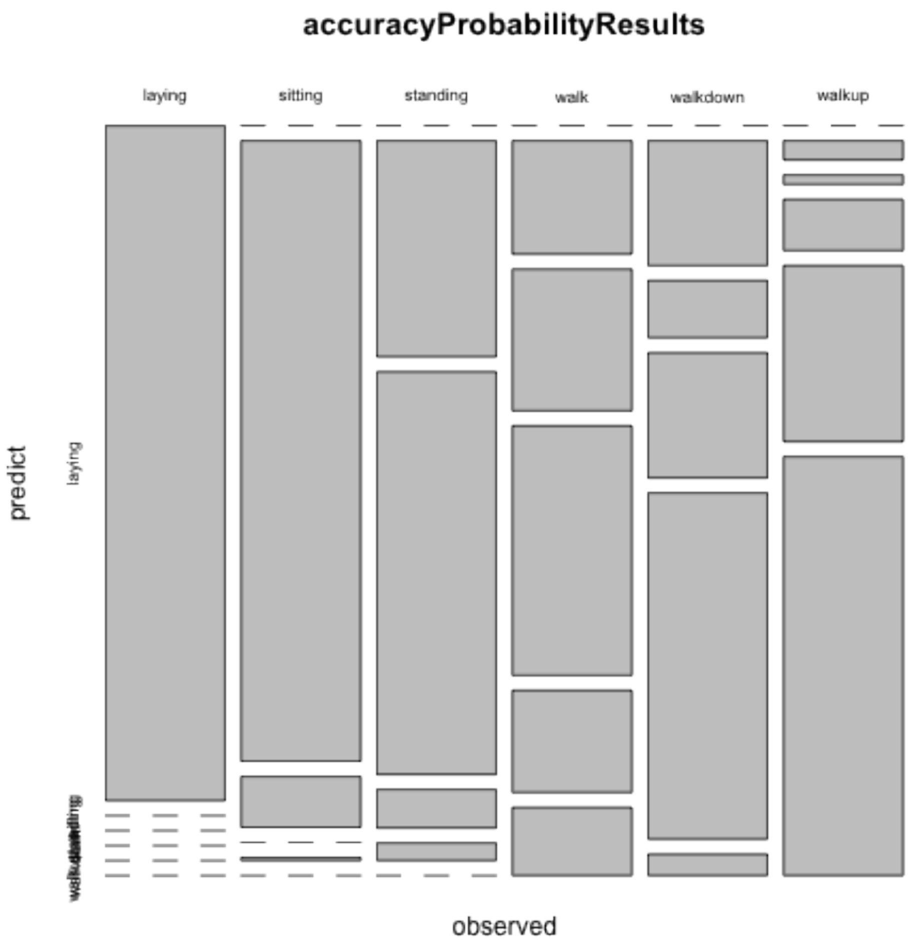
```
## [1] 3012   10
```

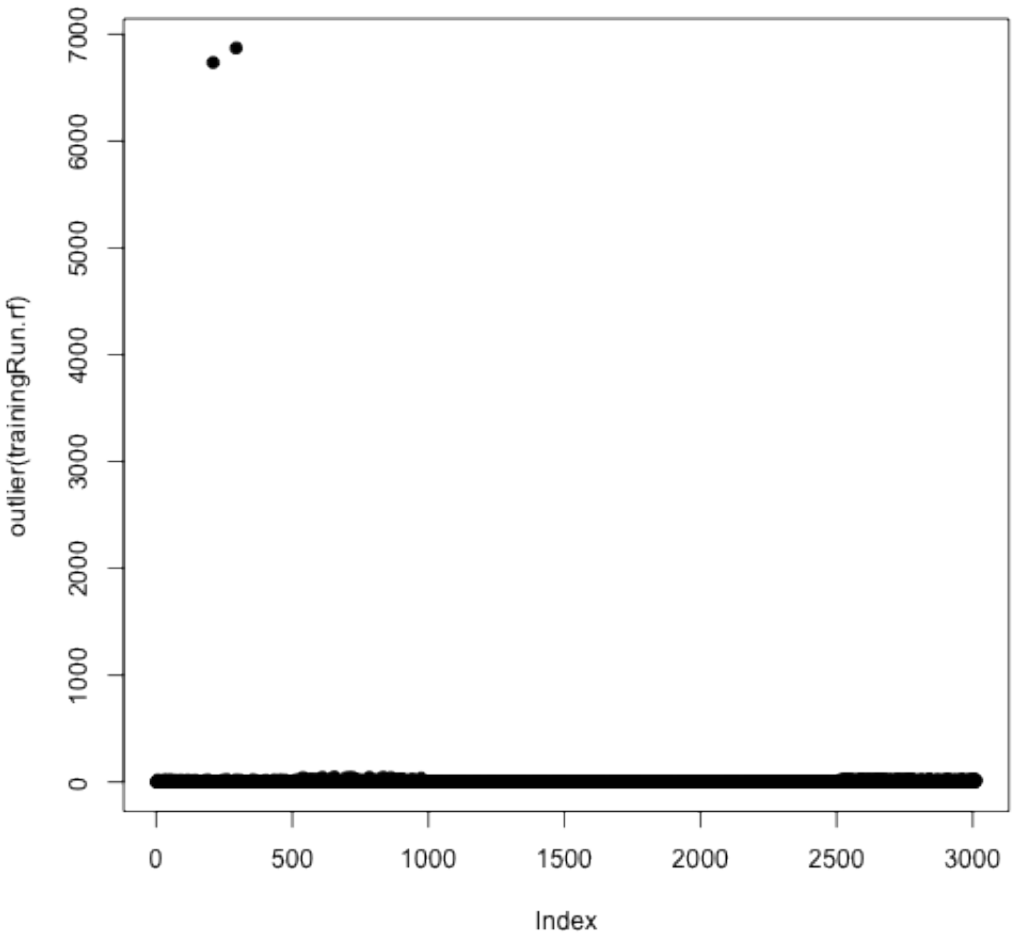
```
data.training.expanded.upSampled <-
upSample(data.training.expanded, data.training.expanded$activity)
dim(data.training.expanded.upSampled)
```

```
## [1] 4272   10
```

```
## Define the prediction formula
model.formula <- activity ~ xMeanBodyAcc + yMeanBodyAcc +
zMeanBodyAcc + xMeanGravityAcc +
    yMeanGravityAcc + zMeanGravityAcc
## Test DownSampling
prediction.results.accuracy <-
performPredictionTraining(model.formula,
data.training.expanded.downSampled,
    data.training.test, splits = 4, "Exp4s1000tDownSampling",
prediction.results.accuracy,
    trees = 1000)
```

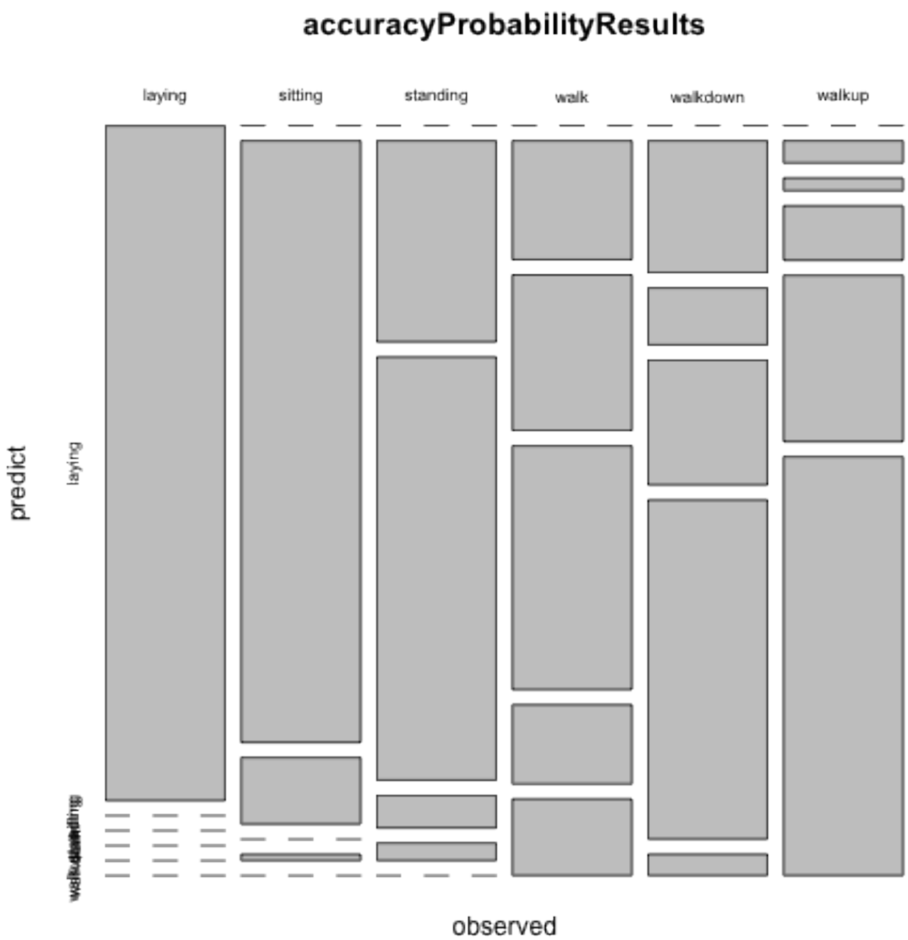
```
## ntree      OOB      1      2      3      4      5      6
##   100:  10.62%  0.40%  5.38% 14.54% 15.54% 18.92%  8.96%
##   200:  10.46%  0.40%  4.78% 14.74% 14.54% 19.12%  9.16%
##   300:  10.62%  0.40%  5.18% 14.74% 14.94% 19.32%  9.16%
##   400:  10.52%  0.40%  5.58% 14.34% 14.94% 18.53%  9.36%
##   500:  10.56%  0.40%  5.38% 14.54% 14.94% 18.92%  9.16%
##   600:  10.46%  0.40%  5.38% 14.14% 15.14% 18.73%  8.96%
##   700:  10.52%  0.40%  5.18% 14.74% 14.94% 18.73%  9.16%
##   800:  10.52%  0.40%  5.38% 14.74% 14.54% 19.12%  8.96%
##   900:  10.52%  0.40%  5.18% 14.54% 14.94% 19.12%  8.96%
##  1000:  10.46%  0.40%  5.38% 14.54% 14.74% 18.73%  8.96%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 1000
## No. of variables tried at each split: 4
##
##         OOB estimate of  error rate: 10.46%
## Confusion matrix:
##          laying sitting standing walk walkdown walkup
class.error
## laying      500       2        0    0        0      0
0.003984
## sitting       0     475       15    3        7      2
0.053785
## standing      0      15      429   35       10     13
0.145418
## walk          0       3       25  428       38      8
0.147410
## walkdown      0       3       15   69      408      7
0.187251
## walkup        0       0        8   21       16    457
0.089641
##           predict
## observed     laying  sitting standing     walk walkdown   walkup
##   laying   1.000000 0.000000 0.000000 0.000000 0.000000 0.000000
##   sitting  0.000000 0.919811 0.075472 0.000000 0.004717 0.000000
##   standing 0.000000 0.320175 0.596491 0.057018 0.026316 0.000000
##   walk     0.000000 0.168067 0.210084 0.369748 0.151261 0.100840
##   walkdown 0.000000 0.185185 0.084656 0.185185 0.513228 0.031746
##   walkup   0.000000 0.028436 0.014218 0.075829 0.260664 0.620853
```

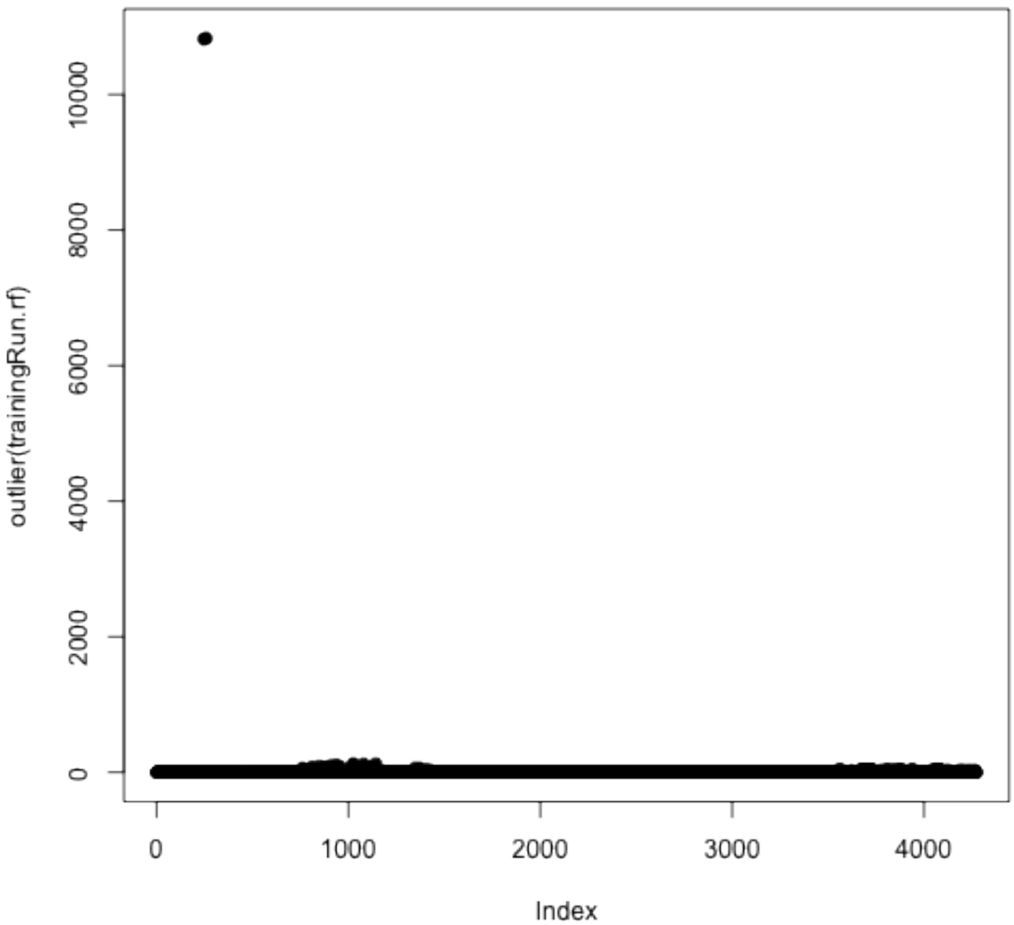

accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
observed




```
## Test UpSampling
prediction.results.accuracy <-
performPredictionTraining(model.formula,
data.training.expanded.upSampled,
    data.training.test, splits = 4, "Exp4s1000tUpSampling",
prediction.results.accuracy,
    trees = 1000)
```

```
## ntree      OOB      1      2      3      4      5      6
##   100:   6.93%  0.28%  3.65% 11.38% 11.52%  9.83%  4.92%
##   200:   6.58%  0.28%  3.65% 11.24% 10.96%  8.85%  4.49%
##   300:   6.74%  0.28%  3.51% 11.94% 11.38%  8.99%  4.35%
##   400:   6.79%  0.28%  3.51% 11.38% 11.38%  9.41%  4.78%
##   500:   6.69%  0.28%  3.51% 11.38% 10.96%  9.27%  4.78%
##   600:   6.62%  0.28%  3.65% 11.10% 10.96%  9.41%  4.35%
##   700:   6.74%  0.28%  3.65% 11.52% 11.24%  9.27%  4.49%
##   800:   6.74%  0.28%  3.65% 11.24% 11.24%  9.41%  4.63%
##   900:   6.62%  0.28%  3.65% 11.10% 11.24%  9.13%  4.35%
##  1000:   6.67%  0.28%  3.79% 10.96% 11.24%  9.41%  4.35%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 1000
## No. of variables tried at each split: 4
##
##         OOB estimate of  error rate: 6.67%
## Confusion matrix:
##          laying sitting standing walk walkdown walkup
class.error
## laying      710       2        0    0        0      0
0.002809
## sitting       0     685       17    4        5      1
0.037921
## standing      0      15      634   40       10     13
0.109551
## walk          0       1       24  632       48      7
0.112360
## walkdown      0       3        8   51      645      5
0.094101
## walkup        0       0        5   18        8    681
0.043539
##           predict
## observed     laying  sitting standing     walk walkdown   walkup
##   laying   1.000000 0.000000 0.000000 0.000000 0.000000 0.000000
##   sitting  0.000000 0.891509 0.099057 0.000000 0.009434 0.000000
##   standing 0.000000 0.298246 0.627193 0.048246 0.026316 0.000000
##   walk     0.000000 0.176471 0.231092 0.361345 0.117647 0.113445
##   walkdown 0.000000 0.195767 0.084656 0.185185 0.502646 0.031746
##   walkup   0.000000 0.033175 0.018957 0.080569 0.246445 0.620853
```


accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
observed



Observation:

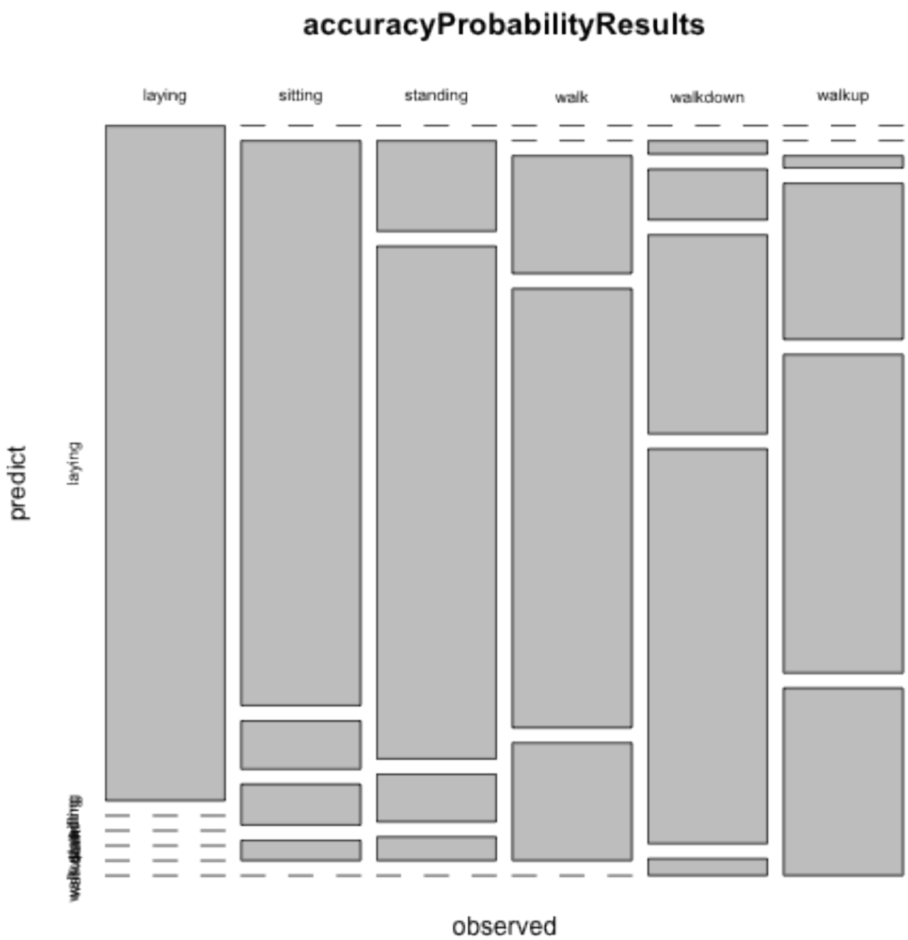
- Using the downSampled dataset, Split / Tree / Error Rate: 4 / 1000 / 10.46%
- Using the upSampled dataset, Split / Tree / Error Rate: 4 / 1000 / 6.67%
- UpSampling has yielded a better error rate as well as much better accuracy. For the first time our accuracy per class is above 50% with the exception of Walk @ 36%. This is a major improvement.
- This approach minimized outliers.

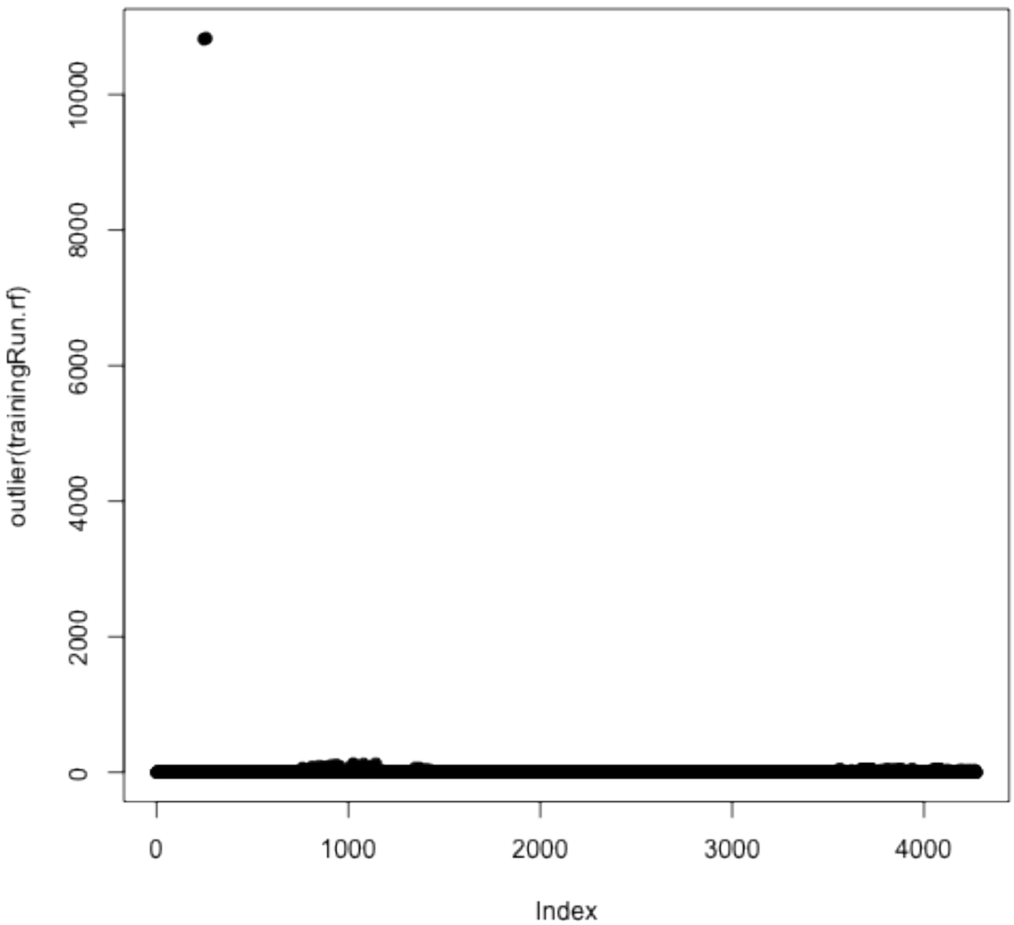
Using Validation Set

Test Prediction Model on Baseline Test Population

```
## Define the prediction formula
model.formula <- activity ~ xMeanBodyAcc + yMeanBodyAcc +
zMeanBodyAcc + xMeanGravityAcc +
    yMeanGravityAcc + zMeanGravityAcc
## Validate Model - Baseline
prediction.results.accuracy <-
performPredictionTraining(model.formula,
data.training.expanded.upSampled,
    data.validation.baseline, splits = 4, "BaselineValidation",
prediction.results.accuracy,
    trees = 1000)
```

```
## ntree      OOB      1      2      3      4      5      6
##   100:   6.93%  0.28%  3.65% 11.38% 11.52%  9.83%  4.92%
##   200:   6.58%  0.28%  3.65% 11.24% 10.96%  8.85%  4.49%
##   300:   6.74%  0.28%  3.51% 11.94% 11.38%  8.99%  4.35%
##   400:   6.79%  0.28%  3.51% 11.38% 11.38%  9.41%  4.78%
##   500:   6.69%  0.28%  3.51% 11.38% 10.96%  9.27%  4.78%
##   600:   6.62%  0.28%  3.65% 11.10% 10.96%  9.41%  4.35%
##   700:   6.74%  0.28%  3.65% 11.52% 11.24%  9.27%  4.49%
##   800:   6.74%  0.28%  3.65% 11.24% 11.24%  9.41%  4.63%
##   900:   6.62%  0.28%  3.65% 11.10% 11.24%  9.13%  4.35%
##  1000:   6.67%  0.28%  3.79% 10.96% 11.24%  9.41%  4.35%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 1000
## No. of variables tried at each split: 4
##
##         OOB estimate of  error rate: 6.67%
## Confusion matrix:
##          laying sitting standing walk walkdown walkup
class.error
## laying      710       2        0    0        0      0
0.002809
## sitting       0     685       17    4        5      1
0.037921
## standing      0      15      634   40       10     13
0.109551
## walk          0       1       24  632       48      7
0.112360
## walkdown      0       3        8   51      645      5
0.094101
## walkup        0       0        5   18        8    681
0.043539
##           predict
## observed    laying sitting standing    walk walkdown  walkup
##   laying   1.00000 0.00000  0.00000 0.00000  0.00000 0.00000
##   sitting  0.00000 0.83712  0.07197 0.06061  0.03030 0.00000
##   standing 0.00000 0.13428  0.75972 0.07067  0.03534 0.00000
##   walk     0.00000 0.00000  0.17467 0.65066  0.17467 0.00000
##   walkdown 0.00000 0.02000  0.07500 0.29500  0.58500 0.02500
##   walkup   0.00000 0.00000  0.01852 0.23148  0.47222 0.27778
```


accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
observed

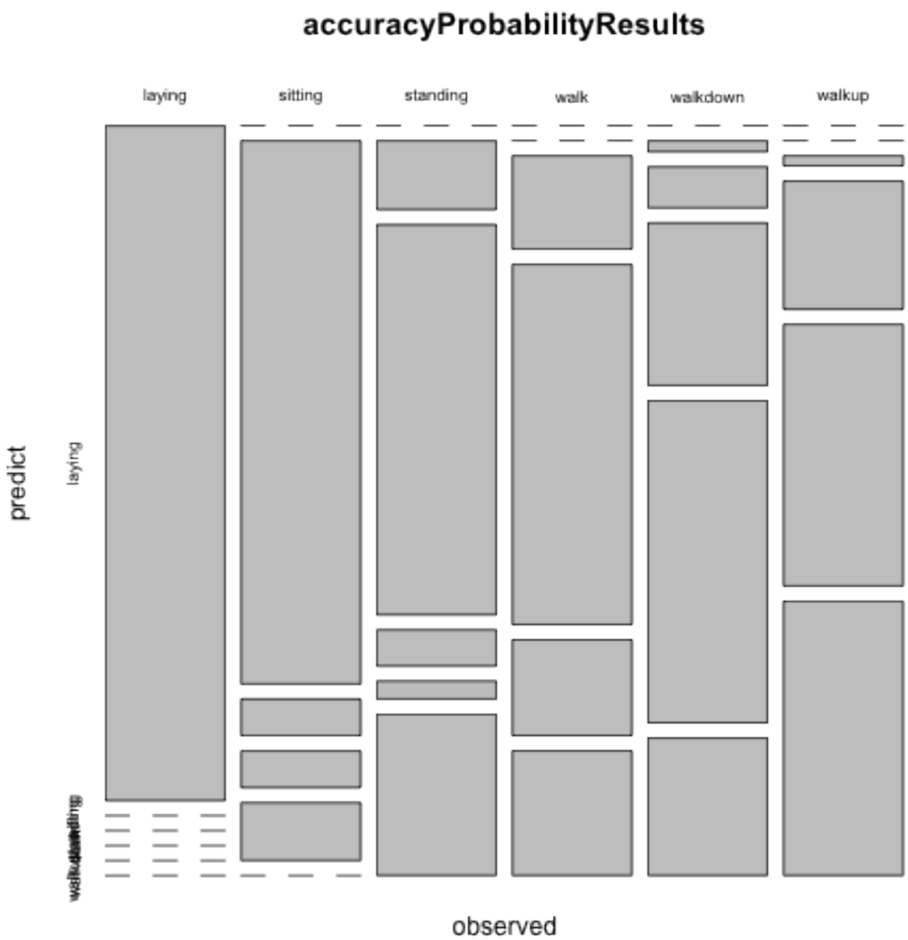


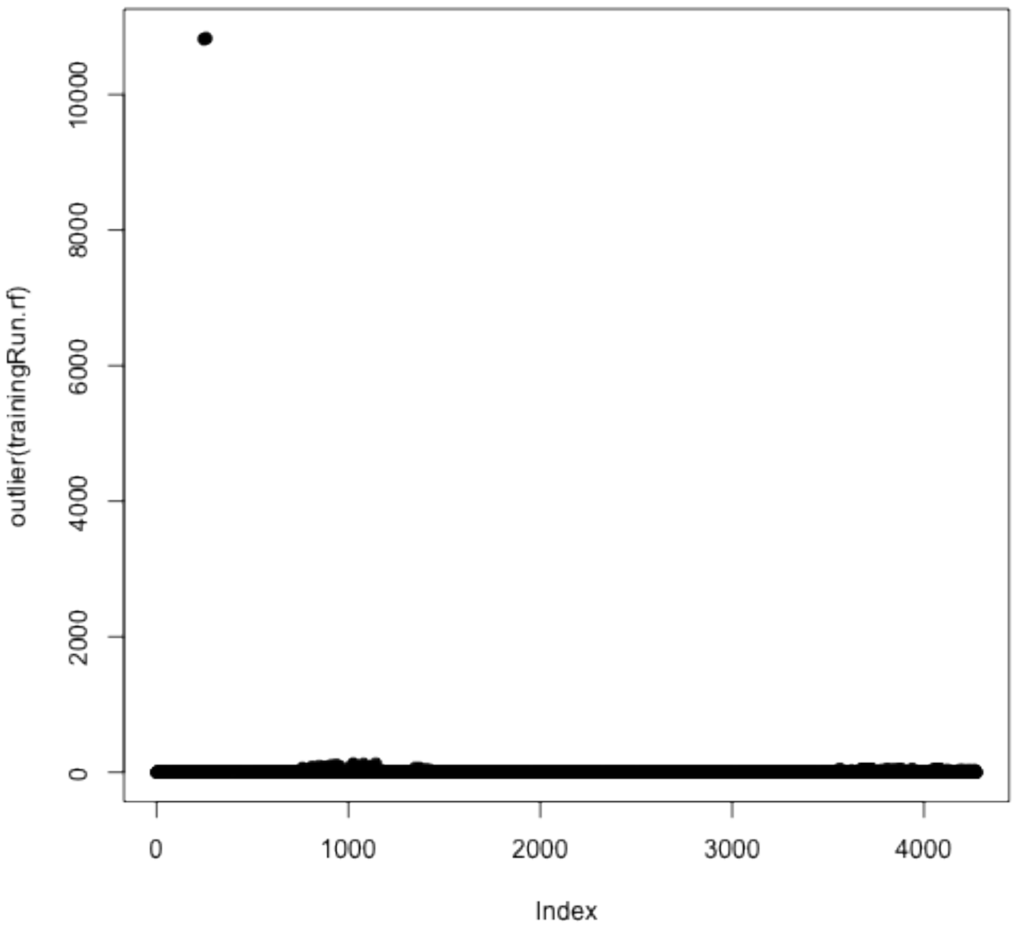
Observation: Outstanding. Our prediction model proved to maintain it's error rate of 6.67%. * The model maintained an accuracy per class above 50% with the exception of Walkup @ 27%.

Test Prediction Model on Expanded Test Population

```
## Define the prediction formula
model.formula <- activity ~ xMeanBodyAcc + yMeanBodyAcc +
zMeanBodyAcc + xMeanGravityAcc +
    yMeanGravityAcc + zMeanGravityAcc
## Validate Model - Baseline
prediction.results.accuracy <-
performPredictionTraining(model.formula,
data.training.expanded.upSampled,
    data.validation.expanded, splits = 4, "ExpandedValidation",
prediction.results.accuracy,
    trees = 1000)
```

```
## ntree      OOB      1      2      3      4      5      6
##   100:   6.93%  0.28%  3.65% 11.38% 11.52%  9.83%  4.92%
##   200:   6.58%  0.28%  3.65% 11.24% 10.96%  8.85%  4.49%
##   300:   6.74%  0.28%  3.51% 11.94% 11.38%  8.99%  4.35%
##   400:   6.79%  0.28%  3.51% 11.38% 11.38%  9.41%  4.78%
##   500:   6.69%  0.28%  3.51% 11.38% 10.96%  9.27%  4.78%
##   600:   6.62%  0.28%  3.65% 11.10% 10.96%  9.41%  4.35%
##   700:   6.74%  0.28%  3.65% 11.52% 11.24%  9.27%  4.49%
##   800:   6.74%  0.28%  3.65% 11.24% 11.24%  9.41%  4.63%
##   900:   6.62%  0.28%  3.65% 11.10% 11.24%  9.13%  4.35%
##  1000:   6.67%  0.28%  3.79% 10.96% 11.24%  9.41%  4.35%
##
## Call:
##  randomForest(formula = formula, data = trainingData, importance
= TRUE,      proximity = TRUE, do.trace = 100, mtry = splits, ntree
= trees)
##                Type of random forest: classification
##                      Number of trees: 1000
## No. of variables tried at each split: 4
##
##         OOB estimate of  error rate: 6.67%
## Confusion matrix:
##          laying sitting standing walk walkdown walkup
class.error
## laying      710       2        0    0        0      0
0.002809
## sitting       0     685       17    4        5      1
0.037921
## standing      0      15      634   40       10     13
0.109551
## walk          0       1       24  632       48      7
0.112360
## walkdown      0       3        8   51      645      5
0.094101
## walkup        0       0        5   18        8    681
0.043539
##           predict
## observed    laying sitting standing    walk walkdown  walkup
##   laying   1.00000 0.00000  0.00000 0.00000  0.00000 0.00000
##   sitting  0.00000 0.80516  0.05444 0.05444  0.08596 0.00000
##   standing 0.00000 0.10215  0.57796 0.05376  0.02688 0.23925
##   walk     0.00000 0.00000  0.13879 0.53381  0.14235 0.18505
##   walkdown 0.00000 0.01633  0.06122 0.24082  0.47755 0.20408
##   walkup   0.00000 0.00000  0.01521 0.19011  0.38783 0.40684
```


accuracyProbabilityResults
laying
sitting
standing
walk
walkdown
walkup
predict
laying
observed



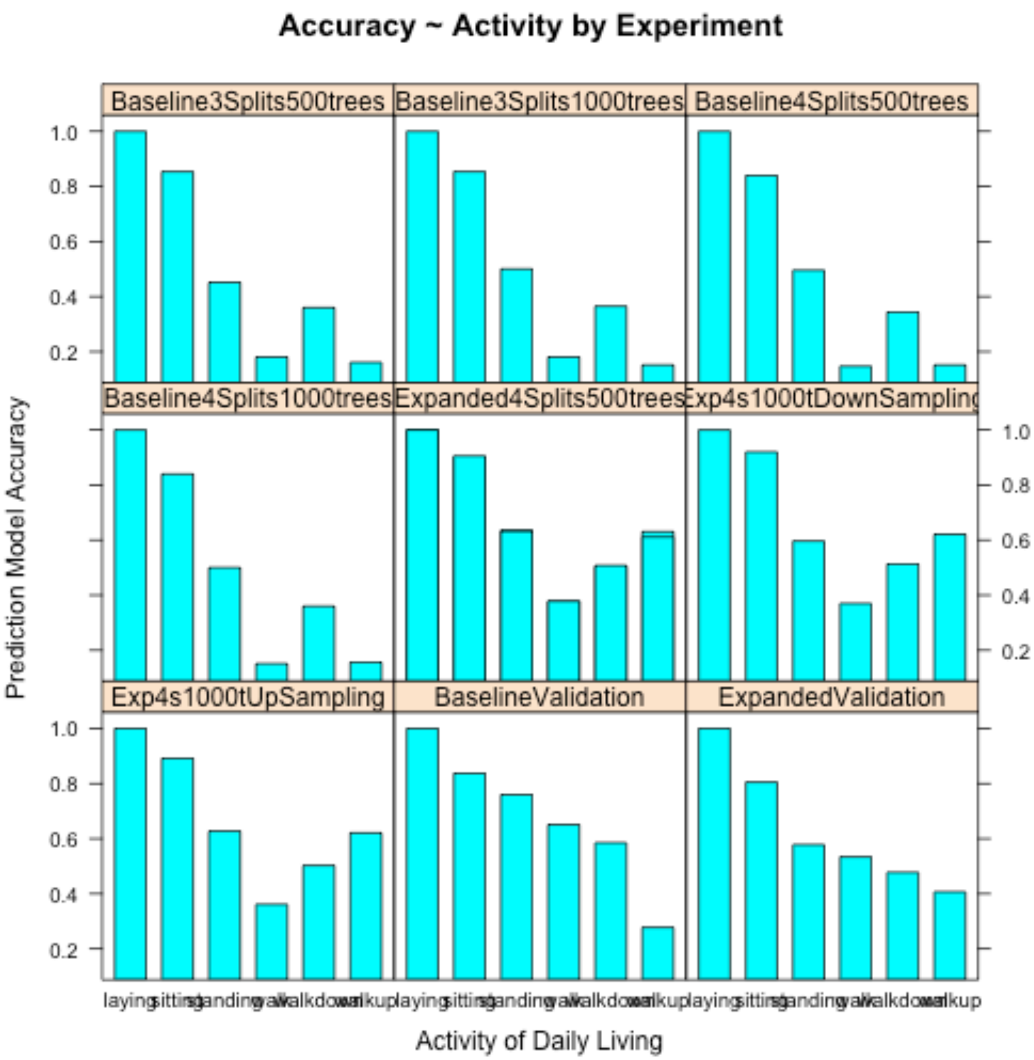
Observation: Outstanding. Our prediction model proved to maintain it's error rate of 6.67%. We maintained accuracy above 50% for all but two classes which now were above 40%.

Action: Plot the results.

Interpret results

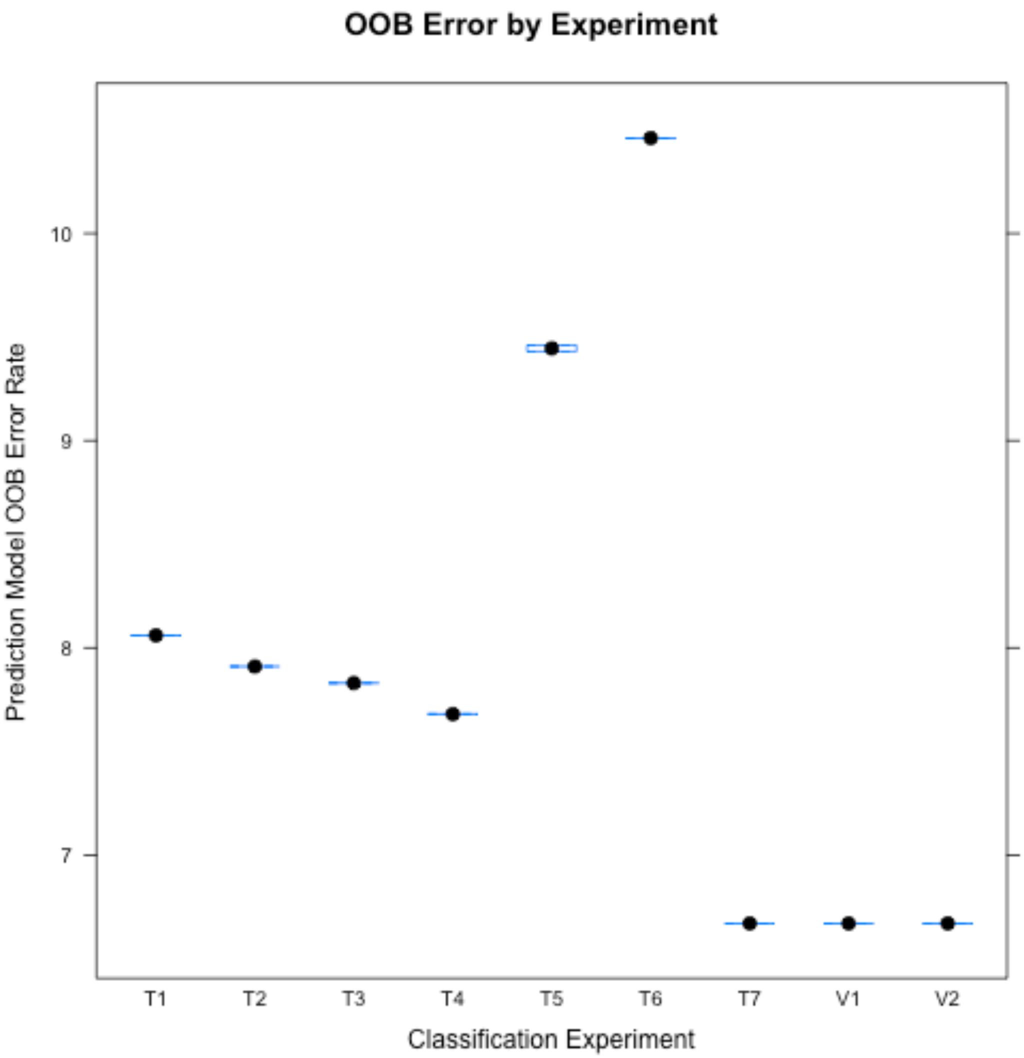
Optimistic prediction rates for human activity is possible using the XYZ coordinates of several Accelerometer signals.

```
prediction.results.accgood <-
prediction.results.accuracy[-which(prediction.results.accuracy$oobError
 >
    15), ]
plot.Colors = rainbow(8, s = 0.3, v = 0.9, start = 0, end = 0.9)
barchart(accuracy ~ adl | runID, data = prediction.results.accgood,
main = "Accuracy ~ Activity by Experiment",
    xlab = "Activity of Daily Living", ylab = "Prediction Model
Accuracy", pch = 19,
    as.table = TRUE)
```



Observation: After 8 iterative training experiments, we were able to establish a model that was able to consistently classify human activity with at least 40% accuracy for all activity classes. This remained true on the baseline and expanded test populations.

```
plot.runID <- factor(prediction.results.accgood$runID, labels =
c("T1", "T2",
    "T3", "T4", "T5", "T6", "T7", "V1", "V2"))
bwplot(oobError ~ plot.runID, data = prediction.results.accgood,
main = "OOB Error by Experiment",
    xlab = "Classification Experiment", ylab = "Prediction Model
OOB Error Rate",
    pch = 19, as.table = TRUE)
```



Observation: Once we tuned our model with a 6.67% OOB Error Rate, we were able to maintain the same error rate on both validation test. Since the Random Forest algorithm does not overfit, we have addressed:

- Avoidance of overfitting
- Improved Accuracy
- Zero optimism *cross validation is handled via internal algorithm bootstrapping

Challenge results

There are several common issues with prediction models:

Accuracy

Our prediction model proved to maintain it's error rate of 6.67%. We maintained accuracy above 50% for all but two classes which now were above 40%.

Overfitting

We have avoided overfitting due to the use of the Random Forest algorithm which does not overfit.

Interpretability

Our ability to interpret the results of our model are tied to the complexity of the model. The fewer variables that we consider the easier it will be to interpret their applicability to the model. We have narrowed our variables of interest from 563 down to 6. Thereby, allowing for better interpretability.

Computational Speed

The Random Forest algorithm is highly optimized and given our narrowing of the variables, we were able to compute 8 training and 2 validation experiments on a single PC within minutes.

Finalize Report

Items to be covered in write:

- Item 1 - Write-up
  - Does the analysis have an introduction, methods, analysis, and conclusions?
  - Are figures labeled and referred to by number in the text?
  - Is the analysis written in clear and understandable English?
  - Are the names of variables reported in plain language, rather than in coded names?
  - Does the analysis report the number of samples?
  - Does the analysis report any missing data or other unusual features?
  - Does the analysis include a discussion of potential confounders?
  - Are the statistical models appropriately applied?
  - Are estimates reported with appropriate units and measures of uncertainty?
  - Are estimators/predictions appropriately interpreted?
  - Does the analysis make concrete conclusions?
  - Does the analysis specify potential problems with the conclusions?

- Item 2 - Figure and caption
  - Is the figure caption descriptive enough to stand alone?
  - Does the figure focus on a key issue in the processing/modeling of the data?
  - Are axes labeled and are the labels large enough to read?